Application of ANFIS for the Selection of Optimal Wire-EDM Parameters While Machining Ti-6Al-4V Alloy and Multi-Parametric Optimization Using GRA Method

Sandeep Kumar, Department of Mechanical Engineering, M. K. Kumarasamy College of Eng., Karur, India
S. Dhanabalan, Department of Mechanical Engineering, M. K. Kumarasamy College of Eng., Karur, India
C. S. Narayanan, Department of Production Engineering, Trichy, India

ABSTRACT

The applications of artificial intelligence (AI) are becoming more popular and relevant research have been conducted in every field of engineering and science by using these AI techniques. Therefore, this research aims to examine the influence of wire electric-discharge machining (WEDM) parameters on performance parameters to improve the productivity with a higher surface finish of titanium alloy (Ti-6Al-4V) by using the artificial intelligent technique. In this experimental analysis, the Adaptive Network Based fuzzy Inference System (ANFIS) model has been highly-developed and the multi-parametric optimization has been done to find the optimal solution for the machining of the titanium superalloy. The peak current (I_p), taper angle, pulse on time (T_on), pulse of time (T_off) and the dielectric fluid flow rate were selected as operation constraints to conduct experimental trials. The surface roughness (SR) and MRR were considered as output responses. The influence on machining performance has been analyzed by an ANFIS model and the developed model was validated with the full factorial regression models. The developed models showed the minimum mean percentage error and the optimized parameters by the GRA method showed the considerable improvement in the process.

KEYWORDS

ANFIS, Artificial Intelligence Techniques, GRA, Titanium Alloy, Wire-EDM

1. INTRODUCTION

Non-conventional machining processes are the requirements of the fastest growing industries because of the precision, complex, intricate shape of the work material, higher tolerances and economically. Hard materials and super alloys such as titanium alloys, tungsten carbides, high carbon tool steels generally used in tool industries, automotive and electronics industries, medical and aerospace are very difficult–to-machine by conventional manufacturing processes. Therefore, the ease of material

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cutting and machining non-conventional machining is preferred. WEDM is generally used to produce complex shapes die cavities and forming tools, fixtures, gauges, etc. which are difficult to produce by means of any other conventional and non-conventional machining methods except micro-machining (Sommer & Sommer, 2016).

Titanium alloys (Ti-alloys) are mostly utilized in aerospace and automotive industries to manufacture higher precision components. Ti-6Al-4V grade 5 titanium alloy is used for the manufacturing of diesel engine components such as connecting rods, gas turbine parts, intake valves, etc. and this alloy covers the 50% of total global consumption (Veiga, 2012).

WEDM is a variation and development of EDM. In 1969, the Swiss firm Agie developed and delivered the world’s initially WEDM machine. These machines had machining ability to cut the material about 21 mm²/min. per hour. These machines were extremely slow in production rate. After the continuous improvements in the machining ability, the machining speed improved. WEDM removes material from the work metal with the use of electricity by means of spark erosion as shown in Figure 1. It is most important requirement that the work material should be electrically conductive. AC serve motors are exploited to provide positioning, stability and enhancement of wire tension. A DC or AC servo mechanism maintains the gap (0.051 to 0.076 mm) between the electrode and the work material. This maintained gap prevents the short circuiting of wire.

‘Dielectric’ is the shield between the wire electrode and material. De-ionized water is generally used as a dielectric medium because the dielectric medium acts as an insulator. In this process, the material is submerged in the dielectric medium. When the voltage is applied, the electric pulses are generated, fluid ionizes and a spark generates between the electrode wire and work material, the controlled spark precisely erodes the metal from the work material causing it to melt and vaporize. Pressurized dielectric fluid flows continuously. It cools the vaporize material and carry away the particles from the cutting section. The dielectric passes through the filter to remove suspended particles and it is used continuously. Chillers are used to maintain the temperature of dielectric fluids for higher machining efficiency and accuracy. In WEDM the wire electrode never comes in contact with the work piece, therefore this process is stress free cutting operation (Sommer & Sommer, 2013; Kumar & Subramani, 2018; Anwar et al., 2017; Miller et al., 2004).

Various researchers have been reported work on WEDM to measure the influence of input parameters on performance parameters such as, Y. S. Liao et al., (1997) reported the influence of Wire-EDM constraints such as ‘on time’ (T_on), ‘off time’ (T_off) and feed rate on the behavior of pulse train i.e. short ratio, arc ratio, normal ratio and gap width. Experiments were conducted on SKD 11

Figure 1. Working principle of WEDM
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