



Annexure - III

**UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002**

Final Report of the work done on the Major Research Project. (Report to be submitted within 6 weeks after completion of each year).

1.	Project report No. 1st /2nd /3rd /Final	FINAL
2.	UGC Reference No. and Date	F. No. 41-982/2012(SR) Dated: July 23, 2012
3.	Period of report	July 01, 2012 to June 30, 2014 (Complete duration of the project)
4.	Title of the Project	Experimental investigation of EDM machined surface of Al-SiC and Al-SiC- B₄C Metal Matrix Composites
5.	(a) Name of Principal Investigator	Dr Ajay Batish
	(b) Department of University/College where the work has progressed	Professor, Dept. of Mechanical Engineering, Thapar Institute of Engineering and Technology, Patiala 147004
6.	Effective date of starting the Project	August 21, 2012
7.	Grant approved and expenditure incurred during the period of the report	
	(a) Total amount approved, Rs.	Approved: Rs. 10,82,000/- (for two years) 1st Installment : Rs. 9,97,000/- (received) 2nd Installment : Not received
	(b) Total expenditure, Rs.	Rs. 9,70,280/- (Unutilized amount of Rs. 26,720/- is refunded vide DD No. 440937, dated 02/09/2014)

Report of Work Done: (Please attach separate sheet)

i.	Brief objective of the project	<ul style="list-style-type: none"> • Study the effect of process parameters like current, pulse on & off time, dielectric, tool etc on the MRR, TWR, roughness, micro hardness and residual stresses of the machined Aluminum-silicon carbide-boron carbide metal matrix composites. • Evaluating the critical process parameters that have impact on the responses. • Optimization of the process considering multiple responses and finding optimum process setting for rough as well finish machining. • Study of metallurgical behaviour of the machined surfaces by Scanning Electron
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		<p>Microscopy (SEM) observations.</p> <ul style="list-style-type: none"> • Determining the amount of residual stresses on the machined surface by X-Ray Diffraction
ii.	Work done so far and results achieved and publications, if any, resulting from the work (Give details of the papers and names of the journals in which it has been published or accepted for publication)	Please see Appendix 1
iii.	Has the progress been according to original plan of work and towards achieving objectives if not, state reasons	Yes, as per plan
iv.	Please indicate the difficulties, if any, experience in implementing the project.	We had fallen short of funds for the equipment. However, the difficulty was overcome with additional support of Rs 6,05,027/- from Thapar Institute of Engineering & Technology, Patiala. This was in addition to Rs 9,00,000/- provide for in the project by UGC.
v.	If project has not been completed, please indicate the approximate time by which it is likely to be completed. A summary of the work done for the period (Annual basis) may please be sent to the Commission on a separate sheet	Completed
vi.	If the project has been completed, please enclose a summary of the findings of the study. Two bound copies of the final report of work done may also be sent to the Commission.	Please see attached Appendix 2.
vii.	Any other information which would help in evaluation of work done on the project. At the completion of the project, the first report should indicate the output, such as (a) Manpower trained (b) Ph. D. awarded (c) Publication of results (d) other impact, if any	<p>PhD Enrolled: Two (One completed and one ongoing)</p> <p>Master of Engineering students are also working on this project.</p> <p>Publications details: Please see Appendix 3 for details. SCI Journal – 3 (One published, another one online) 2 (Communicated, under review) Conference – 2 (1 presented in March 2014; 1 published, November 2013)</p>

**PRINCIPAL
INVESTIGATOR**

**SIGNATURE OF THE
REGISTRAR/PRINCIPAL**

Appendix 1

The experimental layout as shown in Figure 1 was planned to conduct experiments in three Stages (Stage I, Stage II, and Stage III). The experiments are conducted on the basis of availability of resources on the particular stage of the plan.

