THAPAR INSTITUTE OF ENGINEERING & TECHNOLOGY
PATIALA
DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING

QUALITY AND PRODUCTIVITY IMPROVEMENT THROUGH STATISTICAL METHODS

GABRIEL INDIA LIMITED
ENGINE BEARINGS DIVISION
PARWANOO

1st July, 1988

Prepared by

PUNEET ARORA
165/85, INDUSTRIAL ENGG. DEPARTMENT

LETTER OF SUBMITTAL

Plot No. 5, Sector II
Parwanoo.
30th of June, 1988

MR. S.K.SATSANGI
Head : Placement and Co-ordination,
Thapar Institute of Engineering & Technology,
Patiala - 147001.

Dear Sir,

I submit herewith this report, entitled, "Quality & Productivity Improvements through Stastical Methods', my work report for the Quality Control Department of Gabriel India Limited, Engine Bearing Division, Parwanoo. This report has been prepared for my work Term-I at Gabriel India Ltd., from January to June, 1988.

Engine Bearings Division of Gabriel India Limited is mainly engaged in the manufacture of thin walled bimetallic engine bearings.

The Quality Control department is headed by Mr.A.A.Marathe and has the function of maintaining the quality of the manufactured products, to ensure acceptance of the customers, and reducing the percentage of rejections during the process of manufacture.

I would like to convey my thanks to Mr.P.N.Patankar (Plant Manager), Mr.A.A.Marathe (Manager Q.C.). Mr. V.Murli (Asstt.Mgr. Q.C.) & the engineers and other staff of the Quality Control and other departments for the help extended to me during the training and in preparing this document.

This report has been prepared and written by me and has not received any previous accademic credit a t this or any other institution.

Sincerely yours,

Puneet Arora

(PUNEET ARORA)
Roll No.165/85

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SECTION THREE

SUMMARY

This report is for my training during Work-Term I at Gabriel India Limited, Engine Bearing Division, Parwanoo. Gabriel India Ltd's Parwanoo plant is engaged in the manufacture of thin walled bimetallic engine bearings - straight bearings, flanged bearings, bushes and thrust washers. Work during the training period comprised of mainly three categories namely improvement of quality, improvement of productivity and some general or routine work. A brief description of the projects undertaken under these various categories is as follows.

Quality improvement.

Quality is the essense of any product in todays competitive market. Good quality has to be ensured to make the product which would satisfy the demands of the customer. Various studies undertaken are:

Analysis of rejections due to chips/damages & their causes:

About 25% of total rejections are due to embedment of chips on the surface of the bearings during various operations. The reasons for the above have been found to be the presence of excess oil on slides, dirt on bearings, inadequate air supply etc. Recommendations have been given to install chip collectors on broaching machines, to reduce the supply of oil & to install a cleaning plant for degreasing of bearings and their containers.

Analysis of spread of bearings for correlation with physical properties:

Spread is of critical importance in all bearing applications variations were observed after ejection of bearing from the die and

at all operation stages. The attempt to corelate this variation with various physical properties of materials was not successful. However work to use accumulated data by corelating it with the overall changes in spread over the whole process.

Status of lining thickness & hardness of blanks:

This work was taken up to determine the thickness of lining of the bearing after ID broaching operation. This was done with a view to try to reduce material wastage through improper strip manufacture & also put a check on the steel issued by the PPC department. Blank hardness checked to evaluate the formability characteristics of the material.

Location of holes on KCL cam shaft bush-2, Part no. 157870:

Displacement of holes took place every time this application was produced. Displacement found to be due to faulty facing procedures. Adaptor of facing machines modified by using locating pins for the holes. The modification led to a successful production of a lot of about 10,000 pcs.

Effect of annealing on OD of bushes:

Annealing or stress relieving had very good effect on OD of bushes as ascertained by this study of annealing and face & chamfer operations. Bushes of thicker wall sizes are now to be face & chamfered after annealing for good results.

Capability study of ht & ID broaches:

Height & ID broaching are of very critical importance in the process of manufacture of straight & flanged bearings. This study was to find out the capabilities of the broaches & their behavorial patterns. All except one of these machines showed natural behaviour. The unnatural behaviour of H03 explained due to pneumatic mechanism timings. Attempts being made to try to eliminate this defect in timings by installation of electtical devices.

Reducing the wastage of time & effort of operators by standardization of data:

A system of Process cards' has been initiated for the above mentioned causes. There will be one process card for each operation of each application. These will be kept at the machines and would considerably help production & QC operators.

Analysis of face & chamfer operations to determine cause and remedy for semi-faced bearings:

Some bearings were not properly faced during the face & chamfer operation. Cause was found to be due to a bulge at the ends of the bearing arising at the coming stage due to excessive length of blank. Blank length has been reduced by 0.015 inches for all straight bearing applications.

Capability study of centreless grinder:

Capability of centreless grinder was studied with a view to compare it with the new grinder being bought in its place as it was to be sent back to Gurgaon plant from whom it had been taken on loan.

Analysis of variation in rolling thickness of bimetallic strip through the capability analyses of the rolling mill.

A study was undertaken to find out the reasons for the variations in rolling size existing during the rolling process at the second sinter stage. Project not fully completed dur to various reasons.

Productivity Improvement:

Work undertaken to improve the productivity at various stages may be listed as follows:

A study of speed of strip in sinter line

A lot of lost time had been reported in the sinter line. The only plausible cause, suggested was wrong inticated speed. Study was taken up to check the speed of the line. Variations were rectified isx using a potentiometer in the input circuit of the LED display.

Starting of conveyer oiler in final inspection/packing area:

A conveyer oiler was installed to work with the conveyer from plating area to reduce work of final inspection operators. Also the no.of bearings oiled was also increased. The wastage of oil was also reduced to a large extent.

General work

A lot of routine work was also done. It included helping in supervision work in days when attendance was low, preparing of daily/monthly rejection reports and many other works like designing work seat for stage inspectors, preparing staff requirements in QC department etc.

SECTION ONE

A WORD ABOUT THE GROUP

Gabriel India Limited was incorporated in 1962 in collaboration with Mermont Corporation (USA), world leaders in the field of automotive components such as shock absorbers, McPherson struts and exhaust mufflers. Today Gabriel is the largest manufacturer of shock absorbers with a range covering almost all modes of transport. In addition to the shock absorbers division, the other companies that are a part of the Group are:

Anand Engine Bearings.
McPherson Struts.
Purolator Filters Limited.
Perfect Circle Limited. etc.

ABOUT THE COMPANY

In 1978 Gabriel India Limited diversified with the manufacture of thin walled engine bearing. The Engine Bearing diversion was set up in colloboration with Fedral-Mogul Corporation of U.S.A. in the idyllic, pollution free surroundings in the foothills of the Himalayas at Parwanoo in Himachal Pradesh. From its very inception, the division has become a pace-setter in the field of engine bearings as being the only manufacturer in India producing a complete range of bimetal bearings bushes, flanges & thrust washers from the raw material stage. The engine bearings plant is a fully integrated one with a non-ferrous power foundry, sinter lines, semi-automatic presses, high speed broaching machines and an automatic electroplating facility. It also has an inhouse, fully equipped chemical & metallurgical lab.

Other major facilities include a gauge room with high precision metrological equipment such as Talyrond & surface analyser etc.

The company is being managed by a group of trained and experienced personnel. They include Mr. M.K.Kukreja (President), Mr.K.N.Rattam (General Manager, Operation) & Mr. P.N.Patankar (Plant Manager), who are assisted by a group of managers and other professionals. The total working strength in the plant is around 300 including the workers.

The Financial Statement for Gabriel India Limited for the year 1986-87 could be summarised as below:

ASSETS	Gross block	Lac/Rs	1535
	Net block	Lac/Rs	951
	Investments	Lac/Rs	4
	Current Assets	Lac/Rs	1382
	Total Assets	Lac/Rs	2337
LIABILITIES	Secured Loans	Lac/Rs	268
	Unsecured Loans	Lac/Rs	316
	Bank Credit	Lac/Rs	407
	Current Liabilities	Lac/Rs	767
	Total Liabilities	Lac/Rs	1748
SHARE HOLDER's FUND		Lac/Rs	589
SALES		Lac/Rs	3978
GROSS PROFIT		Lac/Rs	507
PRODUCTION	Shock absorbers	Lac/Nos.	27.50
	Bimetal bearings	Lac/Nos.	47.37

THE COLLABORATORS

Fedral Mogul Corporation is an international leader in engine bearing technology. It is the largest and the most well known engine bearing manufacturing concern in the world with plants spread all over Europe, North & South America. Fedral-Mogul also has a most sophisticated & modern R & D centre & a testing facility for testing of new materials and manufacturing processes. Over the years it has shared its technology & knowhow in the field of engine bearings manufacture with Gabriel. The Fedral-Mugul Corporation owns about 39% of the shares of the bearing division.

INTRODUCTION TO ENGINE BEARINGS AND BEARING MATERIALS

An internal combustion engine is a vital part of most gaseous or liquid fuel using power systems. The basic function of an engine would be to introduce fuel (gaseous or liquid), convert this fuel into energy and finally convert this energy into rotational motion by a series of mechanical contrivances.

The combustion or the burning of fuel in an internal combustion engine takes place inside the machine itself as against in external combustion engines (such as steam engines) where the combustion takes place outside the machines. Fuels for IC engines are generally obtained through the processing and refin-ing of petroleum. The most common of these being petrol & deisel.

There are basically four major components required to perform the functions described above. They are the cylinder, piston, connecting rod & crank shaft (see fig 1.1)

Fuel & air mixture burns in the cylinder. An explosion and a rapid expansion of the gas pushes the piston outwards. The combination of connecting rod & crank shaft converts this thrust of the piston into rotative motion.

Bearings & Lubrication:

All points of movement between parts such as between cylinder walls & rings & valve guides & valves have a certain amount of friction. Application of a good/suitable lubricant in these areas helps reduce the friction. So all these require oil; a metered or sometimes a cupious supply. In an engine lubricating oil has five important functions:

1) To minimise friction & wear.
2) To cool the moving parts by carrying away heat.
3) To seal the pistons & prevent the escape of gases.
4) To clean the parts & lubricate them.
5) To reduce corrosion.

It is well known that dissimilar metals slide against each other with less wear & friction as compared to similar metals though lubrication is of great assistance in both the cases. Cast iron operating in conjunction with cast iron or steel against steel is never recommended. Looking at the crankshaft, the connecting rod & the crank case - three parts with relative motion, the dissimilar materials theory would suggest that the connecting rod be made of forged alluminium, crank shaft from steel and the crank case from bronze. But such or any similar combination would involve lack of strength, more expensive materials, problem in replacement, difficulties in forging/machining or a combination of these problems.

The solution to these is, therefore, to provide bearings & wear components as inserts, specially designed for the purpose. Changing an insert when wear eventually takes place would eliminate replacing a more expensive part.

Lubrication in a bearing and the effect of it would be easier to describe through the OIL FILM THEORY.

The Oil Film Theory:

In order to lubricate properly, oil must be allowed to flow through a space between the shaft and the bearing. This

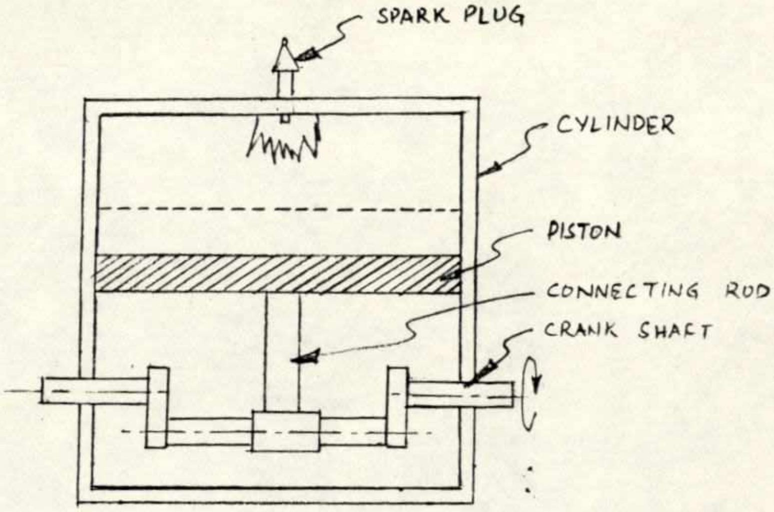


FIG. 1.1

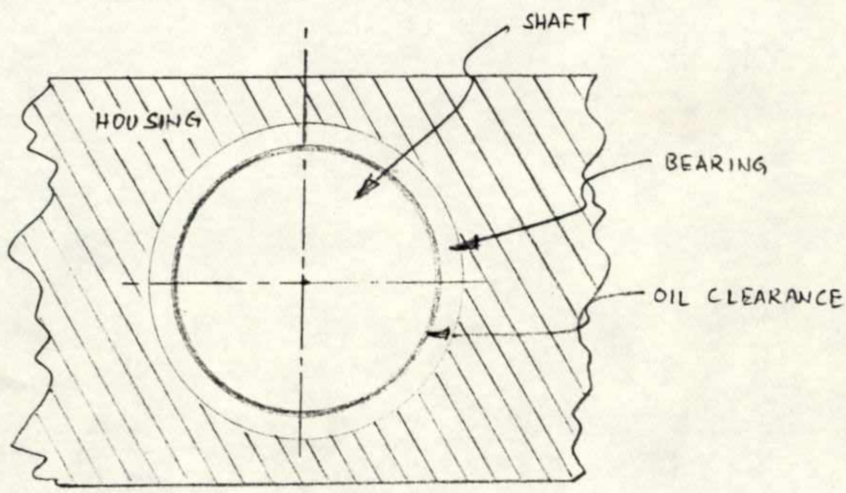


FIG 1·2

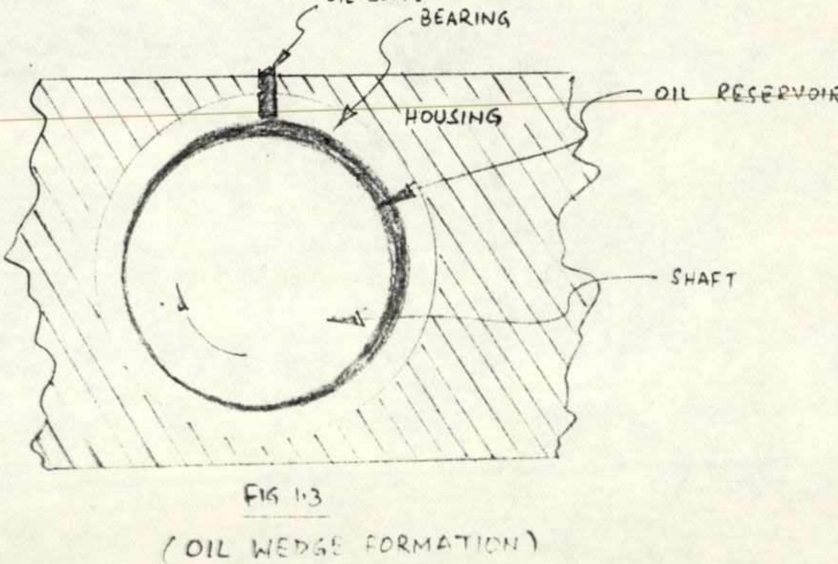


FIG 1·3

(OIL WEDGE FORMATION)

requirement is fulfilled by making the bearing slightly larger in the inside diameter than the shaft by a few thousandth's of an inch (thous') when the bearing is assembled in the housing. The space between the shaft and the bearing purposely provided is called as the oil clearance (fig 1.2) and is usually expressed as the difference of the two diameters.

If a shaft were weighted down with a steady load and operated at a constant speed, provision of a pre-determined oil clearance and a constant supply would allow a contineses film of oil to slide under the loaded area between the shaft and the bearing. Thus the shaft will never actually touch the bearing if ideal condition of speed & load existed.

In fig 1.2 we see in a highly exagarated form such an ideal conditin. In actual working, though, a crescent is formed by the shaft in an escentric position with respect to the bearing diameter. This crescent gets filled up with oil due to the oil pump pressure. The thick portion of the clearance space acts as a reservoir for the oil (fig 1.3). Rotation of the shaft actually slides oil under the loaded area, so that the shaft from its own rotation is actually lifted away from the bearing to permit this passage of an oil film.

Ideal conditions hardly ever exist in a reciprocating piston type engine due to idling, lugging at low speed, acceleration, high speed - full throttle etc. The film, therefore, becomes thin enough to permit the surfaces to protude through the film. If a set of bearings is examined after operation at various speeds in an engine, it can be seen that actual contact does take place between the shaft and the bearing for at least a part of the time during engine operations.

Bearings & Bushings:

Normally, the word 'Bushing' applies to a full round sleeve that is relatively small in size. Bushings are usually associated with the slow rotation, partial or ascillating rotation or medium speed rotation under light load.

A bearing on the other hand, is made up of two halves to fit over a shaft in conjugation with a cap as a part of the housing assembly.

The word bearings, however, is generally used to cover bushings also.

To locate the crank-shaft and to absorb the thrust that is placed upon the crank shaft in the fore or aft direction by the timing gear and the clutch action, most engines use one or two double 'flanged main bearings'. In all of these, the thrust flanges are lined with the same material as the main bearing itself.

In a few engine models, the desire or necessity to use material other than the lining used in the main. bearing, or to lower the tools cost of producing a flanged bearing, has resulted in the use of separate thrust washers which can be used in conjunction with straight bearings to act as flanges. The exact nature of the use of bearings can be estimated by the following example:

In a Tata-Mercedes Benz 73 mm (TMB-73) engine there are-

- 6 small end (con-rod) bushes (one for each con-rods' small end)(Fig.1.4)
- 4 cam - shaft bushes
- 7 main (con-rod) journals (st bearings) with 2 pcs(1 upper & 1 lower) per journal, no of pcs per set = 14 (fig 1.5)
- 12 con-rod bearings (st bearings) (2 for each of con-rod big end) -(fig 1.5)

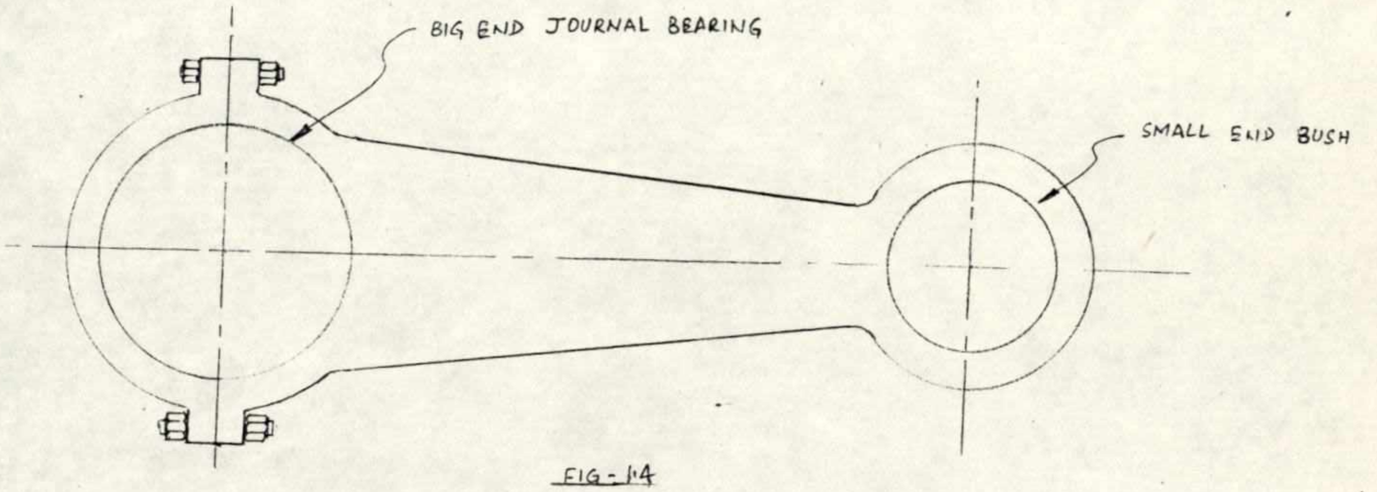


FIG - 1.4

CONNECTING ROD

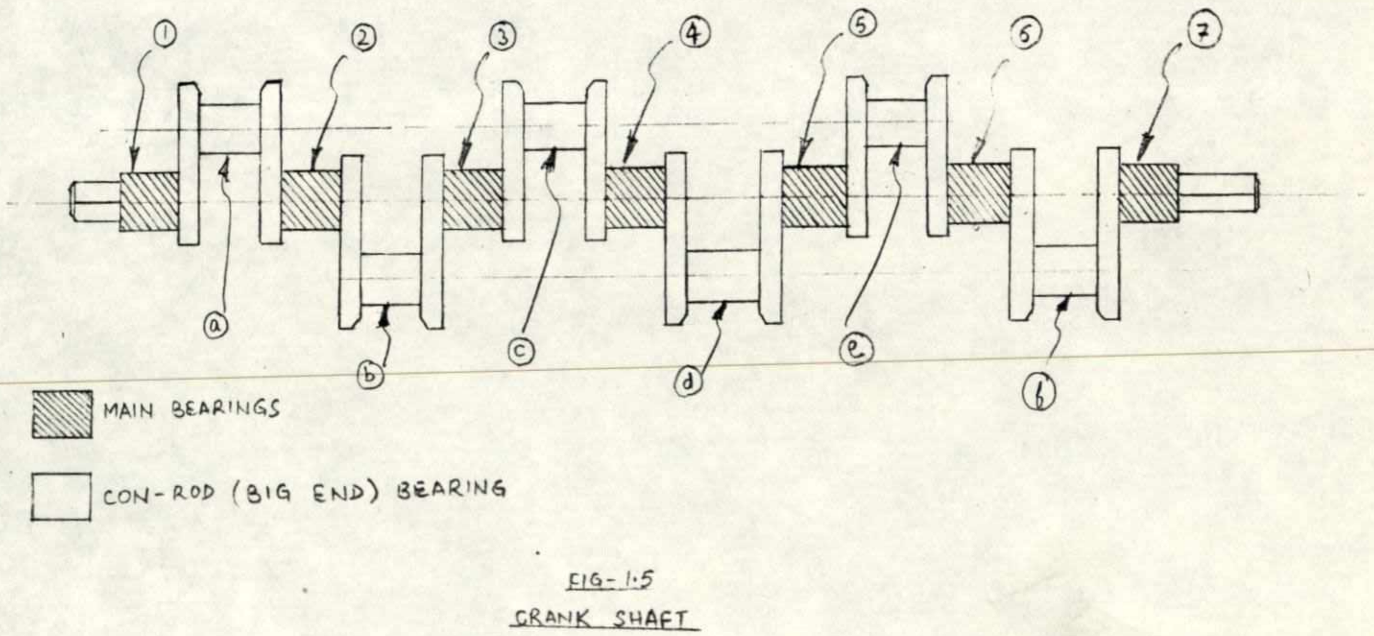


FIG - 1.5

CRANK SHAFT

Bearing Materials:

An engine bearing, whether a main bearing or a con-rod bearing or a cam-shaft bearing, is a simple looking part in the complex piece of machinery called the engine. The simple appearance of the engine bearing is very decieving, for it has both a complex structure as well as a difficult job to perform. During the normal engine life, each bearing must permit free, silent and uncomplaining movement of the engine component it supports. It should also have an excellent resistance to wear.

A bimetal engine bearing usually consists of a steel backing to which one of a number of alloys, called bearing alloys, is adhered on the inside surface. These alloys are also termed as bearing lining material.

Each type of bearing lining material must possess certain desired characteristics or qualities. The four major physical requirements are:

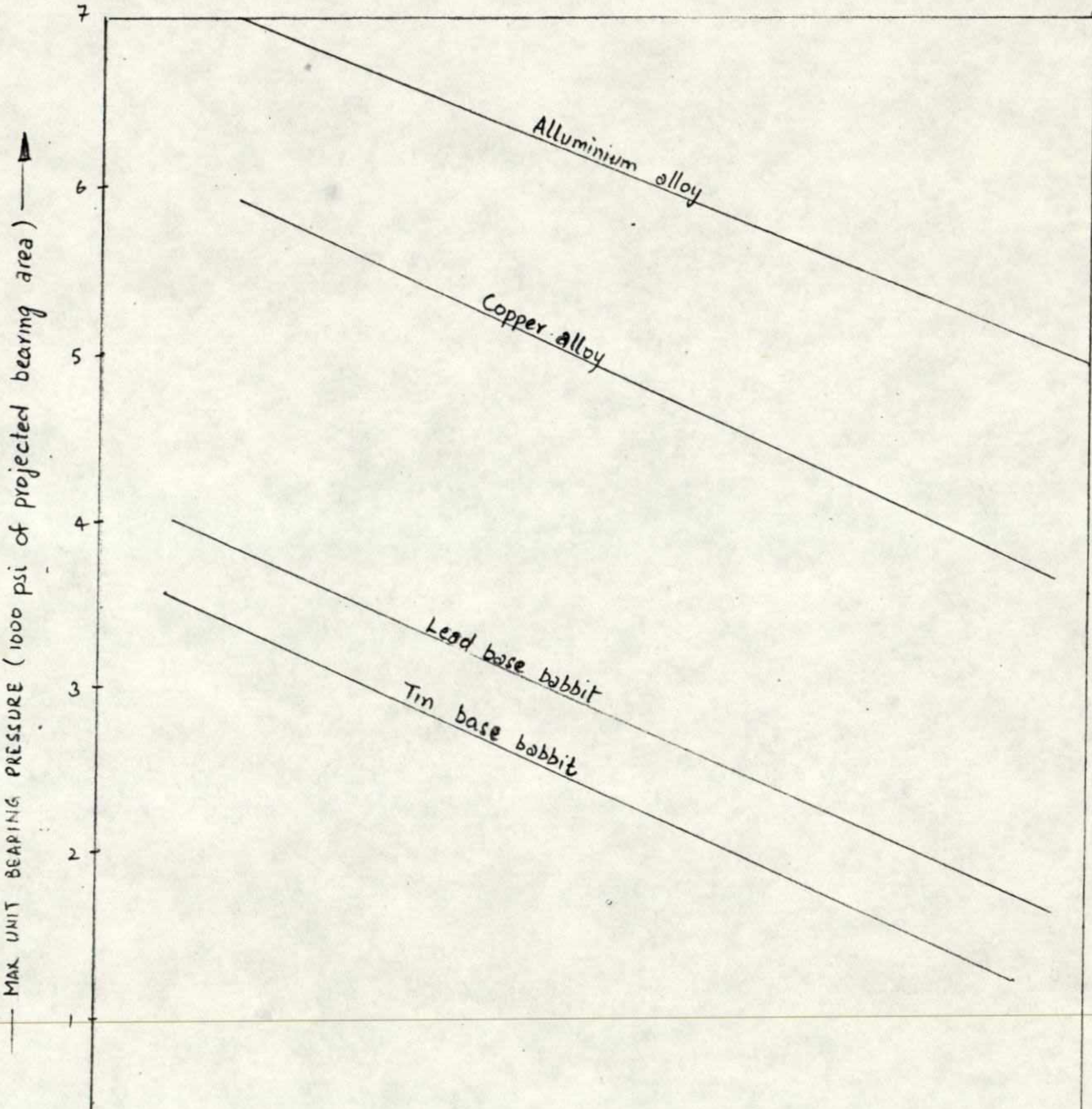
1) Compatibility:

The first requisite in any bearing material is the ability to 'get along' with a rotating shaft in the presence of a good lubricant. Compatibility, therefore, is the ability of the material to slide against another without undue resistance (friction) in the presence of a lubricant under a given set of conditions.

2) Fatigue strength or load carrying capacity:

Another requirement of a bearing is its capacity to withstand repeated heavy loading from the pressures exerted by the explosions against the piston and through the connecting rod,

FIG 1.6


Alluminium alloy
Copper alloy
Lead base babbit
Tin base babbit
MAX UNIT BEARING PRESSURE (1000 psi of projected bearing area)
LIFE EXPECTANCE (THOUSAND OF HOURS)
1
2
3
4
5
6
7

T.I.E.T.

while allowing the shaft to turn. Bearing material have a varying capacity to withstand these loadings without breaking down from fatigue.

Fig 1.6 gives load carrying abilities of some commonly used lining materials.

3) Conformability:

Not all crank shafts and crankpins are perfectly round or straight literally. To overcome these slight inequalities, bearing material should possess some softness or ability to change slightly to conform to the irregularities of the shaft. This characteristic is called conformability.

4) Embeddability:

Dirt or foreign material, which remains in suspension in the lubricating oil, is picked up and circulated through out the system by the oil pump. This is dangerous as it can result in the failure of the bearings . These sometimes hard, sharp particles should either become completely embedded into the lining material or should be bearing lining, they can abarade the shaft. Ability of lining material to absorb the particles is called embeddability.

Other physical requirements:

Some other factors affecting the performance or the manufacture of bearings are

a) Material should have high temp. - strength ratio i.e. it should not weaken seriously at normal or above normal engine operating temperature.

b) Material should preferably be capable of operating against a soft - unheattreated shaft.

c) Material should not have hard constituents in the alloy which will abarade the shaft and score it.

d) Material should not break down or corrode due to complex organic compounds formed in the lubricant due to aeration, blowby, heat or cold.

e) Material should have good thermal conductivity to absorb and take away to the housing, the heat generated at the bearing due to load & rotation.

f) Material should be able to be bonded to a backing material such as steel or bronz.

No bearing material or bearing design can do all jobs better than any other material. So the material selected has to be the one suited best for the particular application and working conditions. Some of the types of bearing materials, their properties and use are given in Appendix- 1.

As can be easily estimated from the annexure data, capper alloys are the most important of the bearing alloys with a very wide range of application.

There are basically two method of applying a copper lead alloy on to a steel backing.

1) Sinter Process.

2) Cast Process.

1) Sintered Process: A molten alloy with proper amounts of copper, lead and tin made to explode in an atomising chamber breaking it into myraids of tiny solid spheres. Powder thus obtained is spread evenly on a continuously moving strip of steel. By sintering and compressive rolling, particles get completely bonded to each other and to the steel. Sintering causes copper & lead to mix thoroughly to form a tough & durable alloy.

2) Cast Process: The ingradients copper, lead & tin are placed in a retort & heated till molten. Heated alloy is then applied at a predetermined rate to a previously prepared & heated continuous steel strip.

The element of control plays a very important part in quality of bi-metal strip obtained by the cast process. Molten-metal has to be be kept thoroughly mixed at time of application and cooling (for solidification) of the alloy has to be done very carefully so that the ingradients do not separate out. Otherwise large quantities of pure lead may seggregate out & gather at localized spots.

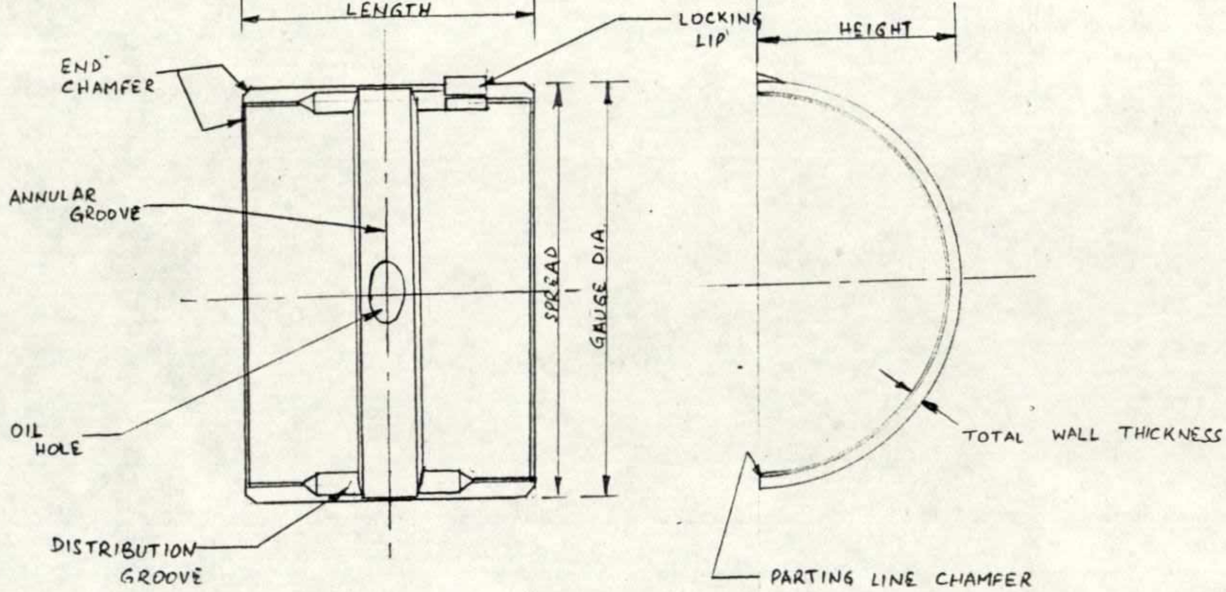
LINING THICKNESS:

Lining thickness is of great consequence for good performance of the bearing. In case of babbit bearings, thin lined bearings are more advantageous to the older thick lined ones. Thick linings are more subjected to fatigue. So thin ones are preferred. Thin linings, however, do not allow for heavy embedment In service, engines operate under adverse conditions of dirt particles. Ordinarily these particles embed themselves in the thicker linings. But in extremely thin linings, these can not embed completely in the lining. Here a danger exists, of lining holding destructive particles and abarading the shaft.

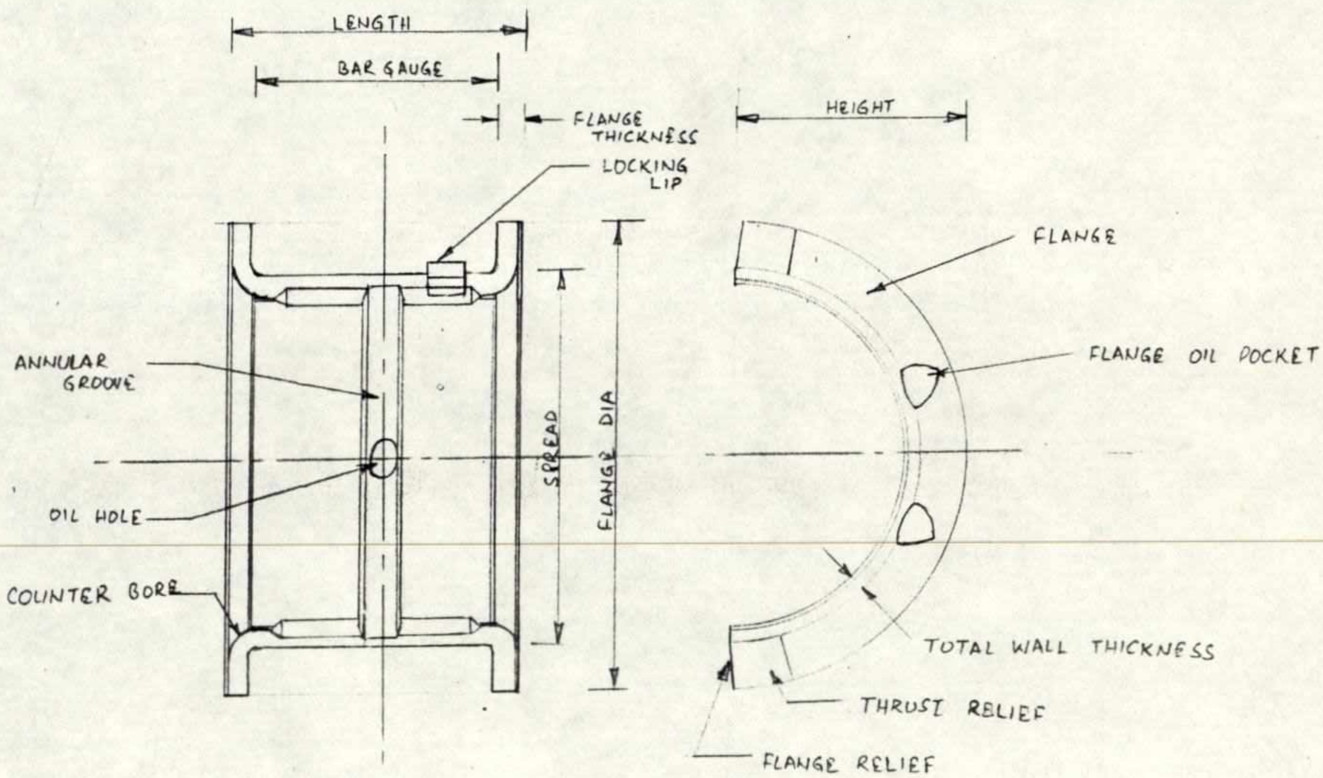
But in case of Cu-alloy or Al-alloy bearings, variations in lining thickness shows literally no performance differences.

BEARING TERMS

Some terms commonly used when discussing/describing thin walled sleeve type bearings are given below.

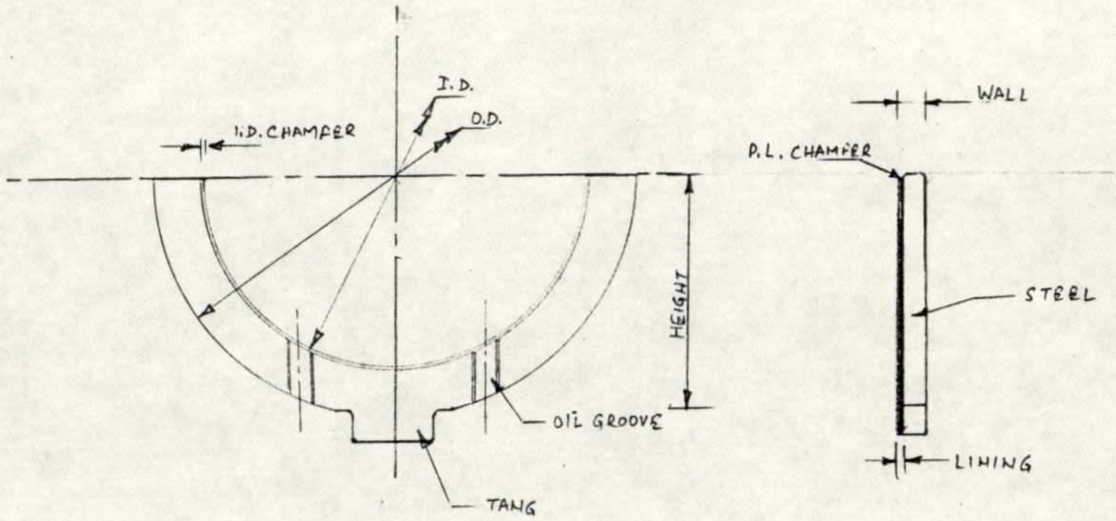


STRAIGHT BEARINGS

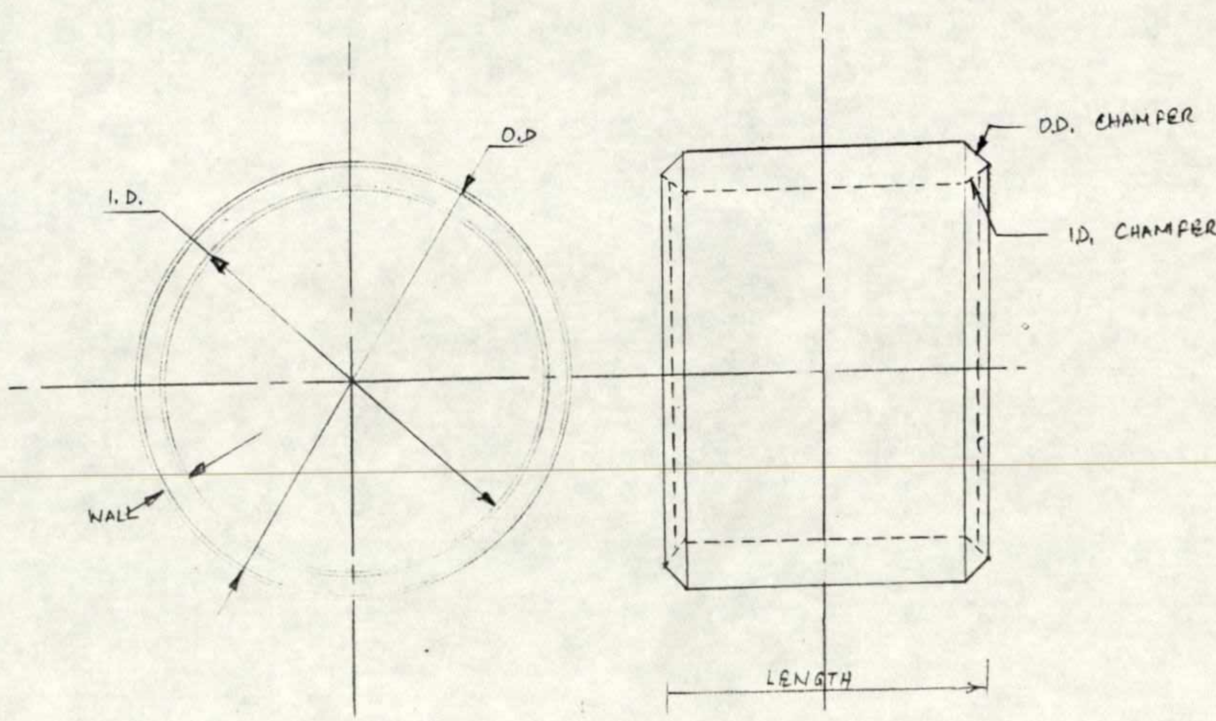


FLANGE BEARINGS

FIG-1.7



THRUST WASHERS



BUSHES

FIG - 1.B

Lining thickness:

It is the thickness of the bimetal alloy which adheres to the steel strip. It varies with the type of application.

