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Optimization of cutting parameter for Surface Roughness, Material Removal rate and Machining Time of Aluminium LM-26 Alloy

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Abstract*— The purpose of this research was to investigate the effect of the various parameters like machine tools, cutting tools material, tool geometry and cutting parameters. In manufacturing system, the variations in input process parameters such as speed, feed and depth of cut affects seriously the surface roughness, material removal rate and machining time of the Aluminium LM-26 alloy which affect the performance of manufacturing process. The purpose of this research is to conduct a study on the effect of milling and turning parameters on manufacturing processes of parts of Aluminium LM-26 alloy and to find out its mathematical model, its validation by ANOVA. Also to find out the optimized parameter levels of milling and turning which give optimize parameters by using Taguchi Design of Experiment.

***Index Terms*— Tool geometry, machine tools, cutting tools material, ANOVA, Taguchi Design of Experiment, Aluminium Alloy LM-26.**

I. INTRODUCTION

In automotive industries Aluminium alloys are extensively used as a main engineering material. In the industries such as mould and the die components manufacturing aluminum is extensively used as well. In such industries, surface roughness is an important parameter, which is a measure of product quality because it greatly affects the performance of mechanical parts as well as production cost. In addition, another factor, which affects the surface quality, was PRAMCs that is produced through milling of particle reinforced Aluminum matrix composites, which is one of the most important parameter, which affects the practical performance of the components. There is a trend of carrying out the optimization of parameters of production processes. It is necessary to optimize the parameters of production processes. It is not only necessary but also mandatory to find out and record the optimizations of machining parameters for alloys of metals.

Now days, the high-speed machining processes are of growing industrial interest, because this not only allow for larger material removal rates, but also because they may positively influence the properties of the finished work-piece material [1]. To shape the Aluminium alloys, milling is one of the most commonly used machining processes. Shaping is finishing step in the fabrication of industrial mechanical parts and hence it has considerable economic importance, because they may cause some critical problems such as the deterioration of surface quality, which reduce the product durability and precision [2]. Surface roughness is an important parameter which affects the product quality because it has an impact on the mechanical properties like creeps life, corrosion resistance, fatigue behavior, etc. To surface finish of desired level is obtained by using only proper selection of cutting parameters, and there have been many great researches developed in modeling surface roughness and optimization of the controlling parameters since it can produce a better surface finish.

In industrialized countries, the value of manufactured products contains 20 % of cost of machining amounts used in the production. Therefore, researchers are focusing on factors such as the cutting force, surface roughness, stress–strain analysis, which are the modeling and simulation techniques. These techniques are used to predict and optimize certain machining parameters. These techniques do not need to perform many experimental tests that will cost a lot of money and are time consuming [3].

II. WHY ALUMINIUM?

The main properties of Aluminium are lightweight, strength, recyclability, corrosion resistance, durability, ductility, formability and conductivity, which make them valuable material. Due to this unique combination of properties, the variety of applications of Aluminium continues to increase.

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Aluminium alloys contains the typical alloying elements, such as copper, magnesium, manganese, silicon and zinc and in which Aluminium (Al) is the predominant metal. There are two principle classifications of Aluminium alloys; casting and wrought alloys. Wrought Aluminium alloys have excellent machine-ability and while cast alloys causes, some machining difficulties because it contains copper, magnesium or zinc as the main alloying elements, both of which are further subdivided into the categories such as heat-treatable and non-heat-treatable.

Aluminium LM-26 alloy is mainly used in pistons of petrol and diesel engines. And, to urgently machine this alloy, by taking into consideration the optimized parameters, we can within no time manufacture the components made up of this alloy. Hence, we can save time, labor, and money and machine hours while producing parts made up of this Aluminium alloy. Contents of Aluminium LM-26 alloy is; Copper (2-4%), Magnesium (0.5-1.5%), Silicon (8.5-10.5%), Iron (1.2% max), Manganese (0.5% max), Nickel (1% max), Zinc (1% max), Lead (0.2% max), Tin (0.1% max), Titanium (0.2% max), and Aluminium (Remainder).