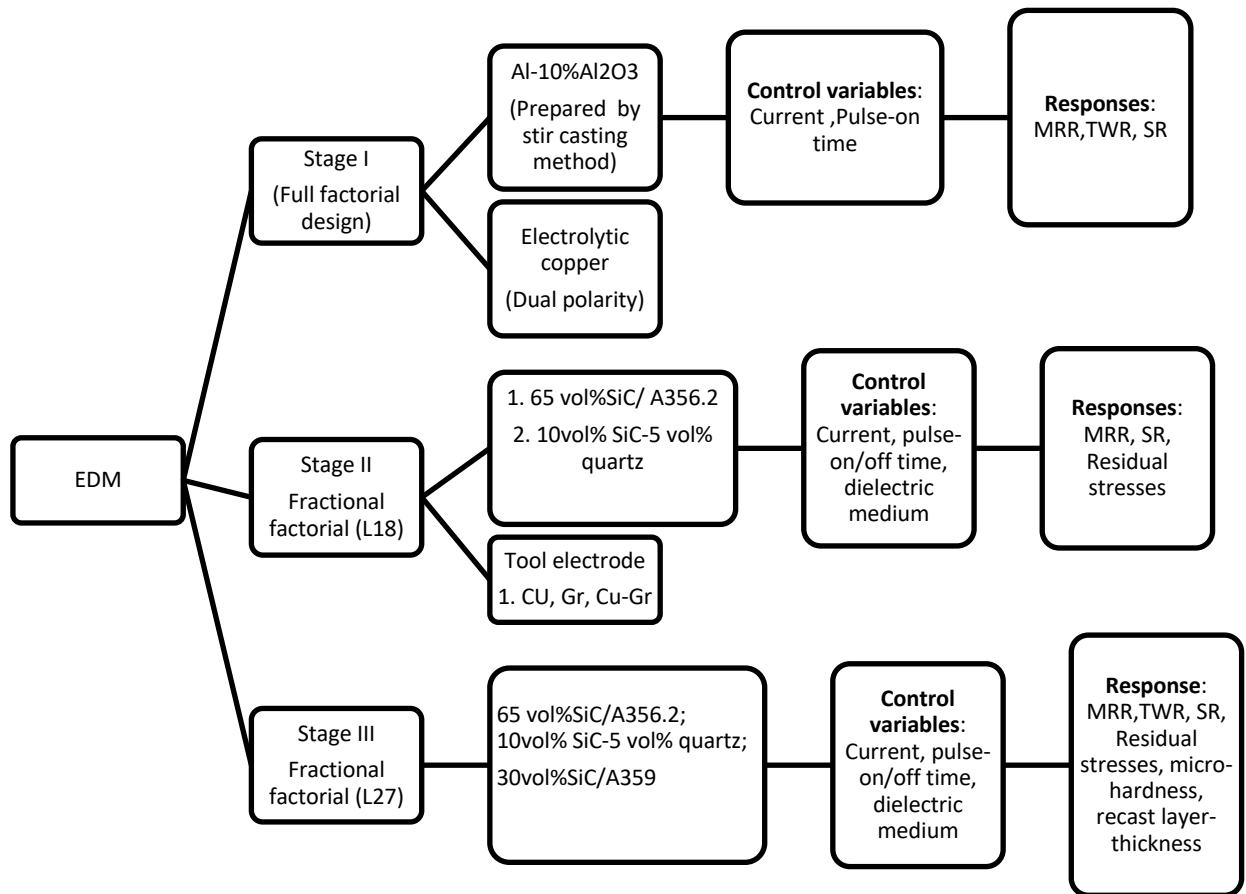


Figure 1 Summary of experimental program

(a) EDM Al-10%Al₂O₃ WITH COPPER ELECTRODE

This section discusses the experimental procedure for machining with copper electrode with dual polarity and setting up of various input process parameters. The desirable machining condition for each trial is modeled by using statistical regression method. The developed equations have been utilized for global optimization using lexicographic goal programming.

In this section, MMC was fabricated by using stir casting method and set of nine experiments were completed on as- received cast MMC with copper as electrode material with dual polarity. The input parameters were current and pulse on time (3- Levels each). The response parameters such as MRR, TWR, SR were measured for all samples. The relative contribution of discharge current and pulse on-time towards each response characteristic was obtained. The analysis of recast layer of selected samples was thereafter performed by observing the microstructure on an optical microscope assisted with inbuilt MIAS 4.0 (Metallurgical Image Analysis system) software. The statistical tool, analysis of variance (ANOVA) was performed on the input parameters. The section includes multiple criteria decision making technique to establish the governing of the input process parameters with a different objective.

(b) EDM OF 65vol%SiC/A356.2 AND 10vol%SiC-5vol% WITH DIFFERENT ELECTRODES IN POWDER – MIXED DIELECTRIC

This section explains the L18 design of input parameters set-up for machining of MMCs with copper, graphite, and copper-graphite electrodes in powder-mixed dielectric. This section includes the estimation of residual stresses along with MRR, SR during EDM process. The desirable machining conditions for each MMC were identified by using analytical hierarchy process (AHP) technique. The capabilities of artificial neural network modeling to predict residual stress is presented.

