International Journal of Scientific Research and Management Studies (IJSRMS)
ISSN: 2349-3771 Volume 2 Issue 7, pg: 300-307

PROCESS OPTIMIZATION USING DOE FOR REALIZING DESIRED VALUE OF SURFACE ROUGHNESS OVER EDM

[1]Javed Mujawar, [2]V.V.Potdar, [3]Swapnil S. Kulkarni
[1]M.E (Mech), A.G.Patil Institute of Technology, Solapur, India
[2]Prof. and Principal, A.G.Patil Institute of Technology, Solapur, India
[3]Director-Able Technologies India Pvt. Ltd., Pune, India

ABSTRACT

Surface finish on the machined surface of an insert used in die cavity influences the life as the same can cause pitting during the ejection of each component resistance to flow or aesthetics could be other considerations for specifying high levels of surface finish. This work shall deal with realization of the desired range of surface finish while attempting to optimize the significant input parameters for the EDM Process. The influence of a given set of parameters over the outcome in terms of Ra value shall be studied and diagnosed for finding a correlation. Analysis of variance and Taguchi method shall be deployed towards statistical treatment of data in the context of analytical methodology. DOE shall be performed to find suitable level for the significant input parameter thus optimizing the process for the operating conditions. Physical experimentation shall be performed for validation.

KEYWORDS: *DOE, EDM, Parameter, Optimization, Ra value, Taguchi Technique, ANOVA*

I. INTRODUCTION

Electric Discharge Machining (EDM) is one of the most widely used non-traditional machining processes. This technique utilises thermoelectric energy to erode undesired materials from the work piece by a series of discrete electrical sparks between the work piece and the electrode. A pulse discharge occurs in a small gap between the work piece and the electrode which removes the unwanted material from the parent metal through melting and vaporizing. Electrical Discharge Machining (EDM) is a non-contact thermal machining process capable of machining conductive and semi-conductive materials regardless of their hardness. The electrical discharges generate impulsive pressure by dielectric explosion to remove the melted material. Thus, the amount of removed material can be effectively controlled to produce complex and precise machine components.
The EDM process has the ability to machine hard, difficult-to-machine materials. Parts with complex, precise and irregular shapes for forging, press tools, extrusion dies, difficult internal shapes for aerospace and medical applications can be made by EDM process. Some of the shapes made by EDM process are shown in Figure 1.

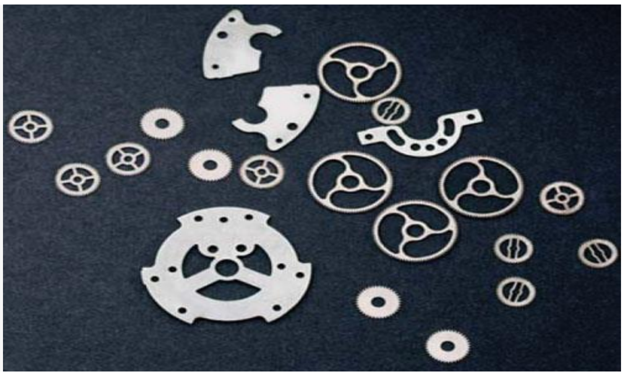


Figure 1: Difficult internal parts made by EDM process

- **Advantages of EDM**

1. By this process, materials of any hardness can be machined.
2. No burrs are left in machined surface.
3. One of the main advantages of this process is that thin and brittle components can be machined without distortion.
4. Complex internal shapes can be machined.

- **Limitations of EDM**

1. This process can only be employed in electrically conductive materials.
2. Material removal rate is low and the process overall is slow compared to conventional machining processes.
3. Unwanted erosion and over cutting of material can occur.
4. Rough surface finish when at high rates of material removal.

1.1. Problem Definition:

The Die-mold Industry, especially is characterized by intricate and complex shaped inserts used in the punch and die cavities. The material for the punch and die is normally pre-hardened or for reasons of dimensional stability, the cavities are cut after hardening. This renders the conventional machining process ineffective in dealing with such requirement. Typically, the hardness of the punch and die occurs in the range of 56 to 62 HRC. This poses a challenge for chip removal or metal cutting methods for machining. The other factor that poses a problem is also the fine and intricate profile required on the machined part with projections or cavities marked by sharp features on the inserts. This calls for precision machining operations to address the needs. Lastly, the accuracy sought is high, usually in the range of only a few microns, which may not be possible for conventional machining methods.
A suitable machining method in turn is optimized over the significant output or input parameters that would help to deliver a modest rate of productivity with the desired surface finish. A rough surface finish results in 'sticking' of the injection molded part during ejection which causes erosion of the die surface.

