ABSTRACT

The best choice of manufacturing conditions is one of the prime factors that has to be envisaged in the common manufacturing processes, especially, in those associated with Electrical Discharge Machining (EDM) and Wire Electrical Discharge Machining (WEDM). Such a process should be capable of machining geometrically complex or hard material components that are precise and difficult-to-machine such as heat-treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. That are being widely used in dies and mould-making industries, aerospace, aeronautics and nuclear industries.

In the booming mechanical industry, the difficulty for tool steel materials having high hardness, toughness and impact resistance are increasing. Wire EDM machines are used to cut conductive metals of any hardness that are difficult or impossible to cut with traditional methods. These machines also specialize in cutting complex contours or fragile geometries that would be difficult to be produced using conventional cutting methods. Machine tool industry has made exponential growth in its manufacturing capabilities in the last decade but still machine tools are not utilized at their full potential. This limitation is a result of the failure to run the machine tools at their optimum operating conditions. The problem of arriving at the optimum levels of the operating parameters has attracted the attention of the researchers and practising engineers for a very long time.
The literature survey reveals that little research has been conducted to obtain the optimal levels of machining parameters that yield the best machining quality in machining of difficult to machine materials like T90Mn2W50Cr45 tool steel.

The T90Mn2W50Cr45 tool steel is extensively used for hot-work forging, extrusion, manufacturing punching tools, mandrels, mechanical press forging die, plastic mould and die-casting dies, aircraft landing gears, helicopter rotor blades, shafts etc.

The consistent quality of parts being machined in electrical discharge machining and wire electrical discharge machining is difficult because the process parameters cannot be controlled effectively. These are the biggest challenges for the researchers and practising engineers. Manufacturers try to ascertain control factors to improve the machining quality based on their operational experiences, manuals or failed attempts. Keeping in view, the applications of the T90Mn2W50Cr45 tool steel, it has been selected and experiments are conducted with that tool steel on EDM machine (Make: EMS 5030) Massive Engineering Private Limited and wire-cut EDM (Elektra Sprint cut 734) from Electronic Machine Tools Limited. The main objective of this research is to select the new work piece material (T90Mn2W50Cr45 cold tool steel) alternate for the conventionally used hard tool steel AISI series, composite materials and to study its suitability for the EDM and WEDM processes. This research work is carried out to investigate the effect of the various process parameters on electrode wear, material removal rate, wire wear rate, surface roughness and rapidly resolidified layer thickness of
the above said base material in EDM and WEDM processes. RSM (Response Surface Methodology), SEM (Scanning Electron Microscope) analysis, Artificial Neural Network (ANN) and Optimization process using desirability approach are used to obtain the optimal sets of process parameters so that the process parameters can be optimized to get the desired responses of maximum material removal rate and minimum surface roughness.

20 experiments are conducted by applying the combination of different process parameters, developed by Design Matrix, in EDM. Similarly, 31 experiments are conducted by executing the various combination of process parameters, developed by Design Matrix in WEDM.

Experimentally observed and theoretically predicted responses for the 20 experiments conducted in EDM are analysed and the experiment that gives optimum response is found out. Similarly, the optimized experiment No. for WEDM process is also found out from the 31 experiments conducted.

ANN has been trained and implemented using a fully developed feed forward back propagation neural network to evaluate the error profile of responses in both EDM and WEDM. Based on these studies the following important conclusions are arrived as

- Optimized condition for the EDM process is being found out in the experiment No.2 and corresponding process parameters are pulse current of 5A, pulse on time of 42μs and pulse off time of 3μs. The experimental observations, predicted values and also from the SEM analysis, it is concluded that
experiment No.2 and corresponding process parameters are the best combinations.

- The experimental observations, predicted values and also from the SEM analysis, it is concluded that experiment No.14 and the combination of parameters of peak current of 170A, pulse on time of 120μs, pulse off time of 48μs and wire tension 6g gives optimized response of maximum material removal rate and minimum surface roughness.

The use of alternative work piece material, T90Mn2W50Cr45 tool steel for different industrial applications to replace the hot tool steel material is investigated.

The present research substantiates that low surface roughness improves the surface finish. A higher value of pulse current results in better material removal rate when compared to a lower value of pulse current. By altering the parameters of pulse current, pulse on time and pulse off time, the optimum condition of higher material removal rate and low electrode wear are achieved.