The workpiece 65vol%SiC/A356.2 was procured from CPS Inc.USA and the workpiece 10vol%SiC-5vol% was fabricated by using stir casting technique. A specially designed tank was used for this stage of experimentation which allows machining with powder-mixed dielectric without disturbing the routine operation of the machine. Each work material was machined using selected L18 orthogonal array. MRR, SR and residual stresses were measured for all samples. The relative contribution of discharge current, pulse on-time, pulse off-time, dielectric medium, electrode and workpiece material towards each response characteristic was obtained. The section establishes neural network modeling technique to predict the residual stresses. The global optimum value for each type of selected MMC, in the given constraints, was evaluated by AHP tool.

(c) EDM OF 65vol%SiC/A356.2; 10vol%SiC-5vol% AND 30 vol% SiC/ A359

WITH DIFFERENT ELECTRODES IN POWDER–MIXED DIELECTRIC

This section explains the L27 design of input parameters set-up for machining of three types MMCs with copper, graphite, and copper-graphite electrodes in powder-mixed dielectric. This section includes the estimation of MRR, TWR, SR residual stresses, micro-hardness and recast layer analysis during EDM process.

In this section, MMC 30vol% SiC/ A359 procured from MC-21,Inc.,USA. was also included in the study. The significant parameters effecting MRR, TWR, SR, micro-hardness and recast layer were identified.

Section – VI ANALYSIS OF THE RESULTS

This section takes a collective view of the results obtained by machining with different electrode materials and with powder-suspended dielectric and presented.

(a) EDM Al-10%Al₂O₃ WITH COPPER ELECTRODE

From the results it was concluded that all the responses have a direct relationship with current but an inverse relationship with pulse-on time, as increased pulse on time decreases the frequency of spark occurrence. The parts machined using straight (positive) polarity resulted in higher MRR as compared to negative polarity. The optimal solution obtained using the lexicographic goal programming matched with experimental results establishing it as a powerful MCDM tool. In the trials conducted using straight polarity, it can be concluded that high current and low pulse-on time should be used for achieving higher MRR. In the same trials, for obtaining good surface finish, the current should be set at low level with intermediate pulse-on time as otherwise no machining may take place. Trials conducted with negative polarity, showed similar results for finish machining operations. However, if TWR is a higher priority as compared to MRR, than current was set at the lowest level and pulse-on time increases to intermediate level. The recast layer was significantly affected by the pulse-on time and current, but pulse-on is highly significant in determining the thickness of recast layer. The formation of clusters or uneven distribution of reinforced particles deteriorates the property of the machined surface; hence due to least presence of reinforced particles in recast layer it is desirable to remove it.

(b) EDM OF 65vol%SiC/A356.2 AND Al-10vol%SiC-5vol%quartz WITH DIFFERENT ELECTRODES IN POWDER – MIXED DIELECTRIC

The study reports the result of an experiment conducted on two different variants of MMCs for assessing the MRR, SR and residual stresses induced while machining. The measurement of residual stresses was done by using classical X-ray diffraction method. The basic concept is X-ray diffraction method is represented in Fig 1.

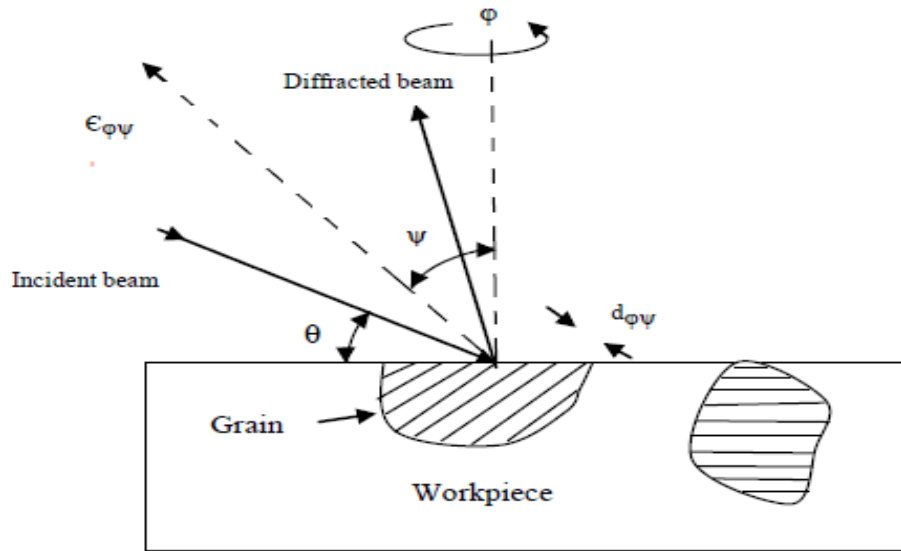


Fig.1 Concept of X-ray diffraction stress analysis.

