

ABSTRACT

The current research focused on the machinability investigation of duplex stainless steel (DSS) 2205 under different types of cooling environments e.g. dry, flood (wet), MQL, cryogenic (LCO₂), and MQL-LCO₂. TiAlN-coated solid carbide drill was used for drilling DSS 2205 because DSS has 31 HRC, so it is difficult to cut material.

The present research is divided into three phases. In the first phase, experimental investigation was carried out on DSS 2205 under dry, and wet conditions with TiAlN coated solid carbide drill. The set of experiments is made by using the design of experiment (DOE) Taguchi method. For the design of the experiment, select three input parameters e.g. machining environment, spindle speed, and feed rate while Ra is a response variable. Total L8 set of experiments generated by the orthogonal array (OA). After parametric optimization, the optimal process parameters, e.g. high spindle speed, low feed rate, and wet cooling condition, were obtained. The mean effect plot and ANOVA are utilized to study the parametric influence on performance outcomes. Furthermore, a confirmation test was carried out to compare the experimental value to predicated value.

In the second phase, experimental work was carried out under dry, MQL, and LCO₂ cooling conditions. In this section, for the design of the experiment, select three input parameters e.g. spindle speed, feed rate, and cooling environment (dry, MQL, & LCO₂) while surface roughness (Ra) and hole deviation as response variables. For the experimental design and parametric analysis, the Taguchi method in Minitab software. In the present investigation, the orthogonal array (OA) gives a total L9 set of experiments. After parametric optimization, it was observed spindle speed is the most contributing factor for both responses. ANOVA is utilized for mean effect plots and to study the parametric influence on performance outcomes. Furthermore, a confirmation test was carried out to compare the experimental value to predicated value Further, the genetic algorithm (GA) is implemented to optimize the value of responses and the optimal value of process parameters by using

MATLAB software. After implementing GA, it was observed the optimal value 0.375271, 0.0207519 for surface roughness and hole deviation, respectively.

In the third or last phase, experimental investigation under a hybrid MQL-LCO₂ cooling condition. MQL-LCO₂ cooling condition is the combination of MQL-LCO₂ for improving the machinability of DSS 2205. In this phase, for the design of the experiment, select three input parameters e.g. drill diameter, spindle speed, and feed rate while hole deviation, cylindricity error, and circularity error as response variables. For experimental design and parametric optimization, the Box-Behnken design of the response surface method (RSM) is utilized in Minitab software. The orthogonal array (OA) gives a total L15 set of experiments. From the ANOVA analysis, it was observed that spindle speed was a significant contributor to 39.90% and 52.41% for hole deviation and cylindricity error, respectively. In term of circularity error, the feed rate is the most effective parameter, contributing 34.73%.

Further, parametric modeling through ANN, FLS, RSM, and ANFIS. The experimental value compared to predicated model value e.g. ANN, FLS, RSM, and ANFIS. After comparing the experimental value to predicated model value, it was observed that a minimum % of error was found by using ANFIS. Finally, TOPSIS (technique for order performance by similarity to ideal solution) is implemented to decide the rank of the experiment, which provides the optimal value of responses.

Keywords: Machinability, environmental friendly machining, cryogenic machining, Taguchi, ANN, FLS, RSM, GA, ANFIS, TOPSIS.