ABSTRACT

Wire electrical discharge machining (WEDM) has become a significant non-conventional machining process which is being extensively used in aerospace, nuclear, die and tooling, and automotive industries, for machining difficult-to-machine materials. Wire cut EDM is used to machine any electrically conductive material irrespective of its hardness. Being such an important process in manufacturing industry, WEDM is considered for exploration in the present work.

In general, the performance of any machining process is based on choosing the right combination of machining variables. In WEDM, the improper settings of machining variables lead to serious consequences like short-circuiting of wire and wire breakages, besides affecting the production rate and the quality of machined components. However, the selection of right settings for these parameters in WEDM is difficult as it is a complex and highly stochastic process in nature.

In the present work, five major performance measures of WEDM, namely, surface roughness (SR), cutting rate (CR), dimensional deviation (DD), gap current (GC) and wire wear ratio (WWR) are analyzed and optimized as they significantly affect the productivity and the quality of components.

In this work, experimentation is carried out on powder metallurgical cold worked tool steel (VANADIS-4E) as it has influential applications in diversified manufacturing industries. Extensive applications of this material are due to good combination of wear resistance and ductility for high performance tools.

WEDM process includes an extensive number of variables that influence its execution. However, based on the literature survey and the pilot experiments, six process variables, viz., pulse-on time, pulse-off time, peak current, spark gap set voltage, wire tension and water pressure are taken into consideration.

The different steps of experiments and the techniques used for the experimentation are as follows:

Step 1

The investigation is carried out to find out the working ranges and the levels of the WEDM process parameters (pilot experiments) affecting the selected quality characteristics, by using One Factor at a Time approach (OFAT).
Step 2

➢ Investigation of the effects of WEDM process parameters on quality characteristics viz. surface roughness, cutting rate, dimensional deviation, gap current and wire wear ratio while machining VANADIS - 4E.

➢ Optimization of quality characteristics of machined parts:
  • Prediction of optimal sets of WEDM process parameters
  • Prediction of optimal values of quality characteristics
  • Prediction of confidence interval (95% CI)

➢ Experimental verification of optimized individual quality characteristics

The Taguchi’s parameter design approach has been used to obtain the above objectives.

Step 3

➢ Empirical models are developed for quality characteristics viz. surface roughness (SR), cutting rate (CR), dimensional deviation (DD), gap current and wire wear ratio (WWR) from experimental data using Response Surface Methodology (RSM). The developed models are tested for their accuracy and adequacy using statistical methods.

The Box Behnken Design (BBD) has been used to plan the experiments and the input parameters like pulse on time, pulse off time, peak current, spark gap set voltage, wire tension and water pressure are varied to ascertain their effects on the responses.

Step 4

➢ Development of multi objective optimization models using desirability function

➢ Determination of optimal sets of WEDM process parameters for desired combinations of quality characteristics

➢ Experimental verification of quality characteristics optimized in different combinations.
In summary, the planned approach empowers the engineers to find the optimal process parameter settings based on the manufacturing requirements. Subsequently, the procedure could be mechanized in view of the ideal settings.