Pulse off time was identified as the most significant factor resulting in residual stresses in the two composite materials. The analysis of results showed that MMCs with low coefficient of thermal expansion and densely reinforced particles (shielding effect) had lower residual stresses as shown in Fig.2.

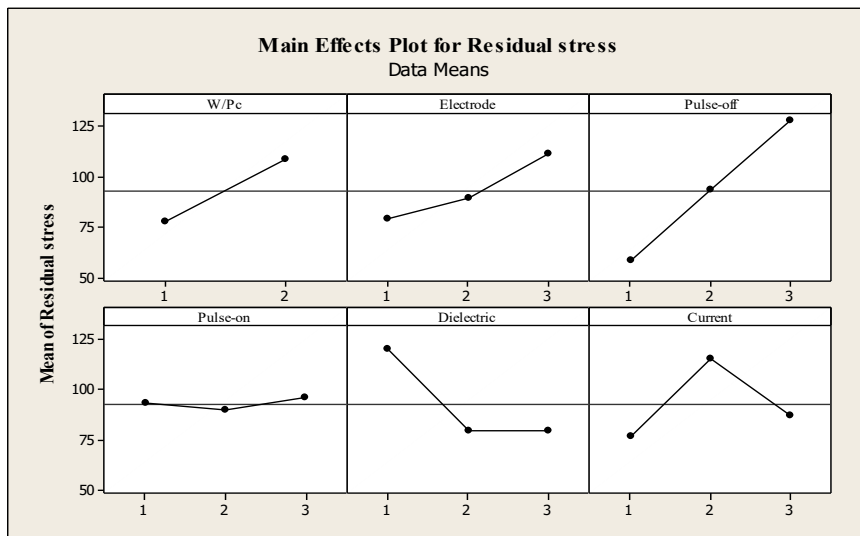


Fig.2 Main effect plots for residual stresses

Those electrode materials which had high conductivity resulting in lower residual stress. The increase in pulse off time causes a steep rise in residual stress while pulse on time has no effect. The addition of power in the dielectric results in consistent flow of energy hence lowers the residual stresses. However, the conductivity of power particles has shown no effect on residual stresses. Subsequently, ANN model

was developed to predict the residual stresses in such materials. The ANN modeling accurately predicted the residual stresses and can be used as a reliable tool for study of residual stresses. In the present study analytic hierarchy process (AHP) was used for optimizing three output response parameters namely residual stresses, MRR and surface roughness collectively. The process conditions that affected the three responses namely residual stresses, MRR and SR were identified and then optimized together using AHP for two difference types of MMCs. Current and pulse on time significantly affected MRR while the addition of powder in dielectric, current and pulse on time affected SR. The pulse off which had no significant effect on MRR and SR had the largest effect on residual stresses followed by powder mixed dielectric, current and the type of electrode used.

(c) EDM OF 65vol%SiC/A356.2; Al-10vol%SiC-5vol%quartz AND 30vol% SiC/A359 WITH DIFFERENT ELECTRODES IN POWDER-MIXED DIELECTRIC

In this section the impact of each process parameters on the response parameters of MRR, TWR, SR residual stress micro-hardness and recast layer has been discussed. In this study, the effect of material properties and machining parameters on the residual stress of a machined surface during EDM was investigated. It is observed that the residual stress is tensile and compressive in nature due to conflicts in thermal properties of matrix and reinforced particles. The presence of splitting of graph in the observation indicates stress-gradient implies the presence of shear stress as shown in Fig 3.

