

A Review of Optimization of Process Parameters of Face Milling on Extruded Brass - Lead Alloy and Inconel 625 on VMC850

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ABSTRACT: Vertical milling centre is widely used in mass production manufacturing with precision without interruption in quick succession. This paper aims at monitoring extruded brass-lead alloy and inconel625 made of nickel and chromium due to their high strength, wear resistance, fatigue resistance and toughness. Their machining is performed on the vertical milling centre using HSS tool material. Experiments have been performed to check for the surface finish, machining time, material removal rate and tool life obtained by machining on extruded brass-lead alloy and inconel625 on the VMC. An experiment will be performed for the purpose of specifying the optimum process parameters for each workpiece and compare their performance results. The cutting tool adopted for experiment is HSS tool. Statistical design of experiments (DOE) based on Taguchi orthogonal array is adopted for experimentation and signal-to-noise ratio (SN ratio) of the responses is used for finding optimally of process parameters. The influence and contribution of process parameters on the responses is been studied with the help of Analysis of Variance (ANOVA).

KEYWORDS: Vertical Milling Centre, Extruded Brass-Lead Alloy, Inconel625, Process Parameters, Performance Parameters

I. INTRODUCTION

Vertical milling centre also known as VMC has been proven as an alternative process to conventional milling process with improved accuracy, precision, tight tolerance and interchangeability. In vertical milling rotary cutters is used to remove material from the workpiece by advancing in a direction at an angle with axis of tool. It covers a wide variety of different operations on scales of small individuals such as counterering, face milling, end milling to large heavy duty gang milling operations with advent of computer numeric control with automatic tool changers, tool magazines or carousals, CNC controls, coolant system. For this different types of tools are used on VMC according to the work piece materials hardness, wear and thermal resistance and power and speed capacity of tool. Any type of material can be machined using VMC irrespective of the hardness or toughness of the material. A super alloy or high-performance alloy such as inconel625 is an alloy that exhibits several following fundamental characteristic such as excellent mechanical strength, resistance to thermal creep deformation, good surface stability and resistance to corrosion or oxidation. Super alloys are the alloys which posses comparatively higher mechanical and thermal strength in comparison to individual metals. These properties of the super alloys make them eligible for the purpose where in high strength to weight ratio of a material is expected. Whereas extruded brass-lead alloy provides good strength, corrosion resistance, good machinability and fine chip improved overall manufacturing capability in face milling process on VMC850.

II. VMC PROCESS PARAMETERS

The process parameters which will influence the experiment of optimizing while machining of the extruded-brass lead alloy and inconel625 are listed below

1. Tool Feed - It is distance advances along the workpiece when tool point passes certain position in its travel over the surface. It represents different level of tool feed in mm/rev supplied by servomotor of vertical milling centre represents kind of material being cut ,hardness and surface finish.
2. Tool depth of cut – It is volume removed per unit time of tool .It will be varied in millimeters upto 0.5mm in numeric control part programming which effectively determines chip thickness, surface finish ,specific power consumption and tool characteristics.
3. Tool rotational speed - It is speed at which the cutting edge passes over material. It can be varied by speed control mechanism upto 8000 rpm by changing numeric control programme logic which leads to found out surface roughness and specific power consumption and best suitable tool life.

III. PERFORMANCE PARAMETERS

The effectiveness of VMC process is evaluated in terms of its machining characteristics. The short product development cycles and growing cost pressures have forced the die and mould making industries to increase the VMC efficiency. The VMC efficiency is measured in terms of its machining characteristics viz. material removal rate, surface roughness, tool life, machining time and specific power consumption . The most important performance parameters considered in the present work are:

1. Surface Roughness (R_a): Surface finish is an essential requirement in determining the surface quality of a product. The average surface roughness is the integral absolute value of the height of the roughness profile over the evaluation length (L) and was represented by the equation given below.

$$R_a = \frac{1}{L} \int_0^L |Y(x) dx|$$

Where 'L' is the length taken for observation and 'Y' is the ordinate of the profile curve.

2. Material removal rate (MRR): Material removal rate is a desirable characteristic and it should be as high as possible to give least machine cycle time leading to increased productivity. Material removal is the difference of weight of work-piece before machining and after machining. It is calculated by the formula as given below.

$$MRR = \frac{W_i - W_f}{\rho_w \cdot t}$$

Where,

- W_i is the initial weight of work-piece in g
- W_f is the final weight of work-piece after machining in g
- t is the machining time in minutes and
- ρ_w is the density of work piece material.

3. Tool life(TL):It is duration of actual cutting time after which tool is no longer usable. It will given by Taylors tool life equation

$$V^P F^Q T = c$$

Where, V is velocity of tool in rpm;F is Feed in mm/rev and t is a tool life in min.

4. Specific power consumption(SPC): It is power consume per unit material removal rate measured in J/mm³ which is given by

$$SPC = \frac{F_c \cdot V_c}{V_c \cdot F \cdot D}$$

Where;

F_c is cutting force in Newton

V_c is cutting velocity in mm/sec

F is feed in mm/rev

D is depth of cut in mm.

5. Machining Time(MT): It is time required for complete machining of parts to be machined. It is measured in minutes which is given by

$$MT = \frac{L}{F \cdot N}$$

Where L is length to be travelled in meters F is feed in mm/rev, N is rpm of tool.

