ABSTRACT

Machining is an important and inherent pre-requisite operation to shape any engineering part. Almost all conventional machining processes make use of a cutting tool which is harder than the workpiece to remove material in the form of chips. However, use of such conventional processes for machining modern hard materials is not only time consuming and costly but also it results into poor surface finish and shorter tool life. So, nowadays the non-conventional machining (NCM) processes are increasingly used in manufacturing industries for machining of difficult-to-machine materials. Electrical discharge machining (EDM) is one of the important NCM processes. EDM is a very crucial technology for the precision machining of complex and intricate shapes. However, it suffers from limitations like low machining efficiency and poor surface quality. So, attempts have been reported to improve the machining efficiency and surface quality of EDM technology to make it competitive as against other machining techniques. The literature available on EDM helps for better understanding about the process developments and performance improvements. It is noticed that not only electrical parameters but also several non-electrical parameters influence the EDM performance to a great extent. In this context, powder mixed EDM (PMEDM) is one of the latest advancement showing the potentials of performance improvement along with good process stability. The good EDM process stability means a few occurrence of arc or short-circuits as a consequence of the proper flushing of eroded particles.

Hence, detailed literature review was carried out to find the significance of various input process parameters of PMEDM. It is observed that the key interest of EDM researchers is focused on process parameters optimization leading to higher rate of metal removal with excellent surface finish and low tool wear. Applications of various optimization techniques for single and multiple responses are also reported for PMEDM process parameters. After an elaborate and comprehensive scrutiny of the published work on PMEDM, the gaps in this area have been identified as follows:

- No guidelines are available for proper selection of powder to known workpiece-electrode combination.
- Most of PMEDM studies have not considered the effect of tool rotational motion on the process performance.
- Dynamic jet flushing with moving nozzles has not been tried by earlier researchers.
- Multi-response optimization of PMEDM process is another thrust area which has been given less attention.
• Aluminum powder is not attempted for PMEDM of AISI D2 steel which is the most
commonly used material by many tool and die making industry.

The present study demonstrates the application of Taguchi method and covers
detailed PMEDM experimental investigations of AISI D2 steel in three stages. It is known
that the time duration between the EDM sparks allow the molten material to solidify and get
washed out the spark gap. If the off-time is too short, it will cause sparks to be unstable.
Therefore, for this experimentation, special experimental setup was developed to achieve a
stable process. It consist of small, specially designed machining tank, lateral dynamic jet
flushing mechanism, dielectric fluid stirrer system, magnetic filter unit and rotary tool
attachment. MRR, RWR and SF were the three important performance measures selected as
they represent and also govern the overall effect of input parameters on machining system
consisting of process-tool-workpiece. Stage-1 covers investigations of three powders (viz.
Aluminum, Silicon and Graphite) for AISI D2 steel under varying machining conditions for
two performance measures viz. MRR and RWR, Stage-2 covers investigations with three tool
materials (viz. Copper, Brass and Aluminum) for AISI D2 steel under varying machining
conditions and Stage-3 covers investigations of three diameters of copper tool (viz. 12, 16
and 20 mm) for AISI D2 steel under varying machining conditions for MRR, RWR and SF.
At the end of first stage it was found that Aluminum powder improves MRR and lowers
RWR which is less than that of Silicon and Graphite powders. Hence, only Aluminum
powder with varying concentration was selected for second stage of experimentation. In the
second stage, it was found that Copper tool improves MRR and lowers RWR as well as SF.
Hence, Copper tool with varying diameter was tried in the third stage. In the third and final
stage of experimentation, it was found that Copper tool with varying diameter has major
effect on MRR, RWR and SF. Process stability of Stage-3 was assessed by generating control
chart and observing arcing/short-circuiting. The optimal machining parameters and the
relative influence of each parameter on the MRR, RWR and SF were determined by
analyzing the experimental data using Analysis of S/N ratios and ANOVA. This work also
presents the multi-response optimization of the PMEDM process for an optimal parametric
combination to yield the maximum MRR, minimum RWR and better surface finish using a
combination of grey relational analysis (GRA) and Taguchi method. The predicted and
experimental values of GRA are almost matching which shows the validity of results
obtained. These results will be useful for the EDM industry for improving productivity and
stability of the process.