III. LITERATURE REVIEW

A brief review of literature on roughness modeling in milling is presented in this section. Lou MS, Chen JC, Li CM in [4] developed the Surface roughness prediction technique for CNC end milling. In this paper they explained the mathematical model of surface roughness for the end milling for 190 BHN steel. They consider only the center line average roughness parameter in terms of cutting speed, feed rate and depth of cut using response surface method. After that they studied the effect of spindle speed, feed rate and depth of cut on roughness in end milling of Aluminium work piece. They used in-process surface roughness recognition and a neural fuzzy system to predict the roughness [5].

Moaz H. Ali el at [6], developed Finite Element Modeling (FEM) to predict the effect of feed rate on surface roughness with cutting force during face milling of titanium alloy. In this paper, focus is on the effect of feed rate (f) on surface roughness (Ra) and cutting force components (Fc,Ft) during the face-milling operation of the titanium alloy (Ti–6Al–4V) and several tests are performed at several feed rates (f) while the axial depth of the cut and cutting speed remain constant in dry cutting conditions. Results showed that one could predict the surface roughness by measuring the feed cutting force instead of directly measuring the surface roughness experimentally through using the finite element method to build the model and to predict the surface roughness from the values of the feed cutting force. The accuracy of both values of the cutting force for the experimental and predicted model was about 97%.

A. Y. Mustafa el at [7], tested the effect of cutting parameters and work piece length on the geometric tolerances and surface roughness in turning operation. In this work, the geometric tolerance and surface quality of an Aluminium piece, produced by turning, is analyzed. The effect of the length and diameter of working piece, cutting depth and feed were also investigated. The cutting speed, which is an important machining parameter, was kept constant in this study. Going from past works experience the effect of cutting speed was ignored. Statistical method of Taguchi was used in this work in order to obtain more reliable and optimum results

IV. METHODOLOGY

In this section, NOVA analysis is performed and experimentally it is observed that when different type of analysis methods such as Taguchi's methods,Regression Analysis etc are used then we get accurate results.Taguchi‘s comprehensive system of quality engineering is one of the greatest engineering achievements of the 20th century. His methods focus on the effective application of engineering strategies rather than advanced statistical techniques. It includes both upstream and shop-floor quality engineering. In the present work Taguchi‘s parameter design approach is used to study the effect of process parameters on the various responses of the dry milling of AL-Alloys. The Taguchi philosophy and its associated experimental design method have been extensively used in the manufacturing environment to improve production processes.

Taguchi Design was applied in planning and conducting the experiments. In performance analysis we analyze the experimental data by using Minitab 16 software. Generally S/N ratio and ANOVA analysis are the tool used for analysis purpose which measures the performance and contribution of individual process parameters towards the surface roughness, material removal rate and machining time. The regression model was postulated in obtaining the

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relationship between surface roughness, material removal rate, machining time and the input process parameters. Finally, the comparison between experimental and predicted values of the response was carried out.

V. EXPERIMENTAL ANALYSIS

1) Desired parameter for surface finish has-been achieved

The main parameters that affects surface roughness (SR), material removal rate (MRR) and machining time (MT) have been identified analyzed under different conditions and finally optimized. The main parameters being cutting speed feed rate, and depth of cut and nose radius. Based on the experimental results, S/N and ANOVA analysis is performed, Regression analysis based Mathematical model is developed for the optimization of machining parameter of Al-Alloy (LM-26), the conclusions have been arrived to obtain optimal machining parameters to achieve better surface finish characteristics during milling.

The surface roughness in the milling process has been measured for machining of Al-Alloy (LM-26) under different cutting conditions with a end mill cutter using Taguchi‘s orthogonal array. Comparison of the experimental and analytical results has been carried out. In this project, we only studied the literature which are collected and we come to this conclusion that, if wechange cutting paratmeters the surface finish also changes.