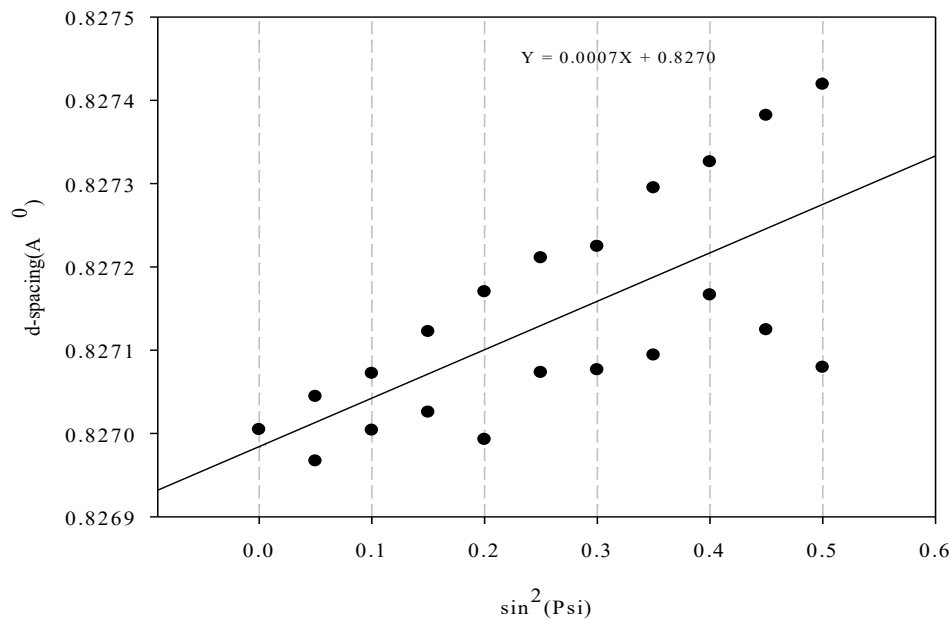


Fig.3. The d-spacing vs. $\sin^2\psi$ plot with splitting pattern.

The surface residual stresses are observed to be mainly dependent upon concentration/ particle size and the conductivity of the workpiece. The residual stress increases with an increase in pulse-off time due to re-solidification time of recast layer. The depositions on the workpiece as a result of copper powder in dielectric results in higher residual stresses as compare to conditions where graphite powder is mixed. Due to weak bonding in composite tool electrode (Cu-Gr), significant quantities of disintegrated particle are deposited on the surface of the workpiece. The effect of each selected electrode on residual stress is as shown in Fig. 4

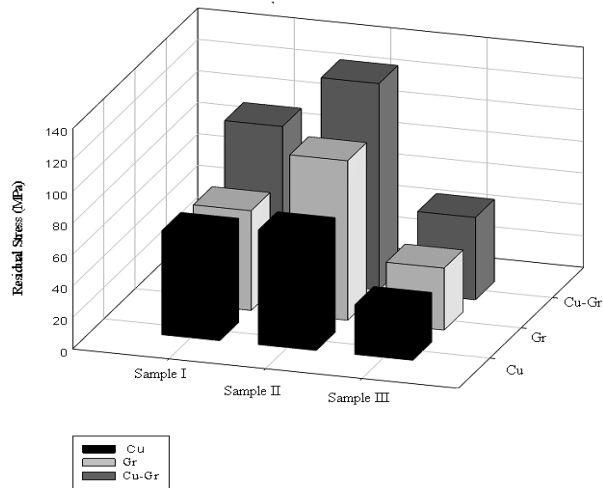


Fig.4 Effect of electrodes on different samples

The micro-hardness and recast layer was maximum for the workpiece having dense reinforced particle due to the oxidation of decomposed silicon. The SEM of recast layer for each type of MMC is shown in Fig 5. It can be observed that the recast layer thickness is minimum for the smaller size reinforced particles workpiece.

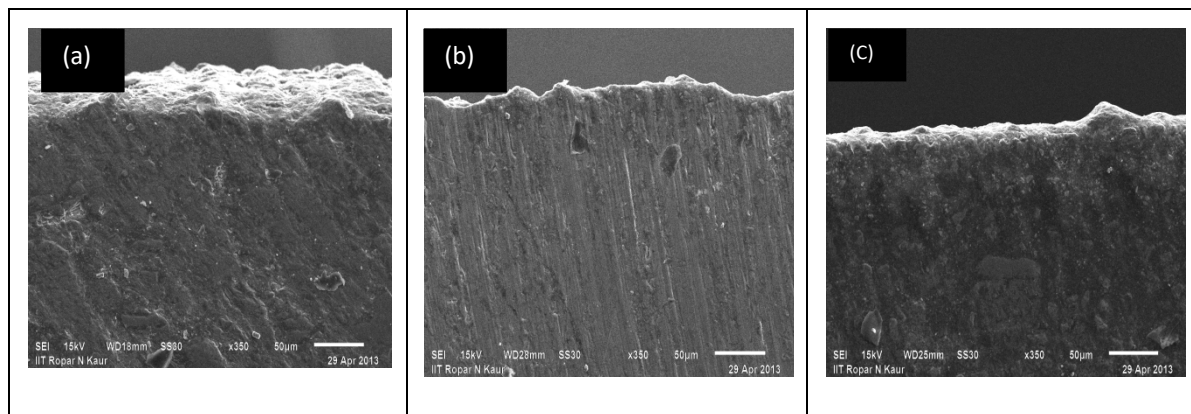


Fig.5. SEM of recast layer (a) Al-65% SiC (b) Al-10%SiC-5% quartz (c) Al-30%SiC

Section – VII CONCLUSIONS

This section lists the conclusions of this research work. Some of the important conclusions drawn from the research work are:

➤ While EDM of Al-10%Al₂O₃ MMC, at conventional polarity, the MRR increases as the current increase but inverse relationship was found with pulse on time i.e. current at its highest level (12 amps) and pulse on time at its lowest level (10 μsec). The lexicographic goal programming proved to be a powerful tool in determining the setting of response parameters under the given constraints. The recast layer formed during machining depends upon current and pulse on time settings.