II. LITERATURE REVIEW

Yusuf Keskin, H. Selcuk Halkacı, Mevlut Kizil(1) investigated the effects of machining parameters on the surface roughness values of machined components by EDM experimentally. It is apparent that the surface roughness has an increasing trend with an increase in the discharge duration. This is mainly due to more discharge **energy** released during this time and expanding the discharge channel.
A. M. Nikalje & A. Kumar & K. V. Sai Srinadh (2) studied MDN 300 steel using Taguchi method. Maraging steel (MDN 300) exhibits high levels of strength and hardness. Optimization of performance measures is essential for effective machining. In this paper, Taguchi method, used to determine the influence of process parameters and optimization of electrical discharge machining (EDM) performance measures on MDN 300 steel, has been discussed. The process performance criteria such as material removal rate (MRR), tool wear rate (TWR), and surface roughness (SR) were

evaluated. Discharge current, pulse on time, and pulse off time have been considered the main factors affecting EDM performance. Surface morphological study indicates that at higher discharge current and longer pulse on duration gives rougher surface characteristics with more craters, globules of debris, and microcracks than that of lower discharge current and lower pulse on duration.

RAVINDER KATARIA* AND JATINDER KUMAR (3) studied AISI 01 Tool Steel. The effect of several process parameters such as tool nose radius, speed, feed and depth of cut on the machining performance of turning operation has been studied using AISI O1 tool steel as a work material. The machining characteristics that are being studied are material removal rate (MRR) and surface roughness (SR) of machined surface. Taguchi method is utilized for single response optimization.

Anup B. Patel, Krunal Shah, Divyang(4) have done Experimental Analysis and Optimization of Process Parameter in WEDM for Aluminum-6082 and found that Surface Roughness is affected by the combination of wire tension and pulse width, with both having maximum values highest is the roughness and with both having minimum value minimum is the roughness.

N. Tosun, C. Cogun, and A. Inan1(5) studied the variation of workpiece surface roughness with varying pulse duration, open circuit voltage, wire speed and dielectric fluid pressure was experimentally in Wire Electrical Discharge Machining (WEDM). Brass wire with 0.25 mm diameter and SAE 4140 steel with 10 mm thickness were used as tool and workpiece materials in the experiments, respectively. It is found experimentally that the increasing pulse duration, open circuit voltage and wire speed, increase the surface roughness whereas the increasing dielectric fluid pressure decreases the surface roughness. The variation of workpiece surface roughness with machining parameters is modelled by using a power function. The level of importance of the machining parameters on the workpiece surface roughness is determined by using analysis of variance (ANOVA).

R. Ramakrishnan , L. Karunamoorthy(6) studied the effect of various machining parameter such as pulse on time, wire tension, delay time, wire feed speed, and ignition current intensity has been studied though machining of heat-treated tool steel. It was identified that the pulse on time and ignition current intensity have influenced more than the other parameters considered in this study. Moreover the multiple performance characteristics such as material removal rate, surface roughness, and wire wear ratio for the WEDM process can be improved concurrently.

Yan-Cherng Lin &Ho-Shiun Lee(7) focused their attention on the effects of the novel process of magnetic-force-assisted EDM, and the optimizing machining parameters associated with multiple performance characteristics of magnetic-force-assisted EDM was determined using gray relational analysis. They observed that the topography of the machined surface was smoother than that of conventional EDM. Moreover, the thickness of recast layer and the surface cracks on the machined surface were significantly reduced in the magnetic-force-assisted EDM process. The machining parameters of magnetic-force-assisted EDM could be optimized for multiple performance characteristics. Moreover, MRR, EWR, and SR were greatly improved when the machining parameters were set at the optimal levels.