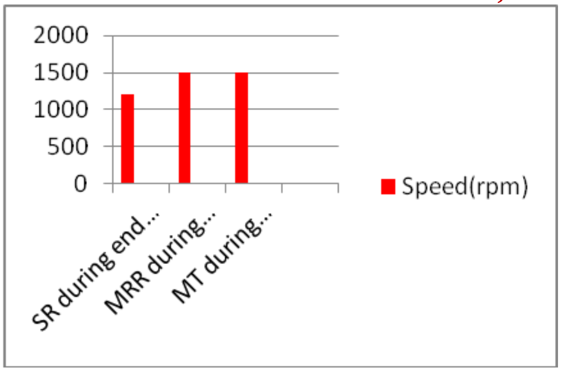
The surface roughness could be efficiently calculated by using spindle speed, feed rate, and depth of cut as the input variables. Considering the individual parameters, spindle speed has been established as most influencing parameter, followed by depth of cut and feed rate. The spindle speed increases for increasedsurface roughness. For higher feed rates, the surface roughness changes considerably. We observed carefully that when we used different type of analysis methods “Taguchi's methods And Regression Analysis” then we get accurate result of surface roughness(SR) , material removal rate(MRR) and machining time(MT) efficiently calculated by using spindle speed, feed rate and depth of cut as the input variable.Rigidity of set up has marked effect on maximum speed that will not cause chatter. Chatter is a condition in which the cutter and the work piece vibrate in resonance at a frequency determined by the natural frequency of one or more elements of machine.

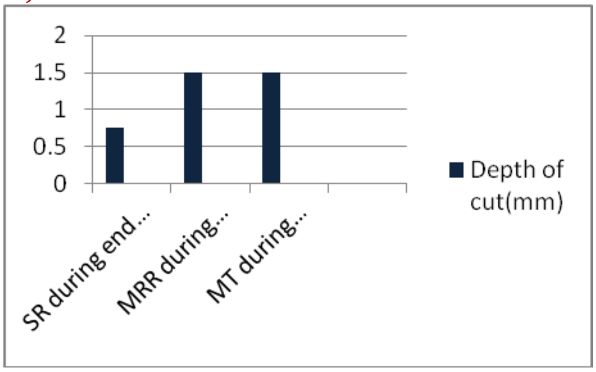
The Taguchi method was applied to find an optimal setting of the milling and turning of process. The result from the Taguchi method chooses an optimal solution from combinations of factors if it gives maximized normalized combined S/N ratio of targeted outputs. The L-9 OA was used to accommodate three control factors and each with 3 levels for experimental plan. Selected process parameters are speed, feed and depth of cut. The results are summarized as follows:

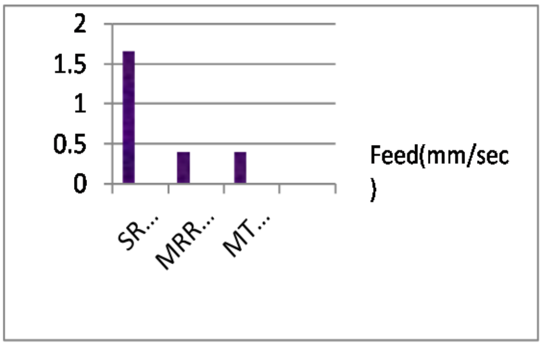
From the analysis, it is clear that the three process parameters speed, feed & depth of cut have significant effect on SR(surface roughness),MRR(material removal rate) and MT(machining time).The analysis of variance proves that the most influencing parameters on surface roughness are speed and depth of cut, while feed is least significant as compared to speed. While in case of MRR during turning speed is most influencing parameter followed by feed and depth of cut. But in case of machining time during turning speed is more influencing parameter followed by depth of cut and feed. The result of present investigation is valid within specified range of process parameters. Also the prediction made by Regression Analysis is in good agreement with confirmation results. The optimal levels of for end milling process parameters are found to be $A_3B_2C_1$:

	SR during end milling(µm)	MRR during turning(m3/rev)	MT during turning(min)
Speed(rpm)	1200	1500	1500
Depth of cut(mm)	0.75	1.5	1.5
Feed(mm/sec)	1.66	0.4	0.4

Following graph shows the end milling parameters founds experimentally







VI. CONCLUSION

Aluminium LM-26 alloy is mainly used in pistons of petrol and diesel engines. Various parameters affect the manufacturing as well as production cost and these parameters has been discussed and reported in this paper. The work done in this field is reviewed in literature review.

Based on the experimental results, S/N and ANOVA analysis performed, Regression analysis based Mathematical model developed for the optimization of machining parameter of Al-Alloy (LM-26), the conclusions have been arrived to obtain optimal machining parameter to achieve better surface finish characteristics during milling, better material removal rate during turning and better or optimum machining time during turning.

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