➤ The powder mixed EDM performance of two types (65vol%SiC/A356.2 and Al-10vol%SiC-5vol%) of MMC were compared and it was concluded that:

- The higher density of reinforced particles in the matrix results in lower MRR, SR and residual stress as ceramic particles act as a shield of matrix material against sparks energy.
- MRR variation with current was inline with results obtained while machining Al-10%Al₂O₃ composite.
- The MRR was observed to decrease when the pulse on time is stepped up from 10 to 30 μsec, further it increases drastically as prolonged pulse on time causes intense melting and evaporation of matrix material, thus resulting in easy removal of reinforced particle by spalling mechanism.
- The copper powder mixed EDM results in smoother machined surface as compared to graphite suspended particle in the dielectric due to its higher conductive properties.
- Higher setting of pulse-off time results in higher magnitude of induced residual stress in the EDM region whereas pulse on time had no effect.
- The suspended powder in dielectric facilitate the smooth formation of plasma between the electrodes hence the residual stress of lower magnitude has been observed.
- The three responses MRR, SR and residual stress were globally optimized, assigning maximum weight age to the residual stress response, with modified AHP optimization approach.
- The capability of ANN to predict residual stress during EDM has been presented, feed forward back propagation neural architecture with two hidden layers with 9 and 7 neuron in each layer has been used. The learning rate and momentum were selected as 0.001 and 0.7 respectively.

➤ The powder mixed EDM performance of three types (65vol%SiC/A356.2, Al-10vol%SiC-5vol% and 30vol%SiC/A359) of MMCs have been compared and found that:

- Current and pulse-on time, which tends to increase the spark energy effected MRR significantly.
- The density of reinforced particles shields the matrix material from spark energy; hence the high MRR and high SR were observed with lowest reinforced particle. Vice versa is true for higher density reinforced MMCs.
- TWR was highest with Cu-Gr electrode due to easy disintegration of the weakly bonded particles in the composite electrode. High current also affects significantly TWR adversely.
- It is observed that the residual stress is tensile as well as compressive in nature due to conflict in thermal properties of matrix and reinforced particles.
- The residual stresses increases with increase in pulse-off time due to higher re-solidification time of the recast layer. Also, the residual stresses increase with the increase in current 4 Amp to 8 Amp but decreases with any further increase in current.
- The SEM analysis reveals that the thickness of recast layer was maximum for dense reinforced particles MMC due its higher heat absorption tendency. Hence high density matrix material also shows high extent cross- sectional residual stress distribution. It also depends upon the size of reinforced particles.
- The recast thickness increases as the current is raised from 4 amps to 8 amps but it shows a decreasing trend with further increase in magnitude of current.
- The PEDM with copper as an additive shows a minimum recast layer thickness due to improved electric conductivity and consistent discharge.
- The micro hardness measured on the matrix portion was maximum for dense particulate reinforced MMC. This is due to the reaction of SiC particles with matrix at high temperature and also the formation of small craters during machining which catalyst the formation of compounds thus improves micro- hardness.
- The MMC surface machined with graphite as a tool electrode shows maximum micro-hardness.

Appendix 2

Summary of the Findings

Experimental investigations were conducted on variant MMCs using electrical discharge machining process. Based on the experiments conducted, the following conclusions have been drawn:

- During electric discharge machining of Al-10%Al₂O₃ MMC, the motivation factors at Stage I of experimentation were to enhance the productivity leading to higher MRR and better SR. The results show that all the responses (MRR, TWR, and SR) have a direct relationship with current but an inverse relationship with pulse-on time. This is because the increased pulse-on time decreases the frequency of spark occurrence.
- The parts machined using conventional (+ve) polarity results in higher MRR as compared to those with negative polarity. Whereas, highest surface finish was obtained for reverse polarity (-ve polarity) when current was set at 8 Amps and pulse-on time at 30 μ s.
- The regression statistical tool was used to develop the non-linear mathematical model to predict the machining response parameters. These models were further optimized using lexicographic goal programming (LGP).
- The LGP proved to be a powerful tool in determining the setting of response parameters under given constraints. The optimal solution obtained using the LGP matched with experimental results and thus it can be used as a powerful tool for optimization of multiple responses. With straight polarity, high current (16 Amp) and low pulse on-time (10 μ s) should be used for maximizing MRR and for good surface finish, the current (8Amp) and pulse-on time (10 μ s) should be set at low levels. Experiments conducted with negative polarity showed similar results for finish machining. However, if TWR is a priority as compared to MRR, then current should be set at a lower level (8Amp) and pulse-on time (30 μ s) should be increased to an intermediate level.
- The recast layer thickness is significantly affected by current and pulse-on time, and pulse-on time is found to be more significant. The formation of clusters or uneven distribution of reinforced particles deteriorates the properties of the machined surface. Hence due to least presence of reinforced particles in recast layer, it is desirable to remove it. The responses in the present stage of study are consistent with the conclusions drawn by other investigators.