Back thickness:

It is the thickness of the bearing without the lining i.e. it is the final thickness of the steel.

Total wall thickness:

It is the combined thickness of the bearing back & the lining material. Total thickness is determined by the shaft size, housing bore size and the desired oil clearance.

Crush:

When two bearings halves assembled in their position in the housing, the height of the bearing provides with a crush fit. Thus ensures that the bearings will remain firmly and properly in place during the operation. Crush hence prevents bearing movement in the housing.

Crush relief:

To minimise the effect of crush at the parting surfaces, wall thickness around the parting line are reduced for crush relief. This helps avoid a bulge of material on the ID surface.

Spread:

It is the distance between the outside limits of the parting surfaces and is generally slightly more than the OD of the bearing.

Annular Oil groove:

The annular groove transfers lubricant for linear distribution across the surface engines grooved bearings are used for main (upper) bearing position.

Oil hole:

It is a hole in the bearing to provide for a transfer of lubricant to the bearing surface. In most engines oil is supplied to the hole through a main oil gallery in the engine block.

Locking lip:

The locking lip locates the bearing in the housing. Its other function is to prevent the bearing from shifting axially in the bearing - housing assembly.

Parting line Chamfer

It is a chamfer given to the parting line surface to eliminate a sharp edge which under slight mis-assembly condition would tend to shear the oil film from the shaft.

Bearing Length:

It is the distance between the outside flanges or faces.

Some terms used only for flange bearings are:

Bar gauge:

It is the inside distance between the flanges of a double flanged bearing

Flange thickness:

It is merely the thickness of the flange.

THE PROCESS:

In general the process manufacture of bimetallic bearings may be divided into the following main departments

A. Powder manufacture.

B. Strip Line.

C. Production.

D. Plating.

The following pages describe the various operations and methods of production adopted by the above mentioned departments.

A. Power Manufacture:

Metal powder, may be manufactured, depending upon the physical properties desired by the following methods:

1) Mechanical Pulverization.
2) Electrolytic process.
3) Chemical reduction.
4) Atomization.

At the powder plant at GIL, Parwanoo, bimetallic powder is made by the process of atomization. So it will only be appropriatee to discuss this process in some detail.

In ATOMIZATION, molten metal is forced through small orifices & broken down into small particles (atomized) by a stream of compressed air or water. Power made by this process may be of very fine quality but the parameters like pressure,temperature and specialized nozzles have to be controlled air, oxidation of the hot metal may occur. This can,however, be avoided by providing with an inert atmosphere for the process.

The powder plant at GIL not only caters to the powder requiremtns of the plant, but also manufactures powder for sale to other bimettalic application manufacturing units. The variety of powder manufactured can be estimated by a glance at Appendix 2 . Since the constituents in each kind of powder are in different amounts and proportion, so the constituent are put by weight in an induction furnace. This feed consists of small metal billets, scrap from ID broaches etc. A single feed to the furnace may be about 150-180 kg each.

The induc-tion crucible is made out of clay graphite & as its name implies, heat generation is by induction.

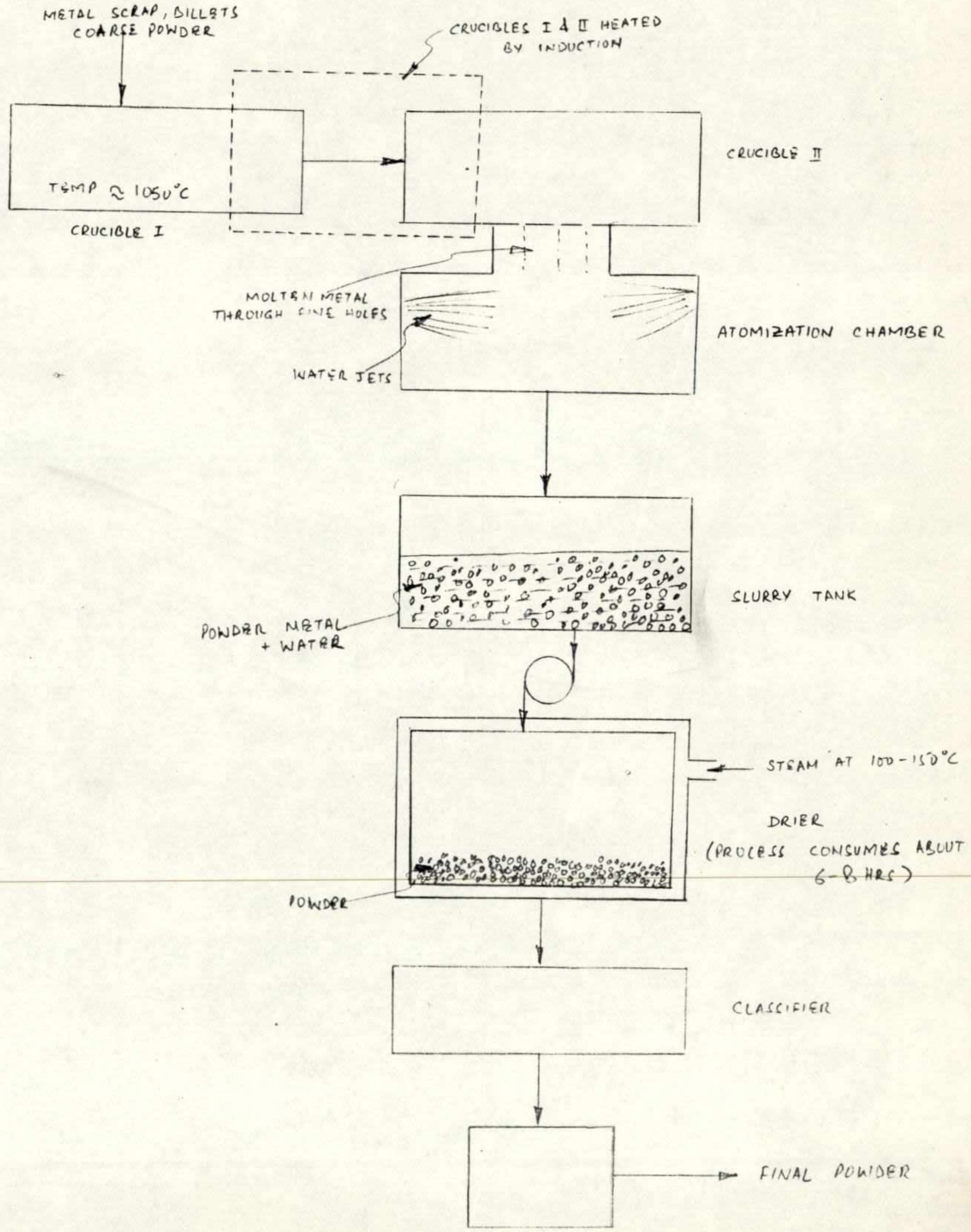
The crucible is surrounded by water. Copper coils are present in the water. Electric current passed this the copper coils heats up the water which inturn heats up the crucibles. Temperature is maintained by regulating the flow of current through the coils. Temperature range generally maintained as 1050-1100°C. P_2O_5 is added in a small amount to the melt in order to remove all sorts of impurities from the metal.

The molten metal is poured into another crucible which is also maintained at the temperature of the molten metal. Three very fine holes are present at the bottom of this crucible. Through these holes, the molten metal enters the atomization chamber, in the form of small streams which are atomized by using jets of compressed water. The particles are allowed to collect in a slurry tank for the purpose of cooling them. The slurry is then pamped off to a drier where the metal particles settle down (being heavier than water). Water is removed from the top, leaving behind a very thick slurry.

The drier itself is a double walled vessel & steam from a boiler is allowed to pass through the space between the walls. Temperature is maintained at 100-150°C. The evaporation of water due to the action of steam leaves behind dry powder in the drier When no more steam comes out of the drier i.e. all the moisture has

FIG : 1·8A

SCHEMATIC REPRESENTATION OF POWDER MANUFACTURE PLANT



been evaporates, the powder is transferred to a classifier the process,however, is not as quick as it may appear. It may take as long as 6-8 hours to dry a single lot of the powder.

The classifier is a vessel mounted on a vibration mechanism and having three seives in order of decreasing size lined one below the other. Generally sizes 40, 80 and 100 are used Size 40 would imply 40 openings per sq inch in the sieve & so on. The vibration of the classifier drum will lead to separation of the powder into 4 categories - one above size 40, one between 40 & 80 the third between 80 & 100 and the fourth below 100. It is the fine powder obtained after the 100 size sieve which is used for coating the steel for producing bimetallic strips.

Powder sizes above the required size may again be melted for producing powder.

The powder obtained finally is stored in large cylindercal drums after thorough mixing for purpose of obtaining a homo-geneous power product.

Strip Line:

Strip line deptt. is concerned with the manufacture of bimetal strip by providing a coat of bimettallic powder on one side of the steel strip. As the name, Sinterline, would suggest, it is done mainly (for Cu-Pb linings) by the process of sintering. The other method used for the production of babbit lined strip is the cast method (Production of babbits is discussed under the heading - Babbit line).

Sintering is the process of forming a powder into a given shape with specific properties by the application of heat and pressure in a controlled environment. The heat helps melt a phase of the bimetal powder which helps in the bonding while the pressure gives the desired compactness and other properties. The temperature is usually the melting point of the bimetal component with the lowest melting temperature. It is this metal which is generally used as a bonding metal which a helps in making a homogeneous and high density product. The type of sintering done in the plant is the contineous type sintering.

The Sinter line consists of the following lines -

1. The degreasing & sander line.
2. Sinter line I
3. Sinter line II

Steel from the steel stores is first mounted on to the decoiler of the degreasing & sander line. Basic function of this line is to provide an oil/dust free steel with a rough surface. These are required for a proper bonding of the metal powder to the steel backing. Steel is made to pass-through a degreaser plant which has two chambers. In the first one electrical heaters heat up the degreasing solution to vaporization. The vapours of Tri Chloro Ethyline (TCE for short) help loosen up the greasy & oily material on the strip. This strip is then passed through a tank of TCE where all the grease is a removed. The vapours of TCE in the first chamber are recycled after cooling them, allowing them to come in contact with copper tubes where cold water is being circulated. The strip that is coming out is dried by passing at between layers of highly absorbent felt.

The dry strip is then passed through the sanding machine where the top surface is roughened up by the action of an abbarading belt. (Abbarasive used is Alluminium oxide). The output is a steel strip with a very rough surface. The rough surface helps in providing a good impeteus for proper bonding.

The rough steel is then rewound into rolls using a recoiler (Fig 1.9).

Sinter lines I & II are exactly similar in operation as well as construction. The process of the coil manufacture goes on simultaneously on both the lines.

The steel strip with the roughened surface from the degreasing & sanding line is mounted on to the decoiler of one of the two lines. The strip is made to pass through a coil straightner and then on through a muffle furnace. Before going into the furnace required thickness of the powder is spread on the rough surface of the coil by means of a contineous feed mechanism. The thickness of the loose powder layer is much more than the required thickness of the lining. This is due to the fact that there is a reduction in volume of powder upon heating as also there is a reduction in volume due to the rolling of the strip.

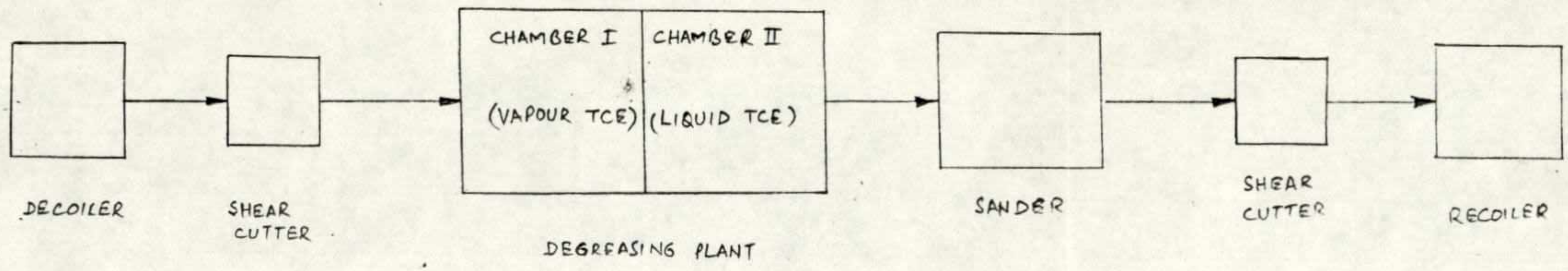


FIG 1.9

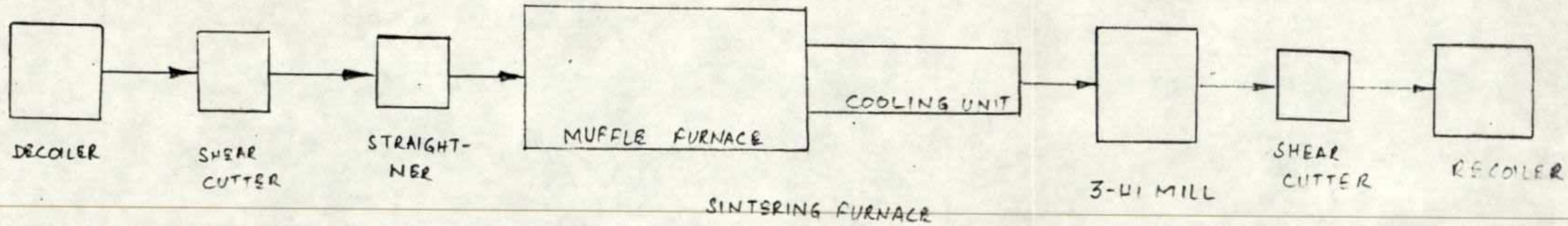


FIG 1.10

The strip as allowed to go through a long oven in the muffle furnace which has been divided into 9 elements. The muffle is provided to allign the strip and reduce the possibility of jerks which might spill the powder inside the furnace. The speed and temperature relation of the strip line is maintained in such a menner that the strip is able to remain at a particular temperature for the required length of time. A mixture of cracked liquified petroleum gas (LPG) with a composition of

6 - 7% CO_2
8 - 9% CO
12 - 14% H_2O
& the rest N_2

is made to envelop the strip inside the muffle. The basic purpose of such an operation is to provide a reducing atmosphere to prevent the hot metals from oxidising.

The time & temperature combination is also maintained to the desired level. This results in a good bonding of the copper & tin particles in the powder by molten lead. But there are a lot of pores in the bonded metal so produced (Fig. 1.11)

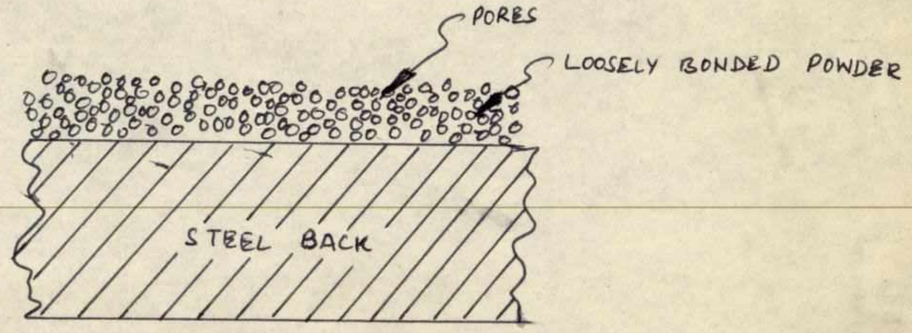


Fig. 1.11
(exagarated view of cross section of srip)

These are undesirable since they mar the compactness requirements of the strip. Hence the strip is rolled in a 3 High mill. The compactness of the strip and to a certain extent, the overall thickness of the strip is maintained at this level. Compactness of the strip is easily estimated though not in the absolute sense by the hardness of the lining material. Bond is also checked by using a variety of chisel and visual techniques.

The procedure described above is used for the first sintering only. The first sintered coil is again coiled on the recoiler, taken to the begining of any of the two lines and again taken through the process of heating up, cooling down and rolling although no powder is applied this time. This helps in foundation of the required bond strength and strip thickness. The second sinter is thus, an operation to get the parameters required in the strip.

The strip coming out of the muffle furnace passes through the cooling unit where the high temperature of the strip is brought down. Further cooling if required is done by a spray of water outside the furnace. The cracked gas inside the furnace is burnt at the ends of the muffle to prevent any air from going inside.

If the thickness of the finally rolled strip after sinter No.2 is still more than the required thickness, then a separate high speed 2 High Fenn Mill is used to re-roll it to the required size.

In case a slitted strip is required i.e. if blanking is to be done lengthwise, a slitting mill is also available.

Babbit Line:

Steel to be used for producing babbit lined strip has to be annealed before hand. The annealed strip is passed through a preheating chamber. The heated steel is passed through a large container which has a partition in the middle. The first part contains a solution of a flux called 'Frysol Tinning Salt'. The main purpose of this procedure is to give a good bonding surface to the steel. The temperature of the partitioned container is kept at around 260°C throughout the operation. As the coil passes through this Frysol soldering fluid, it gets deposited on both sides of the coil.

There is liquid Tin in the second chamber. A fine layer of liquid tin gets deposited on to the surface of the coil when the coil is passed thogh this solution. Extra Tin on the back of the strip is removed using a rubber skiver. The annealed tin coated coil so obtained passes through a molten metal applicator, which applies metal melted in a furnace on to the strip. Metal generally used is called as L-200 and has the following combination

Pb	-	84%
Sb	-	15%
As	-	1%
Sn	-	0.03%

The temperature of L-200 is kept at 450°C with the help of gas burners. The molten metal application consists of fine holes through which the metal is poured on to the strip. Strip is simultaneously cooled by water under pressure. Excess lining metal that gets deposited on to the strip is removed with the help of a metal skiver. The thickness is controlled in the end by passing the strip through a pair of rolls before recoiling it on the recoiler.

This strip is now ready to be used for making babbit metal applications.

The schematic flow of the process is shown in <u>Fig. 1.12</u>

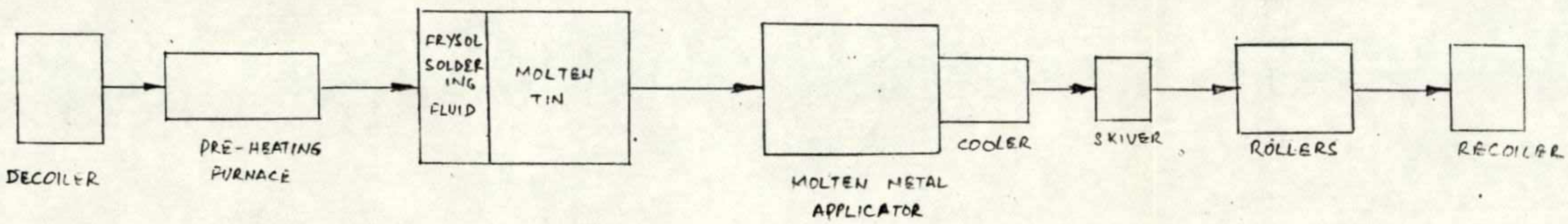


FIG 1.12

SCHEMATIC REPRESENTATION OF BABBIT LINE

Production Department

Production department is the one most directly associated with the production of bearings, washers, bushes and flanges in their recognizable forms. Production would include the conversion of the bimetallic strip, produced in the strip line, to a finished bearing by taking the material through a series of operations. These operations would differ for each of the above mentioned classes as also would very for various applications within a class. But in all, the production department may be divided into various sections although these sections may not be physically existent as on the floor. These sections are:

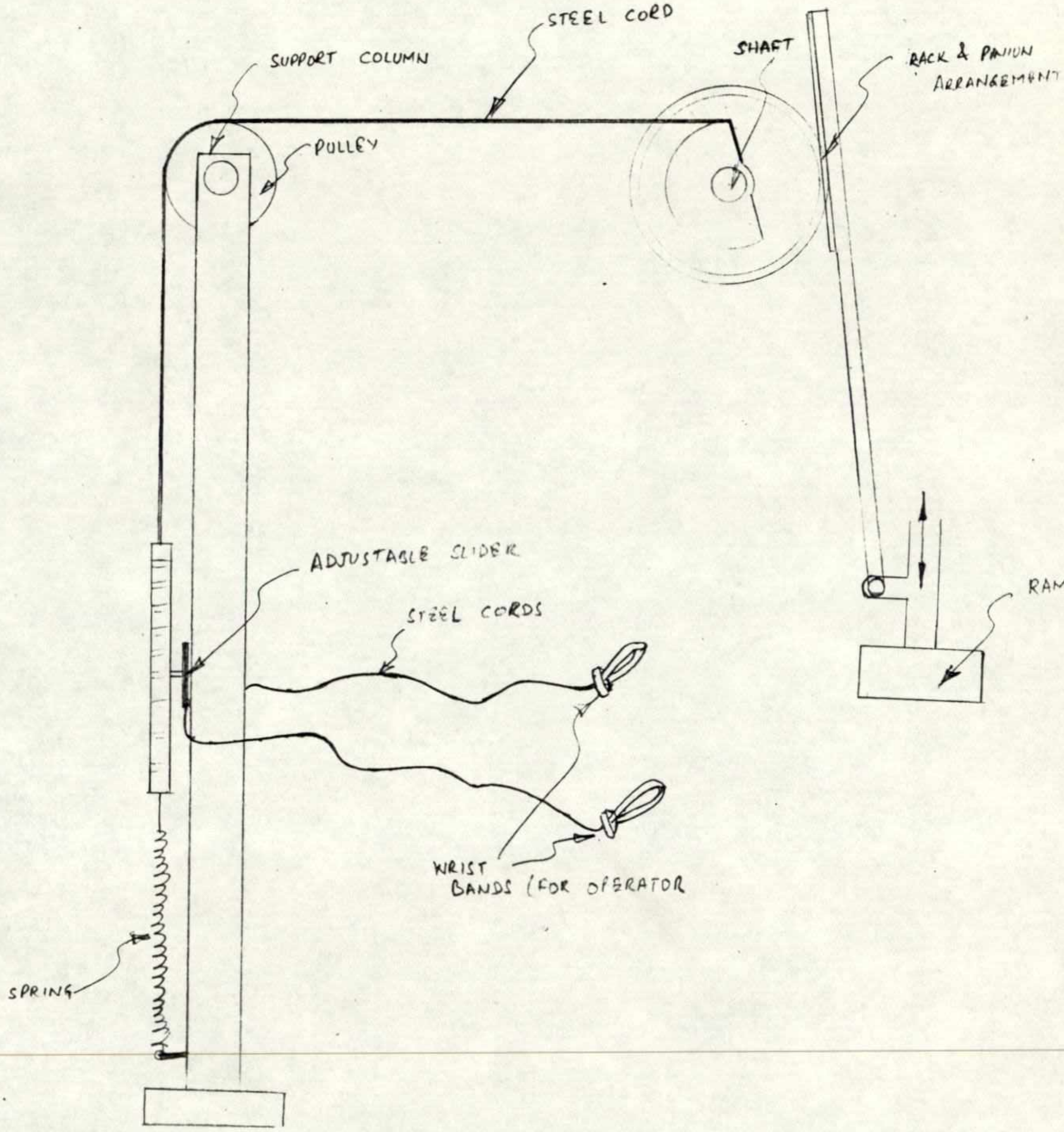
1) Press section.
2) Milling section.
3) Broaching section.
4) General section.

As may be evident from the layout of the plant attached as Appendix- 3, the machines of these sections have been kept intermixed on the floor to create what are called as production lines (Bearing line, bush line, flange line & wahser's line). The arrangement is such that material movements is in a straight line without creation of bottle-necks from the begining to the end of the process. Still for purpose of economy and feasibility, some machines have been kept common although they form a part of a single line only.

A brief note on the various parts of production department are given below:

1) Press section : As the name suggests, it includes all the presses in the production department. The list of these presses,

FIG 1·13



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SCHEMATIC DIAGRAM FOR SAFETY MECHANISM IN HAND-FED PRESSES with their identification numbers and functions is given below:

Press No.	Capacity	Function
PO1	90T	Blanking (crosswise) Brgs. & bushes.
PO2	200T	Form & coining,straight bearings.
PO3	200T	Blanking (lengthwise), bearings & bushes.
PO5	63T	First form bushes.
PO6	225T	Final forming bushes, flattening washers.
PO7	16T	Lip & hole pinching.
PO8	16T	-----do------
	16T	-----do------
PO9	540T	Final form & coinflanges,flattening washers, final form bushes.
PO10	160T	Blanking washers,First form flanges, flattening washers.

The nature of the operations performed is quite clear from the name of the operation.

All the above mentioned presses are pneumatic clutch operated type. For the ones where the pieces are to be fed by hand, to avoid the risk of an accident, a safety mechanism has been put up. In this mechanism,whose schematic diagram is given in Fig 1.13 in case the operator fails to take his hands away from the dropping ram, a wire attached to his wrists would pull his hand out of the danger area, thus reducing the risk of injury and mishap.

2) Milling section: It includes in it, the various milling machines. Milling machine & find use in various operations like oil grooving, oil distribution grooving,notch milling,lip milling etc. The various milling machines along with their identification numbers coded with the prefines MO & TCC are shown in the plant

layout (Appendix 3).

The operation procedure is generally similar for all the above mentioned operations. The piece to be machined is held in an adapter and holder system and the tool is made to cut the metal either by moving the tool or the work table. The shape and nature of the milling tool however varies with the operation to be performed and specifications to be met.

3) Broaching machines: These machines are used for the purpose of broaching either the inner diameter or the height of straight bearings and flanges. They are indicated in the plant layout by prefines IO for ID broaches and HO for height broaches. The purpose of broaching is to machine the piece within very close tolerances. Operation sequence includes the insertion of piece in an adaptor, holding it with a core and then shearing the material from the work piece with the help of a set of blades. One shear broach is also installed for shear broaching flanges of double flange bearings (Prefix SO).

4) General section: This would include all machines which have not been included in all the above mentioned section. Machines include -

Face & Chamfer (Prefix FO)
Hole Chamfer drills (Prefix DO)
Centreless grinder (Prefix CLO)
Boring machine
Wire Brushes (Prefixes WO & AWO)
Belt grinders (Prefix BO)
Bar turning lathe.
Annealing furnace etc.

Some other accessoryequipment like the decoilers, strip flateness, feed mechanism, height & wall checking fixtures, chip collectors are also installed at appropriate places.

Plating Department

Almost all bearing applications are plated after completion of nearly all operations that are to be performed on it. Plating may be

Tin plating - for bushes/washers
Overplating (lead,tin & copper) for straight bearings/flanges

Tin plating serves the basic purpose of protection of the bearing surface against rust & corrosion. Overplating on the other hand serves the main purpose of giving the bearings a higher degree of conformability characteristics. Both Tin-flash plating & overplating are electrolytic processes where tin & lead-tin-copper resp. are plated on to the surfaces of the bearings.

Overplating would,literally,be defined as an electrolytic process for depositing a compatible,relatively soft and pliable alloy over the tough, strong bearing lining material. The soft material acts as a 'cushion' and compensates or moves to adjust for any high areas on the shaft during the critical run in period.

The current practice is to overplate a lead tin alloy. Lead is usually co-deposited with about 10% tin and sometimes a small amount of copper. Tin & copper (when used) provide some stiffness or a slight hardening of the lead.

At a high temperature and high leads, tin in the overplate tends or rather attempts to migrate or travel into the copper of the Cu-alloy lining. This is resolved by building a wall or dam of nickel between the lining material and the overplate. This thin coating between the two so called as the barrier plate.

In the highest capacity Cu-alloy bearings,the finished Cu alloy on steel is first plated on the inside with a barrier plate of Nickel, then overplated with the lead-tin-copper overplate of about 0.001" thickness. The finished bearing including the back is then flash plated (if required) with tin or lead (about 0.00075" thick). This flash plate is a corrosion resistance coating (as stated earlier) (Fig. 1.14)

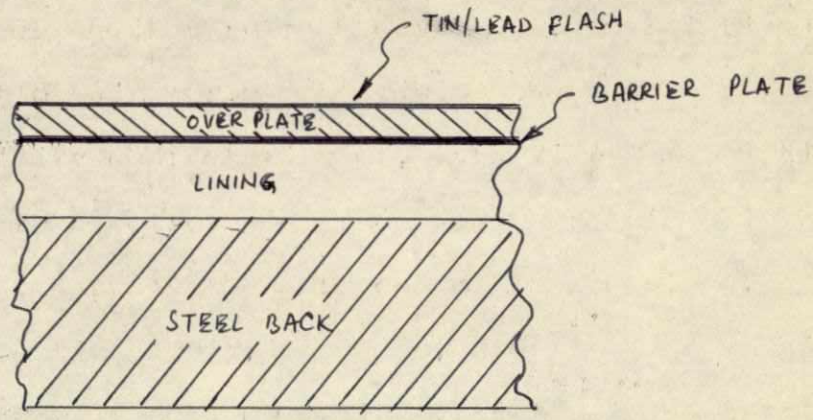


FIG 1.14
OVERPLATING

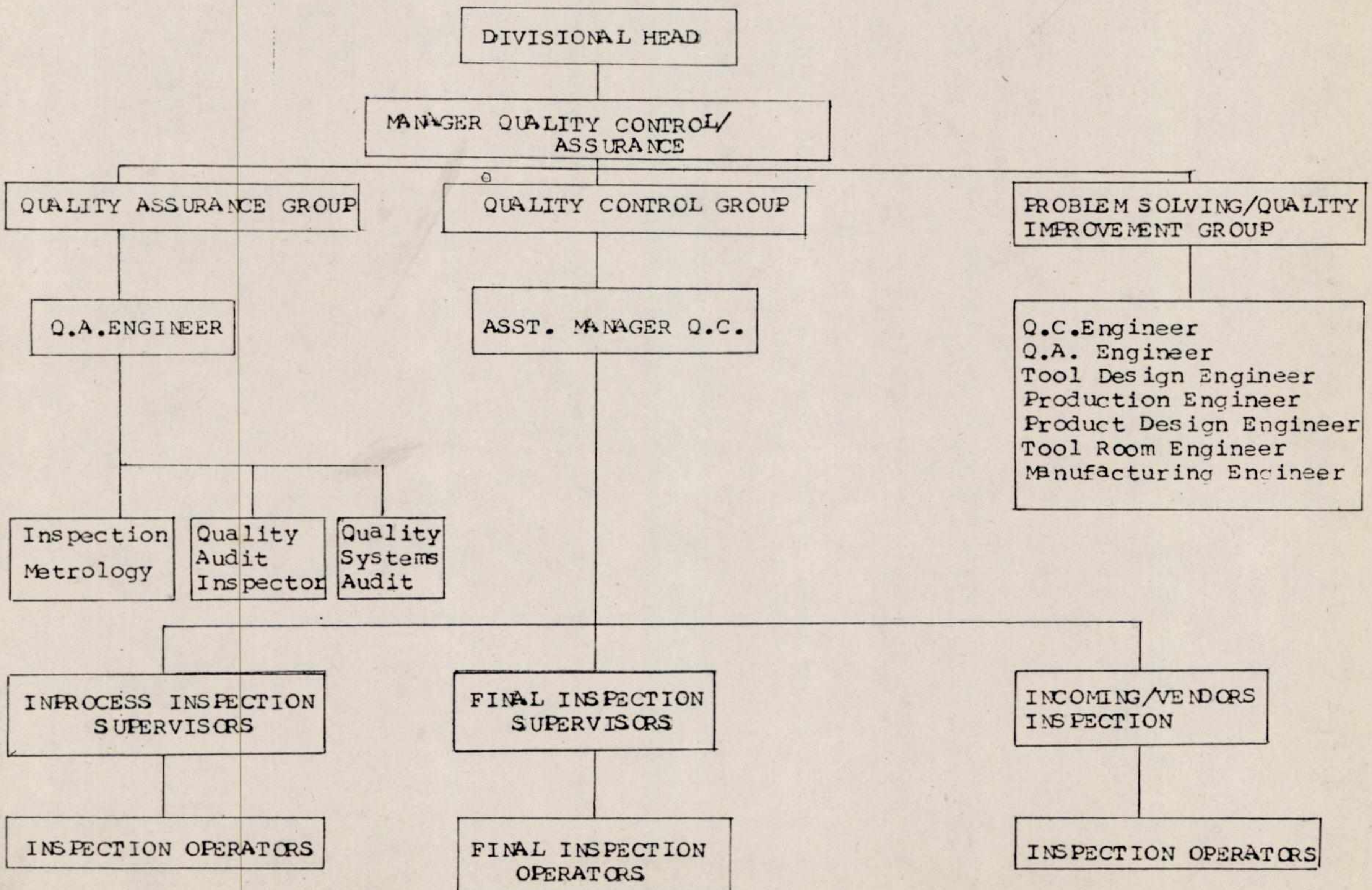
Quality Control

Quality control is a very major part in any of today's industry for maintaining a high standard of products. Moreover since a very major part of my training comprised of working towards improving the standards of quality as also reducing the percentage of rejections due to various causes, it would only be appropriate to describe the organization & workings methods of the quality control department in detail.

The organization of the Quality Control group may be shown in the enclosed quality control organisation chart (Table 1.1)

Table 1.1

QUALITY CONTROL ORGANISATION CHART



From the chart it is very clear that there are three major groups into which the whole Quality Control Organization may be split up.

1. Quality Assurance Group.
2. Quality Control Group.
3. Problem solving/ Quality Improvement Group.

The responsibilities of these groups are well defined in terms of the work they have to perform and the objectives they have to achieve. These may be listed down as follows:-

1. The Quality Assurance Group : It consists mainly of the Quality Control and other heads and the quality assurance engineer. The main responsibilities of the group are -

- To develop Group Quality Policy.
- To implement Quality Programme.
- To Monitor and assist Plant in Quality System.
- To audit Plant quality systems.
- To assist Product Engineering with customers Acceptance Standards
- To develop New Gauging Systems.
- To make customer service calls/customer contacts etc.

The quality assurance engineer is also responsible for the upkeep and maintenance of the Metrology lab. The Metrology lab. is basically a small sophisticated laboratory with facilities for checking a variety of parameters to a high degree of accuracy. The instruments in the gauge room include a roundness checking m/c (Talyrond 200), a surface furnish analyer (surfanalyser), a visual comparator and various gauges for purpose of inspection & callibration. It is also a responsibility of the QA engineer to furnish standards, acceptable to the customers, for purpose of production through corelations & other such procedures as also to provide with the instrumentation necessary for checking of the various parameters that go in the production of a good bearing. The quality assurance group is also responsible for collecting data concerning Quality Control costs and the rejection percentages & their causes.

2. The Quality Control Group: It functions under the guidance of the Assistant Quality Control Manager and includes the various supervisors and inspectors of the inspection department.

The main responsibilities of this group are -

- To carry out Incoming Material Inspection.
- To carry out Inprocess Inspection.
- To carry out Final Inspection.
- To carry out Tool Inspection.

This group is thus responsible for the quality of all material either being procured from outside or being produced in the plant.

3. The Problem Solving/Quality Improvement Group: It comprises of the various personnel as listed in the control organization chart. The main responsibilities of this group are -

- Study day to day problems concerning quality.
- Monitor plant quality programme.
- Study causes for high percentage rejection in plant.
- Carry out analysis of problem.
- Carry out machine / process study

- Develop new quality systems.
- Make improvements in toolings/process, product design based on customers' acceptance standards.
- Develop methods for better process control
- Impart quality awareness training to the workers.

Although all the groups as described above have a common overall target - to achieve better standards of quality and reduce the percentage of rejections, the Quality Control group is the most functional group of the Quality Control System. It is directly aimed at the production of quality bearings. So a detailed discussion on the working of this major group which has the maximum working strength in the department would be quite in order.

The group may be devided into three major stages.

1) In process inspection or stage inspection.
2) Final Inspection.
3) Incoming material/vendors inspection.

A brief description into the working procedures of these would be as follows:

1) In Process Inspection: This is a system designed to control the quality during the process of manufacture. The task of this stage is to check the material being produced for conformity with the standards required according to the design specifications of the company as well as that of the customer. Method of periodic sampling has been adopted for the purpose of maintaining a constant check on all the operations being performed.

The staff at stage inspection include a supervisor and four or five stage inspectors for each shift. These people are given the work of identifying machines with incorrect settings or machines with inadequate accuracy and allowing only those machines where the material being produced is of an adequate quality to be run.

Working of the stage inspection can be described as follows:

The production operators have to get a 'go' sign from the stage supervisor after each setting or at the start of the shift before normal production can be undertaken. Only if the setting is right can production on the machine be initiated. The stage inspection supervisor has to advise the operator as to any problem/deviation from the standards as required according to the specification. The pieces that have been used for the settings are kept separate in trays marked for the purpose. These pieces are checked hundred percent and the ones that cannot be reworked are scrapped. The good ones are mixed with the pieces made during normal operations while the ones that can be reworked are remachined along with the rest of the pieces.

Once the initial settings of the machines have been checked/cleared i.e. the normal operation on the machines has started, a procedure of periodic sampling is followed to keep a check on the material being produced. Periodic sampling is generally carred out by the stage inspectors who have each been assigned a group of five or six machines. His job is to make periodic check (half hourly) on the machines concentrating only on the machines assigned to him. A sample of five pieces is taken at a stretch and the necessary dimensions & attributes are checked using the specified methods. The checks generally have to do with the particular stage of production but include all critical dimensions as well. The readings and observations of the inspector are noted down on an inspection sheet for easy reference. A system of control charts of critical dimensions has also been started. These control charts are filled at each trip to the m/c by the inspector or his supervisor. A deviation from the required dimensions is made note of & the production operator is asked to reset the m/c.

In case of a major deviation even after repetitive settings, the operator is told to stop the machine. Any problems or confusion regarding the decision on machine behaviour or acceptance standards/specifications are solved by the supervisor. The supervisor along with this problem solving responsibility also has the burden of running the show on the production floor. He has to keep checking the settings of all the machines as a double check on all the operators.

Drawings and all other necessary data which has to be calculated from drawings is given to the stage inspection people in the form of charts etc. for ready reference. A new system of 'Process Cards' for each machines has been started to streamline the information a bit. This would be described in detail in Section 2 of the report.