E. Aliakbari & H. Baseri (8) in their study determined, the optimal setting of the process parameters on rotary EDM. A total of three variables of peak current, pulse on time, and rotational speed of the tool with three types of electrode were considered as machining parameters. Then some experiments have been performed by using Taguchi's method to evaluate the effects of input parameters on material removal rate, electrode wear rate, surface roughness, and overcut. Moreover, the optimal setting of the parameters was determined through experiments planned, conducted, and analyzed using the Taguchi method.

J. Y. Kao & C. C. Tsao & S. S. Wang & C. Y. Hsu (9) In their paper, parameter of the electrical discharge machining process to Ti–6Al–4V alloy considering multiple performance characteristics using the Taguchi method and grey relational analysis was reported. Performance characteristics including the electrode wear ratio, material removal rate and surface roughness are chosen to evaluate the machining effects. The process parameters selected in this study were discharge current, open voltage, pulse duration and duty factor. The validation experiments shown an improved electrode wear ratio of 15%, material removal rate of 12% and surface roughness of 19% when the Taguchi method and grey relational analysis are used.

Venkata Rao & V. D. Kalyankar(10) observed in their review paper that the research on variety of materials was made using EDM process which includes large number of ceramics, composites, tool steels and various alloy steels including aluminium.

III. PROJECT OVERVIEW

3.1scope of work / objectives:

1. To study the importance of EDM for manufacturing inserts in Die-mold Industry
2. To study the significant process parameters for EDM through Literature Review.
3. Identify the input and the output parameters to be undertaken for this work
4. Assign the number of levels for the input parameters for conducting experiment to determine effect over the output (response) parameters like surface roughness, MRR, tool wear.
5. Perform analysis using Taguchi method/ ANOVA for the readings recorded during experimentation.
6. Optimal levels are determined from the Response tables and graphs derived to address surface roughness (Ra value)
7. Conduct Validation using physical experimentation.

3.2 proposed work

- For this case study we are using two different methodologies such as Statistical Method and Experimental Method.
- In statistical method, basic problem solving techniques are used. In this work, DOE (Design of Experiments) methodology was used for optimizing process parameters of EDM process.
- DOE includes following techniques
    - Historical data analysis
    - Taguchi analysis
    - Regression analysis
    - ANOVA analysis

3.2.1. Procurement of raw material

Procurement of raw material as per design of experiment (samples of workpiece material D2, Electrode material copper and dielectric fluid kerosene)

3.2.2. Experimentation/ validation:

Figure 2 shows the typical test setup for EDM Process. Workingat the beginning of EDM operation, a high voltage is applied across the narrow gap between the electrode and the workpiece. This high voltage induces an electric field in the insulating dielectric that is present in narrow gap between electrode and workpiece. This cause conducting particles suspended in the dielectric to concentrate at the points of strongest electrical field. When the potential difference between the electrode and the workpiece is sufficiently high, the dielectric breaks down and a transient spark discharges through the dielectric fluid, removing small amount of material from the workpiece surface.

Equipments

EDM machine has the following major parts
• Dielectric reservoir, pump and circulation system
• Power generator and control unit
• Working tank with work holding device
• X-y table accommodating the working table
• The tool holder
• The servo system to feed the tool