The study was extended by selecting two variants of MMCs; namely 65vol%SiC/A356.2 and 10vol%SiC-5vol% quartz/Al. The machining process parameters such as electrode material (Copper, Graphite and Copper-Graphite composite), peak current, pulse-on/off time and dielectric medium were varied during the study. Due to high carbon emission/deposition at high current and high pulse-on time conditions, the kerosene was replaced by EDM oil. Some experiments were also conducted in dielectric mixed with suspended powders. The following conclusions have been drawn from Stage II of experiments:

- The residual stresses induced in the MMCs after machining were analyzed by X-ray diffraction method. Pulse-off time was identified as the most significant factor resulting in residual stresses in both the MMCs.
- The analysis of results shows that MMCs with low coefficient of thermal expansion and a high density of reinforced particle have lower residual stresses.
- The electrode material with high conductivity resulted in smooth formation of plasma channel between the electrodes; hence the induced residual stresses were minimum.
- The increase in pulse-off time causes a steep rise in residual stresses due to extended solidification period while pulse-on time has no effect.
- The addition of powder in the dielectric lowers the residual stresses. However, the conductivity of powder particles has no effect on residual stresses.
- ANN model was developed to predict the residual stresses in such materials. The capability of ANN to predict residual stresses during EDM was achieved with feed forward back propagation neural architecture with two hidden layers with 9 and 7 neuron in each layer. The learning rate and momentum were selected as 0.001 and 0.7 respectively. The model accurately predicts the residual stresses and can be used as a reliable tool for study of residual stresses in case of complex problems that involve qualitative and quantitative factors.
- The XRD patterns indicate the formation of new phases on the machined surface. The peak intensity after machining is reduced due to dislocation of atomic layer resulting in residual strains.
- Current and pulse-on time significantly affected MRR while the addition of powder, current and pulse-on time affected SR. While pulse-off time had no significant effect on

MRR and SR, it had the largest effect on residual stresses followed by powder mixed dielectric, current and the type of electrode used.

- Analytic Hierarchy Process (AHP), a multiple criteria decision making tool for finite alternative was used for optimizing three output response parameters; namely residual stresses, material removal rate and surface roughness. The identification of process parameters and other requirements involves complex decision making due to conflicting parameter setting for different output responses. In the present stage, AHP was used to obtain more reliable global composite performance score for various machining conditions in a powder-mixed electric discharge machining of MMCs.
- The optimal conditions for both types of materials were identified. The overall process settings for both the samples reveal that machining of MMCs with graphite electrode, higher pulse-on time and lowest pulse-off time in the presence of suspended particles dielectric gives minimum residual stresses with desired MRR.
- Due to the presence of dense ceramic reinforced particles in Sample I as compared to Sample II, the desired results were obtained at intermediate level of current and higher conductivity suspended particles in a dielectric medium.
- The optimal settings suggested that graphite electrode should be used with pulse- on and pulse-off time of $45\mu\text{s}$ and $15\mu\text{s}$ respectively. Addition of powder in the dielectric improved the MRR as the electrical conductivity of powder reduces the dielectric insulating strength. Also, copper powder suspended in the dielectric resulted in an optimal solution for 10vol%SiC-5vol% quartz/Al MMC and graphite powder gives better results for 65vol%SiC/A356.2 MMC. It may be concluded that to overcome problems of poor finish at high current setting in EDM, the dielectric should be mixed with powder.
- Higher density of reinforced particles in the matrix results in lesser MRR, SR and residual stresses as ceramic particles act as a shield of matrix material against sparks energy. MRR variation with current was in line with results obtained while machining Al-10%Al₂O₃ composite. It decreased when the pulse-on time was stepped up from 10 to 30 μs . Further, it increased drastically as prolonged pulse-on time causes intense melting and evaporation of matrix material and easy removal of reinforced particle by spalling mechanism.
- Copper powder mixed EDM results in smoother machined surface as compared to graphite powder in the dielectric due to its higher conductive properties.