For easy reference, duties of the stage inspector have been defined & presented as a set of rules of the thumb. A copy of such instruction is attached as Table 1.2. The various operations that straight bearings, bushes, flanges & washers undergo have been listed in table 1.3.

It is these operations that the stage inspection has to monitor for ensuring a good product.

Sometimes due to some inexplicable reasons or a major fault some attributes are almost impossible to maintain. In such cases the product is made after deciding upon a deviation (through consultations among appropriate personnel), the machines are allowed to run, but in such a case it is ensured that the deviation will not

Table 1.2

INSPECTION PROCEDURE FOR STAGE INSPECTION

FOR OPERATING MACHINES

i) Visit operating machines.

ii) Pick up the sample at a stretch from the running machine.

iii) Check the Inspection equpt./gauges need on the machine for inspection.

iv) Check the sample as per the Inspection plan and note all individual values on the stage inspection sheet. Fill up the necessary control charts.

v) On the basis of results decide whether production should continue or do minor adjustment or stop.

vi) If defective pcs. observed check samples from the quantity produced between two rounds.

vii) Decide on the observation of step vi) whether quantity produced should be accepted, seggregated or rejected.

viii) If result of vii) is seggregation or rejection put the appropriate tag and remove the quantity to stage inspection area.

FOR MACHINES UNDER SETTING AND RESETTING

1. Let the operator set the m/c to his satisfaction.
2. Check the sample offered for inspection.
3. On the basis of observation decide whether m/c should run or needs further adjustment.
4. If result of 3) leads to readjustment inform operator and production supervisor.
5. If the sample is acceptable from observation made at 3) collect all setting pcs., put the tag and shift the material to Stage Inspection area.
6. If the quantity of setting pcs. is less stage inspector should clear it before the end of his shift.
7. If quantity involved is large, get all setting pcs.checked before the end of the shift.

Table 1.3

St.Bearings	Flange Bearings	Washers	Bushes
Blanking	Blanking	Blanking	Blanking
Form & Coin	Flaring	Oil Pocket milling	C'sinking
Face & Chamfer	Sawing	Chamfering	First forming
Grooving	Coining	Tumbling	Second forming
Oil Distribution	Trimming	Tin Plating	Annealing Stress relieving
Notching	C'boring		Face & Chamfer
Lipping Lip Milling Hole/Slot Punching	Bar turning Pre-height broach Grooving		O.D.Grinding Tumbling Tin Plating
C'sinking	Oil Distribution Grooving		I D Boring
<u>For AM Applications</u>	Hole/Slot punching		
Ht.Broach	Lipping		
I D Broach	Lip Milling		
Plating	Pre-ID broach		
<u>For OE Applications</u>	ID broach		
ID broach	Plating		
Plating	Ht.Broach		
Height broach	Tin plating		
	Shear Broach		
	Oil Pocket Milling		

adversely effect the life of the bearing & other critical parameters desired by the customer.

A schedule for the kind of periodic checking required, the attributes to be checked at each stage & the method of checking to be used has been attached at the end of the report as Appendix 4.

Final Inspection

Final inspection as the name would imply is the inspection done just before the packing stage to ensure standards acceptable to the customer. All the attributes of the final product which are of consequence in making the lot acceptable to the customer have to inspected before the product is dispatched to the customer.

Material produced in the production department is transferred to the final inspection with appropriate instructions from the floor inspector as to the nature of the product is terms of the quality of the lot. Any expected problems are also mentioned in such a report. The procedure followed in final inspection department depends a lot on the type of the bearing. But in general the following course of action is taken.

For Straight & Flange bearings:

1. Wall Thickness Inspection.
2. Baking test.
3. Ht/parallelity inspection.
4. Hole location inspection.
5. All other dimentions - may include groove, notch, lip etc.
6. Visual inspection.

For Washers

1. Flatness Inspection.
2. Wall thickness inspection.
3. All other dimensions.
4. Visual inspection.

For bushes

1. OD under load.
2. Wall thickness.
3. Length.
4. Hole location.
5. Visual Inspection.

It is very obvious that it is almost impossible to allow for checking all the bearings produced for the above attributes. Hence it sampling plan is followed for the purpose of taking samples from a lot.

Sampling plans are defined differently for minor & major parameters.

Major parameters include the following dimensions.

For Straight begs/flange Begs.

Wall thickness.
Crush height/parallelity.
Holes location.

Washers

Flatness.
Wall thickness.

Bushes

OD under load.
Wall thickness.
Hole location.

All other dimensions are termed as minor ones. The sampling plans for major & minor parameters have been given in table 1.4 & 1.5 for reference.

After the major & minor dimensions have been checked & accepted, the lot is subjected to 100% visual inspection. The sample for major & minor parameters is g taken for AQL of 1% (AQL - acceptance quality level) or in case of lots accepted under deviations during in-process inspection (stage inspection) plans for AQL of 0.25% or 0.4% may be used.

Sampling is done at random and the lot is subjected to inspection of all major & minor parameters in the sequential order stated before. If the result of the above inspection is accepted, the lot is forwarded for 100% visual checking.

Table 1.4

Sampling Plan for Major Parameters

Lot size	Sample Size	Acceptance number		
		AQL=0.1	AQL=0.25	AQL=0.4
50-100	20	0	0	0
101-150	32	0	0	0
151-300	50	0	0	0
301-500	80	0	0	1
501-1000	125	0	1	1
1001-3000	200	0	1	2
3001-10,000	315	1	2	3
10,001-35000	500	1	3	5

Table 1.5

Sampling Plan for minor parameters

AQL = 0.65

Lot size	Sample size		Cumulative sample size	Acceptance number(a)	Rejection number(r)
50-100	Ist	3	3	0	1
101-150	2nd	-	-		
101-150	Ist	5	5	0	1
	2nd	-	-		
151-300	Ist	8	8	0	1
	2nd	-	-		
301-500	Ist	13	13	0	1
	2nd	-	-		
501-1000	Ist	20	20	0	1
	2nd	-	-		
1001-3000	Ist	32	32	0	2
	2nd	32	64	1	2
3001-10000	Ist	50	50	0	2
	2nd	50	100	1	2
10001-35000	Ist	80	80	0	3
	2nd	80	160	3	4

Any special constraints for a special lot (such as hole location) are generally subjected to 100% inspection for the particular parameter before visual inspection. All dimensional inspection is done as per drawings/specifications while for visual inspection, the company's standards for visual defects is referred to.

Material taken out as rejected/rework after the 100% dimensional/visual checks is seggregated & properly identified by using a system of coloured tags (blue for accepted, yellow rework, pink rejected).

The final inspection inspector is also responsible for preparing a report on the total quantity checked, accepted, rejected or sent for rework in his particular shift. Also cummulative figures of the above data including material cleared from rework are also to be maintained by the final inspection inspectors.

The procedure for the inspection of material for OE applications from the height broach and the procedure for material(AM) comming from plating department on the conveyer can be shown in the form of two flow charts as in Table 1.6 & Table 1.7 respectively.

Audit Inspection:

Audit inspection is an inspection carried out to access and approve the process average quality during the production of a lot as well as out going quality level of the finished product.

Audit inspection is carried out at two stages -

- the Pre-packing stage.
- the Pre-despatch stage (after inspection/packing)

Pre-packing audit would include inspection for all major, minor and visual parameters before packing to know the out going quality of material accepted for dispatch after final inspection.

TABLE 1.6

INSPECTION PROCEDURE FOR MATERIAL FROM WALL BROACH

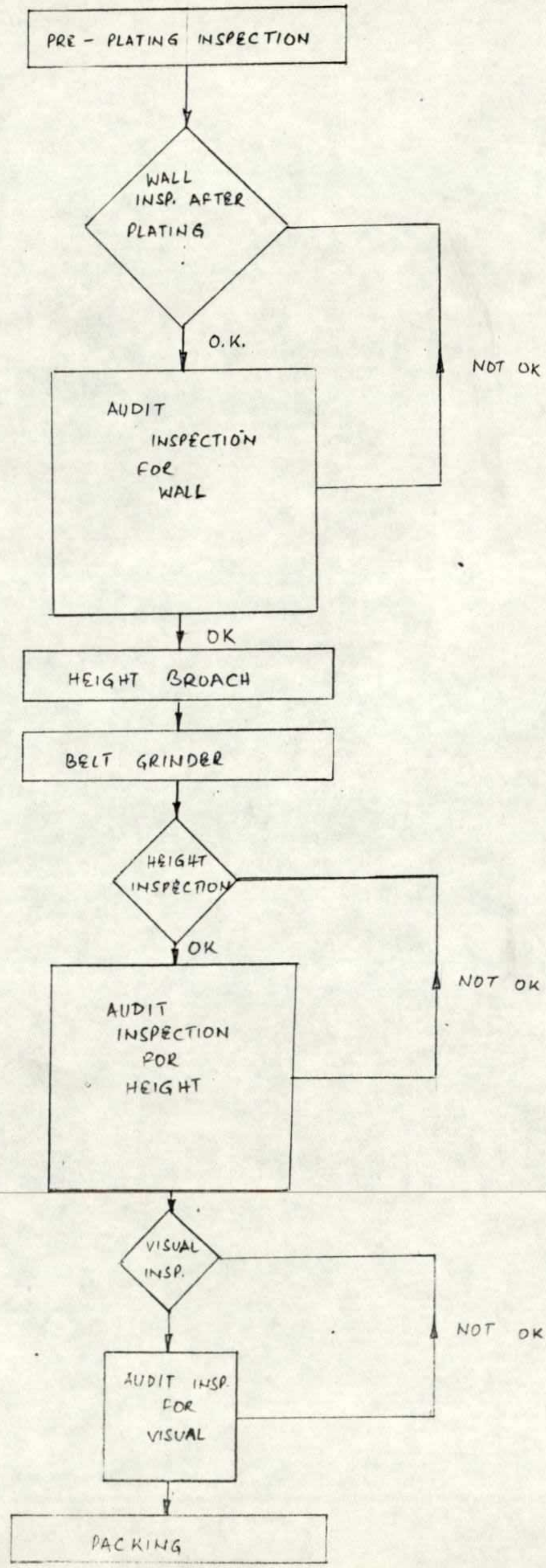
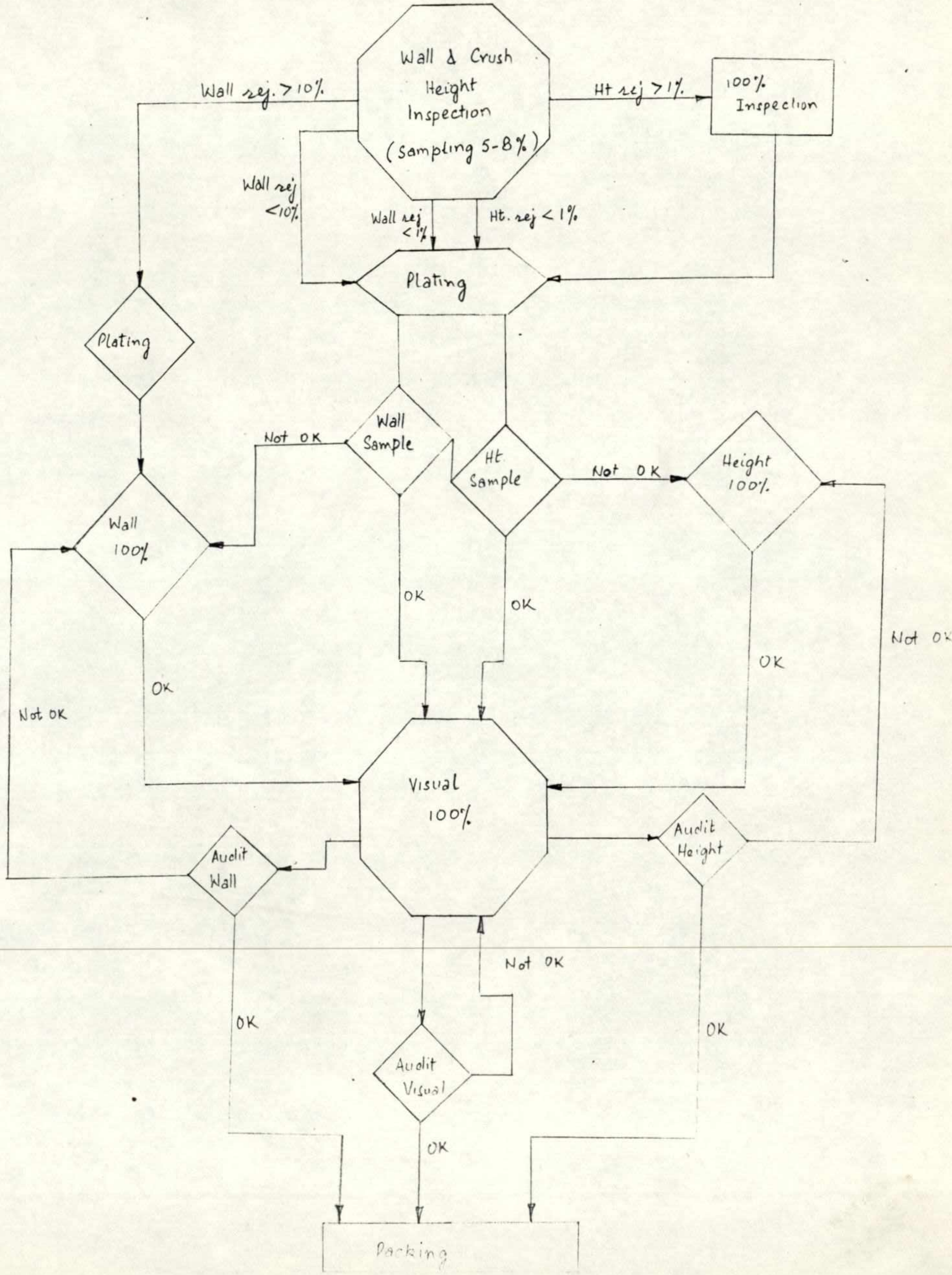


TABLE 1.7

PROCEDURE FOR MATERIAL ON CONVEYER



The major & minor parameters are defined in the manner described earlier. The audit plan is carried out in the order of operations listed below on the basis of sampling plan designed to be used for audit inspection (Sampling plan- Table 1.8 & 1.9).

1. Dimensional checks for Straight bearings & Flange bearings.

- Crush Height
- Wall-thickness.
- Length.
- Spread.
- Lip loaction.
- Lip width.
- Lip spread.
- ID & OD chamfer.
- Bridge size.
- Counter bore.
- Oil groove width.
- Oil hole position.

2. Dimensional Checks for Bushes.

- OD under load.
- Wall Thickness.
- Length.
- Oil hole location & size.
- Groove size & location.
- ID & OD chamfer.

3. Dimensional checks for washers.

- Thickness.
- Flatness.
- Tang location.
- Chamfers.

Table 1.8

SAMPLING PLAN FOR AUDIT INSPECTION OF MAJOR PARAMETERS

Lot Size	Sample size	Cum-size of Sample	AQL=01		AQL = 0.25		AQL=0.4	
			a	r	a	r	a	r
50-100	Ist 8	8	0	1	0	1	0	1
101-150	Ist 13	13	0	1	0	1	0	1
151-300	Ist 20	20	0	1	0	1	0	1
301-500	Ist 32	32	0	1	0	1	0	1
501-1000	Ist 50	50	0	1	0	1	0	1
	2nd 80	130	-	-	-	-	1	2
1001-3000	Ist 80	80	0	1	0	2	0	2
	2nd 80	160	-	-	1	2	2	2
3001-10000	Ist 125	125	0	1	0	2	0	3
	2nd 125	250	-	-	1	2	3	4
10001-35000	Ist 200	200	0	2	0	3	1	4
	2nd 200	400	1	2				

a = acceptance number.
r = rejection number.

If no.of defectives = (a = accept the lot
(r = reject the lot, between a & r take second sample.

Table 1.9

SAMPLE PLAN FOR AUDIT INSPECTION OF MINOR PARAMETERS

LOT SIZE	SAMPLE SIZE	CUMULATIVE SAMPLE SIZE	AQL = 0.65 ACCEPTANCE No.a	REJECTION No.r
50-100	Ist 3	3	0	1
101-150	Ist 5	5	0	1
151-300	Ist 8	8	0	1
301-500	Ist 13	13	0	1
501-1000	Ist 20	20	0	1
1001-3000	Ist 32	32	0	2
	2nd 32	64	1	2
3001-10000	Ist 50	50	0	2
	2nd 50	100	1	2
10001-35000	Ist 80	80	0	3
	2nd 80	160	3	4

If no.of defective =(a = accept the lot
(r = Reject the lot
(between a & r take 2nd sample

4. Visual Inspection.

This is carried out before dimensional audit inspection while the operators are doing Final visual inspection.

Pre-despatch audit. includes the inspection of the quality of packing material and the state of the product in the packed condition including damages of cartons, setention of oil, error in the quantity in a set etc.

Thus pre-despatch audit can be divided into-

- audit of the Quality of packing.
- audit of state of product in packed condition

The procedure followedfor Pre-despatch audit can be listed down in the following main steps.

When the material has been packed and kept ready for despatch one or two wooden crates shall be opened.

- Quality of wooden crates shall be checked.
- One or two multicartions shall be taken out from the opened crate and quality of its contents such as colour cartons, shrink film and hence the product packed inside shall be checked for damages/ distortion etc.

Note: Packing for major st. bearing applications is done as follow:

1) Bearings are kept in form of sets.
2) Sets are packed in shrink film
3) Sets from step 2 are put in colour cartons sticker/stamp etc. is applied.
4) Colour cartons are packed in groups in multicartons.
5) Multicartons are packed in wooden crates.

INCOMING MATERIAL INSPECTION: This includes inspection of all material that has to be brought from outside parties for consumption in various operations. Material may include some material processed by a vendor, an operation got done from outside, packing material, anti-rust oil etc.

The procedure for incoming material inspection is to check the material first at the site of manufacture before allowing it to be transported to the plant and then a re-inspection at the plant to check for quality of material (so that material checked at site of manufature may not be substituted for sub-standard material) Any material found to be out of standard is returned to the party concerned.

SECTION TWO

The work done during the tenure of the Work -Term I training at GIL , Parwanoo,can be divided into three main categories.

1. Analysis for improvements in quality
2. Work for improvement in productivity
3. General work including routine work.

In this section, work done as a part of the above categories is described with a view to highlight the results obtained. Analysis for quality improvement would include the analysis and corrective action for recurring or one time defects, study of the causes of major rejection factors, capabilities of machines/processes etc. Improvement in productivity would include identification and rectification of sources of lost time, installation of conveyer oiler etc.

The procedure adopted for presentation of the above report is to give a brief introduction as the need of the project, method adopted to go about doing it, a sample of the observations, analysis , conclusions/recommendations etc. although not in the same order. Actions taken up or planned to be taken up as a result as also effect of the recommended steps has also been given.

The projects have been described, not in the sequence they were taken up or their dates; but in the order of their categorization.

Analysis of rejections due to chips/damages and their causes

From the very beginingof the training at GIL, Parwanoo the main emphasis has been on work aimed at the improvement of the quality of bearings produced and hence at the reduction of the rejection percentages.

The datum point of the study was the overall rejection analysis for the year 1986-87 which may be summarised as follows:-

A.	Straight Bearings	: 11.52%
B.	Flanges	: 24.85%
C.	Washers	: 5.43%
D.	Bushes	: 7.12%
Overall commulative		: 10.58%

The thurst was to bring down this high percentage of rejection (10.58) to a lower level by suitable modification through an exhaustive study of causes that have an impact on this percentage For this purpose , the major areas where a high percentage of rejection occurs were identified on the basis of the past experiences of a number of people including quality control workers, inspectors supervisors and engineers. The nature ofthe rejection was also very helpful in determining the areas with a high rejection percentage the areas so identified were as follow:

a. Strip defects
b. Chips /damages
c. Final height broach
d. Final wall broach
e. Face and Chamfer
f. Coining
g. Plating

though not in the same order.

Initially, the purpose of simplifying the study and narrowing down its scope by dividing the work into phases, the study waslimited to

a) Strip defects
b) Damages/chips
c) Final Wall broach
d) Final height broach.

Since all the studies involve a number of decisions on whether a particular defects couldbe accepted or not, it was decided that an extension study into the type and nature of the defects to be accepted/rejected be made.

For the above stated purpose, time was spent in discussions with various Q.C. engineers and supervisors and in reading the standards specified in the various manuals from Fedral-Mogul Incorporated (the collaborators) and Gaberiel India Ltd., Parwanoo. The basic idea was to get an insight into the amount and the nature of acceptable visual defects such as chips,scratches,damages etc. Pieces taken out by the final inspection workers pertaining to the afore mentioned ~~dect~~ defects, were also examined to have an idea of the standards actually being followed at the inspection stage.

The first study to be conducted in this context was on the occurance of chips/damages on the inner and outer surfaces of straight bearings during the final height and was broach operations

(For the purpose of simplifications wall and height broaches will henceforth be mentioned as ID/ht broaches)

The procedures adopted for the study were in line with the procedures followed for the identifications of the above problems in final inspection by visual inspectors. A crate with the sample pieces (around 400) was selected from among the total lot and then checked exhaustively piece ~~to~~ by piece for the defects before tie machining is done- These pieces were kept seperate till the machine was set and running under normal working conditions (i.e. after continuous running for about an hour). The samples were then broached and again inspected for the visual defects-chips /damages before the broaching, pieces which were having any kind of strip defects were removed from the sample. This was done because, these pieces might affect the overall percentage of rejection due to chips/damages and hence the true state of affairs might not come into the picture. Hence an attempt was made to avoid any numbers affecting the true final rejection percentages.

A simple format (Exhibit 2.1) was decided upon for making the study more methodical and for making the analysis of results simpler. The format was used as a standard for the chips/damage study in coining and face and chamfer operations also.

A few of the observations of the study are presented in Table 2.1.

A thorough investigation of the probable causes revealed that the large percentage of rejections is mainly due to the following reasons:

(a) Excessive oil on slides-this causes excessive oil on core, adaptor etc.

(b) Unclean cutter, core, adaptor-small metal chips, broach waste dirt etc. present on the surface of the adaptor and core

(c) Ineffective air blowing-air pressure and direction of air flow not enough to blow away the chips from the adaptor. Presence of moisture in the air also hampers this effect.

(d) Pieces unclean before ID/ht broaches-presence of dirt metal chips and oil on ID/OD surfaces which causes damages. Wire brushing not proper.

Presence or absence of the above factors or a combination of the above had a big effect on rejection amounts.

EXHIBIT 2.1

Date:

Time :

Shift:

Total sample pieces:

Bearings: plated/unplated

Part No:

U/S

Operator:

Operation:

M/C No :

Lot size

Before operation

rejects with OD damage/chip =

rejects with ID damage/chip =

Percentage rejection=

After Operation

rejects with ID damages/chips =

rejects with OD damages/chips =

Percentage rejection =

TABLE 2.1

Part No/U/s	M/c/operation	Lot size	Rejection Percentage Before operation	After operation
81102 C/010	HO3 Ht broach	5570	0.7%	23.1% *
81102 C/STD	IO2 ID broach	4750	4.3%	16.96%
81102 C/010	HO3 Ht broach	5570	1.2%	14.32%
206013113101/ STD	HO2 Ht broach	5200	1.75	12.75%
70101C/010	IO1 ID broach	15860	7.76%	15.53%
70701C/060	HO2 Ht broach	4400	1.5%	12.00%
70101C/010	IO1 ID broach	15860	7.5%	16.6%

* rejection % very high prebably due to inspection error so the observation was rejected.

It was recommended to rectify or remove the above causes as far as possible by

1) Regulating the flow of the lubricating oil on to the slides. It has been seen that although themachine's manual requires only 1 drop of lub oil to be fed on to the slide every six strokes, one drop is fed in every stroke. With no other path to flow, this oil starts dripping and hence sticking on to the core and adapter. This lures the chips which have just been removed and they stick to the adaptor or the core causing damage.
2) The cutter, adaptor and core should be cleaned every few (say 100) pieces to reduce the possibility of any dust etc. striping to them Cleaning every piece is also recommended since the dirt or chip on one piece will not only damage that piece but will also damage the next few pieces if it remains stuck to that adaptor or the core.
3) In order to reduce/minimize the risk of a chip remaining in the adaptor or on the cutter, then best method wouldbe to remove the chips as soon as they are cut. Hence the use of the chip collecter is recommended since the plant has already acquire two of them for various purposes and as yet they are lying unused It would be hence appropriate to try them on some machines and check their capabilities.

   A chip collecter will create a strong air draught in a particular direction and if the chips are sent in the collector with this draught as soon as they originate, they would have no chances of sticking to any surfaces (if dry) The external air blowing nozzle should however be maintained for better effect of the collector.
4) Cleaning the pieces thoroughly before the operations

Cleaning involves mainly the removal of oil from the bearing surface by either hand cleaning or degreasing. This degreasing will in turn help reduce the amount of chips and dirt sticking to the surface and hence reduce the rejection percentage.

Based on the above suggestions, it was decided that a chip collector be installed on one of the ID broaches. The result of this installation are not yet clearly indentificable since the method has not been made fool proof. Re Presently tests are being conducted with the chip collecter on IO 1 which are proving to be highly successful.

For the purpose of cleaning the bearing to make them free of oil and grease, proposals are on to instal a degreasing plant.

In continuing with the study of the causes of chips/ damages on various machines, the second in the order was the study of the above rejections on two more, critical machines-mamely the forms and Coin press and the face and chamfer machines. The importance of the form and coin operation can be easily understood by the fact that all straight bearings to be made have to pass through this operation. And hence a high rejection at this stage will definitely have a big impact on the overall percentage of rejections in case of straight bearings.

The procedure adopted for the study was on the same pattern as that for the study of chips/damages on HE/ID broaches. The sample pieces were first checked for the presence of chips/damages before the operations . For the coining operation these samples pieces were blanks and for the face and chamfer they were formed and coined bearings. The samples were again checked after the operation. Operation was performed on the pieces only when conditions of normal running were achieved.The amount of rejection due to the causes under study were determined.

The format used for the purpose of observations was the same as in the previous study i.e. Exhibit 2.1 A note on specific conditions of work, nature of work pieces and other working conditions was also made so that any impact of the same on the rejection percentages may also be known.

Few of the observations taken for this study are given in Table 2.2.

TABLE 2.2

Part Nos/U/S	M/C No/operation	Lot size	REJECTION PERCENTAGE Before opera -tion	After Ope -ration
81102 C 040	FO2, Face & chamfer	3120	8.5%	18-5%
199703 030	PO2, Coining	650	10%	23%
81102 C 040	FO2, Face & chamfer	3120	7%	16.5%
70401 C 010	PO2, Coining	4200	6%	14.2%
70401 C .001	FO2, Face & chamfer	1700	2.5%	9.5%
70401 C 020	FO2, Face & chamfer	8500	3.5%	8.0%
70102 C 020	PO2, Coining	8200	4.0%	18.5%
70102 C 020	FO2, Face & chamfer	8200	20 %	9.5%

The high percentage of rejection was found to be due to the following reasons:

(a) Air supply not adequate to blow away chips-air pressure/ direction not effective enough to blow away all the chips, Sometimes air not used by operator.

(b) Bearing/blanks unclean before the operation-oil,dirt, chips sticking to the surface of thebearings.

(c) Execessive lubrication oil present in the die/adapter-causes chips to remain sticking to the die/adaptor thus damaging the bearings.

(d) Crates used to dump bearings on tables for face and chanfer operators - both crates and tables are very dirty.

The recommendations given for rectifying the above problems were as follows:-

(1) Bearings/blanks to be cleaned before the operation. It would be preferable if they were degreased as this would remove the oil from the surface and hence most of the dirt and chips will also be cleaned away. A degreasing plant wouldbe very effective and economical since the quantity of bearings that have to be degreased is very large.

(2) The lubrication of the slides especially on the form and coin press has to be controlled since a lot of this oil keeps spilling on to the ram, the die, cores and the floor, Not only it causes a lot of wastage of costly lubrication oil but also increases considerably, the chances of a drip remaining stuck in the die.

(3) Crates and tables should be kept clean. Chips and metal cuttings should not be allowed to get collected at the bottom of the crates/ tables. All this would require good house keeping on the part ofthe whole of the production department.

(4) Workers should be well educated to the need ofusing air so that they can appreciate this simple step for preventing some rejections. The should be instructed not to close down the air supply when the machine

is not under operation.

As described earlier, a couple of chip collectors have already been installed and efforts are being made to identify a suitable degreasing /cleaning system for cleaning of the pieces before the operations. Classes are also planned to be held for the workers to hammer a sense of quality in their minds, thus preventing them to follow the steps for operation without missing out on things like closed air valves etc.

Analysis of spread of bearings for corelation with physical properties.

properties

Form and Coin is the second in the series of operation carried out on the strip for forming a straight bearing. By a straight bearing we imply a sleeve type semi-circular (half) bearing. The operation consists of two basic parts- the forming and the coining.

Forming comprises of shaping the straight blank into a semi-circular shape with the help ofa die and a core.

Coining consists of pressing the two edges of the bearing from the top in the die- itself so tha, the height (h) of the bearing as well as the spread (s) of the bearing are maintained (fig 2.1)

The whole operation is performed on a 200 Tonne press with the help of a progressive die. The straight blank piece undergoes change in two effective strokes of the press. During the first stroke, the blank is fed into the die and the forming core forms, the blank in the die into a semi-circular shape (fig 2.2). In the second stroke, while a new blank is fed in for the Ist stroke, the formed piece is fed into the rear of the die where a coining core, of a size little large than the forming core, is used to press the edges of the piece (fig 2.3) This leads to the maintaining of the height of bearing to the required specifications.

Thus the final output after these two strokes shouldbe a bearing with a near exact semi-circular shape and a height which is within the the calculated limit. The shape of the bearing is checked by checking the blue contact from a back blue test block which has been prepared with very close tolerances. The minimum blue contact at this stage should be about 90% of the outer surface area .Thus it is the

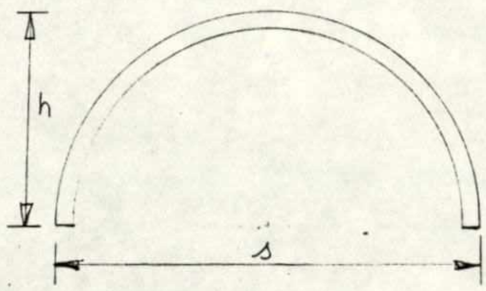


FIG 2·1

A Straight Bearing

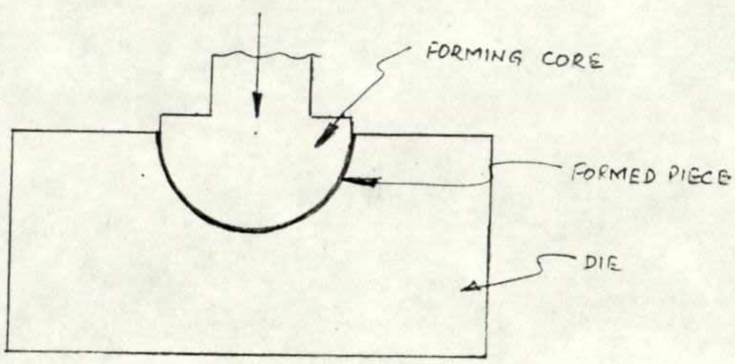


FIG 2·2

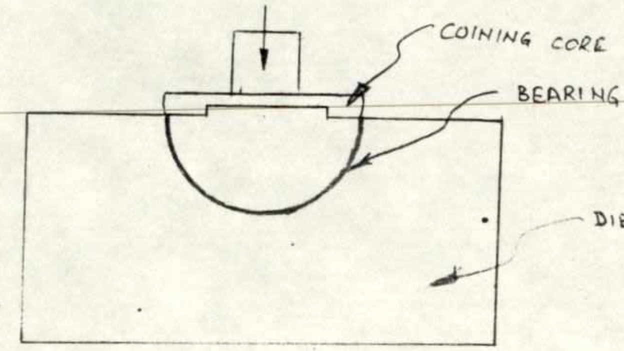


FIG 2·3

SCHEMATIC DIAGRAM FOR FORM AND COIN OPERATION main task of the operator to maintain these critical parameters during the operation.

Another equally important parameter, however is the free spread of the bearing. Although since the forming and coining has been done in a die , it would seem frivilous to check the spread which should be equal to the dia of the die, but there is a very big tendency for this spread to change when the piece is ejected out of the die. This change may be an increase in spread in all bearings comprising of a Cu-Pb lining while it will be a decrease in case of babbit linings.

The nature of the change can be generalized for the cases of copper-lead or babbit linings but the extent of this spring back, as it is generally termed, is not known. Also a variation in the spread occurs along the process of manufacture. This is due to the fact that in almost all operations, the bearing is held in position in a core-adaptor or a similar combination. This repetitive holding in a fixed position/state will lead to a change in the spread . So the spread of the final product is almost a complete difference from the spread at the coining and forming stage. It is hence essential that the relation between these spreads is known so that the final product obtained has the requisite spread.

The change in spread has been termed spring-back as the extent and nature of this change in free spread seems to depend on

1) Hardness
   a) of steel
   b) of lining
2) Young's modulus of elasticity of the bi-metal combination
3) Pressure applied for the operation (by the press)

For the purpose of getting an insight into the behaviour as the quality of the final bearings is at stake, an attempt was made to identify, out of the causes listed, the ones which were effecting this parameter the most and relate them to the variation in spread.

At the plant these was no method for checking the elasticity or even a variation in elasticity ofthe various bimetallic strips. Discussions with various personnel, specializing in material properties le-d to a conclusion that since the elasticity of steel being acquired in constant as is the elasticity for the bimetal powder on the babbit lining, a combination of the two would have more or less a similar elastic behaviour. So as the bimetallic strip being used for making st bearings consists of the steel backing andthe lining in more or less a similar fashion, any effect of the elastic behaviour , which should be the same for all brgs. can be safely neglected. Thus, the factor of elastic behaviour or in other words of a variation/difference in the youngs modulus of elasticity being constant through out is neglected.

Also pressure being applied by the press will depend on a variety of factors such as the thickness of the blank, length of the stroke, minimum height of ram setting etc. All these factors are variable and hence the pressure applied is also varying . Also there is no method available to determine the absolute pressure being applied . It was hence decided to neglect the effect of pressure for the time being.

So the hardness of steel and lining or a combination of the two were the only factors which were available for scrutiny.

Hence the effort was focussed on trying to find a relationship between the spring-back and the hardness of the two materials.

The hardness machine used at the plant was a very simple one giving only a relative surface hardness of the material. Two type of steel identors- 1/8" dia with a major load of 15 kg for Lining material & 1/6" dia with a major load of 30 kg forsteel were used. Procedure followed for collecting data was very simple. The hardness for the steel and lining were taken before the Forming and Coining was done. A sample of 5 pcs was taken for more accurate results. The average of the above sample readings was considered to be true for all practical purposes. After the form and coin operation had been done, five samples were again taken up. The spreads of these were checked and the average taken up. Also noted were the diameters of the form and coin die, the coining and forming cores etc.

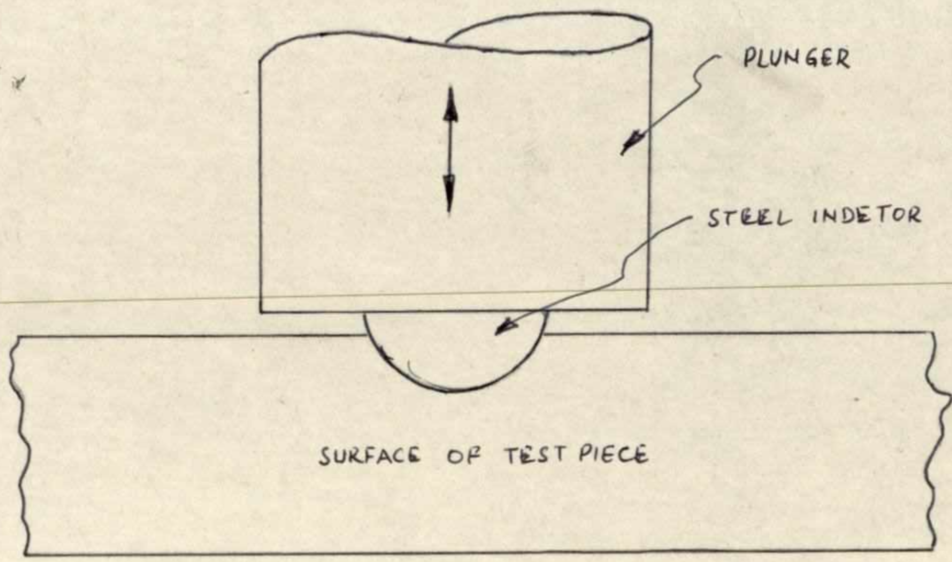


FIG 2·3A
SCHEMATIC REPRESENTATION — HARDNESS TESTER

Variation in spread would be defined as the deviation from the expected spread. Spread expected was equal to the dia of the form and coin die. So difference in actual free spread and the diameter of the die was taken up as variation in spread. These observations were noted down in the form of a table. Some of the data collected is being given in Table 2.3

These observations were carefully studied with the help of scatter charts and rules to find relation between two quantities (as specified in the ISI SQC manual under heading-Methods of correlation). In all the cases described above as well as some trial and error functions which had been successfully used earlier the attempts to find out a relation between the hardnesses and the spread variation proved to be futile. So the study as such was abandoned for the lack of proper instrumentation and quidance . To utilize the data that had been collected and to try salvage some of the lost time, a comparison of the spread at the coining stage was taken with the final spreads at the time of packing (after plating) The study of the samples is still continuing and a list of the corresponding spreads being made for future use.

Data is proposed to be collected over a period of time so that an estimate of the change occuring in the spread during the process can be made. If successful, this could lead to changes in the operations at the forming stage.

A sample of the observations taken for the purpose of comparison of final spread with spread at form and coin stage is given in Table 2.4 .

Table 2.3

Part No/ u/s	Hardness Steel	Lin-ing	Coining die diameter (inches)	Coining core diameter (inches)	Forming core diameter (inches)	Spread (inches)	Variation
80401C/020	66	84	2.336	2.128	2.134	2.340	0.004"(+)
70302A	74	69	1.756	1.598	1.601	1.747	0.009"(-)
70101C/020	68	85	2.624	2.361	2.353	2.630	0.006"(+)
70101C/060	70	84	2.626	2.327	2.318	2.630	0.004"(+)
70101C/090	66	84	2.626	2.291	2.284	2.636	0.010"(+)
70101C/100	68	83	2.626	2.284	2.277	2.631	0.004"(+)
85101C/010	68	85	3.112	2.878	2.887	3.125	0.013"(+)
85101C/020	68	84	3.112	2.890	2.878	3.124	0.012" (+)
203670/STD	74	87	3.2495	3.100	3.090	3.265	0.0155(+)
3019192/STD	72	84	4.779	4.535	4.504	4.806	0.025"(+)
80102C/010	68	71	3.701	3.523	3.516	3.734	0.033"((+)
70102C/040	74	85	2.562	2.374	2.369	2.576	0.014"(+)
70101C/010	73	85	2.613	2.380	2.354	2.633	0.020"(+)
70509C/0.25	68	81	2.9735	2.754	2.747	2.986	0.0025"(+)
80509C/0.25	73	83	2.9735	2.754	2.747	2.986	0.0025"(+)
T72030100Ø NO25	70	84	3.170	3.080	3.000	3.180	0.010"(+)

TABLE 2.4

Part No/U/s	Initial spread (coining stage) inches	Final spread (before packing) inches.
80401C/020	2.340	2.331
70101C/020	2.630	2.626
70101C/060	2.630	2.630
70101C/090	2.636	2.633
70101C/100	2.631	2.635
85101C/020	3.124	3.111
85101C/010	3.125	3.122
203670/STD	3.265	3.310
70102C/040	2.576	2.586

Status of lining thickness and hardness of blanks

Blanking is the first operation towards the making of a good bearing. So any variation in the various parameters defining blank size will tend to create problems at a later stage. The strip being produced by process of sintering had some variations in thickness. Thiscouldbe either due to variation in thickness of steel being procured or issued or due to faulty sanding of the steel strip. As described in Section One, powder is deposited on the steel surface which has been roughened on one side with a sanding belt to have proper bonding. Overall thickness of the strip is being maintained by the operators afters second sinter.