Figure.2 Typical Test setup for EDM Process

3.3.Experimentation

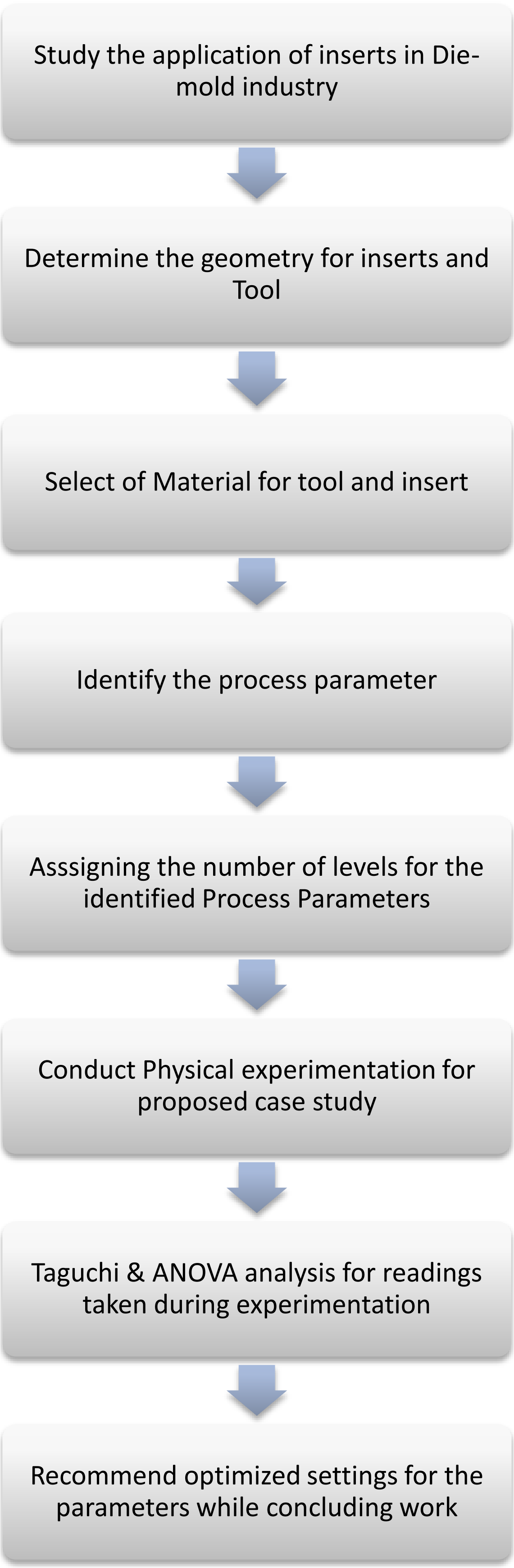
The effect of various input parameters were studied through the experimentation. All the factors were varied at 4 levels and the L16 orthogonal array is used for experimentation.

3.4.Analysis and results

For the analytical purpose Minitab 14 software shall be used. In this dissertation work we shall use the tools such as Taguchi Method/ANOVA/ Grey Relational Analysis/ Genetic Algorithm/ Regression Equation. For the Result analysis ANOVA is preferred. Results achieved are compared with results of experimental EDM.

International Journal of Scientific Research and Management Studies (IJSRMS)
ISSN: 2349-3771 Volume 2 Issue 7, pg: 300-307

IV. METHODOLOGY



V. CONCLUSION

Literature review also shows that machining by EDM is generally assessed on the basis of , Surface Roughness along with the TWR (Tool Wear Rate) & MRR (Metal Removal Rate),The Current, pulse-on time, workpiece material, and electrode material have a significant effect on surface roughness, besides other factors.

From the Literature Review it is found that Taguchi's method is used to obtain optimum parameters combination for desired surface roughness.

For Surface Roughness, the setting for the response shall be "smaller is better". The levels of significant factors which resulted in the minimum Surface Roughness shall be recommended.

The level of importance of machining parameters and their individual contributions on Surface Roughness is determined using Analysis Of Variance (ANOVA).

5.1 Expected Outcome

Using different statistical tools, the results would be giving the best desired Surface roughness(Ra-value) for the material D2 using Tool Material as Copper.

5.2 Facilities Available

5.2.1. A.G.P.I.T. Solapur

- Handbooks, reference books and E-journals are available at Central Digital Library.
- Computer facility, Internet facility and necessary softwares are available in the laboratory.

5.2.2. Able Technologies (I) Pvt. Ltd., Pune.

Following facilities are provided with the Able Technologies(I) Pvt. Ltd. Pune for the Technical Sponsorship for the assignment.

- Facility provided to observe and perform experiment set up for EDM.
- To observe different process parameters.
- Taking readings for the surface roughness.
- Library facility for books/ journals.

5.3. Validation:

Validating the surface roughness of the workpiece by comparing results obtained from experimentation with results of ANOVA analysis. The experimentation work for finding surface roughness will not be done; as it will required more time and also it is costlier. The surface roughness of workpiece is considered as a 'response' parameter for validation.

