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Analysis for optimal decisions on turning Ti–6Al–4V with Taguchi–grey method

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Abstract

The problem of machining titanium is one of the ever-increasing magnitudes due to its low thermal conductivity and work-hardening characteristic. In the present work, experimental studies have been carried out to obtain the optimum conditions for machining titanium alloy. The effect of machining parameters such as speed, feed, depth of cut and back rake angle on cutting force, and surface roughness were investigated. The significance of these parameters, on cutting force and surface roughness, has been established using the analysis of variance. The degree of influence of each process parameter on individual performance characteristic was analyzed from the experimental results obtained using the grey relational grade matrix. The back rake angle was identified as the most influential process parameter on cutting force and surface roughness. The cutting speed is identified as the most significant parameter for the turning operation according to the weighted sum grade of the cutting force and surface roughness.

Keywords

Cutting forces, surface roughness, Taguchi–grey relational analysis, analysis of variance

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Introduction

As compared to steels or aluminum alloys, titanium alloys must be considered a much younger structural material. The first alloys were developed at the end of the 1940s in the United States. Among these was the classic titanium alloy, Ti–6Al–4V, which still captures a large portion of aerospace applications today. The outstanding properties of titanium alloys include high specific strength and excellent corrosion resistance. Therefore, the titanium alloys are found in aerospace applications where the combination of weight, strength, corrosion resistance, and/or high temperature stability of aluminum alloys, high strength steels, or nickel-based superalloys are insufficient.

Superalloys such as titanium, Inconel, and nickel are attractive for many engineering applications due to their high strength at elevated temperatures, wear resistance, and low density. The effective use of these materials in such functional applications demands the machining of these alloys with low cutting force and good surface finish. The main problems concerning the use of these alloys in industry are the complexity involved in the machining because of their high harness, low thermal conductivity, and also the high cost of machining. Thus, the advancements in alloys processing and manufacturing technology, in addition to process optimization will be necessary for the commercialization of these alloys.

Titanium alloys have a specific weight of about two-thirds than that of steel and about 60% higher than that of aluminum. In tensile and sheet stiffness, titanium falls between steel and aluminum. But, titanium's strength is far greater than that of many alloy steels, giving it the highest strength-to-weight ratio when compared to any of today's structural metals. Titanium alloys have high melting points, which is usually a sign of excellent temperature stability. In view of these properties, the usage of titanium alloy has been increased in day-to-day life in heat resistant parts. Titanium alloys have high melting points, which is usually a sign of excellent temperature stability. Ti–6Al–4V is one of the most widely used titanium alloys, which is an α–β type containing 6 wt% of aluminum and 4 wt% of vanadium.[1] Lalwani et al.[2]

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