If, the steel being issued for manufacture of bimetal strip is not of a proper thickness or the thickness variation shows after sanding has been done, a variation in the thickness ofthe lining will exist in the final strip. Lining thickness may vary from piece to piec Normally a thickness of (minimum) 8 to 10 thousandth's of an inch is required on the bearing after it has been broached. Close scrutiny, however, shows that generally lining thickness varied from about 3 to 20 thousandth of an inch. A lining thickness of less than 0.008" is not advisable since it could lead to a loss of embeddability charactristics. In actual practice, it was found that in some cases after ID broach, the steel backing becomes visible to the naked eye. This is due to an excess steel backing thickness.

In order to identify such problem cases and putting a stop to the malpractices of letting bad steel to be issued or improper sanding of steel to be undertaken, a study which involved finding the difference between the actual and required steel thicknesses and the thickness of the lining after ID broach. Thickness of lining after broach was calculated from the data given in the specifications and the actual data.

Information that was available for a particular part number/ undersize from the drawings were

1) Part No
2) U/S

3) Raw Steel (reqd)	all with tolerances
4) First roll (reqd)	
5) Final mill	
6) Final steel	
7) Broached Wall	
8) Final Wall	

Actual observations gave the following information .

a) Final mill (micrometer)
b) Lining thickness (Perma -scope)

(A permascope is an instrument based on the principle that resistance of a material changes with its thickness. It is, used to determine the thickness of the lining material at any point immediately and without any distructive testing).

Final steel(actual) was calculated as

Final steel = (Final mill)-(Lining thickness).

This was compared to the final steel requirements in the specifications. Difference between the actual and the required steel thicknesses is calculated as

Difference = (Actual steel) - (required steel)

Thickness of the lining after ID broach was calculated by substracting the actual steel from the broach wall thickness.

i.e. Lining after broach= (Broach wall thickness)- (Actual steel)

This thickness gives the amount of effective lining which remains on the wall ofthe bearing even after all the operations have been completed. Purpose of steel backing for the lining is increase the capability of the bearing to take more loads. If used alone lining was a tendency to deform on the application of even quite small loads

Data collected was first noted down in the format shows in Exihibit 2.2 for easy access and error removal. Any deviation in thickness of lining from the required range was made note of and the information given to the concerned personnel for quick action. The rest ofthe data was also presented on a weekly basis in the form of table. Some of the observations are being given as Table 2.5 for references:

EXHIBIT 2.2

Part no :

U/s :

Specifications

	Raw Steel	Size	First roll	Final mill	Final steel
Tol.					
required					

Final wall :

Broach wall:

Actual final wall :

Actual lining thickness :

Actual steel :

Difference :

Lining after Broach :

Table 2.5

Sr. No.	Part No/ u/s	Final Steel (specs)	Actual Steel (thickness)	Diff.	Broach Wall (specs) (+0.0003)	Lining after broach (inches)
1.	70502C/STD	0.062	0.066	0.004(+)	0.0711	0.0054
2.	82104C/040	0.128(+0.001)	0.129	0	0.1421	0. 0134
3.	86405C/STD	0.106 (+0.001)	0.110	0.005(-)	0.1159	0.0057
4.	81405C/0.75	0.116	0.1195	0.0035(+)	0.1307	0.0105
5.	T72010020/ N000	0.102 (+ 0.001)	0.1015	0.0005(-)	0.1136	0.0134
6.	80405C/STD	0.106	0.1085	0.0025(+)	0.1159	0.0077
7.	85101C/020	0.095	0.0978	0.0028(+)	0.164	0.0089
8.	85405C/030	0.115	0.1200	0.005 (+)	0.1307	0.0110
9.	80101C/020	0.095	0.097	0.002 (+)	0.1064	0.0097
10.	80101C/080	0.120	0.123	0.003 (+)	0.1362	0.0135
11.	70101C/020	0.114 (+0.001)	0.11	0.004 (-)	0.1259	0.0162
12.	70101C/030	0.119	0.1107	0.0083(-)	0.1309	0.0205
13.	70101C/050	0.124 (+0.001)	0.1322	0.0032(+)	0.1408	0.0089
14.	70101C/070	0.136 (+0.001)	0.141	0.008 (+)	0.1506	0.0099
15.	70101C/080	0.139 (+0.001)	0.1405	0.0005(+)	0.1556	0.0154
16.	80102C/010	0.068	0.069	0.001 (+)	0.0841	0.0154
17.	81102C/010	0.068	0.070	0.002 (+)	0.0841	0.0143
18.	3019174/STD	0.110	0.1082	0.0018(-)	0.1221	0.0142
19.	80509C/0.25	0.088 (+0.001)	0.087	0	0.1027	0.016
20.	T72030100/ N025	0.069	0.0645	0.0045(-)	0.0778	0.0136
21.	80509C/1.25	0.103 (+0.001)	0.1015	0.0015(-)	0.1226	0.0211
22.	70509C/1.00	0.103((+0.001)	0.101	0.002 (-)	0.1175	0.0165
23.	80509C/STD	0.088 (+0.001)	0.087	0	0.0978	0.0108
24.	70502C/010	0.062	0.065	0.003 (+)	0.0751	0.0167
25.	C5CE6211A1/ STD	0.082	0.0835	0.0015(+)	0.0934	0.0099

Another study was carried out simultaneously on all the type blanks being produced. This involved the finding of hardness of both the steel and the lining ofthe blank. Hardness was found with the help of a pair of steel ball indentors

- a 1/8" indentor for lining side (to be used with a 15 kg major load)
- a 1/6" indentor for the steel side (major load in this case is 30 kg)

The reason for this finding of the hardnesses of the lining and the steel was to compare this data with the one which specifies the requirements for hardness of the steel and lining as required by the customer and for the manufacture. The method followed for the study was to collect at least five blanks of each application that had been blanked and then note the hardness of the lining and the steel.The sample of five pcs was taken to eliminate the chances of a freak readings. The observations were noted down in the table shown in exhibit 2.3.

EXHIBIT 2.3

Date	Part no/ U/s coil no	Application	Hardness	
			Lining	Steel

A comparison with the standard data was made. The amount of deviation of the actual observations from the actual required standards was noted down and corrective actions taken. This method was particularly good for noting the behaviour of the bushes being formed, since formability of metal does, to a great extent, depend on the hardness of the material.

The overall effect ofthis regular study was to identify a lot many bearings, bush and flange applications which had 'out of range' hardnesses and hence were creating problems in subsequent operations.

Hence it helped in giving better control to the personnel engaged in production of these parts. Thesuccess ofthiswork can be estimated from the fact that a quality control supervisor has been assigned the task of making this study regularly to spot faulty lots.

Location of holes on K.C.L.cam shaft bush-2, Part no 157870

Every time the above mentioned part number (157870) was taken up for manufacture, a problem was faced in the location of the four oil holes at the final stage (fig 2.4) . The reason for the change in hole's position from the centre was not known. Hence a study was taken up to try and locate , starting from the very begining i.e. the blanking stage the reasons for such a displacement. Fig 2.4 gives the drawing of the blank for the bush with the relevant dimensions.

It was decided to take a sample of around 25 pieces from the whole lot at the blanking stage and note down the distance (x) of the holes from the end opposite to the locating notch end.

Distance of centre line of note from any end = 1.760/2
= 0.880"

Note: Width of blank = 1.760 inches
& Centre line of blank = Centre line of holes.

Diameter of holes = 0.125

$$\text{i.e. } x = 0.880 - \frac{0.125}{2}$$

$$= 0.8175$$

$$\text{i.e. } x = 0.8175 \pm 0.010$$

$$= 0.8075''/\ 0.8275''$$

The distance x was measured for a sample of 30 blanks for all the four holes. The observations are attached as Table 2.6 . It was noticed th the location of all the holes was within the prescribed limit i.e. 0.8075' - 0.8275" from one edge of the blank. Hence till this stage the location of the holes was fine . Similar observations were made at the forming stages and it was found that there was not ~~in~~ much change in hole locatic

At theface and chanfer stage however, location of holes changed infinitely because there was no method to locate the work piece centrally in the adaptor. A suggestion on introducing locating pins

..or the holes) in the adaptor was agreed upon and using this modified adaptor, it was found that the holes were located within the tolerance given in the drawings (0.782+0.010" i.e. 0.772"/0.792"). The observations of the hole location from the same end after face and chamfer using the locating pins in the adaptor are given in Table 2.7.

Hence the problem of hole displacement was solved by a minor adjustment in the adaptor being used for facing and chamfering the bushes. It was , so , decided that in all bushes where hole location is of critical importance, locating pins would be used for the holes although they might reduce the rate of production to a certain extent. The reduction in cost of the rejections due to unsatisfactory quality would however, cover up the increase in cost of the procedure due to a decrease in production rates.

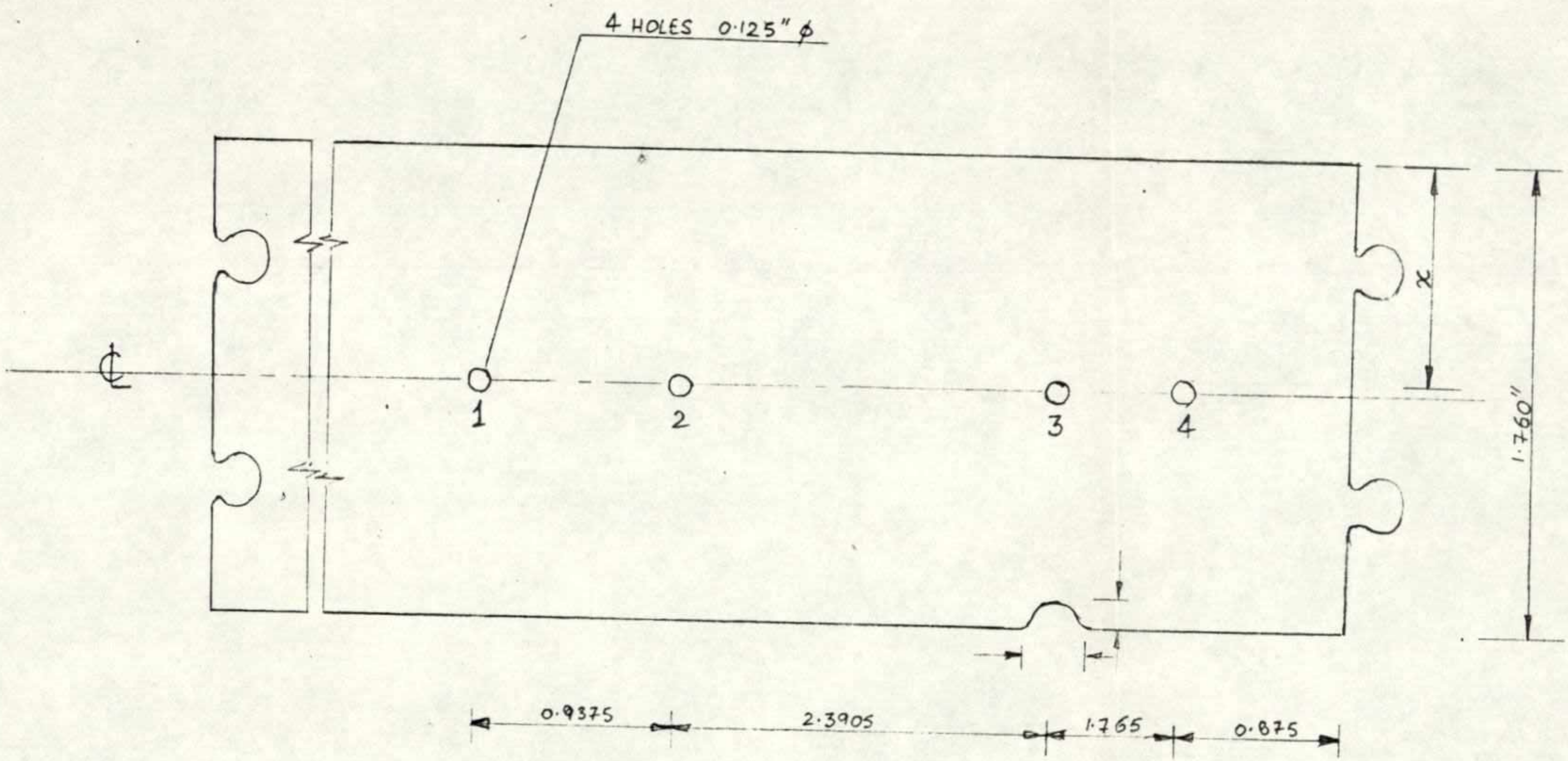


FIG 2·4

PART NO 157870 KCL CAM-SHAFT BUSH NO 2

Posisition of holes upon blanking
(displacement from one end)
Dated 8.3.1988

Part No. 157870
KCL Cam Shaft Bush -2

Sr.No.	Hole 1	Hole 2	Hole 3	Hole 4
1.	0.820	0.823	0.822	0.824
2.	0.818	0.820	0.820	0.820
3.	0.816	0.820	0.826	0.824
4.	0.821	0.821	0.822	0.825
5.	0.817	0.823	0.824	0.824
6.	0.818	0.820	0.825	0.825
7.	0.820	0.820	0.820	0.820
8.	0.817	0.821	0.825	0.825
9.	0.825	0.824	0.823	0.824
10.	0.820	0.820	0.820	0.820
11.	0.820	0.820	0.821	0.820
12.	0.820	0.821	0.823	0.822
13.	0.821	0.821	0.822	0.821
14.	0.824	0.824	0.823	0.822
15.	0.822	0.822	0.818	0.820
16.	0.817	0.822	0.824	0.824
17.	0.819	0.818	0.819	0.820
18.	0.823	0.822	0.824	0.824
19.	0.820	0.822	0.820	0.818
20.	0.821	0.818	0.820	0.819
21.	0.822	0.823	0.823	0.823
22.	0.818	0.820	0.818	0.819
23.	0.820	0.820	0.820	0.821
24.	0.821	0.821	0.822	0.820
25.	0.822	0.818	0.820	0.818
26.	0.820	0.821	0.821	0.822
27.	0.821	0.821	0.821	0.821
28.	0.823	0.820	0.824	0.822
29.	0.821	0.822	0.823	0.822
30.	0.824	0.821	0.822	0.821

Dated 23.3.1988

Position ofholes after face & chamfer — KCL Bush 157870 — M/C No F03

Sr. No.	Hole 1	Hole 2	Hole 3	Hole 4
1.	0.774	0.775	0.773	0.774
2.	0.774	0.773	0.776	0.775
3.	0.775	0.777	0.776	0.775
4.	0.772	0.774	0.772	0.773
5.	0.775	0.776	0.776	0.775
6.	0.785	0.780	0.778	0.777
7.	0.772	0.773	0.773	0.774
8.	0.774	0.774	0.777	0.779
9.	0.780	0.779	0.780	0.779
10.	0.774	0.775	0.780	0.778
11.	0.775	0.774	0.774	0.775
12.	0.772	0.771	0.777	0.775
13.	0.779	0.780	0.775	0.770
14.	0.775	0.775	0.781	0.780
15.	0.779	0.775	0.775	0.775
16.	0.774	0.778	0.775	0.774
17.	0.780	0.780	0.776	0.775
18.	0.774	0.775	0.780	0.780
19.	0.780	0.775	0.775	0.774
20.	0.774	0.778	0.772	0.770
21.	0.776	0.776	0.776	0.775
22.	0.774	0.779	0.776	0.776
23.	0.778	0.778	0.776	0.776
24.	0.779	0.776	0.776	0.777
25.	0.778	0.774	0.775	0.775
26.	0.777	0.780	0.775	0.775
27.	0.775	0.778	0.778	0.778
28.	0.778	0.778	0.777	0.775
29.	0.776	0.776	0.776	0.775
30.	0.777	0.780	0.786	0.778

Effect of annealing on OD ofbushes

Annealing is a form of heat treatment which is aimed at relieving stresses in a part which has been worked on mechanically. In case of bushes heating for a certain period of time leads to a relieved of stress which has two effects on the physical characteristics of bushes that have been made by cold forming.

1) Change in OD
2) Reduction of ovality

Since a lot of work had already been done to relate the annealing aspects like temperature & time with a reduction in the ovality of the bushes, it was decided to limit this particular study to study the effect of annealing on the outer diameter of the bushes.

It may be noted that outside diameter of the bushes is measured in a split block which is kept under pressure. The pressure corresponds to the pressure which would be applied on the bush when put in its housing. The block itself is callibrated with the help of a master block which has the required dia to quite near the required value. Prodedure is to set the pressure on a height fixture. Then after putting the split block with the master block under the ram to set the dial of the test fixture to the required value according to the dia of the master. For checking the OD of the bush, the master block is replaced by the bush and pressure is applied. Reading on the dial gives variation of the OD from the reqd value. A negative reading would imply that OD of bush is larger than required while a positive reading would indicate that OD of bush is less than OD desired. Fig 2.5 gives the appearance and position of master in the checking block.

The face and chamfer operation on the bush alongwith the facing and chamfering , also reduced the possibility of

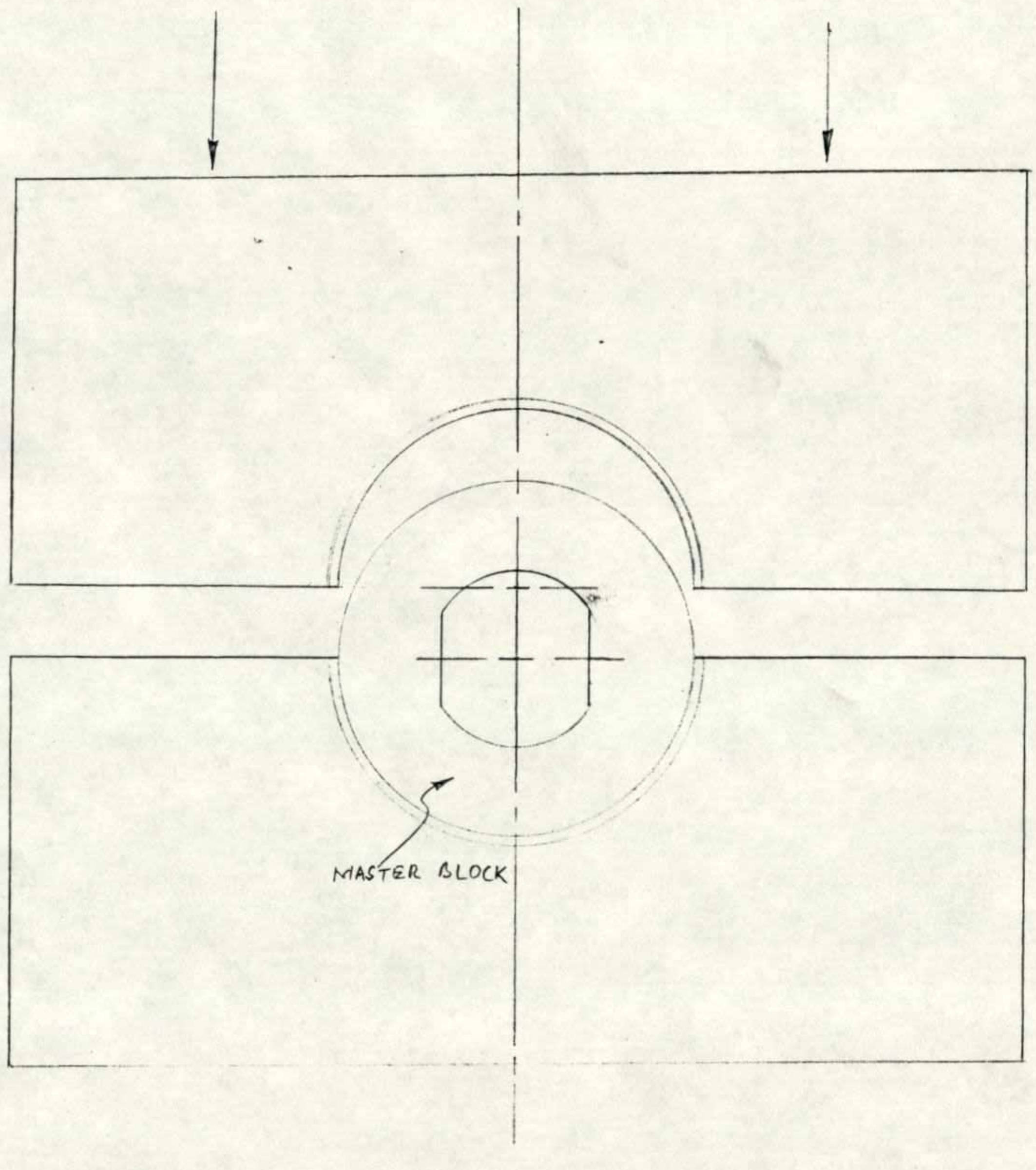


FIG 2.5

SPLIT BLOCK

burrs on the edges of the bush. So the study of effect of face and chamfer on the OD was also taken along side the study for annealing.

A sample of 100 pieces was taken out for the study after the final forming operation. The Tata Cam - shaft bush (part Number 3520510010/STD) was selected for the study. The OD was first checked for these pieces before they were annealed or face and chamfered . For purpose of determining the distribution of the OD characteristic, a histogram was prepared for these observations . It was seen that many of the pieces (27) lay outside the limits provided by the specifications (0 to - 20 due) The distribution was highly erratic- shifted from the mean position (fig 2.6).

These pieces were then face and chamfered, thus removing all the burrs on the outside of the bush . In this case it was seen that most of the pieces were inside the specified limits when the OD was checked again. The distribution was normal but the mean position had shifted to a more positive value (Fig 2.7)

After face and chamfering the same pieces were annealed in the annealing furnace at 300° C for about 3 hours. Annealing had a very good effect on the outside diameter of these bushes . All the samples had their outside diameter within the specified tolerance limits. The distribution of the O.D. characteristics was also in the normal manner although the mean was shifted from the mean of the tolerance (fig 2.8)

The results of the above study were highly encouraging. Hence it was decided that all thick walled highly stressed bushes should be annealed but face and chamfer should be done after the annealing in case of open end bushes i.e. bushes without a 'clinch' . This was to avoid any chance of getting out of square bushes if the two ends shift in opposite directions.

FIG 2·6

GABRIEL INDIA LIMITED — BEARING DIVISION

QUALITY CONTROL DEPARTMENT

OUT GOING AUDIT — CRUSH/WALL THICKNESS

CUSTOMER: TATA

APPLICATION: CAM SHAFT BUSH

PART NO: X 25230511 3101 / STD

DIMENSION: FINAL OD

SPECIFICATION: 0 to -20 div

CHALLAN NO:

LOT SIZE:

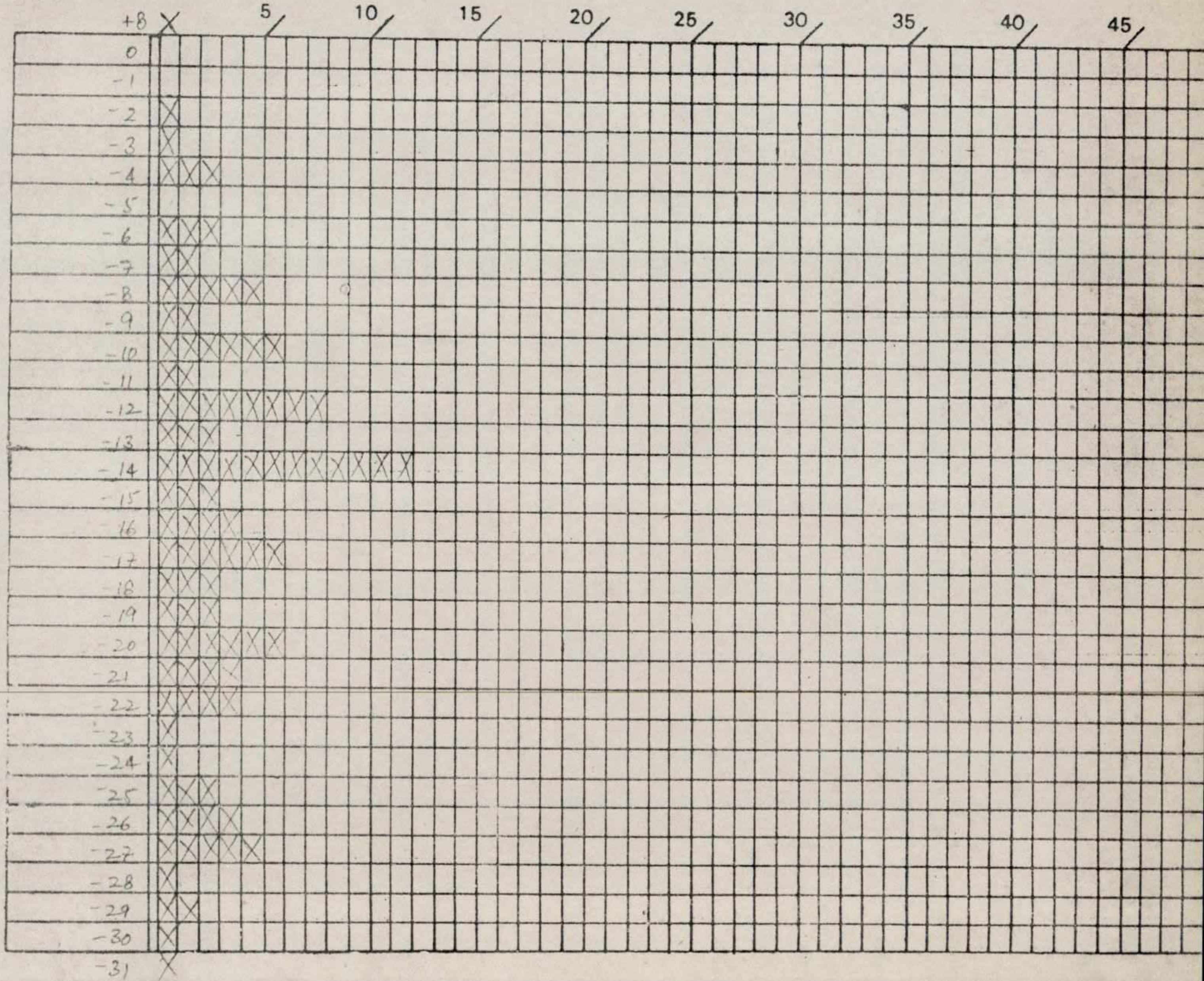
SAMPLE SIZE: 100 pcs

INSPECTOR:

SIGNATURE:

DATE: 19/2/88

BEFORE FACE AND CHAMFER
BEFORE ANNEALING



DIMENSION:

SPECIFICATION:

FIG 2·7

GABRIEL INDIA LIMITED BEARING DIVISION

QUALITY CONTROL DEPARTMENT

OUT GOING AUDIT CRUSH/WALL THICKNESS

CUSTOMER TATA

CHALLAN NO ______

INSPECTOR ______

APPLICATION CAM SHAFT BUSH

LOT SIZE ______

SIGNATURE ______

PART NO X 25230511 ~~301~~ 3101 / STD

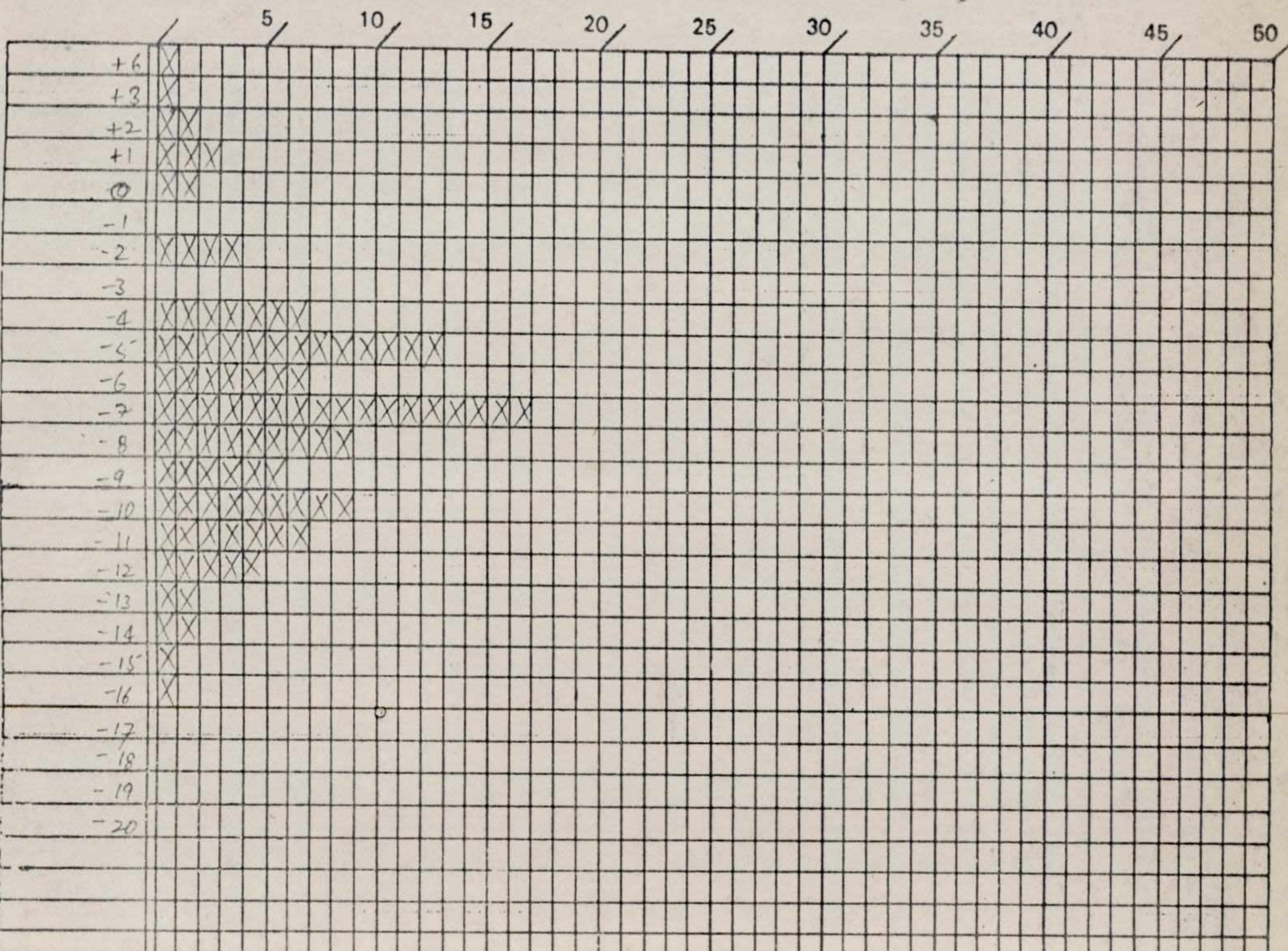
SAMPLE SIZE 100 pcs

DATE 19/2/88

DIMENSION FINAL OD

SPECIFICATION 0 to -20 div

AFTER FACE & CHAMFER BEFORE ANNEALING.



DIMENSION ______

SPECIFICATION ______

FIG 2·8

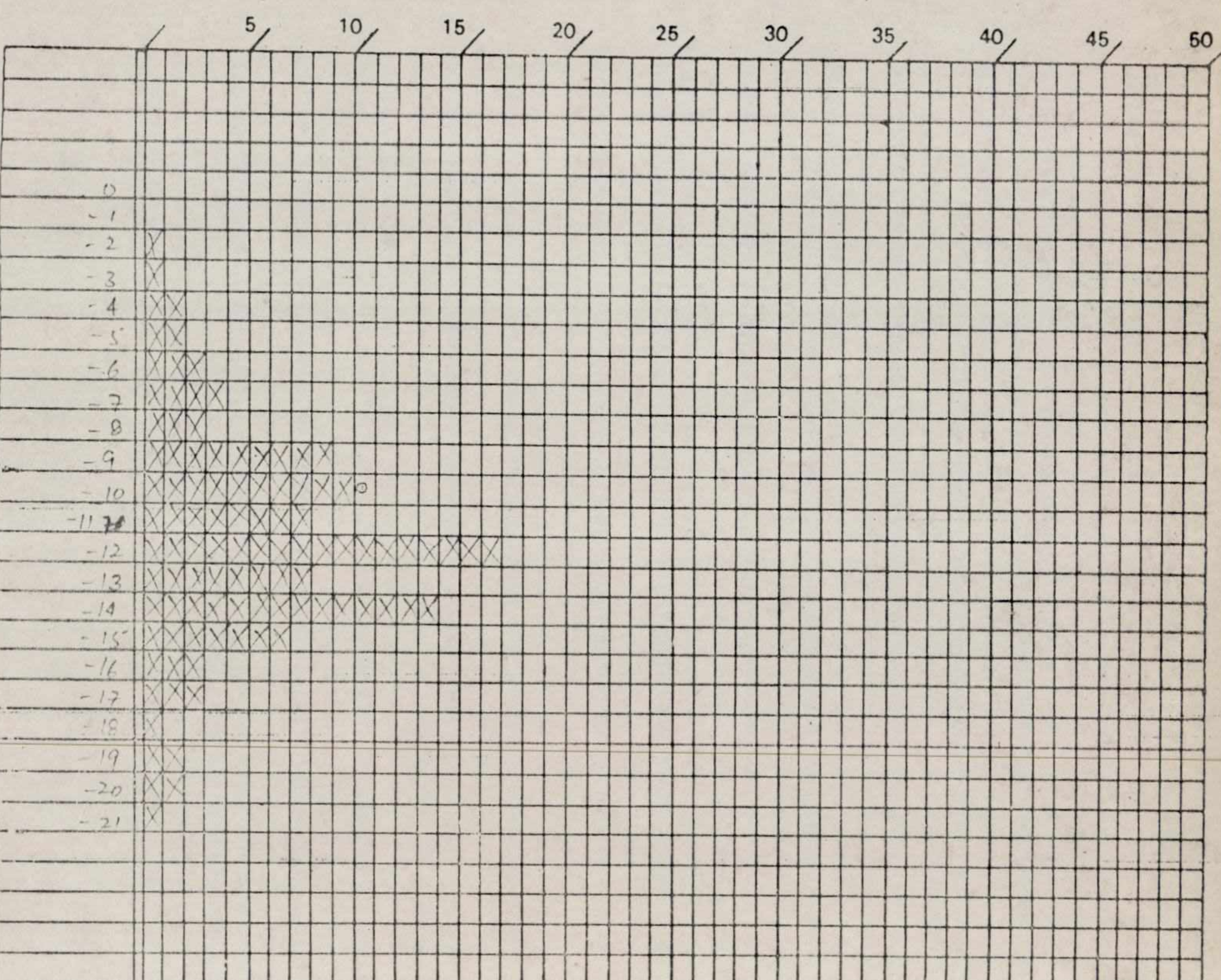
GABRIEL INDIA LIMITED — BEARING DIVISION

QUALITY CONTROL DEPARTMENT

OUT GOING AUDIT — CRUSH/WALL THICKNESS

CUSTOMER: TATA
CHALLAN NO:
INSPECTOR:
APPLICATION: CAM SHAFT BUSH
LOT SIZE:
SIGNATURE:
PART NO: X 25230511 3101/STD
SAMPLE SIZE: 100 pcs
DATE: 19/2/88
DIMENSION: FINAL OD
SPECIFICATION: 0 to -20 div

AFTER FACE & CHAMFER
AFTER ANNEALING



DIMENSION:

SPECIFICATION:

Capability study of height and ID broaches

Height and ID broaching are two very cricital operations in the making of any straight or flanged bearings. Depending upon the requirements and specifications of the customer, these may be done either before or after plating of the bearing. The main purpose of ID broach is to maintain the internal diameter (I) alongwith the various reliefs of the bearing. Main purpose of height broach is to maintain the height (h) of the bearing which is required to provide the necessary crush when the bearing is assembled in the housing (fig 2.9).

It is, so, very necessary that the behaviour and capabilites of the machines which are performingthese operations be known. It will not only help to estimate their level of performance but also to identify causes for awakward behaviour , if any. For the above state purposes, the study of the performances of these machines was taken up. The study was started by taking a sample out of the pieces being worked on . Every tenth piece being produced by the machine was taken as a sample and the appropriate dimensions- height in case of ht. broach and wall thickness in case of ID broach, measured. Behaviour of these machines was studied by plotting readings of these samples on process control charts. Information from operators and other concerned production and quality control staff revealed that the machine might show a change in behaviour due to any of the following reasons:

1. Nature of work - size, shape (st bearing or flange) material of the bearing.
2. Whether machine is in continuous operation or breaks have been made.
3. Inherent characteristics in the machine.

It was noticed that the behavious of each machine varied considerably for each application. The reason might be a

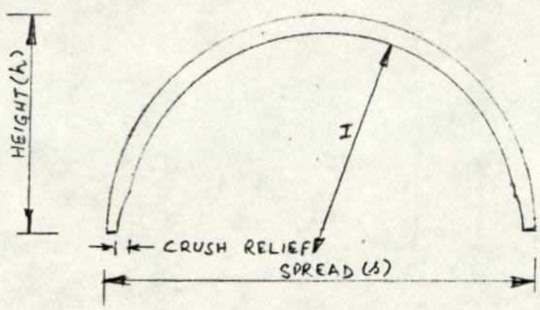


FIG 2·9

STRAIGHT BEARINGS

change in size and nature of a adaptor or the core or any ofthe other parts that are changed for each application. So the factor of the nature of work will become further divided into a number of sub-factors. These factors will make it impossible to study the effect ofthe various applications on the machines.