In Stage III, the EDM performance on three variants of MMCs (65vol%SiC/A356.2, Al-10vol%SiC-5vol% and 30vol%SiC/A359) was compared. The machining conditions of this stage were similar to Stage II. The following conclusions have been drawn:

- Current and pulse-on time increases the spark energy which affects MRR. The density of reinforced particles shields the matrix material from spark energy; hence high MRR and high SR were observed with lowest reinforced particle matrix.
- The pulse-off duration at its lowest level is sufficient to remove entrapped debris by the flushing pressure of dielectric which helps in improving MRR.
- TWR was highest with Cu-Gr electrode due to disintegration of the weakly bonded particles in the composite electrode. High current also affects TWR adversely.
- The effect of material properties and machining parameters on the residual stresses of a machined surface was investigated by measuring the shift in selected peak at highest angle by diffractometer method. It was observed that the residual stresses were tensile as well as compressive in nature due to conflicts in thermal properties of matrix and reinforced particles. The splitting of graph (d vs. $\sin^2\psi$) in the observation indicates a stress-gradient that represents the presence of shear stresses.
- The surface residual stresses were observed to be mainly dependent upon concentration/particle size and the conductivity of the work piece. The residual stresses increase with an increase in pulse-off time due to higher re-solidification time of the recast layer (as observed in Stage II of the experimental plan). Also, the residual stresses increase with increase in current from 4Amp to 8Amp but decrease with any further increase in current.
- The depositions on the work piece due to the presence of copper powder in dielectric result in higher residual stresses as compared to conditions where graphite powder is mixed. Due to weak bonding in composite electrode (Cu-Gr), significant quantities of disintegrated particles were deposited to form thick recast layer on the work piece.
- The study also reports the phenomenon of surface modification while machining with EDM process. The density of reinforced ceramic forming oxides (SiO_2) at elevated temperature (above 17000C) is the most significant factor imposing micro-hardness on the machined surface.
- The XRD spectra reveal the formation of copper oxide as the major transferred element from electrode/dielectric medium which is responsible for the modification of machined

surface. This is due to its higher conductivity as well as reactivity potential of copper as compared to graphite, which is less reactive to form compounds or surface modifier. This results in improved conductivity and corrosive resistance of the surface.

- The traces of carbon particles were observed under optical microscopical examination in the free form on the surfaces and the craters of the machined MMCs.
- The deposition of carbon was observed when the machining parameters setting were at the highest level. Finally, the cross-sectional view of recast layer analysis reflected the profile of sparks generated during EDM. Hence, PMEDM may be designated as the most suitable machining option for MMCs to enhance surface properties.
- In the SEM analysis, the thickness of recast layer is found to be maximum for dense reinforced particles MMCs due to its higher heat absorption tendency. Hence, high density matrix material also shows high extent cross-sectional residual stresses distribution. It also depends upon the size of reinforced particles. The recast layer thickness increases as the current increases from 4Amps to 8Amps but it shows a decreasing trend as the magnitude of current further increases. The PMEDM with copper as an additive shows a minimum recast layer thickness due to improved electrical conductivity and consistent discharges.

Appendix 3: List of Publications

Journal Publications:

Author(s)	Title of Paper	Name of the Journal, volume/ page numbers,	Name of the Publisher	Impact Factor
Sarabjeet Singh Sidhu, Ajay Batish, Sanjeev Kumar	Study of surface properties in particulate reinforced MMC using powder-Mixed EDM	Materials and Manufacturing Processes, 29: 46–52, 2014	Taylor & Francis	1.297
Geeta Bhatt, Ajay Batish, Anirban Bhattacharya	Material Transfer Mechanism during Magnetic Field Assisted Electric Discharge Machining of AISI D2, D3 and H13 Die Steel	Proceedings of the Institution of Mechanical Engineers, Part B, Journal of Engineering Manufacture Published online before print March 14, 2014, doi:10.1177/0954405414522797	SAGE	0.770

Conference Publications:

Author(s)	Title of Paper	Name of the Conference
Sarabjeet S. Sidhu, Sanjeev Kumar, Ajay Batish	ED machining of particulate reinforced MMC's	International Conference on Emerging Trends in Engineering and Technology on March, 10-11, 2014 at Miami, USA
Geeta Bhatt, Anirban Bhattacharya, Ajay Batish	Experimental Investigation of Magnetic field assisted Powder Mixed Electric Discharge Machining	Proceedings of International Conference on Powder, Granule and Bulk Solids: Innovations and Applications, Mechanical Engg Department, Thapar University Patiala – 147004, Punjab November 28-30, 2013, pp. 344 – 350.