VI. FUTURE SCOPE (FOR HIGHER RESEARCH WORK)

1. Investigation of Ra value (Surface roughness) can be pursued using Response Surface Methodology (RSM) or Grey Relational Analysis (GRA).
2. Use of alternative materials for work-piece. E.g – HCHCr, OHNS
3. Use of alternative material for Electrode. E.g.- Graphite, Aluminium
4. The parameters like Di-electric fluid can be altered to record responses

REFERENCES

[1]. Yusuf Keskin, H. Selc¸uk Halkacı, Mevl ¨ut Kizil, (2006), "An experimental study for determination of the effects of machining parameters on surface roughness in electrical discharge machining (EDM)"; International journal of Advanced Manufacturing Technology (2006) 28: 1118–1121.

[2]. M. Nikalje & A. Kumar & K. V. Sai Srinadh,(2013), "Influence of parameters and optimization of EDM performance measures on MDN 300 steel using Taguchi method" International journal of Advanced Manufacturing Technology (2013) 69:41–49.

[3]. Ravinder Kataria And Jatinder Kumar,(2014), "A comparison of the different multiple response optimization techniques for turning operation of AISI O1 tool steel" Journal of Engg. Research Vol. 2 No. (4) Dec 2014 pp. 161-184.

[4]. Anup B. Patel,Mr. Krunal Shah, Mr. Divyang,(2014), " Experimental Analysis and Optimization of Process Parameter in WEDM for Aluminum-6082"; 2014 IJEDR Volume 3, Issue 1 | ISSN: 2321-9939 .
[5]. N. Tosun, C. Cogun And A. Inan,(2003), "The Effect Of Cutting Parameters On Workpiece Surface Roughness In Wire EDM"; Machining Science And TechnologyVol. 7, No. 2, Pp. 209–219, 2003.
[6]. R. Ramakrishnan , L. karunamoorthy, (2006), "Multi Response Optimization Of Wire EDM Operations Using Robust Design Of Experiments"; International Journal Of Advanced Manufacturing Technology (2006) 29: 105–112.
[7]. Yan-Cherng Lin &Ho-Shiun Lee,(2009), "Optimization Of Machining Parameters Using Magnetic-Force-Assisted EDM Based On Gray Relational Analysis" ; International Journal Of Advanced Manufacturing Technology(2009) 42:1052–1064.
[8]. E. Aliakbari & H. Baseri,(2012), "Optimization of machining parameters in rotary EDM process by using the Taguchi method"; (2012) 62:1041–1053.
[9]. J. Y. Kao & C. C. Tsao & S. S. Wang & C. Y. Hsu,(2010), "Optimization of the EDM parameters on machining Ti–6Al–4V with multiple quality characteristics"; International Journal Of Advanced Manufacturing Technology (2010) 47:395–402.
[10]. R. Venkata Rao & V. D. Kalyankar,(2014), "Optimization of modern machining processes using advanced optimization techniques: a review" ; International Journal Of Advanced Manufacturing Technology (2014) 73:1159–1188

BIOGRAPHY

Javed MujawarM.E (Mechanical) A.G.Patil Institute of Technology, Solapur, Maharashtra, India.

V.V.Potdar is presently working as Professor of Mechanical Engineering & Vice-Principal at A.G. Patil Institute of Technology, Solapur, Maharashtra, India. He has completed his Graduate and Post-Graduate studies in Mechanical Engineering from Karnataka University, Dharwad and Shivaji University, Kolhapur respectively. Presently, he is carrying out his Ph. D. Research at JNTU, Hyderabad, in the area of Computational Fluid Dynamics(CFD) Applications. He has a rich experience of over 30 years in the field of Teaching, Research and Industrial consultancy He has published number of research papers in National and International journals and in National and International conferences. He is a Senior Member of professional organizations like, IEI(India),ISTE,ISHRAE,ISME,CSI. He is a Chartered Engineer. His main areas of research are CAD/CAM/CAE/CFD

Swapnil S.Kulkarni Director, Able Technologies India Pvt. Ltd., Pune. The Company offers Engineering Services and Manufacturing Solutions to Automotive OEM's and Tier I and Tier II Companies. He is a Graduate in Industrial Engineering with PG in Operations Management. With around 20 years of working experience in the domain of R&D, Product Design and Tool Engineering, he has executed projects in the Automotive, Medical and Lighting Industry. His area of interest is Research and Development in the Engineering Industry as well as the emerging sector of Renewable Energy.