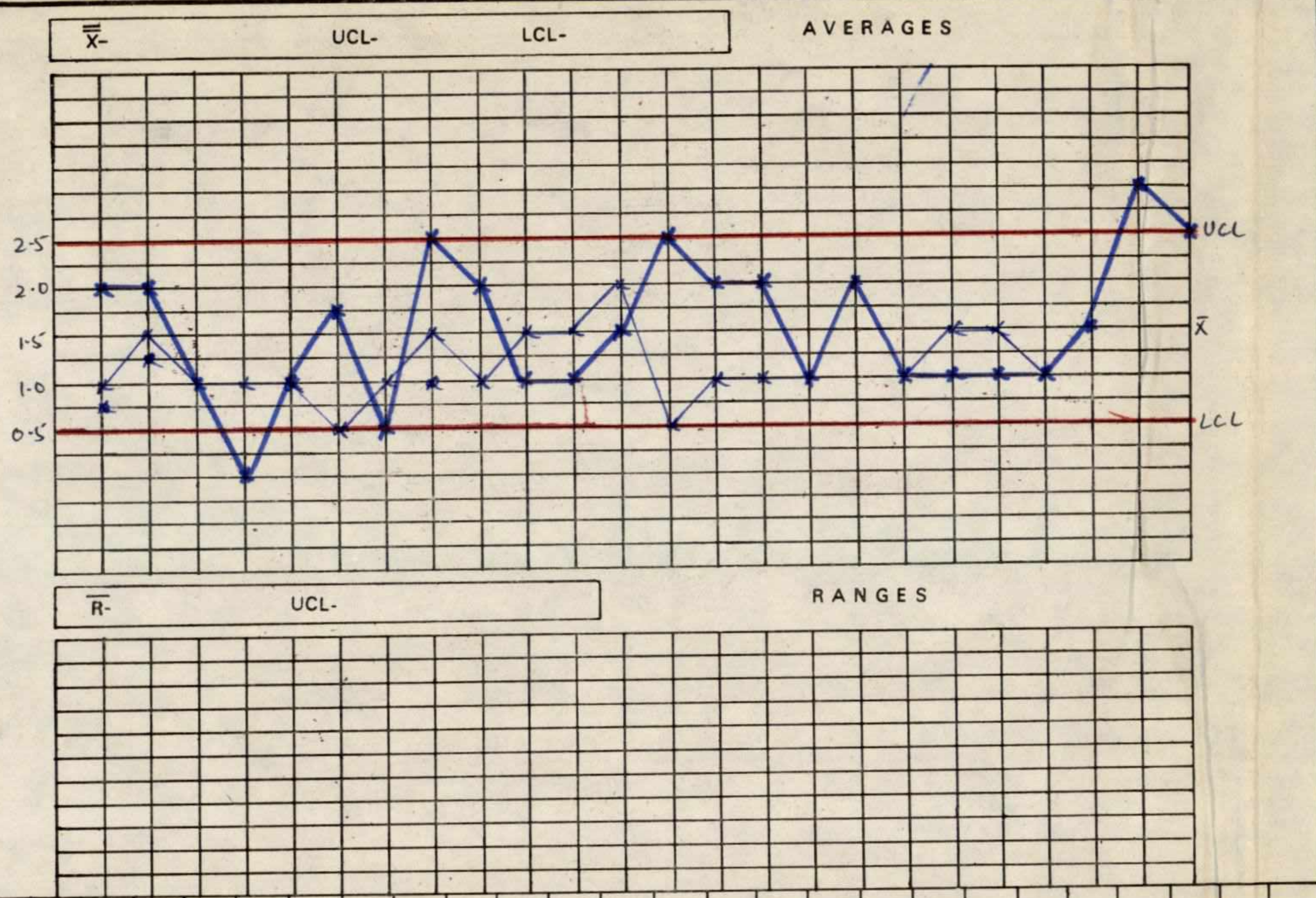
The other two factors are easy to identify and understand for each machine individually. Hence the first study to be started was to identify whether there is a difference in the operational and functional characteristics of the machine andhence the pieces produced on it when the machine is used continuously and when there is a stopping of the machine for a considerable period of time (say 10min)

Continuous operation would imply that the machine is run continuously for a long period of time without chaning its setting Characteristics of the machine in continuous ooeration is taken only when machine has already been running for say about half an hour without a break. Discontinuous operation would imply running of a machine after break of about 10 minutes or more.(say a break for water, for lunch etc.) Charactristics are taken right after the machine is re-started.

As stated earlier every tenth piece was taken as sample in all the cases. All six height and wall broaching machines were studied in the process. First, samples were taken for machine in contineous operation. The appropriate dimensions were measured and a plot was made on the process control chart ($\bar{X}$ chart). Afterwards, observations were taken at the same sample rate just after machine had started production after a break. The same control chart was used to plot these observations for easy comparison. Some such charts have been attached as fig 2.9 fig 2.10, fig. 2.11, fig 2.12a and fig. 2.12.b.

A quick study of these charts reveals the following information:

FIG 2-9 a



DATE	
TIME	
READINGS 1	
2	
3	
4	
5	
SUM	
$\overline{X}$	
R	

Gabriel India Ltd. (Brg. Div.)

PARWANOO

PROCESS CONTROL CHART

MACH NO.	I02
DEPT	QC
DATES	4/2/88
PART. NO.	70102C/020
PART NAME	Ashok Leyland Conn rod
OPERATION	ID broach
CHARACTERISTIC	0·5 – 2·5 div
ENGINEERING SPECIFICATION	
SAMPLE SIZE/FREQUENCY	

CALCULATIONS AND NOTES

$UCLx = \overline{\overline{X}} + A2\,\overline{R} =$

$LCLx = \overline{\overline{X}} - A2\,\overline{R} =$

$UCLR = D4\,\overline{R} =$

$LCLR = D3\,\overline{R} =$

$\sigma' = \frac{\overline{R}}{d2}$

X–X BEFORE BREAK

X–X AFTER BREAK

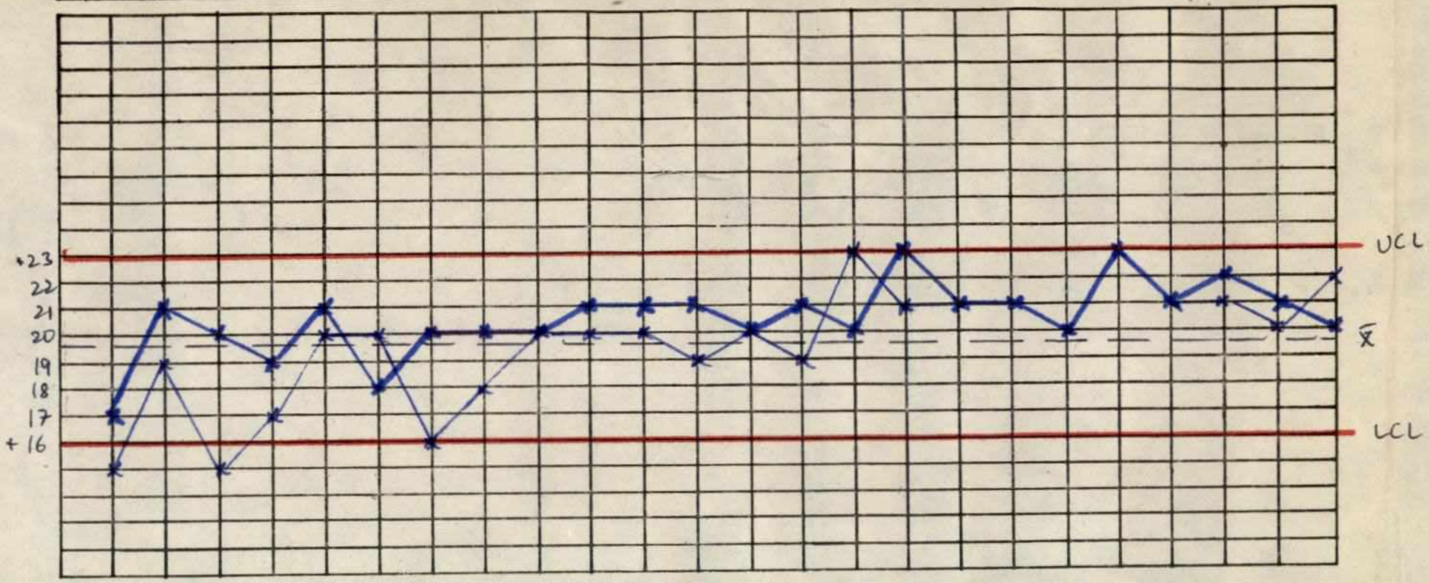
FIG 2·10

Gabriel India Ltd. (Brg. Div.)

PARWANOO

PROCESS CONTROL CHART

$\overline{\overline{X}}$- UCL- LCL- AVERAGES



$\overline{R}$- UCL- RANGES

DATE																								
TIME																								
READINGS 1																								
2																								
3																								
4																								
5																								
SUM																								
$\overline{X}$																								
R																								

MACH NO.	H02
DEPT	QC
DATES	1/2/88
PART. NO.	3210380010/STD
PART NAME	TATA CON-ROD
OPERATION	Ht Broach
CHARACTERISTIC	+16 – +23 div
ENGINEERING SPECIFICATION	
SAMPLE SIZE/FREQUENCY	

CALCULATIONS AND NOTES

$UCLx = \overline{\overline{X}} + A2\ \overline{R} =$

$LCLx = \overline{\overline{X}} - A2\ \overline{R} =$

$UCLR = D4\ \overline{R} =$

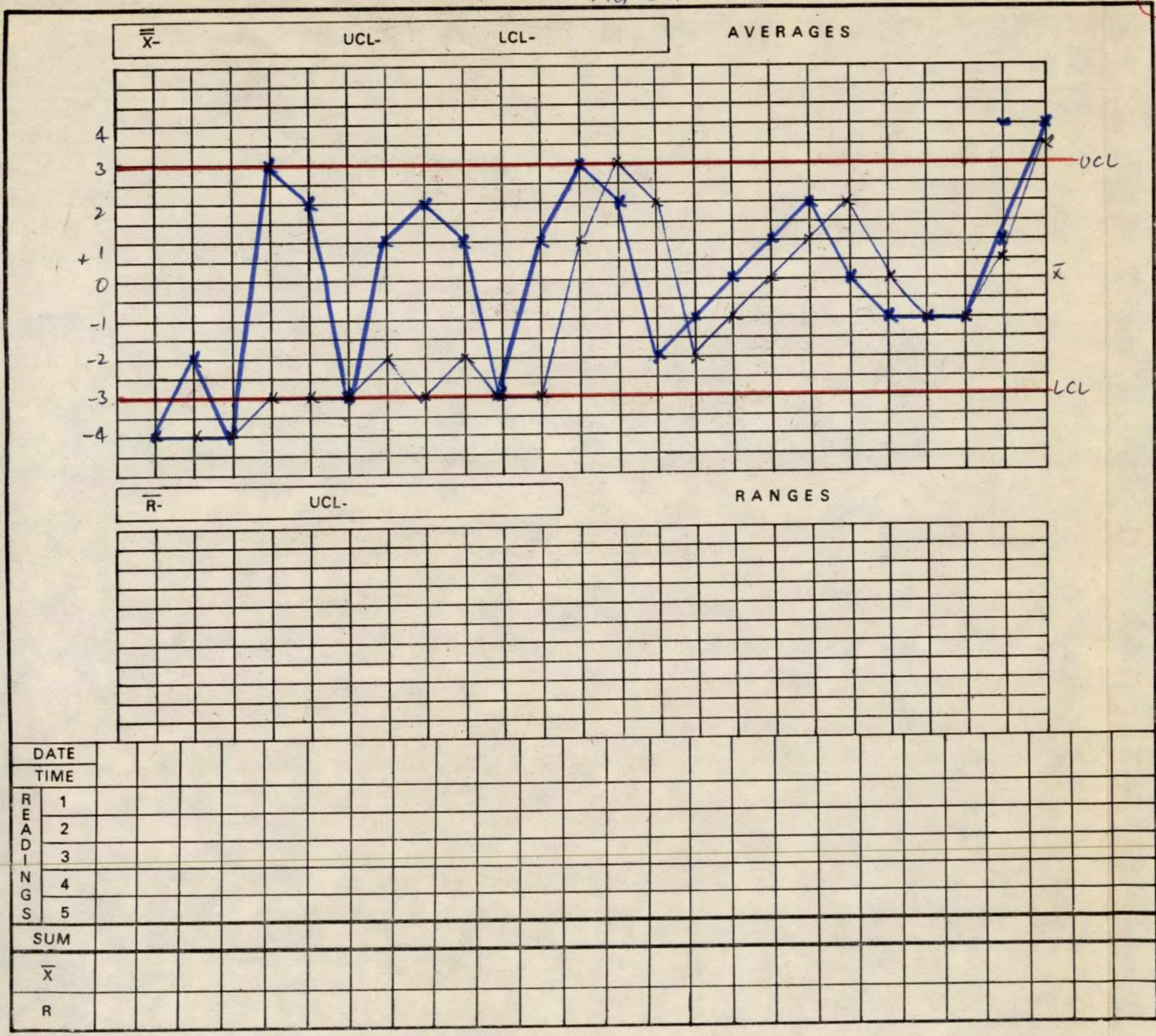
$LCLR = D3\ \overline{R} =$

$\sigma' = \frac{\overline{R}}{d2}$

x—x BEFORE BREAK

✱—✱ AFTER BREAK

FIG 2.11



Gabriel India Ltd. (Brg. Div.)

PARWANOO

PROCESS CONTROL CHART

MACH NO.	H01
DEPT	QC
DATES	22/2/88
PART. NO.	T 72010020 / N001
PART NAME	ESCORTS MAIN 228
OPERATION	Ht Broach
CHARACTERISTIC	+3 to -3 div
ENGINEERING SPECIFICATION	
SAMPLE SIZE/FREQUENCY	

CALCULATIONS AND NOTES

$UCLx = \overline{\overline{X}} + A2\,\overline{R} =$

$LCLx = \overline{\overline{X}} - A2\,\overline{R} =$

$UCLR = D4\,\overline{R} =$

$LCLR = D3\,\overline{R} =$

$\sigma' = \frac{\overline{R}}{d2}$

x—x BEFORE BREAK

x—x AFTER BREAK

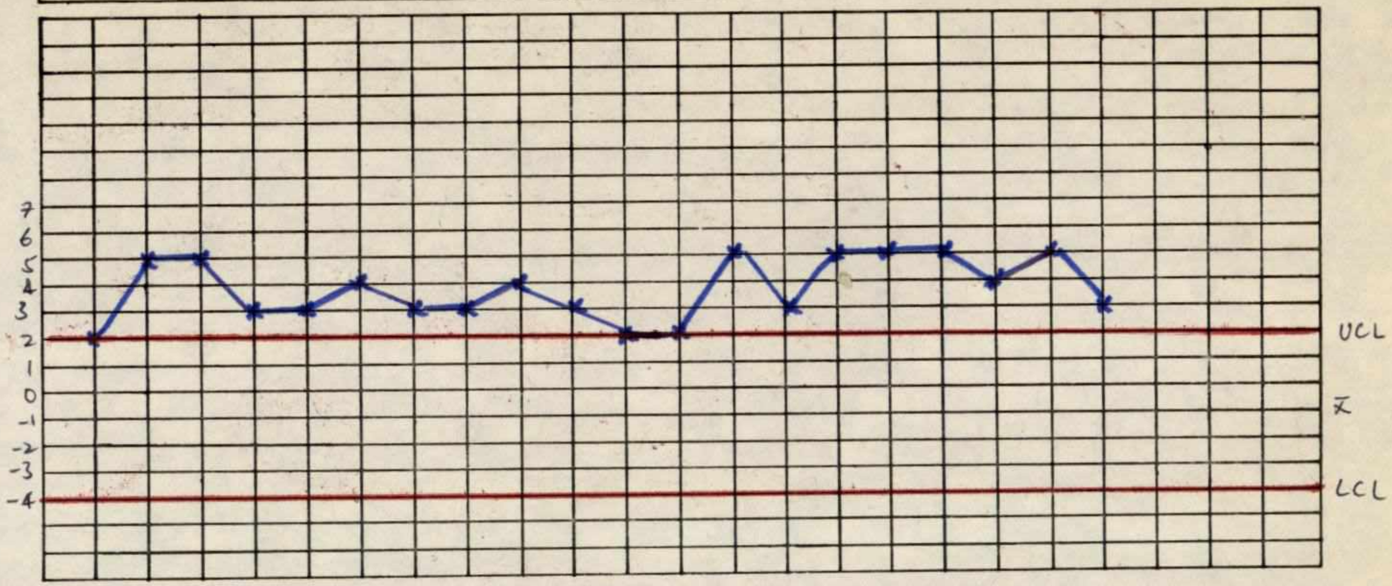
Fig 2·12 a

Gabriel India Ltd. (Brg. Div.)

PARWANOO

PROCESS CONTROL CHART

$\overline{\overline{X}}$- UCL- LCL- AVERAGES



$\overline{R}$- UCL- RANGES

DATE	
TIME	
READINGS 1	
READINGS 2	
READINGS 3	
READINGS 4	
READINGS 5	
SUM	
$\overline{X}$	
R	

MACH NO.	H02
DEPT	QC
DATES	29/1/88
PART. NO.	
PART NAME	ITCI CON-ROD
OPERATION	At broach
CHARACTERISTIC	+2 to -4 div
ENGINEERING SPECIFICATION	
SAMPLE SIZE/FREQUENCY	

★ NORMAL CONDITIONS OF WORK

CALCULATIONS AND NOTES

$UCLx = \overline{\overline{X}} + A2\,\overline{R} =$

$LCLx = \overline{\overline{X}} - A2\,\overline{R} =$

$UCLR = D4\,\overline{R} =$

$LCLR = D3\,\overline{R} =$

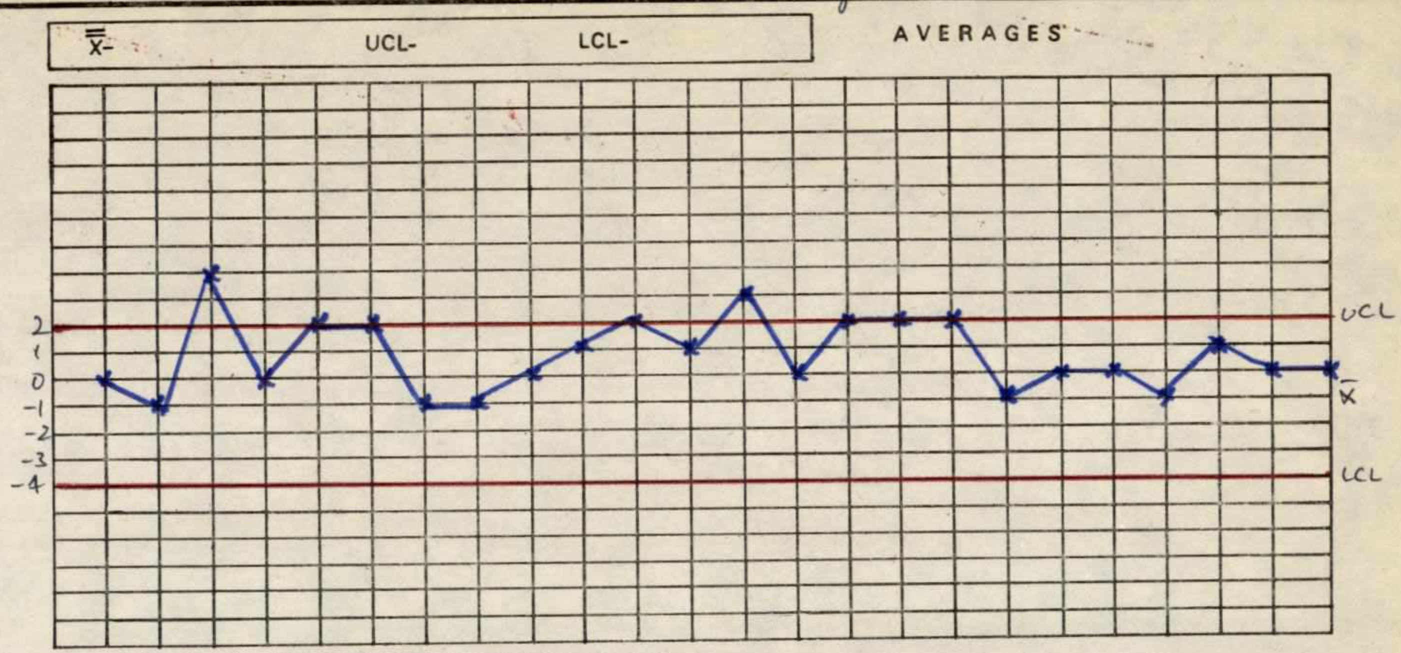
$\sigma' = \frac{\overline{R}}{d2}$

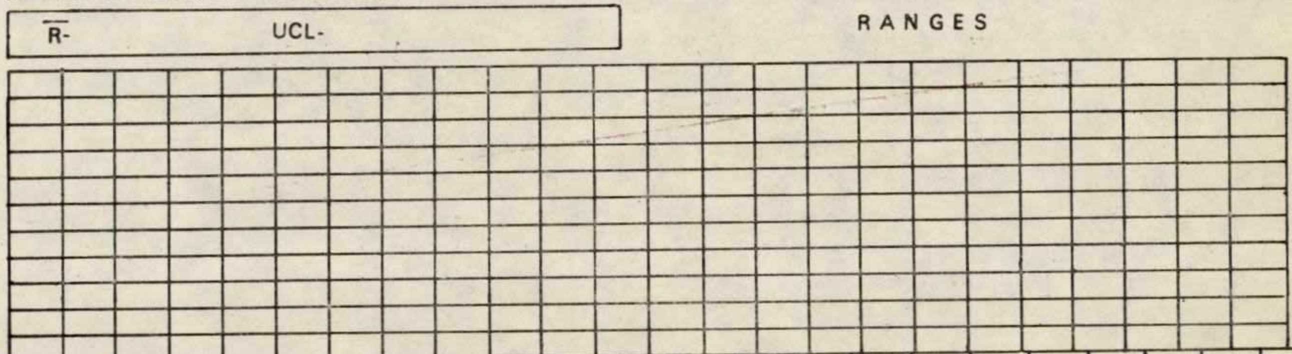
Fig 2.12b

Gabriel India Ltd. (Brg. Div.)

PARWANOO

PROCESS CONTROL CHART





DATE	
TIME	
READINGS 1	
2	
3	
4	
5	
SUM	
$\bar{X}$	
R	

MACH NO.	HO 2
DEPT	QC
DATES	29/1/88
PART. NO.	
PART NAME	ITCI CON ROD
OPERATION	Ht broach
CHARACTERISTIC	+2 to -4 div
ENGINEERING SPECIFICATION	
SAMPLE SIZE/FREQUENCY	

★ AFTER BREAK

CALCULATIONS AND NOTES

$UCLx = \bar{\bar{X}} + A2\,\bar{R} =$

$LCLx = \bar{\bar{X}} - A2\,\bar{R} =$

$UCLR = D4\,\bar{R} =$

$LCLR = D3\,\bar{R} =$

$\sigma' = \frac{\bar{R}}{d2}$

a. The machine behaviour shows a considerable change after the break.

b. The control charts showed a very clear tendency to climb up or down after the break

This change in behaviour varied for each individual machine.

On the basis of the above observations, it was decided to follow the following steps in order to prevent this behavirial change which usually led to changes in the machine settings at the insistance of the patrol inspector after each break. These new settings would again show unwanted results after a few pieces had been made.

a. The operator of the broaches should run the machine at idle after each break for about 5 min. before he starts to broach the pieces. It would be still better if the machine could be run at idle during the break also.

b. In case there is a variation in the 5 piece sample taken by the patrol inspection at the begining of the shift when setting had been done in the previous shift and no such variation was showing in the readings in the last shift, the worker should be advised to run the machine at idle for some more time and the sample should be taken again. Only, if this sample is not up to the required mark, should the setting be changed.

This would help in reducing the number of settings and resettings carried out during the process of production since behavorial changes exist in the machine after it is stopped for a certain period of time. The above procedures will to some extent also help reduce wastage of time for setting.

In order to find the inherent charactristics of each individual machine, a very similar procecure was adopted.

The only difference in this cost being that all observations were during normal running of the machines. Also in some of the cases sample was taken after every fifth piece. The observations for the purpose were noted on the $\overline{X}$ chart. The upper and lower control limits were also marked as usual and the graph completed. These control charts were then studied to find the nature of the process i.e. whether the behaviour is

- natural
- un-natural

If it is un-natural, is it a mixture or is it stratified or whether it is instable and whether the un-natural pattern of the chart is a; Relatively simple

b; Relatively complex

and so on

A natural pattern will have all the following characteristics.

1. Most of the points are near the centreline i.e. the mean
2. A few of the points spread out and approach the control limits.
3. None of the points exceeds the control limits.

On the other hand un-natural pattern will show the following features:

1. Mixture i.e. absence of points near the centreline.
2. Stratification i.e. absence of points near the control limits
3. Instability i.e. presence of points outside the control limits.

Un -natural patterns may show many varieties of behaviour like cyclic, trends, sudden/gradual change in levels, mixtures, freaks bunching, inter-action etc.

All the machines taken up for the study showed a variety of behaviour depending on a number of factors. It will not be practical to discuss and present all the charts that were prepared, in this report. So the study of a few of these charts is being described here.

Let us first take the case of fig 2.13 dated 1.3.88 . Machine under study was the ID broach No. IO2.

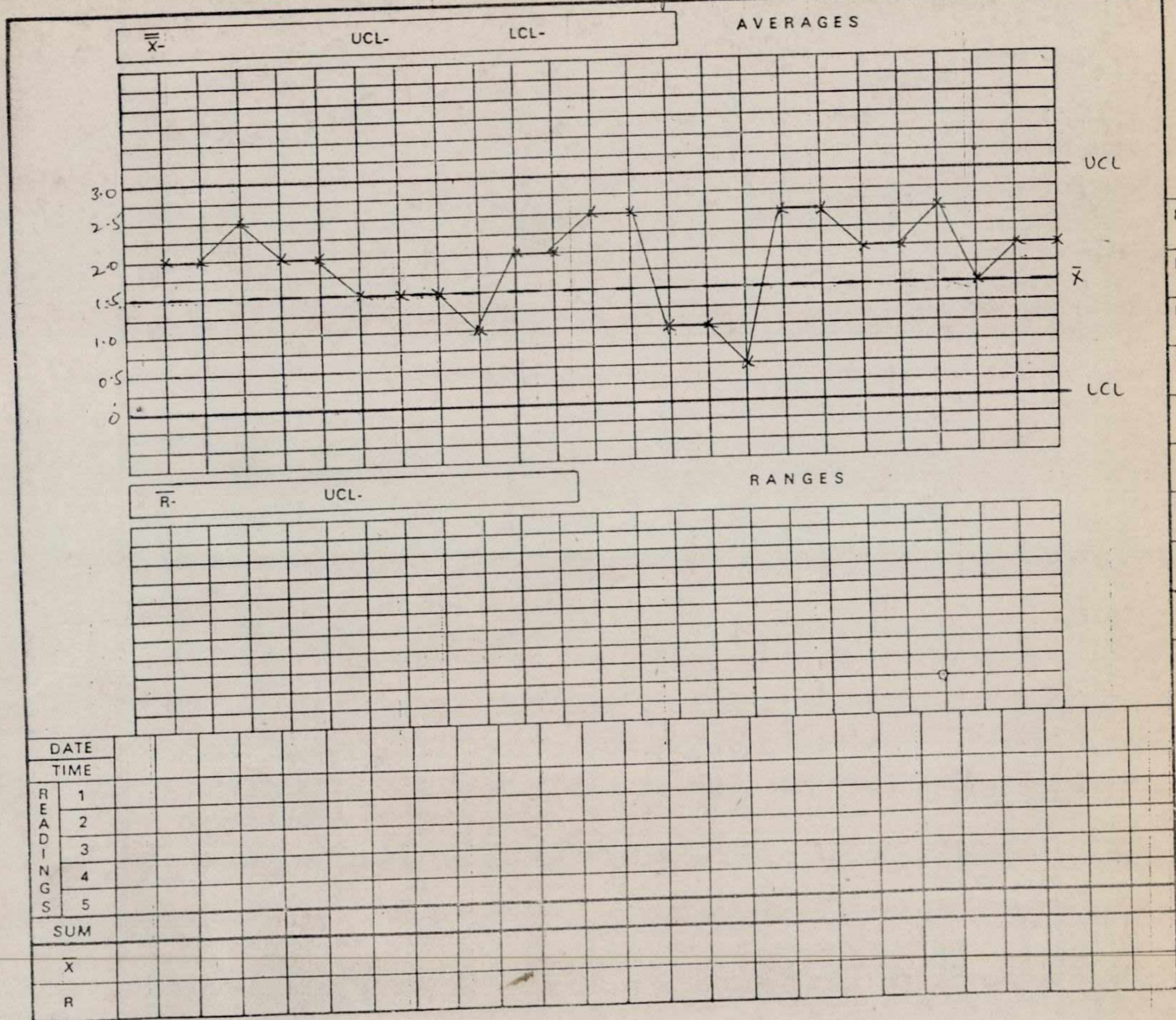
Applying the conditions for a natural pattern we see that all the conditions are fulfilled simultaneously which means that the machine is showing a natural behavious . Thus it implies that the average of the parent distribution did not change during the charted period and most of the product was actually near the indicated average. A frequency histogram (fig 2.14) shows that the nature of the distribution is well within the specifications for a natural pattern.

A similar study can be made for the pattern shown in fig 2.15 (dated 23.2.88) for height broach machine No. HO2 , Again the pattern was found to be a natural one. Hence the same characteristics of the behaviour of the machine are the same as in the above case (Histogram fig 2.16).

It was, generally, seen that all the machines except height broach HO3 showed a natural behaviour . HO3 showed a very erratic un-natural behaviour . So after a first few weeks of studying all the broaches HO3 was singled out in order to find a cause for the un-natural behaviour It would be well in order to discuss a few cases involving machine HO3.

Applying the rules of a natural pattern to the chart in fig 2.17 (dated 24.2.88) we see that all the three conditions remain unfulfilled. Hence the pattern is an un-natural one. Applying the various techniques used to analyses control charts, it is not very difficult to see that thre are no tendencies, shifts in level, stratifications, freaks, bunching etc.

Fig 2·13



Gabriel. India Ltd. (Brg. Div.)

PARWANOO

PROCESS CONTROL CHART

MACH NO.	I02
DEPT	QC
DATES	1/3/88
PART. NO.	70101C/010
PART NAME	
OPERATION	ID Broach
CHARACTERISTIC	0 - 3 div
ENGINEERING SPECIFICATION	
SAMPLE SIZE/FREQUENCY	

CALCULATIONS AND NOTES

$UCL_x = \bar{\bar{X}} + A2\,\bar{R} =$

$LCL_x = \bar{\bar{X}} - A2\,\bar{R} =$

$UCL_R = D4\,\bar{R} =$

$LCL_R = D3\,\bar{R} =$

$\sigma' = \frac{\bar{R}}{d2}$

FIG 2·14

GABRIEL INDIA LIMITED BEARING DIVISION

QUALITY CONTROL DEPARTMENT

OUT GOING AUDIT CRUSH/WALL THICKNESS

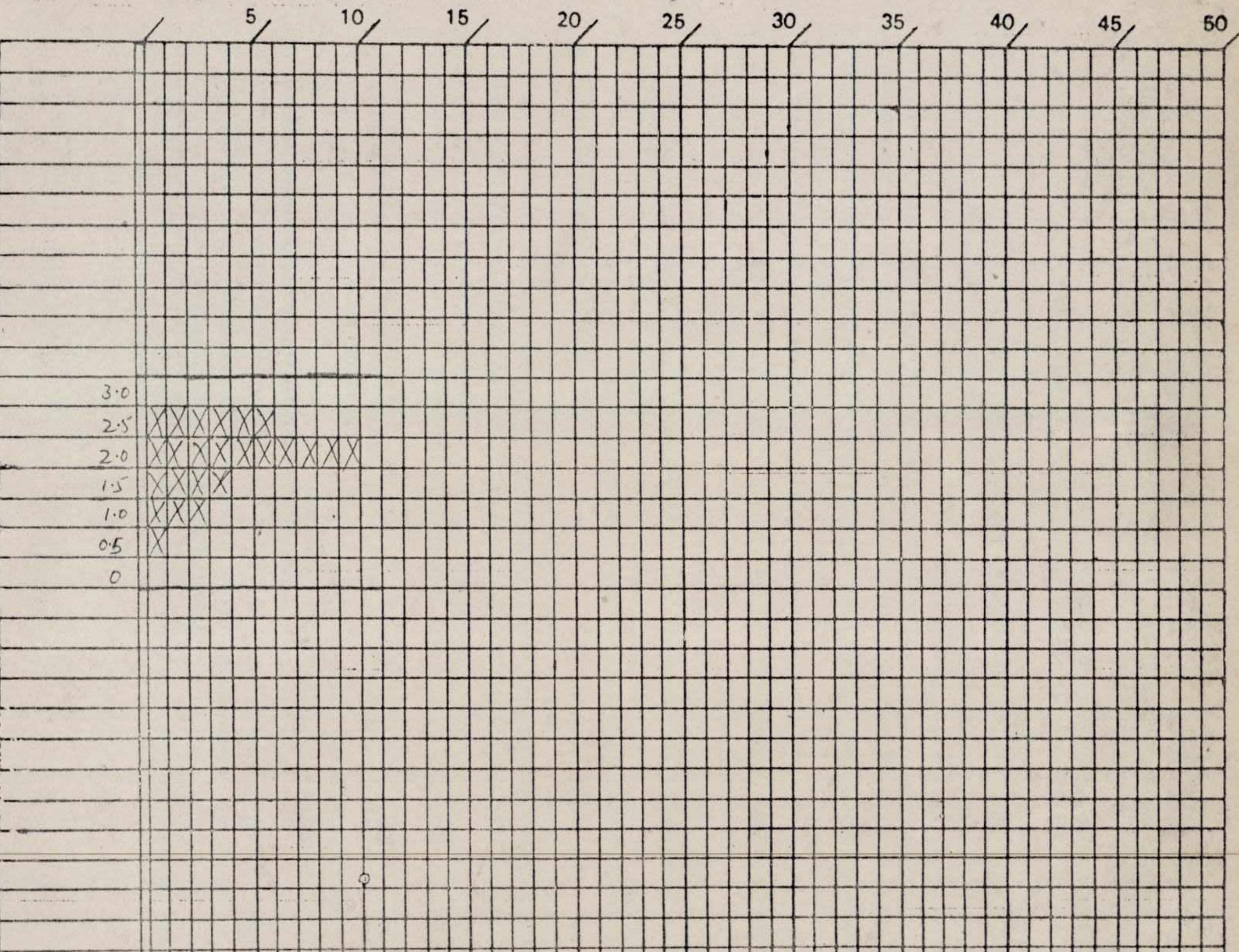
CUSTOMER ______ CHALLAN NO ______ INSPECTOR M/c I02

APPLICATION ______ LOT SIZE ______ SIGNATURE ______

PART NO 70101C/010 SAMPLE SIZE 24 pcs DATE 1/3/88

DIMENSION ID Broach

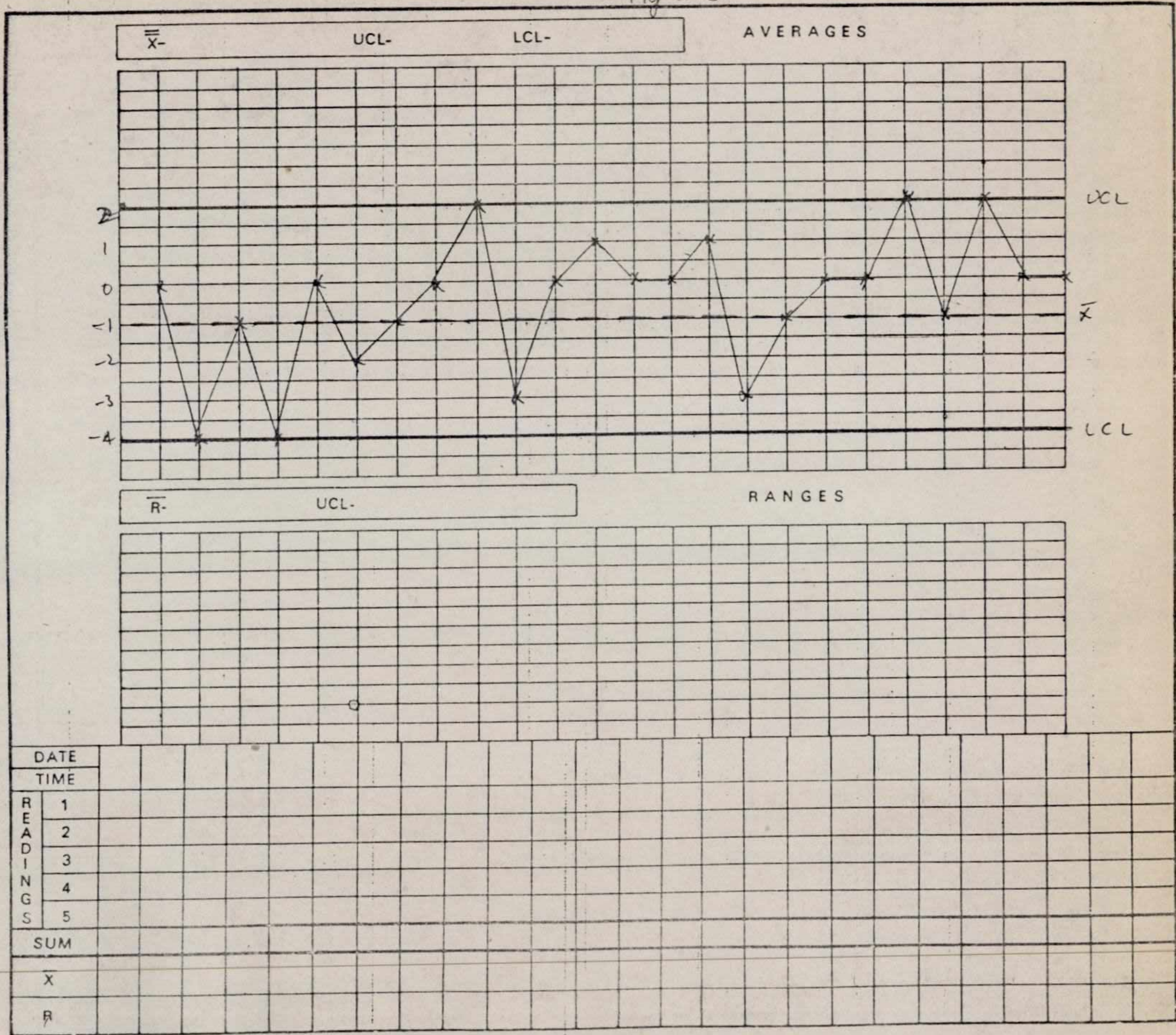
SPECIFICATION ______



DIMENSION ______

SPECIFICATION ______

Fig 2.15



Gabriel India Ltd. (Brg. Div.)

