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Procedia Technology 24 (2016) 399 – 405

Procedia Technology

International Conference on Emerging Trends in Engineering, Science and Technology (ICETEST - 2015)

Optimization of Process Parameters for Increasing Material Removal Rate for Turning Al6061 Using S/N ratio

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Abstract

Modern industries strive to improve the quality of their product by choosing proper materials and methods. Selection of materials of high strength to weight ratio like aluminum and setting of optimum machining parameters ensures the desired quality of product at affordable cost. Industries look for high productivity and better surface finish in machining operations which depends on process parameters. In this article the process parameters such as feed rate, cutting speed and depth of cut are selected to optimize the material removal rate in turning of Al-6061. The analysis is carried out using signal to noise ratio for predicting optimum process parameters. The effect of process parameters on material removal is discussed in this article.

Peer-review under responsibility of the organizing committee of ICETEST – 2015

*Keywords:*Al6061; Material removal rate ; Turning Process; S/N ratio; ANOVA

1. Introduction

Aluminium used in variety of applications such as automobile and aerospace components, missile parts, storage containers, marine applications, etc. This being a light weight material possesses excellentcorrosion resistance, thermal and mechanical properties, has replaced steel in many engineering applications. Its high strength to weight ratio and low specific cutting energy (0.4 - 1.1 Ws/mm^3) has made this material as the best in automobile industry. Al 6061 is heat treatable material which has gained importance in the manufacturing industries.In this view there

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Peer-review under responsibility of the organizing committee of ICETEST – 2015
doi:10.1016/j.protcy.2016.05.055

Nomenclature

A Cutting Speed (m/min)
B Feed (mm/rev)
C Depth of Cut (mm)
Ra Surface roughness µm
SN Signal to Noise ratio
n Total number of trial runs at i^{th} setting
y_i Value of the response at i^{th} setting
k Total number of replications.
DF Degrees of freedom
SS Sum of squares
MS Mean sum of squares
F Fisher's Number
d Confidence interval
η_{eff} Effective sample size

have been many attempts by researchers to optimize the manufacturing process either by improving the composition of the material or by selecting proper process parameters for machining. Machinability is the ease with which the material is machined. The performance measure of machinability includes MRR, specific energy consumption, surface finish, tool life and chip flow pattern (Songmene et. al, 2011). To enhance certain properties aluminum is alloyed with copper, manganese, silicon, magnesium, zinc, etc. Aluminium alloys with magnesium and silicon are designated by 6XXX series. Al6061 has excellent mechanical properties and corrosion resistance (Xuewu Lia,2015). It also exhibits good weldability (Omega Research, 2002). There are cited literatures on optimization of the machining parameters which has the focus on surface roughness. The effect of process parameter like cutting speed, feed rate, depth of cut, amount of lubrication, type of tool, tool overhang and ageing of work material are investigated. The surface integrity effects of turned Al 6061 and Al6061-T6 is studied by Tohet. al. (2004). Sreejith (2008) found that machining with minimum quantity lubricant improved machinability compared with dry or flooded lubricant machining. Mukesh Kumar et. al. (2009) studied the effect of speed, feed rate and depth of cut using a coated carbide tool on Al6061-t4. HalilDemir et al (2009) investigated the effect of artificial ageing of aluminum on the surface finish of Al6061. Authors have reported the effect of ageing and cutting speed on the surface roughness. Optimization of cutting parameters was made by Carmita (2013) to minimize the energy consumption in turning process. Higher feed rate was found to reduce energy consumptionbut it increased the surface roughness. The influence of tool overhang on surface roughness was studied by Vinod et. al. (2014). The authors have reported that too small or too large overhang lead to poor surface finish. If the surface finish is within the acceptable range, it is desirable to improve the production rate by increasing MRR. In consideration of these factors, the present work attempts to optimize the process parameters to improve the MRR and hence productivity.

2. Experimental set up and methods

Figure 1 shows the experimental setup used in the present work. Al6061 work pieces of diameter 40 mm and length 150 mm were used in the experiments. The cutting tool used is SiC insert. Al6061 contains 95% Al along with the traces of other elements like Fe, Si, Cu, Mn, Mg, Cr, Ti and Zn. Figure 2 shows the sample work pieces machined.The process parameters such as cutting speed, feed and depth of cut were chosen with each parameter having three levels as shown in the Table 1. Settings for levels of each process parameter is chosen based on the pilot study. For the present experimental condition the best suitable design is Taguchi's L_9orthogonal array which is shown in Table 2. Taguchi's orthogonal array enables the researchers to conduct the minimum number of experiments by optimum use of resources. Experiments were conducted with two replications with the supply of coolant SAE 40. The material MRR obtained in each run is determined by the weight loss method and corresponding values of MRR are shown in Table 2. The analysis is carried out using S/N ratio for Higher the Better (HB) criteria using the formula as given below. The SN ratio obtained in each run is also shown in Table 2.The