PARWANOO

PROCESS CONTROL CHART

MACH NO.	H02
DEPT	QC
DATES	23/2/88
PART. NO.	70101C/080
PART NAME	TATA CON-ROD
OPERATION	Ht broach
CHARACTERISTIC	+2/-4 div
ENGINEERING SPECIFICATION	
SAMPLE SIZE/FREQUENCY	

CALCULATIONS AND NOTES

$UCLx = \bar{\bar{X}} + A2\,\bar{R} =$

$LCLx = \bar{\bar{X}} - A2\,\bar{R} =$

$UCLR = D4\,\bar{R} =$

$LCLR = D3\,\bar{R} =$

$\sigma' = \frac{\bar{R}}{d2}$

FIG 2.16

GABRIEL INDIA LIMITED BEARING DIVISION

QUALITY CONTROL DEPARTMENT

OUT GOING AUDIT CRUSH/WALL THICKNESS

M/c no HO2

CUSTOMER TATA

CHALLAN NO

INSPECTOR

APPLICATION CON - ROD

LOT SIZE

SIGNATURE

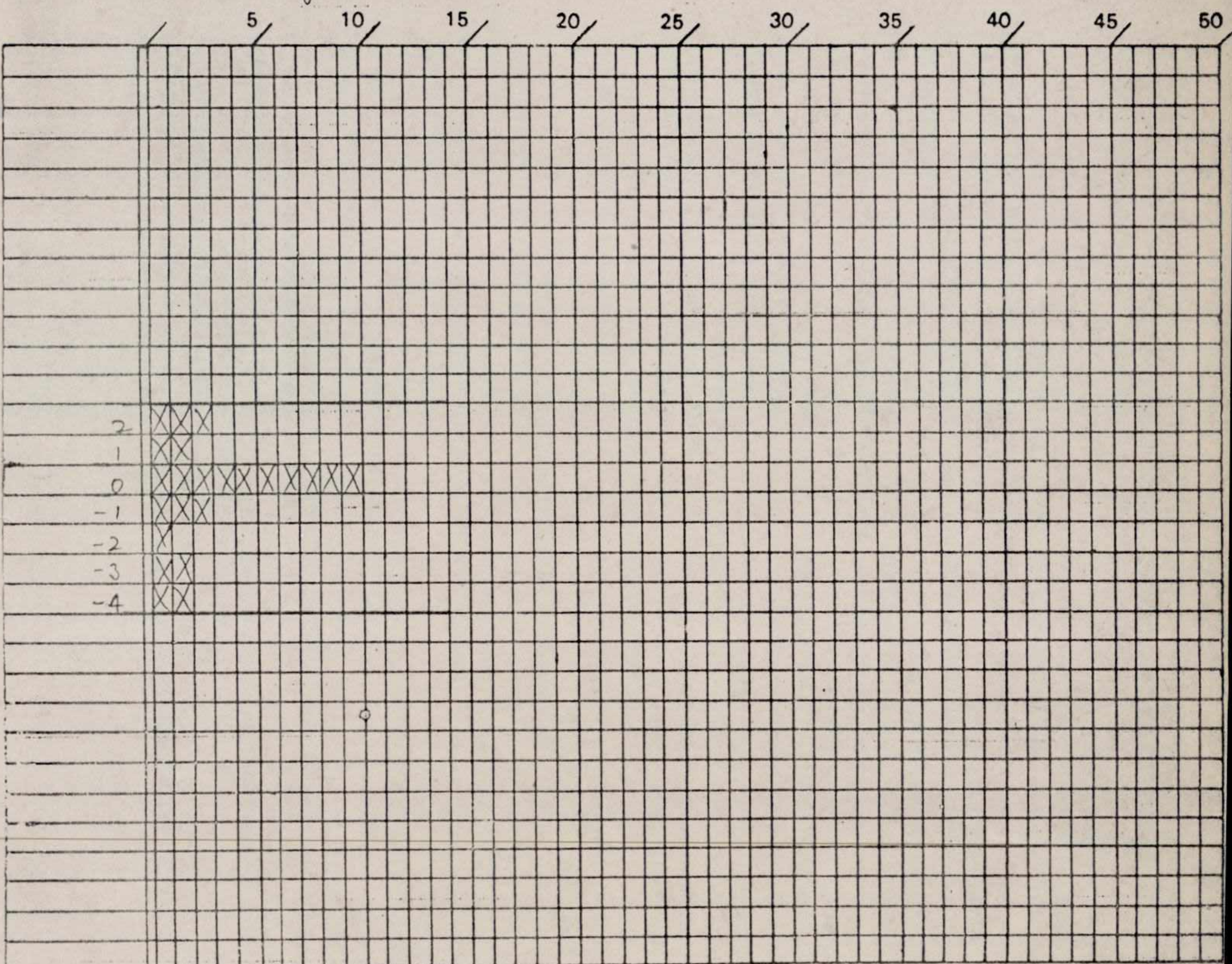
PART NO 70101 C/080

SAMPLE SIZE 24 pcs

DATE 23/2/88

DIMENSION

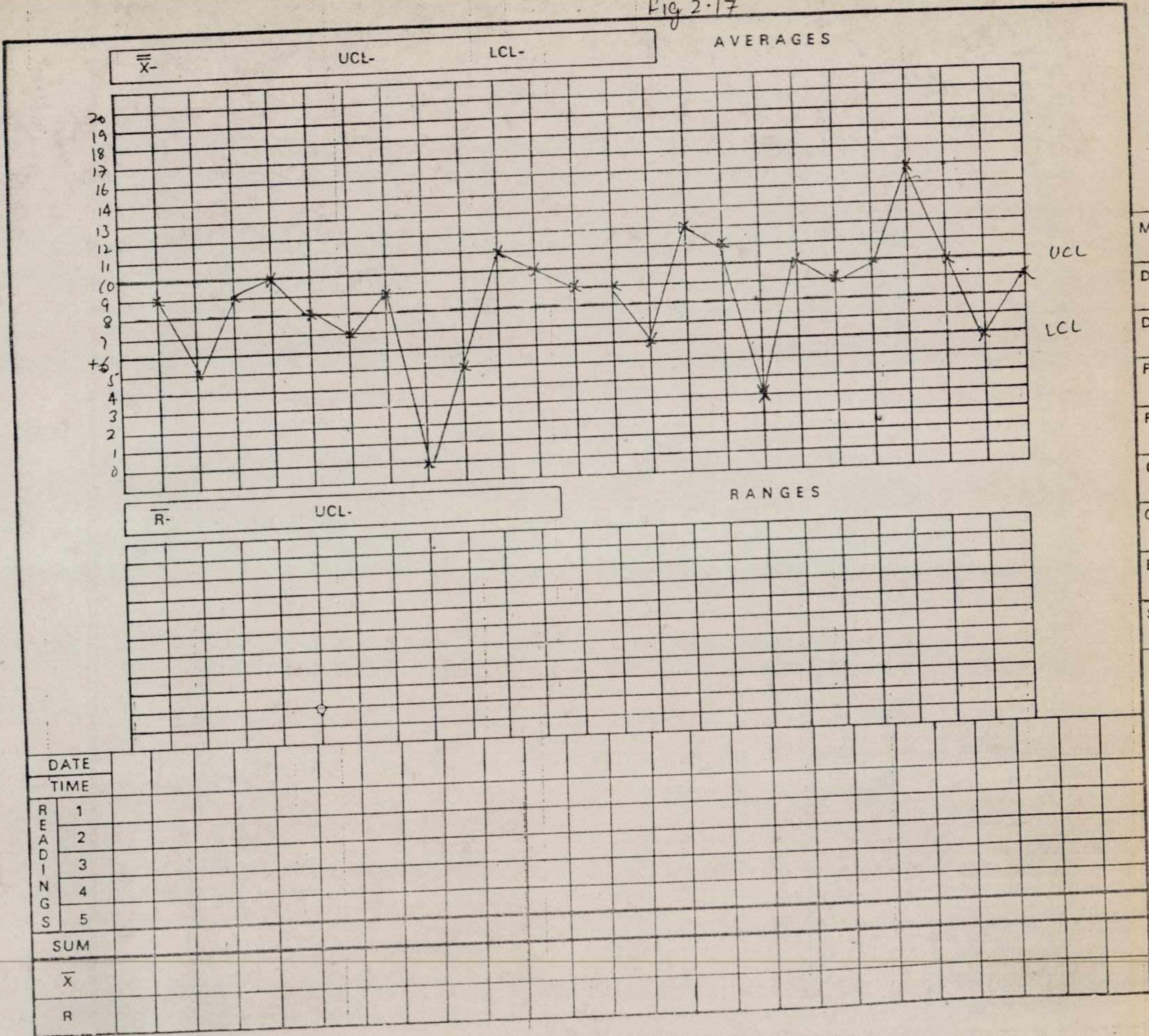
SPECIFICATION Height



DIMENSION

SPECIFICATION

Fig 2·17



Gabriel India Ltd. (Brg. Div.)

PARWANOO

PROCESS CONTROL CHART

MACH NO.	H03
DEPT	QC
DATES	24/2/88
PART. NO.	85101C/020
PART NAME	TELCO MAIN
OPERATION	Ht broach
CHARACTERISTIC	+10/+6 div
ENGINEERING SPECIFICATION	
SAMPLE SIZE/FREQUENCY	

CALCULATIONS AND NOTES

$UCLx = \bar{\bar{X}} + A2\,\bar{R} =$

$LCLx = \bar{\bar{X}} - A2\,\bar{R} =$

$UCLR = D4\,\bar{R} =$

$LCLR = D3\,\bar{R} =$

$\sigma' = \frac{\bar{R}}{d2}$

FIG 2·18.

GABRIEL INDIA LIMITED BEARING DIVISION

QUALITY CONTROL DEPARTMENT

OUT GOING AUDIT CRUSH/WALL THICKNESS

M/C NO H03

CUSTOMER TATA

APPLICATION MAIN

PART NO 85101C/020

DIMENSION

SPECIFICATION Height

CHALLAN NO

LOT SIZE

SAMPLE SIZE 24 pcs

INSPECTOR

SIGNATURE

DATE 24/2/88

5 10 15 20 25 30 35 40 45 50

	1	2	3	4	5	6	7
16	X						
15							
14							
13							
12	X						
11	X	X					
10	X	X	X	X			
9	X	X	X	X	X	X	X
8	X						
7	X						
6	X	X					
5	X	X					
4							
3	X						
2							
1							
0	X						

DIMENSION

SPECIFICATION

A frequency histogram (fig 2.18) of the above observations shows that there exists instability of the pattern which is shown on the control chart by un-naturally large fluctuations. Pattern is characterised by ' Ups and Downs' on both sides of the chart.

A similar analysis can be made for the large pattern in fig 2.19 where again we find that pattern is highly instable. Fluctuations are again very wide for the control limits. (Histogram fig 2.20)

There are two ways which may lead to a pattern such as this.

A. A single cause capable of affecting the centre or the spread of distribution- operating on the process eratically.

B. A group of causes , each cabable of shifting the centre of spread (or both) may operate on the process in conjunction with one another.

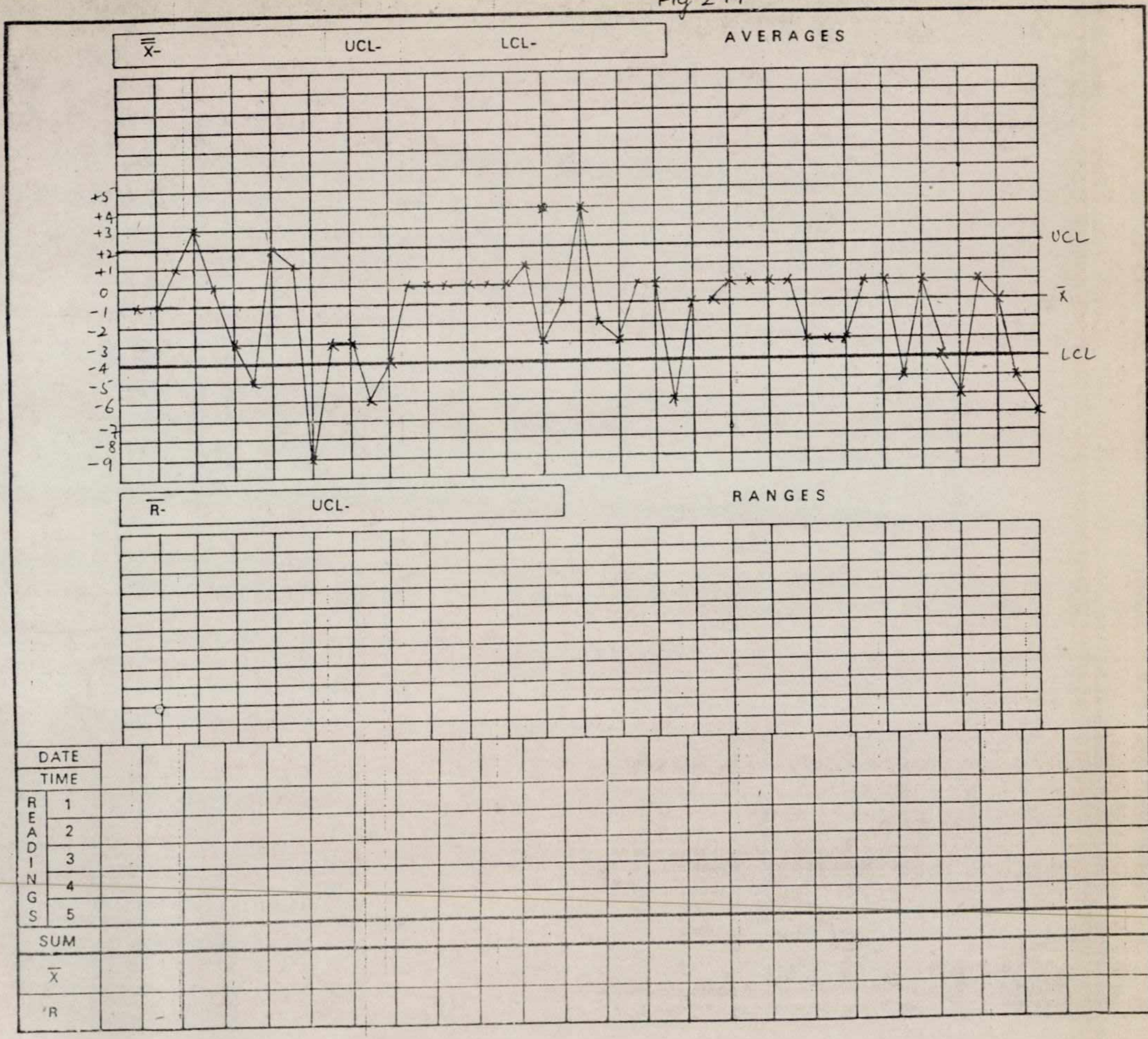
It was seen that for all control charts made for the height broach no H03 , a similar behaviour existed . So an attempt was made to try and indentify the cause for such a pattern shown by the machine. For this purpose, the process of height broaching a straight or flanged bearing was ~~deviated~~ divided up into a number of basic steps.

These steps were :

1) Loading bearing into adaptor
2) Activating position-adjusting clamp
3) Activating core to hold bearing in adaptor
4) Moving broach slide and broaching the height
5) Removal of core
6) Removal of bearing from adaptor

It was noticed that almost no time lag existed between steps 2,3 & 4. Since 2 & 3 involved usage of mechanisms working on pneumatic pressures, it would take some time to

Fig 2·19



Gabriel India Ltd. (Brg. Div.)

PARWANOO

PROCESS CONTROL CHART

MACH NO.	HC3
DEPT	QC
DATES	27/2/88
PART. NO.	70102C/040
PART NAME	Ashok Leyland Con-rod
OPERATION	Ht Broach
CHARACTERISTIC	+2 to -4 div
ENGINEERING SPECIFICATION	
SAMPLE SIZE/FREQUENCY	

CALCULATIONS AND NOTES

$UCLx = \bar{\bar{X}} + A2\ \bar{R} =$

$LCLx = \bar{\bar{X}} - A2\ \bar{R} =$

$UCLR = D4\ \bar{R} =$

$LCLR = D3\ \bar{R} =$

$\sigma' = \frac{\bar{R}}{d2}$

FIG 2·20

GABRIEL INDIA LIMITED BEARING DIVISION

QUALITY CONTROL DEPARTMENT

OUT GOING AUDIT CRUSH/WALL THICKNESS

CUSTOMER ASHOK LEYLAND
CHALLAN NO
INSPECTOR

APPLICATION CON - ROD
LOT SIZE
SIGNATURE

PART NO 70102 C/040
SAMPLE SIZE 48 pcs
DATE 27/2/88

DIMENSION

SPECIFICATION Height

	5, 10, 15, 20, 25, 30, 35, 40, 45
+4	X
+3	X
+2	X
+1	XXX
0	XXXXXXXXXXXXXXXXX
−1	XXXXXX
−2	X
−3	XXXXXXXX
−4	XX
−5	XXX
−6	XXX
−7	
−8	
−9	X

DIMENSION

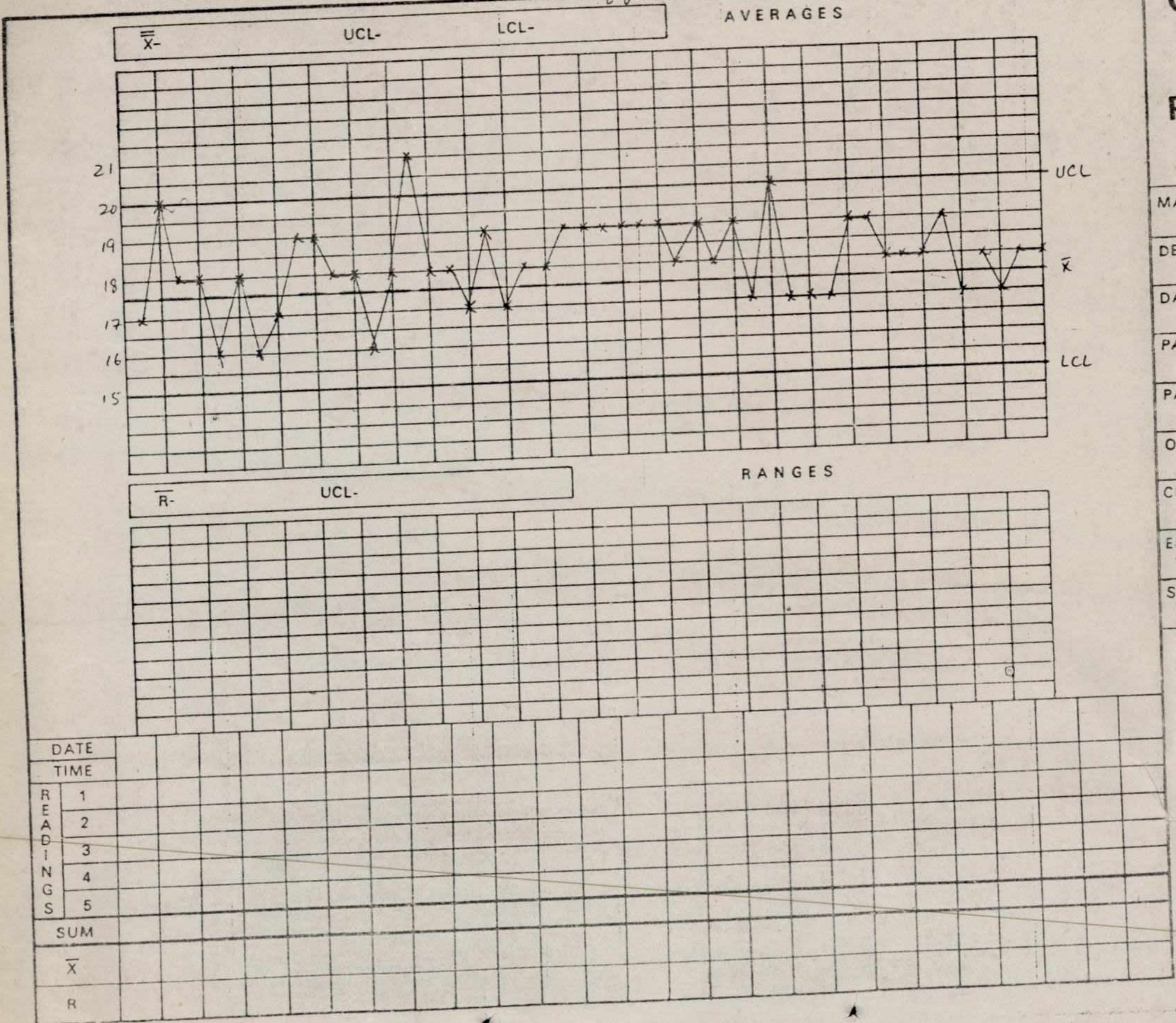
SPECIFICATION

build up the requisite pressure. So it wouldbe advisable to create a small time lag between the clamping by the core in step 3 and step 4 i.e. the actual broaching operation.

So observations for height were taken for present normal running conditions and for height after creating a time lag between the two mentioned steps. The two cases are shown in fig 2.21 and fig 2.22 for normal and slow clamping resp. It was seen that there was considerable improvements in the pattern formed in the second case where the pattern showed signs of a natural pattern rather than of an un-natural one as HO3 patterns generally did. Histograms of the two cases (fig 2.23) shows that the distribution in the lagged clamping and slide was quite like a natural distribution. Hence the reasoning of the timing principle is quite accurate.

Efforts are now on to form a system where such timings can be adjusted in order to have better control over the behaviour of such machines. Some electrical and pneumatic control systems have already been tested for the purpose. Machine HO3 has since been overhauled completely to locate any other faults.

fig 2.22



Gabriel India Ltd. (Brg. Div.)

PARWANOO

PROCESS CONTROL CHART

MACH NO.	H03
DEPT	QC
DATES	10/3/88
PART. NO.	70509C/1.50
PART NAME	
OPERATION	Ht. Broach
CHARACTERISTIC	+15 to +20 div
ENGINEERING SPECIFICATION	
SAMPLE SIZE/FREQUENCY	

★ SLOW CLAMPING (WITH TIME LAG)

CALCULATIONS AND NOTES

$UCLx = \bar{\bar{X}} + A2\,\bar{R} =$

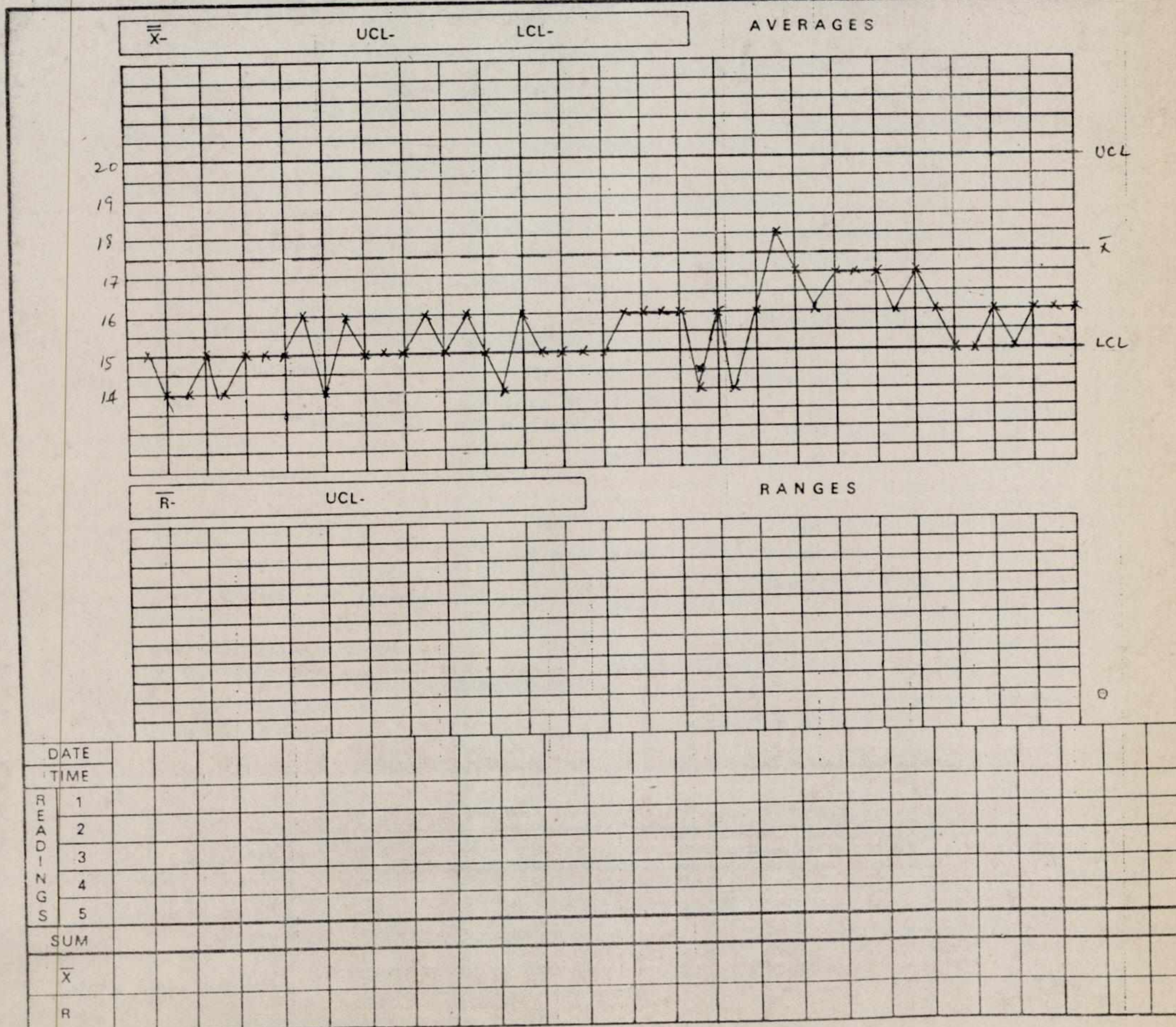
$LCLx = \bar{\bar{X}} - A2\,\bar{R} =$

$UCLR = D4\,\bar{R} =$

$LCLR = D3\,\bar{R} =$

$\sigma' = \frac{\bar{R}}{d2}$

FIG 2·21



X̿-
UCL-
LCL-
AVERAGES
20
19
18
17
16
15
14
UCL
x̄
LCL
R̄-
UCL-
RANGES
0
DATE
TIME
READINGS
1
2
3
4
5
SUM
X̄
R

FIG 2.23

GABRIEL INDIA LIMITED — BEARING DIVISION

QUALITY CONTROL DEPARTMENT

OUT GOING AUDIT — CRUSH/WALL THICKNESS

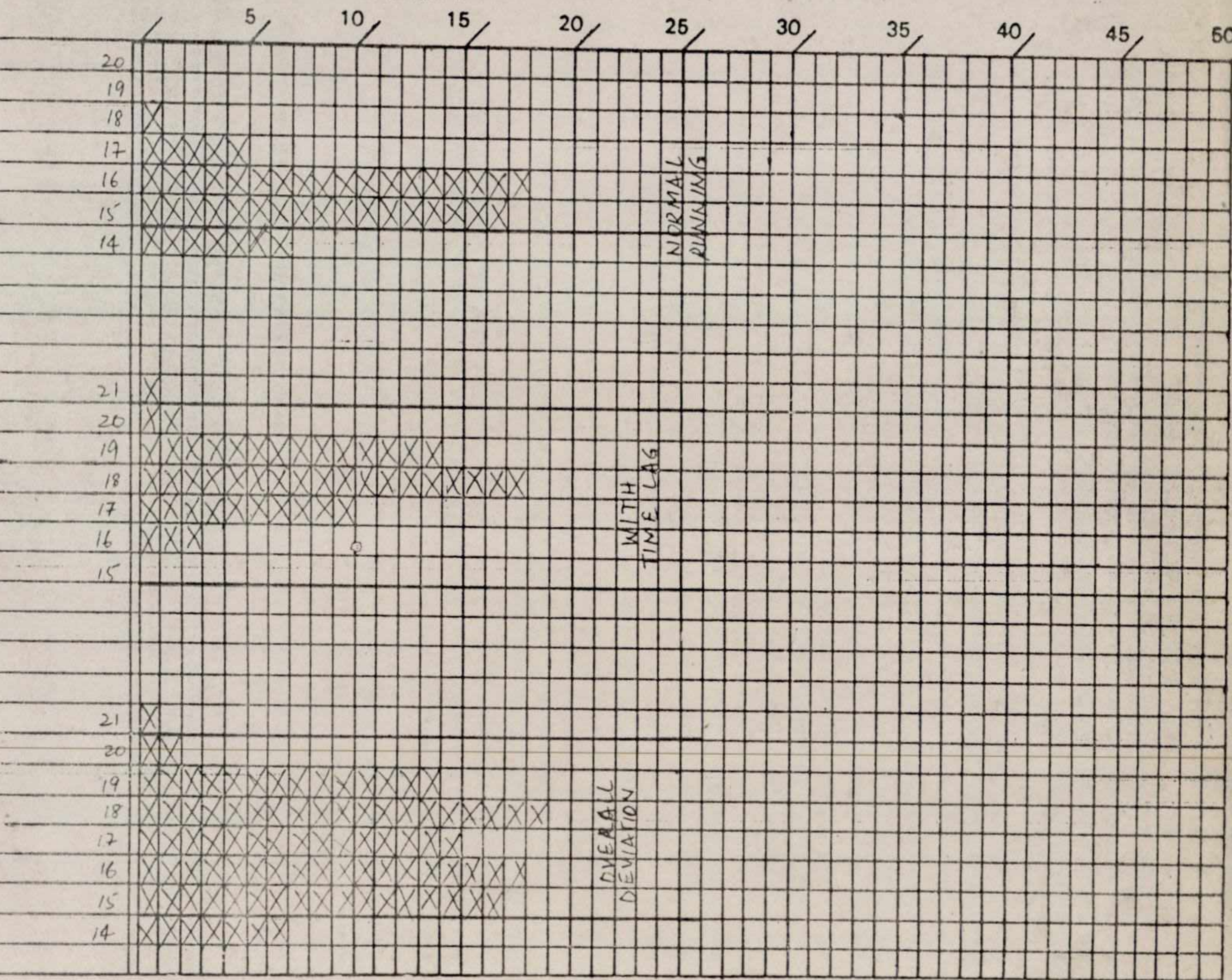
CUSTOMER ______ CHALLAN NO ______ INSPECTOR ______

APPLICATION ______ LOT SIZE ______ SIGNATURE ______

PART NO 70509C/1·50 SAMPLE SIZE 49 pcs DATE 10/3/88

DIMENSION ______

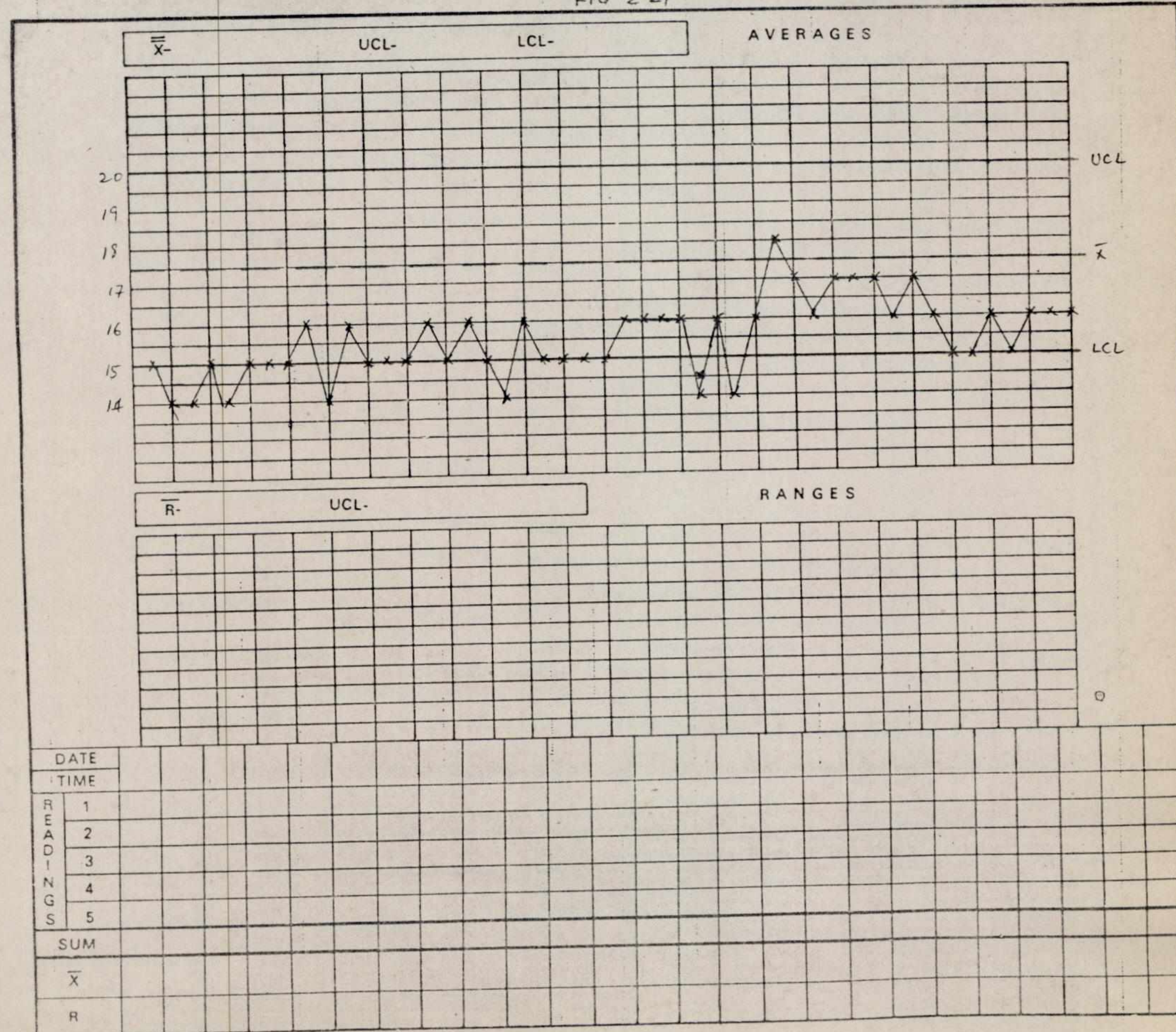
SPECIFICATION Height Broach SETTING AT 16



DIMENSION ______

SPECIFICATION ______

FIG 2·21



$\bar{\bar{X}}$-
UCL-
LCL-
AVERAGES
20
19
18
17
16
15
14
UCL
$\bar{x}$
LCL
$\bar{R}$-
UCL-
RANGES
0
DATE
TIME
READINGS
1
2
3
4
5
SUM
$\bar{X}$
R

Reducing wastage of time and effort of operators by standardization of data.

As described earlier in this report, a system of stage inspection has been set up at the production stage for controlling the quality of the bearings at the manufacturing stage. The basic aim of this system is to ensure that the physical and dimensional qualities of the material being produced conform to the specifications of the customer. Since the procedure laid down for the checking involves periodic inspection of the material during production, the risk of any worker producing a large number of pieces as scrap due to a faulty setting or some other fault in the machine, is considerably reduced. Hence the rate of rejection also shows a decline to a certain extent since the system was introduced.

A number of visual and dimensional aspects have to be checked by the stage inspectors for the bearing under manufacture. The number of applications being produced at a given time being quite large, it is almost impossible for a person to remember accurately all the dimentions and features for all the applications. For this purpose, drawings and other relevant data is available at the stage supervisors table but for consulting this data, the inspector has to make a number of trips to & fro from this area. Also there is a big possibility of the inspectors missing a vital piece of data/information from the drawing. This could have very dire consequencies if the missed aspect is not checked on time.

In order to reduce the time spent by the inspectors in going to the stage inspection area everytime they have to check on some data as also, to eliminate the possibility of a critical information to be missed, a system of "Process Cards" has been devised.

In addition to the inspection personnel, the production operators have to go through the same routine for their settings. Rather the time wasted in this case is much higher. The reason for this is that at the start of the shift when all the operators have to check their settings all of them crowd at the drawings. These workers waste a lot of time in

- Waiting for the particular drawing book when another worker is consulting it.
- Trying to locate a dimension which is not mentioned at its usual place.
- Going to and from the machine to the stage inspection area.

At times of shift change and sometimes when a number of machines are set at the same time, the time lost or wasted is very considerable. Production targets suffer due to this wasted time. Moreover inexperienced workers will almost always make a mistake while referring to the drawings.

The system of process cards was so designed that information for a particular application and a particular operation is given on a single card. This information is complete in itself in the sense that all the data required both for the setting of the machine as also for checking of the various aspects including methods of checking would be given in the card. For the purpose of consistency a different format for all operations giving x due considerations to the information/ data to be provided have been designed. These cards, when completed, checked and finally compiled are to be kept at the work seat itself. The card for the application to be run for that operation would be kept at the machine. This would eliminate effectively the time wastage by both the quality control & production operators in referring to the drawings. Also since for a particular operation , the format of data presentation is to be the same, it would eliminate errors due to 'missed' data or due to non availability of data at the appropriate position. Any additional information is given in the card in the form of a note or a sketch in the space provided for the purpose.

Moreover any information that has to be modified before being given to the worker can be given in the card. Such an information is generally a tolerance which is generally reduced according to the capability of the machines as also as a measure of keeping a factor of safety in case the machine deviates from the setting.

The design of the card is such that the information concerning that operation, for all the undersizes of that particular application are given on the same card. This would help reduce the extent of duplication of information. In addition to spaces for remarks, tolerances, diagrams & notes space has been kept for including the toolings to be used for the application. This will only be possible only when tools & dies have been standardised for all the applications. Other related information, like machine setting time & the standard production etc. is also incorporated in the card.

Once the system is put to use, it will ~~ks~~ be to a great extent, help reduce the wastage of time & loss of material due to wastages in scrap and, in general, streamline the working of the two main departments in the plant. The process of filling the cards started in the first week of April. Cards of the main applications bring produced in the plant (st.bearings only) have almost been completed. They include -

ASHOK LEYLAND

Connecting rod	OE/OES/AM	
Main intermediate bearing	81102C	
Main Front, Centre & Rear	80102C	OE/OES/AM

TELCO

Main (Lower)	OE/OES
Main (Lower)	85101C(AM)
Con-rod	OE/OES
Con-rod	70101C(AM)
Main (upper)	OE/OES
Main (upper)	80101C(AM)

KCL

Main rear (lower)	3019204
Main centre(lower)	86501C(44386)
Main front (lower)	3019180
Main front (upper)	3010174
Main Rear (upper)	3029108
Main centre(upper)	81501C (44385)

BAJAJ

Bajaj Tempo (OM 616 Engine)		Main (U + L)	81308A
" " "		Con-rod(U+L)	70308A
" " "		Main (upper)	80308A
" " "		Main (lower)	85308A
	Bajaj	Con-rod	70305C
	Bajaj	Main (upper)	85305C
	"	" (Lower)	80305C

ITCI

Main (upper)	80401C
Main (lower)	85401C
Con-rod	70401C

As already mentioned, special formats have been prepared for all operations that are performed on the bimetal strip to convert it into a good bearing. The formats for some of these operations as also the design of the cards can be seen in Appendix 5. Some of the operations whose sample cards have been included are -

Blanking
Form & Coin
Face & Chamfer

Lipping
Notch Milling
Oil Distribution groove milling
Oil groove milling
Hole punching
Height broach
Wall Broach etc.

Process cards are expected to be brought into use in the production and the stage quality control departments in a phased manner. This will be done after cards have been checked, corrected and final master cards prepared. When in use, these will replace the tedious method of locking up the drawings. The system is to be introduced in the plant in early 1989.

Analysis of face & chamfer operations to determine cause & remedy for semi faced bearings.

Face & chamfer as the name suggests, is an operation used to control the length of the bearing along with giving it ID & OD chamfers. A chamfer is provided in order to reduce the possibility of lining chip off at the sharp edges and also to reduce chances of a burr. The purpose of the facing is to control the length of the bearing so that it fits snuggly into place in the housing. It also helps in eliminating the burred edges formed at the blanking stage.

As described earlier, the face & chamfer machine is simply a modified lathe where the job is held stationary and two rotating chucks on which cutters have been alligned move in to fact it as shown in Fig. 2.24.

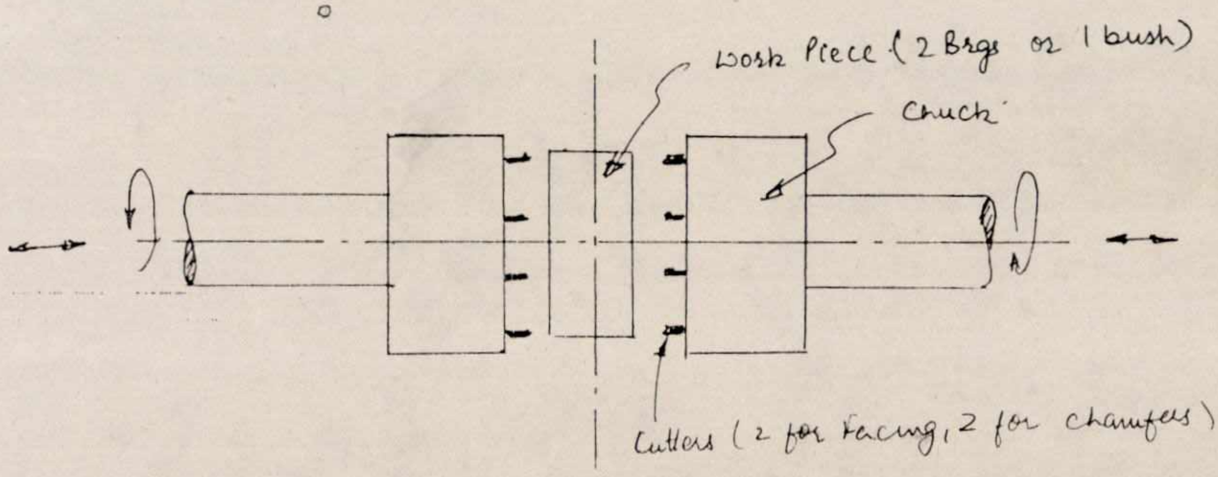


FIG 2.24

Each chuck has 2 cutters for facing & one each for ID & OD chamfering. The work piece is held in place with the help of pneumatic pressure on an adoptor. Sometimes a problem arised in case of facing the bearings. What happens is that a part of the face is left rough & untouched by the facing cutters. The rest of face is clean as usual. There can be three major reasons for the above problem.

1) The size of the bearing is already smaller than the required length.
2) The bearings are kept pushed too much towards one of the chucks while facing.
3) The bearings may not be properly square i.e. the sides & parting faces may not be perpendicular.

The second reasons that the placement of bearings in the adaptor may be too much towards one side can easily be omitted since it was found that in most of the cases both the faces of the bearing were not faced properly, that is both the ends had untouched, rough patches on them. So the possibility of the bearing being improperly placed can hardly be true, otherwise one side would have been given a complete facing cut.

Squareness is a very critical factor in the manufacture of good bearings. A lot depends on the squareness of a bearing. So very rigorous checks are carried out at the form & coin stage on the bearings for this attribute. Hence the possibility of on out of square bearing being faced is very remote. Even if a piece slightly out of square (to an allowable extent) does reach the face & chamfer machine, it will get square when pressure is applied on it in the adaptor. Hence the third suggested reason may as well be rejected for purposes of this study. There can almost be no chance that the width of the blank is less than the length of the bearing since stage inspection is very strict about these checks. A piece of lesser width will almost never be blanked.

However, on examining a few pieces after forming & coining, it was seen that most of them had deformed edges. The edges tended to bulge at the two ends where the coining & crush reliefs would force the metal to flow. Thus the coined bearing would show a lateral bulge at both the ends. It was suggested that this increase in the unmachined bearing length might be having to do with undue force on the bearings as well as the cutters which would lead to a semi-machined part.

Hence it was decided to check on the extent of the bulge in some of the applications. Procedure used was to check the width of a few sample pieces before the form & coin stage i.e. after the blanking operation. This was almost invariably found to conform to the width required in the specifications. These pieces were then allowed to be coined. Now again the width was checked at three points at the ends and at the centre. Some of the observations have been attached (Table 2.6) for reference. It was generally seen that a bulge of around 5-20 thousands was present at the ends of most of the bearings. Although length at the centre had also increased by a few thousandth's of an inch, it was much less wider than the ends.

These observations led to a basic conclusion that a big bulge does exist at the ends of the bearing.

The main reason that could be thought of for this flow of material was that length of the bearing blank might be more than required at the coining stage, the 'extra' material would create the bulge. Hence it was decided that experiments be carried out to find out if such was the case. For this purpose some pieces be ground so as to decrease the length by 5 thousands & some by 10 thousands. Then the same procedure of noting down the widths before & after coining be repeated as also was the variations in thickness. The observations have been attached for reference (Table 2.7).

These observations have led to the reduction of the lengths of the blanks for straight bearings by 0.015"

Table 2.6

S.No.	Part no/ u/s	Blank width specification (inches)	Blank width actual (inches) (average)	After form & coin length of bearing(averages) (inches) (1) (Stamp side)	(2) (Centre)	(3)
1	70101C/020	1.299 IO.005	1.299	1.328	1.321	1.327
2	80102C/STD	1.645 IO.005	1.647	1.668	1.659	1.668
3	70401C/030	1.079 IO.995	1.092	1.114	1.108	1.116
4	81102C/STD	1.125 IO.005	1.122	1.132	1.122	1.131
5	85401C/020	1.107 IO.005	1.107	1.142	1.126	1.140
6	203670/STD	2.015 IO.005	2.017	2.042	2.033	2.042
7	85101C/STD	0.990 IO.005	0.991	1.012	0.999	1.013
8	70101C/010	1.299 IO.005	1.303	1.325	1.313	1.324

Table No. 2.7 a

Part No. 80101C/020- Man (AM)

Case I No change in blank length

Blank length	Blank width Before form & coin	Blank width After form & coin 1.	2.	3.	Blank Thickness Before form & coin	Blank Thickness After form & coin 1.	2.	3.
1. 4.845	0.995	1.025	1.000	1.024	0.1105	0.1155	0.1115	0.1155
2. 4.843	0.998	1.027	1.007	1.076	0.111	0.1165	0.1115	0.115
3. 4.842	0.999	1.025	1.004	1.026	0.1115	0.116	0.1125	0.116
4. 4.840	0.995	1.025	1.000	1.025	0.1105	0.115	0.1115	0.1145
5. 4.840	0.995	1.025	1.000	1.026	0.111	0.1165	0.1115	0.1155
6. 4.846	0.998	1.025	1.002	1.028	0.115	0.116	0.112	0.1155
7. 4.846	0.994	1.024	1.000	1.022	0.1115	0.1155	0.112	0.145
8. 4.846	0.995	1.025	1.002	1.028	0.111	0.116	0.1115	0.1155
9. 4.842	0.999	1.025	1.005	1.023	0.1115	0.1155	0.1125	0.1155
10.4.841	0.997	1.024	1.005	1.022	0.112	0.1165	0.113	0.1165
Average	0.996	1.025	1.002	1.023	0.1112	0.1155	0.1119	0.1155

Table 2.7 b

Tata Main (AM)

Pa rt No. 80101C/020

Case II : Blank length reduced by 0.0005"

Length Blank	Width: Before form & coil	Width: After form & Coin 1.	2.	3.	Thickness: Before form & coin	Thickness: After form & Coin 1.	2.	3.
1. 4.840	0.996	1.013	1.002	1.020	0.1115	0.116	0.112	0.116
2. 4.841	0.998	1.017	1.003	1.019	0.112	0.115	0.211	0.115
3. 4.840	0.997	1.008	1.003	1.017	0.1105	0.1165	0.112	0.115
4. 4.838	0.994	1.014	1.002	1.023	0.1115	0.117	0.113	0.116
5. 4.834	0.994	1.013	1.004	1.016	0.1125	0.1155	0.1125	0.115
6. 4.828	0.998	1.015	1.006	1.0.15	0.1115	0.1165	0.1135	0.1135
7. 4.838	0.998	1.009	1.010	1.013	0.112	0.117	0.114	0.116
8. 4.837	0.999	1.014	1.007	1.018	0.113	0.1165	0.1125	0.1165
9. 4.836	0.998	1.018	1.010	1.012	0.111	0.114	0.1125	0.114
10.4.840	0.997	1.013	1.004	1.015	0.112	0.1165	0.1125	0.116
Average	0.997	1.015	1.005	1.018	0.1117	0.1160	0.2125	0.1153

Table 2.7 c

Part No 80101C/020

Case III   Blank Length reduced by 0.010 "

Blank Length	Width: Before form & coin	Width: After form and coin 1.	2.	3.	Thickness: Before for & coin	Thickness: After form and coin 1.	2.	3.
1. 4.833	0.995	1.002	1.002	1.000	0.111	0.115	0.1115	0.114
2. 4.833	0.999	1.001	1.006	1.012	0.1105	0.115	0.1115	0.1135
3. 4.837	0.997	1.000	1.005	1.002	0.1115	0.1155	0.112	0.1155
4. 4.833	0.995	1.002	1.002	1.001	0.112	0.116	0.1125	0.1155
5. 4.833	0.998	1.004	1.006	1.001	0.1115	0.115	0.112	0.1145
6. 4835	0.995	1.001	1.001	1.006	0.1125	0.1165	0.114	0.1155
7. 4.832	0.997	1.002	1.0008	1.002	0.111	0.1155	0.113	0.115
8. 4.835	0.998	1.002	1.009	1.000	0.1115	0.1155	0.113	0.115
9. 4.835	1.000	1.002	1.015	1.005	0.111	0.1165	0.1135	0.115
10.4.836	0.998	1.006	1.012	1.004	0.1115	0.115	0.113	0.1145
Averages	0.997	1.002	1.001	1.002	0.1114	0.1155	0.1131	0.1148

Capability study of centreless grinder

In case of bushes, the second/final forming is done by placing the first formed piece in a die with a core to form it from the inside. The OD of the bush is formed by the two halves of the die and the ID is controlled by the core. The shape of the outside as well inside surfaces of the bush changes when the piece is taken out of the die & the core is removed. The bush tends to show ovality after pressure is removed from it. There is variation in the outer diameter of the bushes after removal of the pressure. This leads to a variety of problems during installation of the bush in the housing especially when it has to be bored before the installation. Inaccurate boring or installation which will result from this ovality will do a lot of damage to the shaft. In order to reduce this avality the outside surface of all clinch-type bushes is ground on a centreless grinder to give it a shape as nearly circular as possible. The grinding wheel removes material more from the points which are bulging out & less from the rest of the places. This action helps reduce the avality of the bushes as well as the inconsistency of the bush dia-meters.

A centreless grinder (Cinncinati make) was being used in the plant for the purpose of grinding these bushes. However, this grinder had been borrowed from Gabriel India Limited, Gurgaon plant and was to be sent back in May, 1988. So a new grinder had to be brought in to take its place. This grinder should have similar or better capabilities as the old grinder. In order to compare the capability of the new grinder with the previous one, a study of the capability of the old grinder was taken up before it was removed. A sample of 50 pcs was taken for this purpose after final forming & face & chamfer

CABABILITY STUDY (OVALITY IN CL01 m/c)

FIG 2.25

GABRIEL INDIA LIMITED — BEARING DIVISION

QUALITY CONTROL DEPARTMENT

OUT GOING AUDIT — CRUSH/WALL THICKNESS

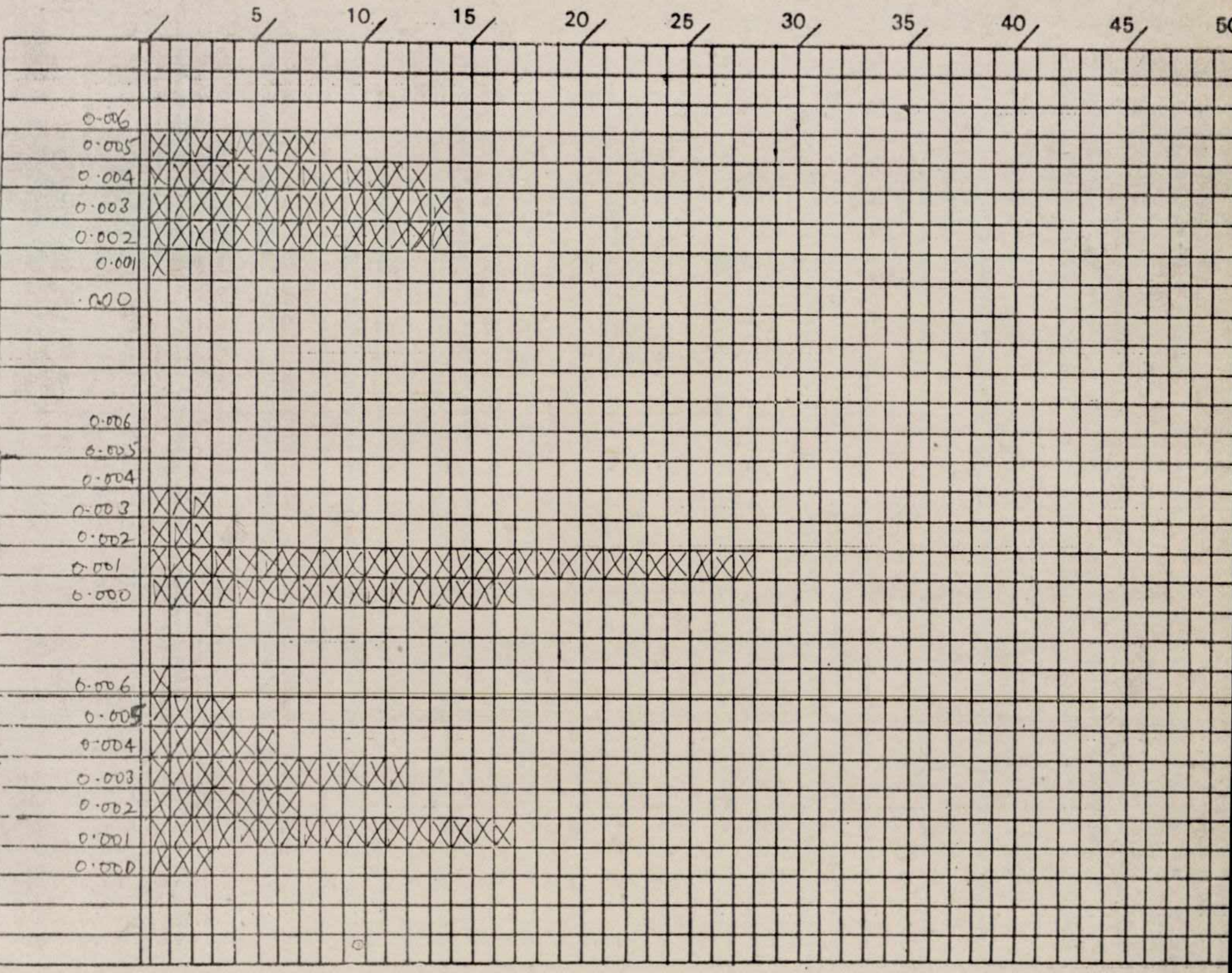
CUSTOMER: KCL
CHALLAN NO:
INSPECTOR:

APPLICATION: Piston Pin Bush
LOT SIZE:
SIGNATURE:

PART NO: 3232556
SAMPLE SIZE:
DATE: 7/3/88

DIMENSION:

SPECIFICATION:



DIMENSION:

SPECIFICATION:

operations. Part No.3232556 (KCL piston pin bush) was selected for this purpose. The maximum & minimum values of the outer diameters in each of the pcs was taken up to find the maximum possible difference. These differences were plotted on to a histogram to know the pattern of behaviour of the pcs. These pcs were then given a semifinal grinding pass. Similar study of the dias was done after the semifinal & then final pass in the grinder. The differences in the diameters were noted down and plotted on to the same histogram (Fig 2.25) for purpose of comparison.

The capability of the grinder was calculated using ovalities after the final grinding pass.

Capability = $\frac{6\,s}{T}$ (expressed as a percentage)

where 's' is the standard deviation

& 'T', the tolerance required in the product.

Calculations for capability revealed that process capability for the grinding operation is = 116%.

This implies that the full ability of the grinder is not being properly used. Surface finish obtained after final grinding was of the order of 28 micro inches.(Surface finish was measured on the surf analyser).

The new grinder brought in was a smaller version of the old grinder (Amba Peltier make). Cost of the new grinder was just about Rs 1 lac compared to the larger version costing about Rs 18 lacs. The only major problem that was anticipated and later, faced in the new buy was that since the width of the drinding wheel was quite less, the number of passeso required to be given for obtaining the desired results will be more than before.

The relevant information about the new grinder, as provided by the manufacturing engg.department who were responsibleffor the installation & testing of the new machine are given in Table 2.8. These observations are as a result of a month long study of the grinder behaviour after its installation in May, 1988.

It can be easily seen that the new grinder is showing desirable results comparable to the old machine. However, as predicted, the problem of the large number of passes does exist.

TABLE 2.8

Capability analyses of centreless grinder

Bush : 71 NH 3109A Ford.

1) Dia consistency (capability) $= \frac{6s}{T} = 38\%$

$T = 0.036$ mm

2) Ovality

max = 0.020 mm = 0.0008"
min = 0.015 mm = 0.0006"
avg. = 0.018 mm = 0.00072"

3) Ra = 31 micro inch
(compared to Ra = 28 micro inch in case of old grinder)

Note:
Additional passes reduce these dimensions.

Parameters

Grinding wheel RPM	= 2800
Regulating Wheel RPM	= 44
Feed rate	= 1.76 m/min
Wheel dressing frequency	= 10000 pcs
Material removal	= 0.05 mm/pass
Avg.no.of passes	= 7 - 8 (compared to 2 - 3 for old grinder)

Analysis of the variation in rolling thickness of bimetal strip through the capability analysis of the rolling mill.

As has already been discussed in Section One the desired thickness of the bimetallic strip is maintained during the second sinter process by rolling in a 3-High rolling mill. It has been noticed that due to some unknown reasons, after an initial setting of the mill size, a variation sets in the rolling size, which forces a repetitive resetting by the operators. The extent of this problem can be estimated from the fact that in some cases, the mill had to be reset every 5-10 m of the strip. Not only does this involve a lot of extra effort but also in many cases, the thichness of the strip goes out of the tolerance limits.

This study was taken up to estimate the nature of this variation & identify the trends, if any. The 3-High rolling mill is constructed in such a manner that the lower roll has a fixed position for its bearings. The second roll which along with the lower roll, comes in contact with the strip has movable ends. The third roller is the pressure roller which is adjustable with the help of two gear operated mechanisms (one for each end). The various identificable causes for the rolling size variation are -

- Defective roller surfaces
- Ovality in rollers
- Play in the bearings
- Taper in rollers
- Spring back of strip after rolling
- Error in setting mechanism

A systematic study of the afore listed causes was taken up before chalking out a line of action. It was felt that as there was no method to check the surface of the roller for its finish without removing the roller and also as this aspect is not very likely to have a major effect on the rolling size, so it is better left untouched. The presence of a taper and ovality can be ruled out as the rollers had just been reground a few days back after being chrome plated. However the possibility of their effect however small the ovality or taper be, in combination with other effects cannot be ruled out.

The rollers are supported on both sides by roller bearings. According to literature on bearings, the roller or for that matter any shaft rests at the bottom surface of the bearing as shown in Fig. 2.26 a. When the shaft starts to rotate, there is a shift of this stready position to a point 'A' as shown in Fig. 2.26 b. After the acceleration is over, this position shifts back and a new steady position is obtained at 'B' (Fig. 2.26 B). However, there exists a thin layer of lubricant between the surface of the shaft and the bearing. The same is true for roller bearings to some extent. So even if there is a lot of play in the bearing (some space is required as oil clearances), this fixing of positions would nullify the effect of a the same. Hence the explanation of the presence of a play between the shaft and the bearing is also not correct.

Spring-back is another possible cause. There may be an increase in thickness of a rolled strip just after it has come out of the rolls due to some elasticity. The extent of this action will depend,among other things, the modulers of elasticity.

Again since there was no method to check on the elastic behaviour, the information that the combination of both steel and

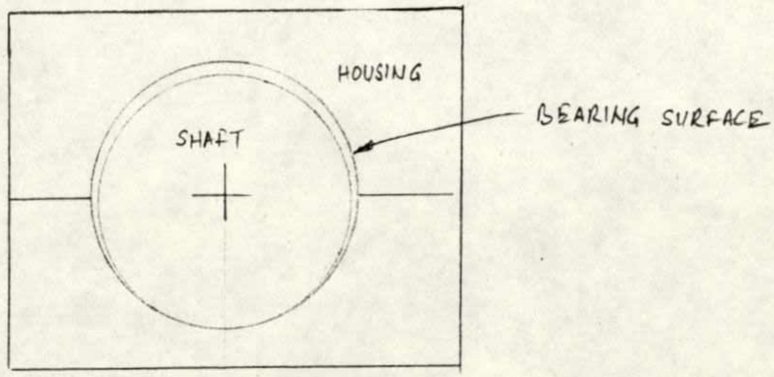


FIG 2·26a

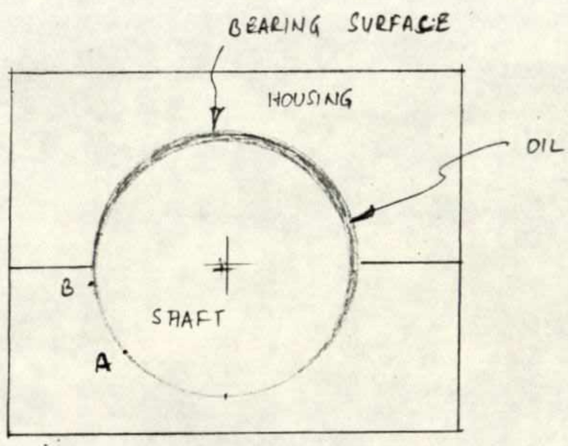


FIG 2·26b

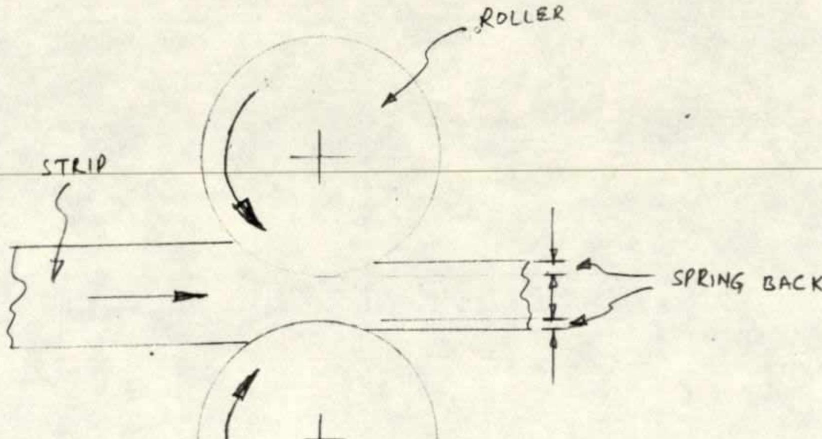


FIG 2·27

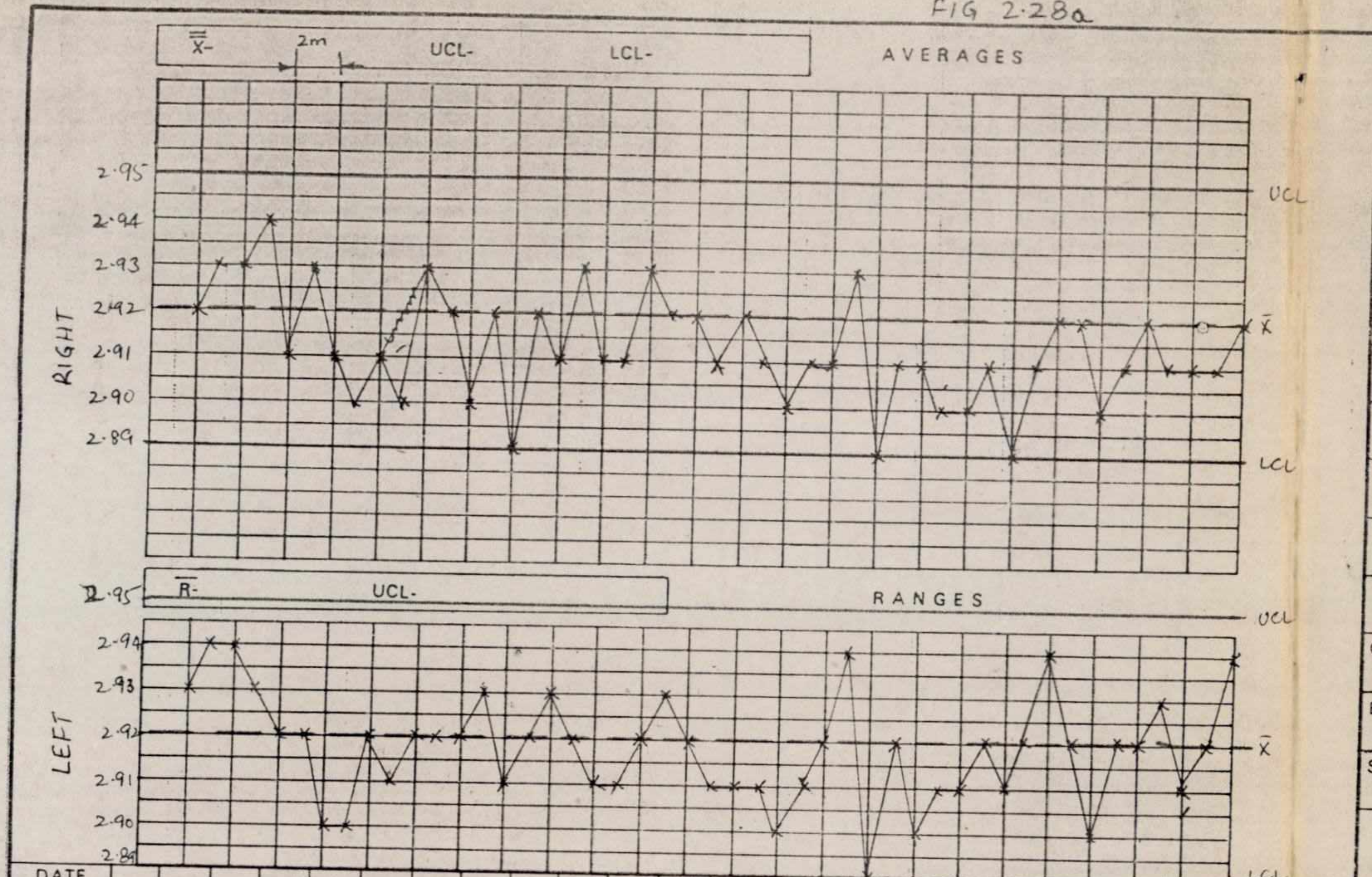
metal powder will have a consistent, elastic behaviour within, at least, the same coil has to be taken as true. The effect of spring back is illustrated in Fig 2.27.

There can be afault in the setting mechanism for the rolls. However, there is no direct method to ascertain this. The only easy way is to check the capability of the rolling process & then find out whether this was the actual cause for the variation.

The behaviour of the rolling mill was studied by drawing a process control chart after taking a reading every one meter of the strip for about 80 meters at a stretch. Any resettings, stapping of the line etc. were noted down on this chart. Initially, as is the general practice, the thickness was taken using an inches micrometer with a least count of 0.001 inch. However after the first few days, a mm micrometer (least count 0.01 mm) was brought into use to increase the accuracy of measurement. Some of these charts showed a very clear trend but again others should quite natural patterns in between settings. Thickness was measured on the two sides of the strip to find if these is any taper in the strip.

Readings from the charts were transferred on to probability charts where capability of the process was calculated for both the left and the right sides of the mill. A sample process chart and their probability charts are attached as Fig. 2.28(a) and 2.29(a,b) respectively. The calculations to be performed as also method of drawing these charts is quite evident from the looks. Some of the observations concerning the capabilities of the mill are given in Table 2.9.

FIG 2·28a



DATE	
TIME	
READINGS 1	
2	
3	
4	
5	
SUM	
$\bar{X}$	
R	

Gabriel India Ltd. (Brg. Div.)

PARWANOO

PROCESS CONTROL CHART

MACH NO. SINTER LINE NO 2	SECOND SINTER
DEPT	
DATES 19/4/88	
~~PART. NO.~~ COIL NO F 942	
PART NAME TATA (E) BSE (STD)	
OPERATION SECOND SINTER (ROLLING)	
CHARACTERISTIC 0.115" ± 12 (2·89–2·95 mm)	
ENGINEERING SPECIFICATION	
SAMPLE SIZE/FREQUENCY	

CALCULATIONS AND NOTES

$UCLx = \bar{\bar{X}} + A2\,\bar{R} =$

$LCLx = \bar{\bar{X}} - A2\,\bar{R} =$

$UCLR = D4\,\bar{R} =$

$LCLR = D3\,\bar{R} =$

$\sigma' = \frac{\bar{R}}{d2}$

FIG 2·29 a

GABRIEL

BEARING DIVISION

PARWANOO

RIGHT

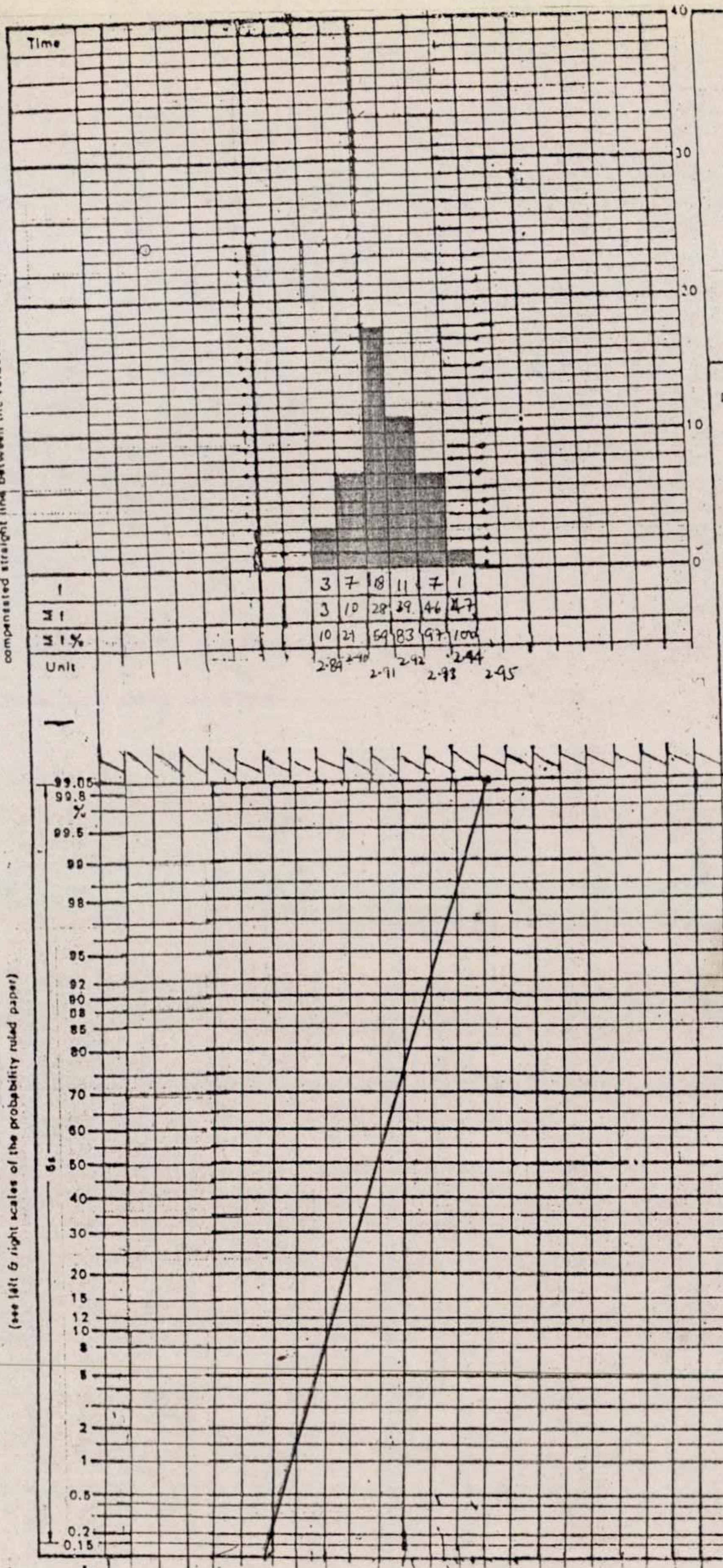
F-942 10AM

NOT FOR MACHINE VARIATION   ONLY FOR PROCESS VARIATION

Instructions: 1. Measurement series with 25, 50 or 100 values are preferred, because calculation of cumulative % is avoided.
(see left & right scales of the probability ruled paper)

2. Compensated straight line: Fix Σf or Σf % on the right end of the class limit & the probability ruled paper. Join points through a compensated straight line.

3. Obtain values x̄ at 50%. 6s-spread lies between the intersection points of compensated straight line between the values at 99.85% and 0.15%.



Drawing No..

Sample size..

Sampling time

Type of Opn.. Rolling

Machine:....... 3/HIGH/MILL/LINE 2

Workshop.....

Operator.......

Inspector......

Meas. Device. Mic

Setting gauge.

Specified Values

Nom Value..

Tolerance..

Tol. Middle

Actual Values

x̄:... 2·91 mm

s:....

x̄: 2·91

6s = 0·07

s = 0·0117

6s =

s =

$\frac{6s}{T}$ = 138%.

Dept...... QC.........

Date........ 19/4/88

Name...........................

FIG 2·29 b

GABRIEL

BEARING DIVISION

PARWANOO

LEFT

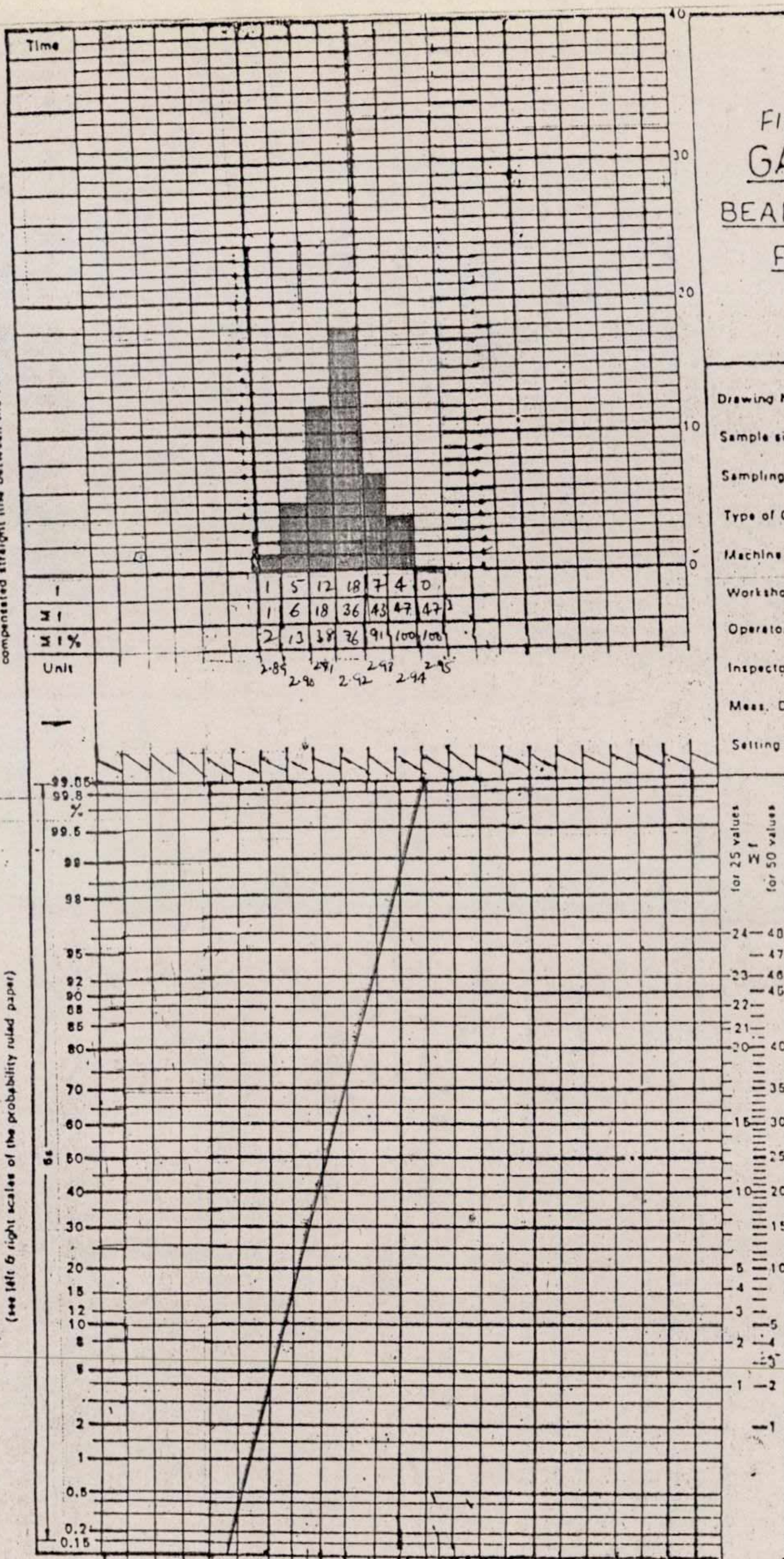
F942 10 AM

NOT FOR MACHINE VARIATION   ONLY FOR PROCESS VARIATION

Instructions: 1. Measurement series with 25, 50 or 100 values are preferred, because calculation of cumulative % is avoided.
(see left & right scales of the probability ruled paper)

2. Compensated straight line. Fix Σf or Σf % on the right end of the class limit on the probability ruled paper. Join points through a compensated straight line.

3. Obtain values $\bar{x}$ at 50%. 6s-spread lies between the intersection points of compensated straight line between the values at 99.85% and 0.15%



f	1	5	12	18	7	4	0
Σf	1	6	18	36	43	47	47
Σf %	2	13	38	76	91	100	100
Unit	2·85 / 2·90	2·91	2·92	2·93	2·94	2·95	

Drawing No.

Sample size ..

Sampling time

Type of Opn.: Rolling

Machine: 3-HI MILL LINE 2

Workshop .....

Operator ....

Inspector ......

Meas. Device.

Setting gauge.

Specified Values

Nom Value..

Tolerance..

Tol. Middle

Actual Values

$\bar{x}$: 2·91 mm

s: ....

$\bar{x}$: ±3s:

6s = 0·06

s = 0·01

6s =

s =

$\frac{6s}{T}$ = 118%

Dept. Q.C.

Date 19/4/88

Name ......

Table 2.9

Date /	Time	Coil no/ application	L/R	Average ($\bar{x}$)	6s	s	$\frac{6s}{T}$
6/4/88	10.00 AM	F 899	L	0.1558"	0.0018"	0.0003	90%
		Tata-CR/070	R	0.1554"	0.0024"	0.0004	100%
12/4/88	9.30 AM	F 915	L	0.0674"	0.001"	0.00017	50%
		ITCI-CR/STD	R	0.0674"	0.002"	0.0003	100%
13/4/88	8.00 AM	F 920	L	0.0930"	0.0026"	0.00043	130%
		ITCI M/010	R	0.0938"	0.0016"	0.00026	80%
14/4/88	11.05 AM	F 924	L	0.0768"	0.002"	0.0003	100%
		KCL CR/STD	R	0.0772"	0.0024"	0.004	120%
16/4/88	10.00 AM	F 929	L	0.0984"	0.0024"	0.0004	120%
		Petter CR/STD	R	0.992"	0.002"	0.0003	100%
18/4/88	1.30 P.M.	F 933	L	0.1204"	0.0032"	0.00053	160%
			R	0.1204"	0.0024"	0.0004	120%
19/4/88	10.00 AM	F 942	L	2.91 mm	0.06 mm	0.01	118%
		Tata(E)BSE/STD	R	2.91 mm	0.07 mm	0.0117	138%
19/4/88	11.15 AM	F 939	L	0.1092"	0.0016"	0.00027	80%
		Tata BSE 2,3,4	R	0.1088"	0.0024"	0.0004	120%
4/5/88	11.15 AM	F 973	L	4.37 mm	0.05 mm	0.0083	83%
		Ford flg/STD	R	4.37 mm	0.08 mm	0.013	133%
5/5/88	11.15 AM	F 975	L	1.70 mm	0.05 mm	0.0083	83%
		Auto spares	R	1.68 mm	0.07 mm	0.01170	116%
5/5/88	1.30 PM	F 975	L	1.70 mm	0.06 mm	0.015	100%
		Auto spares	R	1.69 mm	0.09 mm	0.01	150%
7/5/88		F 982	L	2.27 mm	0.07 mm	0.012	140%
		Tata M/010	R	2.28 mm	0.06 mm	0.01	120%

The analysis of the data collected could not be made during the duration of the training due to some unforseen circumstances. So the project could not be completed in time.

Study of speed of strip in sinter line.

Apart from the quality of steel & powder being used, the quality of the bimetallic strip being produced depends directly on a number of aspects such as temp of the furnace, cooling temperature & the speed of the strip feed.

Speed plays a very important role, from among the above mentioned factors, since it directly affects the bonding of the Cu-Pb lining to the steel back. This is due to the fact that for proper & effective bonding, the strip has to be kept at a certain temperature for a particular duration of time & hence as the system is of contineous fed sintering, speed has to be maintained at a particular value so that this effective time is achieved by the strip in the furnace. Hence only if this timing is right will we obtain a quality strip suitable to be converted to high precision bimetallic application such as a bearing.

Speed of the strip in sinter line is indicated by LED displays. The input to the display is through electrical connections from a tachogenerator which forms an integral part of the drive unit. (The drive unit consists of a module containing a mill drive motor, an eddy current generator & a tachogenerator). The output signal of the tachogenerator is in the form of a voltage which is directly proportional to the speed of the motor. Motor speed depends upon -

1) The supply votage from the mains.
2) Devices like decoiler & râcoiler etc. with whose motors, this motor has been syncronized.

The rotation of the motor is converted into the linear movement of the strip being rolled. Relation between the roller movement or motor movement & speed of the strip is via the dimater of the rollers. Larger is the diameter of the rollers, lesser is the number of turns required to feed a length of the strip & vice the versa. What is being displayed is,however, the rotation of the rollers. So variations in the speed may occur i.e. there may be a difference in the actual and indicated speeds because of variations in roller diameters. Due to contineous operation, a certain amount of wear is likely to occur on the roller surfaces. This wear will not be consistent for all the rollers as also it will not be the same all over the same roller. In order to reduce this as also to avoid reduction of strip quality, these rollers are reground after a certain amount of wear has taken place. This grinding however has a quite adverse effect on the indicated speed which will vary more than before from actual speed.

To have better control over the bonding through good & accurate speed setting as also to put a check to the number of avoidable lost hours being reported in the sinter line, a study was undertaken to find the fault & attempt to rectify it.

Procedure adopted for the collection of data was as follows:-

A mark was made on the strip going in (on one side of the muffle furnace) the furnace & the time taken by it to reach the other side of the furnace noted down. Speed was calculated by dividing the length of the furnace with the time taken. Readings of the displayed speed were also taken down every minute and an average indicated speed calculated. Comparison of these two average speeds was made & it was seen that a lot of variation exists between the two.

ON LINE - 1

Display was originally callibrated in inches/minutes. Displayed reading was about 9% more than actual speed readings Table 2.10 gives a few of the observations for line 1.

TABLE 2.10

Date / Time	Actual speed inch/min.	Display speed (inch/min) Avg.	Max.	Min.
13/4/88 2.00 PM	31.8	34.77	36.7	32.1
14/4/88 9.30 AM	29.4	31.95	32.9	28.3
18/4/88 1.30 PM	31.6	35.32	38.7	30.1

ON LINE - 2

Display was originally callibtrated in m/min but due to inexplicable reasons, workers would note on the job card, the reading in inches per min after multiplying the displayed figure by 10.

e.g. If the display is giving a reading of 2.68 m/min. the worker would note it as 26.8 inches/min. An error of more than 200% showed if the readings were noted down in m/min while if the 'wrong' method described in the example is used, error of about 25% was detected. Table 2.11 gives some of the observations for line-2. It may be seen that actual speed was less than indicated speed.

Table 2.11

Date / time		Actual speed m/min	Display reading (as noted by worker) Avg.(inches/min.)	Max. inch/min.	Min. inch/min.
13/4/88	10.55 AM	1.34	65.8	66.7	65.5
13/4/88	1.10 PM	1.31	66.0	66.6	65.5
13/4/88	3.45 PM	1.33	65.6	66.4	65.2
14/4/88	10.00 AM	1.13	56.9	58.0	55.5
14/4/88	1.30 PM	1.13	57.1	58.8	55.5
14/4/88	2.20 PM	1.15	56.1	56.7	55.7
14/4/88	3.30 PM	1.12	56.2	56.9	55.8
14/4/88	4.15 PM	1.10	56.1	56.9	55.8
16/4/88	8.45 AM	1.31	61.5	63.8	59.2
16/4/88	11.15 AM	1.22	59.6	6.01	59.1
18/4/88	4.20 PM	1.36	66.3	6.73	65.6
19/4/88	9.00 AM	0.57	27.1	2.89	25.4

The speed display is actually a function of the voltage input from the tachogenerator. So the voltage input to the display can be varied proportionately to the variations required in the speeds by introducing a variable potentiometer (1000 Kohm) in the input circuit of the display. Through minor adjustments, the potentiometer allowed for the varying of this voltage & hence the speed display.

In order to maintain a consistency as most of the work at Gabriel was being done in inches the display in line 2 was re-callibrated in inches/min although the reading had to be taken by multiplying the observed figure by 10.

Some of the observations during & after alterations are being given in Table 2.12.

TABLE 2.12

Date/Time	Actual speed	Indicated speed	Diff
LINE No. 2			
Ist Alteration			
21/4/88 9.15 AM	42.15 inch/min	37.1 inch/min	+ 14%
21/4/88 10.30 AM	41.37 inch/min	36.3 inch/min	+ 13.9%
21/4/88 11.15 AM	42.51 inch/min	36.1 inch/min	+ 14.2%
		NOT ACCEPTABLE	
2nd Alteration			
22/4/88 1.30 PM	35.6 inch/min	34.7 inch/min	+ 2.5%
23/4/88 8.45 AM	31.7 inch/min	29.8 inch/min	+ 3.9%
23/4/88 10.15 AM	30.72 inch/min	30.3 inch/min	+ 1.3%
		ACCEPTED	
LINE No.1			
Ist Alteration			
26/4/88 8.45 AM	37.5 inch/min	37.75 inch/min	- 0.6%
26/4/88 9.45 AM	37.15 inch/min	37.94 inch/min	- 2.1%
26/4/88 10.20 AM	36.69 inch/min	37.85 inch/min	- 2.1%
		ACCEPTED	

The speed has since been rechecked twice to see if such a variation is constant or how much it is increasing. Lost time has been reduced by 2 hrs per shift by this analyses.

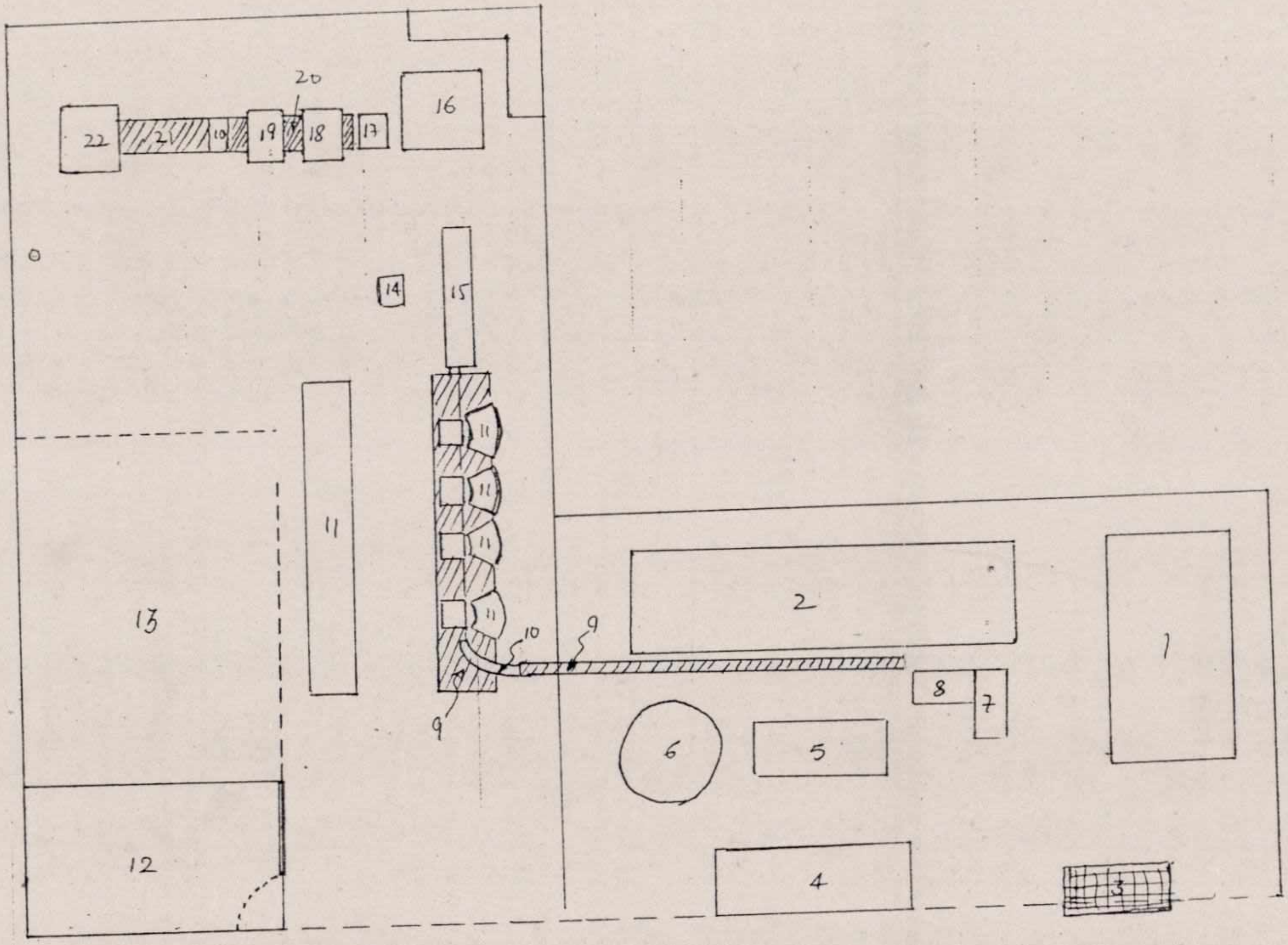
Starting of the conveyer oiler in final inspection/packing area.

For the purpose of After Market (AM) bearing lots where the standards of inspection are somewhat relaxed, a conveyer belt was installed from the plating area to the final inspection area to have the visual inspection of bearings being plated done simultaneously. The layout of the conveyer from the plating plant to the final inspection is given in (Fig. 2.28). The present normal working procedure in cases where the conveyer is being used is as follows.

Sampling is done for wall thickness from each rack as soon as they are unloaded after plating. By rach we imply the fixture in which a number of bearings are assembled to be plated. If the sample is O.K. then all the bearings of the rack are put on the conveyer. Otherwise the rach is kept separate for 100% wall checks later on. The conveyer from plating feeds a distributin conveyer which passes just below the work tables via a chute. Operators at the work tables on the conveyer pick up the bearings from the conveyer & visually inspect them. Defective pieces are kept in the space allotted to them in the table. The O.K.pieces are storched in trays.

These trays are then taken for packing where they are oiled at the pneumatic oiler which dips the whole of the tray in ante-rust oil. After this the bearings are either taken to packing or to the BAP (Bearings awaiting packing) store.

Although the above procedure is quite efficient it involves a lot of extra labour on part of the operators to stack the bearing in trays and also a lot of oil gets wasted since even the tray gets oiled which has to be degreased if to be used



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13 BAP stores
14 Pneumatic oiler
15 Conveyer oiler
16 Hand packing
17 Sealing unit
18 Oven
19 Cooling fan
20 Bar conveyer
21 Conveyer
22 Chute to dispatch

FIG 2·28

elsewhere. Both these problems can be solved by using a conveyer oiler which is kept in line with the supply conveyer, a part of which may be used to feed the oiler with visually OKed bearings.

The conveyer oiler consists of a chain conveyer, which is driven by a motor-gear drive, and an oil sprayer which is fed from an oil reservoir by a pump. Bearings moving on the conveyer get oiled by the spray. The extra oil on the bearings seeps through the links of the chain into a tank which in turn feeds the oil reservoir.

The bearings oiled in such a manner with the help of the conveyer oiler have the advantage that they can directly be taken in for packing. Also oil wastage is reduced by a considerable amount.

Problems faced in the oiler included tripping of the starter switches, belt shifting, inadequate foundation support for motor/gear drive & motor vibrations. The electrical of the above work was done with the help of electricians from the maintenance department. The rest of the modifications & repairs were done with the help of the fitters in the manufacturing department.

Trial runs were conducted and after a few alterations in b belt settings and oil levels, tests turned out to be highly successful. The conveyer is however yet to be used regularly due to inadequate receiving arrangements in packing area. The bearings bushes & flanges etc. which are coming in crates from production or plating have to be oiled on the pneumatic oiler only.

Scrap analysis report

Scrap analysis report is a monthly report released by the Quality control department with the aim of providing information about the amounts & percentages of the straight bearings, flanges, washers and bushes rejected due to various reasons in the past month. The classification of the kinds of rejections has been done on the basis of the cause of the rejection. The report also gives information about the total quantities checked & accepted during the month & year as also the status of rework generated, quantity of returned material checked etc.

The report for the month of March - 1988 was prepared by me. Most of the information about the various aspects to be given in the report can be obtained from the daily reports filled in by the workers in the final inspection department, daily reports on the rejection at the production stage etc. In these reports, codes have been maintained for specifying the nature & reason for the rejection as also whether the product is a straight bearing, a flanged bearing, a thrust washer or a bush. The rejections would include pieces rejected during setting of a machine.

Procedure for organizing this data was to prepare daily totals for rejected materials & the good material under the various reason heads. These daily totals were then added up to form a monthly total. Similar totals were found out for materials returned by various consumers as rejections and for seggregation of the good material from defective lots, material for rework etc. The format for the presentation of report as also the actual report for the month of March - 1988 is attached for purpose of reference (TABLE 2.13).

TABLE 2.13

SCRAP ANALYSIS FOR THE MONTH OF MARCH 88

Sr. No.	Defects	St.Brgs.		Flanges		Washers		Bushes		Total	
		Qty.	%age	Qty.	%age	Qty.	%age	Qty.	%age	Qty.	%age
1.	Damages	7974	2.37	671	2.67	297	0.82	736	0.38	9658	1.64
2.	Strip Defect	7759	2.31	1335	5.31	659	1.81	3228	1.69	12981	2.20
3.	Blanking	867	0.26	27	0.11	164	0.45	1502	0.78	2560	0.43
4.	Flaring	-	-	-	-	-	-	-	-	-	-
5.	Form & Coin	101	0.03	-	-	-	-	274	0.14	375	0.06
6.	Bar Turning	-	-	66	0.26	-	-	-	-	66	0.01
7.	Face & Chamfer	1623	0.48	140	0.56	64	0.18	842	0.44	2669	0.45
8.	Press Punch	520	0.15	55	0.22	-	-	-	-	575	0.09
9.	Milling	858	0.25	113	0.45	39	0.11	12	0.00	1022	0.17
10.	C'sinking	299	0.09	16	0.06	-	-	26	0.01	341	0.06
11.	O.D. & F.Ht.	4922	1.46	370	1.47	-	-	91	0.05	5383	0.91
12.	Final Wall	7571	2.25	682	2.71	281	0.77	89	0.05	8623	1.38
13.	Plating	2365	0.70	203	0.81	-	-	10	0.00	2578	0.44
14.	Rust	2	0.00	3	0.01	-	-	249	0.13	254.	0.04
15.	Shear Broach	-	-	14	0.06	-	-	-	-	14	0.00
16.	Power Failure	-	-	-	-	-	-	-	-	-	-
17.	Misc.	502	0.15	-	-	-	-	1	0.00	503	0.08
18.	Total rejected	35343	10.54	3696	14.69	1504	4.13	7060	3.69	47602	8.09
19.	Total good accepted for facing	300038	89.46	21459	85.31	34915	85.87	184280	96.31	540692	91.91
20.	Total accepted	335381	100	25151	100	36419	100	191340	100	588294	100

Sr. No.	Defects	St.Brgs. Qty.	St.Brgs. %age	Flanges Qty.	Flanges %age	Washers Qty.	Washers %age	Bushes Qty.	Bushes %age	Total Qty.	Total %age
21.	YTD Rejected	109079	10.66	10693	19.21	6439	3.75	24924	4.49	152135	8.40
22.	YTD good accepted for packing	913500	89.34	49154	80.79	165614	96.25	530274	95.51	1658542	91.60
23.	YTD checked	1022579	100	60847	100	172053	100	555198	100	1810677	100

24. Rework
    Generated 32896
    Cleared 15103
    Good 12763
    Rej 1124 % 7.44

25. Qty.checked from returned material D3 :
    Good 15224
    Rej. 678 % 4.06
    Rework from D3 : 814

26. Qty.checked from finished product store F P.I
    Good 1234
    Rej. 307 % 18.63
    REwork 107

It may be seen that the various defects have been listed in order of reasons for rejection, in order to identify areas which have given more rejections in the previous month. Then going step by step to find whether the higher rate of rejection is due to a one time problem or a major problem requiring thought for rectification.

In all, the report is an excellent way to study the nature & percentages of various defects & place of occurance of the same.

SECTION THREE

Appendix -I

BEARING LINING MATERIAL CHARACTERISTICS

BABBITS

Type specifications	Nominal % composition	Properties	Applications
B-100 Tin Base SAE-12 ISO : Sn Sb 8 Cu 4	89.0 Sn 3.5 cu 7.5 sb	Soft, good embeddability corrosion resistance & lubricity cannot withstand high load & temp	Cam shafts, low load engines, motors, pumps, refrigerator compressor (hard and soft shafts)
L-200 Lead Base (fortified SAE -15 ISO: Pb Sb 15 Sn As	83.0 Pb 1.0 Su 15.0 sb 1.0 As	Soft, good embeddability lubricity, conformability less corrosion resistance good load carrying capacity	Cam shafts, low load engines, motors, pumps refrigator compressors (hard and soft shafts) not used in corrosive environment.
L-100 Lead base SAE-13 ISO: Pb Sb 10 Su 6	84.0 Pb 6.0 Su 10.0 Sb		
L-300 Lead base SAE-14 ISO: Pb Sb 15 Su 10	750 Pb 10.0 Su 15.0 Sb		

ALUMINIUM ALLOY

Type specifications	Nominal % Composition	Properties	Applications
AT-20 SAE - 783 ISO: Al Sn 20 Cu	79.0 Al 20.0 Su 1.0 Cu	Good fatigue , Corrosion and conformability, high load & speed rating	Medium load engines, pumps compressors, electric motors (hard and soft shafts)
AL-6	89.5 Al 6.0 Pb 4.0 Si 0.5 Sb	Good fatigue Corrosion & conformability charactristics High load and speed ratings	Medium load engines pumps compressors electric motors, automatic transmissions (hard and soft shafts)

BRONZES

Type specifications	Nominal% composition	Properties	Applications
HF-2 SAE-792 ISO: Cu Pb 10 Sn 10	80.0 Cu 10.0 Sn 10.0 Pb.	High physicals, excellent resistance to poundings and shock, high load capacity good wear resistance	Piston pin, steering, track rollers, cylinders, rock shaft, axle bushings, wear plate, high impact thrust washers/(hard shaft diesirable)
HF-3 SAE-798	84.0 Cu 4.0 Sn 8.0 Pb 4.0 Max Zn.	Good shock, load capacity and corrosion resistance, somewhat lower physical strength than HF-2	General purpose bushings material, spring eye, rocker arm, utility bushings (hard shafts desirable)
HF-16 SAE-799 ISO: Cu Pb 24 Sn 4	72.0 Cu 3.5 Sn 23.0 Pb 3.00 Max Zn	Combines good friction, embeddability, compatibility with medium load capacity, will accept higher surface speed and load.	Heavy -duty cam shaft electric motor, automatic transmissions Hydraulic pump gear changers.

OVERPLATED COPPER-LEAD

Type specification	Nominal % composition	Properties	Application
H-24 SAE - 49 ISO: Cu Pb 24 Sn	74.5 Cu 24.5 Pb 1.0 Sn	Very high fatigue Very good corrosion resistance	Heavy-duty engines Pumps, compressors for soft and hard shafts.
H-116 ISO: Cu Pb 24 Sn 4	73.0 Cu 23.75 Pb 3.25 Sn	Higher fatigue & very good corrosion resistance	Primarily for heavy duty engines with top load and durability requirements (hard shafts)
H-14	83.0 Cu 14.0 Pb 3.0 Cu	Highest fatigue with improved corrosion resistances	Highest load capacity for diesal engines (hard shaft)

APPENDIX 2

REQUIREMENT OF METALS AND CALCULATIONS FOR POWDER MANUFACTURE

Standard metal content of powder output

Metal/Powder	H24	HF2	HF 16
Copper	75.00%	80.00 %	74.00%
Lead	24.00%	10.00 %	22.5 %
Tin	1.00 %	10.00 %	22.5 %
Total	100.00%	100.00%	100.00%

Standard virgin metal content of inputs in Power

	H24		HF2		HF16	
	Virgin metal%	ID broach Rework Powder%	Virgin Metal%	ID Broach Rework Powder%	Virgin Metal%	ID broach Rework Powder%
Copper	75.4	75.0	80.0	80.0	73.5	74.0
Lead	24.5	24.0	10.0	10.0	23.0	22.5
Tin	1.0	0.9	10.0	9.0	3.5	3.15
PhosCopper	0.1	-	0.1	-	0.1	-
Total input excluding Phos-Copper	100.0	99.9	100.0	99.0	100.0	99.65
Loss in tin (to be added)	-	0.1	-	1.0	-	0.35
Process loss	0.5	0.5	0.5	0.5	0.5	0.5
Net output	99.5	99.5	99.5	99.5	99.5	99.5

Standard input mix in powder

	H 24	HF 2	HF 16
Coarse Powder	35.0 %	42.5%	30.0%
ID broach	20.0%	-	-
Virgin metal	45.0%	57.5%	70.0%
Total;	100.00%	100.00%	100.00%

Method of determining standard virgin metal required for different mix of inputs

H 24

Particulars	Copper (kg)	Lead (kgs)	Tin (kgs)	Total (kgs)
a) Output required (kgs)	112.500	36.000	1.500	150.000
Percentage	(75%)	(24%)	(1%)	100.00%)
b) Input mix Coarse Powder(35%)	39.375	12.600	0.473	52.448
ID broach(20%)	22.500	7.200	0.270	29.970
c) Sub -total (virgin metal content)	61.875	19.800	0.743	82.418
d) Virgin metal to be added (a-c)	50.625	16.200	0.757	67.582
e) Total input (c+d) in terms of output	112.500	36.000	1.500	150.000

HF 2

Particulars	Copper (kgs)	Lead (kgs)	Tin (kgs)	Total (kgs)
a) Output required (kgs)	120.00	15.000	15.000	150.000
Percentages	(80.0%)	(10.0%)	10.0%)	1000%)
b) Input mix Coarse powder(42.5%)	51.000	6.375	5.738	63.113
c) Sub total (Virgin metal content)	51.000	6.375	5.738	63.113
d) Virgin metal to be added(a-c)	69.000	8.625	9.262	86.887
e) Total Input (c+d)	120.00	15.000	15.000	150.000

HF 16

Particulars	Copper (kgs)	Lead (kgs)	Tin (kgs)	Total (kgs)
a) Output required (kgs)	111.000	33.750	5.250	150.000
Percentages	(74.0%)	(10.0%)	(10.0%)	(10000%)
b) Input mix Coarse powder (42.5%)	33.300	10.125	1.418	44.843
c) Sub total (virgin metal content)	33.300	10.125	1.418	44.843
d) Virgin metal to be added (a-c)	77.700	23.625	3.832	105.157
e) TotalInput (c+d)	111.000	33.750	5.250	150.000

APPENDIX-4

INSPECTION PLAN
(STAGE INSPECTION)

ST. BEARINGS

a) Blanking

Characteristic	Method	Frequency
Coil Finish	Visual and Ra valve	Loading of each coil
Coil Thickness	Micrometer	-do-
Lining Thickness	Permascope	-do-
Blank Length	Veriner Caliper	1/2 hr.
Blank Width	Verinier Caliper	1/2 hr.
Stamp Position	Vernier Calpper	1/2 hr.
Stamp Details	Visual	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

b) Form and Coin

Back Blue	Blue Block	1/2 hr.
Free Spread	Spread Gauge/vernier	1/2 hr.
Coin Height (Coin)	Coin Ht Gauge/Scribe gauge	1/2 hr
Build up	Micrometer/Permascope	1/2 hr.
Squareness	Visual/Squareness gauge	1/2 hr.
Damages	Visual	1/2 hr,

Sample size : 5 pcs.

In case of Flange bearings, Bar Gau e, Bridge Size and Flange Equalisation and Flange Radius to be checked.

c) Face & Chamfer

Brg. Length	Length Gauge	1/2 hr.
O/D Chamfer	Bevel Protractor/ Vernier/Scribe Gauge	1/2 hr
I/D Chamfer	-do-	1/2 hr.
Squareness	Visual	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 Pcs.

I/D chamfer should checked considering the I/D broach allowance. Normally .008" to .010" more than mean valve

..2

d) Grooving

Characteristics	Method	Frequency
Back Thickness	Point Micrometer	1/2 hr.
Groove Width	Vernier Caliper	1/2 hr.
Groove Location	Vernier Galiper	1/2 hr.
Back Blue	Blue Block	1/2 hr.
Groove Length	Vernier Caliper	1/2 hr.
Damages	Visual	1/2 hr.

Sample Size : 5 pcs.

Gsoove length to be kept considering the I.D.Broaching allowance.

e) Oil Distribution Grooving

Groove Location	Vernier Caliper	1/2 hr.
Groove Length	-do-	1/2 hr.
Groove Width	-do-	1/2 hr.
Back Thickness	Point Micrometer	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

Groove length to be kept considering the I.D.Breach allowance.

f) Notching

Notch Depth	Depth Gauge	1/2 hr.
Notch Length	Depth Gauge/scriber	1/2 hr.
Notch Radius	Radius Gauge	1/2 hr.
Notch Location	Veriner/scribe guage	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

Notch length to be kept considering Ht.Broach allowance.

g) Lipping

Lip Spread	Lip Spread Gauge	1/2 hr.
Lip Width	Lip Width Gauge/Disc Micrometer	1/2 hr
Lip Length	Veriner Caliper	1/2 hr.
Lip Location	Lip Location Gauge	1/2 hr.
Budge Up	Micrometer	1/2 hr.
Back Blue	Blue Block	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 Pcs.

ip Milling

Characteristic	Method	Frequency
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

i) **Hole /slot Punching**

Slot Length/slot Width/ Hole Dia	Varnier Caliper	1/2 hr.
Slot/Hole Location	Varnier Caliper	1/2 hr.
Slot /Hole Angle	Hole Angle/gGauge/ Vernier Caliper	1/2 hr.
Back Blue	Blue Block	1/2 hr.
Free Spread	Variner Caliper/ Free Spread Gauge	1/2 hr.
Damages	Visual	1/2 hr.

Sample siz : 5 pcs.

1. In case of Flange Brgs. Bar Gauge to be checked
2. For slot radius to be checked with radius gauge.

j) **C'Sinking**

Damages	Visual	1/2 hr

Sample size : 5 pcs.

k) **Height Broach**

Brg. Height	Ht Test Block	1/2 hr.
Parting Line Blue	Ht.Test Block	1/2 hr.
Parting Line Taper	Taper Attachment	1/2 hr.
Rock	On surface plate	1/2 hr.
Back Blue	Ht Test Block	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

In case of flange brgs. P.L.Flange relief and relief length free spread and bar gagge to be checked.

l) **I.D.Broaching**

Characteristic	Method	Rrequency
Wall thickness	Wall thickness gage	1/2 hr.
Eccentricity/concen-tricity	-do-	1/2 hr.
Concavity/Convexity	-do-	1/2 hr.
Crush Relief	Wall Gage	1/2 hr.
Relief Length	Wall gage/vernier caliper	1/2 hr.
I.D.Finish	Visual	1/2 hr.
Damages/Nicks/Burr	Visual	1/2 hr.
Free Spread	Vernier Caliper/ Free Spread Gage	Twice in a shift.
Crush Height	Ht Test Block	-do-

Sample size : 5 pcs.

In case of Flange Bearings Free Spread and Bar Gauge to be checked

m) **Plating**

Wall thickness	Wall thickness gage	1 hr
Plating Finish	Visual	

Sample size : 5 pcs.

INSPECTION PLAN

FLANGE BEARINGS

a) Blanking

Characteristic	Method	Frequency
Coil Finish	Visual & Ra value	Loading of each coil
Coil Thickness	Micrometer	-do-
Lining Thickness	Permascope	-do-
Blank Length Steel/ Lining	Vernier Caliper	1/2 hr
Blank Width Steel/ Lining	Vernier Caliper	1/2 hr.
Stamp Position	Vernier Caliper	1/2 hr.
Stamp Details	Visual	1/2 hr.
Distance between scribed lines	Vernier Caliper	1/2 hr.
Location of scribed Lines.	Vernier Caliper	1/2 hr.
Depth of scribed lines	Point mike	1/2 hr.
Damages	Visual	1/2 hr.

Sample Size: 5 pcs.

b) Flaring

Squareness	Try Square	1/2 hr.
Flare Angle	Visual	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

c) Sawing

Saw Ht	Ht Gauge	-
Damages	Visual	

e) Trimming

Flange O/D	Outside Mike	1/2 hr.
Back Blue	Blue Block	1/2 hr.
Free Spread	Free spread gauge/ V. Caliper	1/2 hr.
Bar Gage size	Bar Gauge	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

f) Counter Boring

Characteristics	Method	Frequency
Flange O/D	Outside Mike	1/2 Hr.
O/D & I/D C'bore dia & Chamfer Angle	Vernier Caliper/ Protractor	1/2 hr.
Flange O/D & I/D Chamf.	-do-	1/2 hr.
Counterbore radius	Radius Gage	1/2 hr.
Free Spread	Free spread Gage/ V.Caliper	1/2 hr.
Bar Gauge size	Bar Gauge	1/2 hr.
Back Blue	Blue Block	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

g) Bar Turning

Bar Gauge Size	Bar Gauge	1/2 hr.
Flange Equalization	Micrometer	1/2 hr.
Back Blue	Blue Block	1/2 hr.
Free Spread	Free Spread Gauge/ V.Caliper	1/2 hr.
Under cut	Profile matching	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

h) Oil Pocket Milling

Pocket Width	Vernier Caliper	1/2 hr.
Pocket Location	-do-	1/2 hr.
Pocket depth	Point Mike	1/2 hr.
Centre Distance	Vernier Caliper	1/2 hr.
Damages	Visual	1/2 hr.

Sample Size : 5 pcs.

In case of washers flatness to be checked.

......3

i) Sheer Broach

Characteristics	Method	Frequency
Bridge Size	Bridge Gage	1/2 hr.
Bar Gage Size	Bar Gage	1/2 hr.
Flange thickness Equalization	Micrometer	1/2 hr.
Thrust Face relief	Feeler Gage	1/2 hr.
Thrust Face Relief Length	Vernier Caliper	1/2 hr.
Damages	Visual	1/2 hr.

Sample # 5 pcs.

INSPECTION PLAN

WASHERS:

a) Blanking :

Characteristics	Method	Frequency
Outer Diameter	Micrometer	1/2 hr.
Inner Diameter	Vernier Caliper	1/2 hr.
Thickness	Micrometer	1/2 hr.
Flatness	Flatness Gage	1/2 hr.
Washer Height	Height Gage	1/2 hr.
Tang Height	Vernier Caliper	1/2 hr.
Tang width	-do-	1/2 hr.
Tang Location	-do-	1/2 hr.
Stamp Details	Visual	1/2 hr.
Parting face angle	Bevel Protractor	-
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

c) Chamfering :

I/D Chamfer	Vernier & Protractor.	1/2 hr.
P/L Chamfer	-do-	1/2 hr.
Flatness	Flatness Gage	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

d) Tumbling :

Flatness	Flatness Gage	-
Burrs	Visual	-
Damages	Visual	-
Thickness	Micrometer	-

e) Plating

Flatness	Flatness	-
Thickness	Micrometer	-

INSPECTION PLAN

BUSHES:

a) Blanking:

Characteristic	Method	Frequency
Blank Length	Vernier Caliper	1/2 hr.
Blank Width	-do-	1/2 hr.
Blank thickness	Micrometer	1/2 hr.
Hole dia	V. Caliper	1/2 hr.
Hole location & position	V. Caliper	1/2 hr.
Oil Groove parameters	-	-
Stamp Details	Visual	1/2 hr.
Damages	-do-	1/2 hr.

Sample size : 5 pcs.

b&c) First Forming & Second Forming:

Squareness	Try square & surface plate	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

d) Final Forming:

O/D under load	Split Block	1/2 hr.
O/D Free	GO,No-GO,Ring Gauge	1/2 hr.
Hole Angle	Angle Gage	1/2 hr.
Thickness	Ball Point Micrometer	1/2 hr.
Hole Diameter	V.Caliper	1/2 hr.
Blue Contact	Proof Gage/ split Block	-
I/D under load damages	Visual	1/2 hr.

Sample size : 5 pcs.

e) Face & Chamfer:

Characteristic	Method	Frequency
Bush Length	Length checking gage	1/2 hr.
O/D Chamfer	V.Caliper & Protractor	1/2 hr.
I/D Chamfer	V.Caliper	1/2 hr.
Hole Location	V.Calip r	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

f) C' sinking:

Hole diameter	V.Caliper	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 pcs

g) O/D Grinding:

O/D Free State	Micrometer	1/2 hr.
O/D under load	Split Block	2 hrs.
O/D Surface finish	Visual	1/2 hr.
Taper/Ovality on O/D	Micrometer	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

h) I.D.Boring:

I.D.underload	Plug Gage	1/2 hr.
Wall thickness	Ball Point Micrometer	1/2 hr.
I.D.Surface finish	Visual	1/2 hr.
Damages	Visual	1/2 hr.

Sample size : 5 pcs.

ANNEXTURE - 5

TYPE/PART NO.

OPERATION BLANKING

STANDARD PRODN/HR.

M/C

STANDARD SETTING TIME

TOOLINGS

CHECKS	METHOD	RED STD	BLUE STD	SPECIFICATIONS 010	020	030	040	050	060	TOL.	REMARKS/CAUTION
											STAMP DETAILS
SIZE (STAMP)	VISUAL										
PART NO.	VISUAL										
LENGTH	VERNIER										
WIDTH	-do-										
FINAL MILL	Mic.										
FINAL STEEL	P. SCOPE										
LINING THICK	-do-										
SQUARENESS	T- SQUARE										
GEN. APPEARANCE	VISUAL										

CHANGES

PROCESS SHEET

GABRIEL INDIA LIMITED
BEARING DIVISION
PARWANOO

TYPE/PART NO.

OPERATION FORM & COIN

M/C

STANDARD SETTING TIME

STANDARD PRODN/HR.

TOOLINGS

CHECKS	METHOD	RED STD	BLUE STD	SPECIFICATIONS 010	020	030	040	050	060	TOL.	REMARKS/CAUTION
COIN HT. AT ϕ =	Mic + Gauge										NOTE:
FREE SPREAD	Spread Gauge										
BACK BLUE	Blue Block										
THICKNESS	Mic.										
SQUARENESS	VISUAL										
BEARING LENGTH	VERNIER										
GEN. APPEARANCE	VISUAL										

CHANGES

PROCESS SHEET

GABRIEL INDIA LIMITED
BEARING DIVISION
PARWANOO

TYPE/PART NO.

OPERATION FACE & CHAMFER

STANDARD PRODN/HR.

M/C

STANDARD SETTING TIME

TOOLINGS

CHECKS	METHOD	RED STD	BLUE STD	SPECIFICATIONS 010	020	030	040	050	060	TOL.	REMARKS/CAUTION
LENGTH	MIC + GAUGE										
OD - CHAMFER	BEVEL PROTRACTOR										
ID - CHAMFER	BEVEL PROTRACTOR										
BLUE - MATCH	BLUE MATCH										
SQUARENESS	SURFACE PLATE										
GEN. APPEARANCE	VISUAL										

CHANGES

PROCESS SHEET

GABRIEL INDIA LIMITED
BEARING DIVISION
PARWANOO

TYPE/PART NO.

OPERATION GROOVING

STANDARD PRODN/HR.

M/C

STANDARD SETTING TIME

TOOLINGS

CHECKS	METHOD	RED STD	BLUE STD	SPECIFICATIONS 010	020	030	040	050	060	TOL.	REMARKS/CAUTION
Groove back thickness	Mic.										
Groove width	Vernier										
Groove location	Vernier										
Groove length	Vernier										
Back blue	Blue block										
Groove Cutter dia.	Vernier										
Gen. appearance	Visual.										

CHANGES

PROCESS SHEET

GABRIEL INDIA LIMITED
BEARING DIVISION
PARWANOO

TYPE/PART NO.

OPERATION OIL DISTRIBUTION GROOVING

STANDARD PRODN/HR.

M/C

STANDARD SETTING TIME

TOOLINGS

CHECKS	METHOD	RED STD	BLUE STD	SPECIFICATIONS 010	020	030	040	050	060	TOL.	REMARKS/CAUTION
GROOVE LOCATION	VERNIER										
GROOVE LENGTH	GAUGE										
GROOVE CHAMFER ANGLE											
GROOVE CUTTER DIA.	MIC										
RELIEF	VERNIER										
GEN APPEARANCE	VISUAL										

CHANGES

PROCESS SHEET

GABRIEL INDIA LIMITED
BEARING DIVISION
PARWANOO

TYPE/PART NO.

OPERATION LOCATION NOTCH MILLING

M/C

STANDARD SETTING TIME

STANDARD PRODN/HR.

TOOLINGS

CHECKS	METHOD	RED STD	BLUE STD	SPECIFICATIONS 010	020	030	040	050	060	TOL.	REMARKS/CAUTION
Notch Location											
Notch depth											
Notch Length											
Notch cutter dia											
Gen appearance											

CHANGES

PROCESS SHEET

GABRIEL INDIA LIMITED
BEARING DIVISION
PARWANOO

TYPE/PART NO.

OPERATION LIP PUNCHING

M/C

STANDARD SETTING TIME

STANDARD PRODN/HR.

TOOLINGS

CHECKS	METHOD	RED STD	BLUE STD	SPECIFICATIONS 010	020	030	040	050	060	TOL.	REMARKS/CAUTION
Lip spread	Gauge										
Lip width	Gauge/Mic										
Lip length	Ht gauge										
Lip location	Gauge										
Back blue	Blue block										
Gen	Visual.										

CHANGES

PROCESS SHEET

GABRIEL INDIA LIMITED
BEARING DIVISION
PARWANOO

TYPE/PART NO.

OPERATION HOLE LOCATION

M/C

STANDARD SETTING TIME

STANDARD PRODN/HR.

TOOLINGS

CHECKS	METHOD	RED STD	BLUE STD	SPECIFICATIONS							REMARKS/CAUTION
				010	020	030	040	050	060	TOL.	
HOLE DIA											
Hole location											
Chord M1											
Chord M2											
Free Spread											
Back blue											
Gen appearance											

CHANGES

PROCESS SHEET

GABRIEL INDIA LIMITED
BEARING DIVISION
PARWANOO

TYPE/PART NO.

OPERATION WALL BROACH

STANDARD PRODN/HR.

M/C

STANDARD SETTING TIME

TOOLINGS

CHECKS	METHOD	RED STD	BLUE STD	SPECIFICATIONS 010	020	030	.040	050	060	TOL.	REMARKS/CAUTION
Wall thickness.	Wall gauge										
Form	-do-										
Crush relief	-do										
Crush relief length	Wall + ht gauge										
Height	Ht fix										
Free spread	Gauge										
Surface finish	Surtronic										
Gen appearance	Visual										

CHANGES

PROCESS SHEET

GABRIEL INDIA LIMITED
BEARING DIVISION
PARWANOO

REFERENCES

1. Introduction to Engine bearings (R&D deptt.GIL Parwanoo)

2. Gabriel- Twenty sixth annual report 1986-87

3. Handbook of Stastical Quality Control (ISI)

4. Material Science and Processes by R.B.Gupta.

5. Physical Metallurgical Principles. by Reedhill

6. Quality Control Manual (Gabriel India Ltd, Engine bearing division)

7. Manual on the system of Standard Casting of Bearings, M D Management Consultants (For GIL)

8. Stastical Quality Control Handbook (Western Electric)

9. Visual acceptance standards (Fedral -Mogul Corporation , USA)

10. Bearings terminology (Gabriel India Ltd, Bearing division)

11. Gabriel Engine bearings Manual (GIL, Parwanoo)