IV. RESEARCH ON VMC PROCESS OPTIMIZATION

VMC process conditions play an important role in improving surface roughness, dimensional accuracy, mechanical properties, material behavior and build time. Critical process parameters that affect the quality of processed part have been discussed. There has been extensive research on this topic focusing on experimental results and process optimization. Most of the researches on VMC process parameters have been directed toward optimizing process parameters to improve the surface finish, dimensional accuracy and mechanical properties for super alloys processed parts as well as ductile materials too such as Aluminium, Brass and so on . Many researchers have suggested using appropriate statistical designs and optimization techniques to study the effects of process parameters on VMC processed parts. In the following sections, research on each quality characteristic is reviewed in detail.

Performance and surface integrity of super alloy and brass-lead alloy machined by vertical milling centre Mehmet Emre Kara ,Erhan Budak en al.[7] The ongoing developments in the field of materials science have developed many high strength and temperature resistant (HSTR) metal alloys that are difficult to machine by the conventional milling with accuracy and precision which demands for high class interchangeability. Vertical milling centre is one of the commonly used to machine hardened tool steels from smallest to largest job with mass production without interruption in production.

To study the effect of various process parameters on performance parameters Yuan Ma ,Pingfa Feng , Jianfu Zhang ,Zhijun Wu ,Dingwen Yu et al. [3] VMC is used for machining of parts of aerospace, automobile, nuclear industry, agricultural equipments. In this research paper an attempt has been made to study the effect residual stress imposed on machine component due to thermal and mechanical loading. They claim that tensile stress shortens the fatigue life of component. Meanwhile compressive residual stress are beneficial as it prolongs fatigue life. A surface methodology(RSM) is used for prediction of residual stress ,cutting force and surface roughness. Result found that residual stress affected by two factors: 1.plastic deformation 2.change in volume of material associated with thermal gradients and metallurgical alterations in structures. Result found that effect of spindle speed and feed rate is less significant at low depth of cut but significantly increases the residual stress , cutting force and surface roughness as the depth of cut increases. A surface residual stress tends to be more tensile with increase in tool nose radius and tool wear greatly influence the stress distribution. a cooling effects makes residual stress more compressive. Result found that at the optimum 75-125m/min speed the residual stress is more compressive. A feed increases then material removal rate increases also machining time reduces but it effects directly on to the surface finish cutting force from dynamometer transmitted to amplifier which is proceed by x ray diffraction stress analyzer. To improve machining performance such as tool life and workpiece surface finish lubricant oil is introduced in cutting zone. This research uses graphite as nano lubricant in order to enhance grinding by Taguchi method here optimum parameters selected as cutting speed , feed and depth of cut to be 5000rpm ,100mm/min,5mm respectively. The lubricant utilised is ECOCUT SSN 322 neat lubricant oil. A machning performance evaluated by field emission scanning electron microscopy and energy dispersive X-ray is used. The result found that SiO₂ nanoparticles provides less friction and thermal deformation between tool workpiece interface.

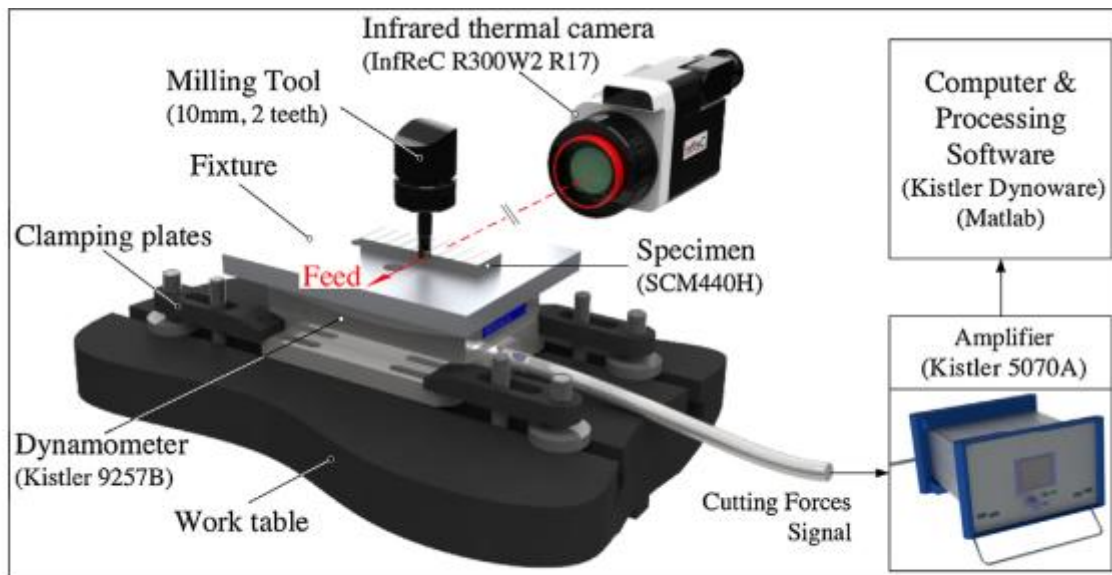


Fig. 1. Experimental system for milling process and the measurement of cutting forces and temperature.

Performance of different alloy Materials in VMC . Mehmet Emre Kara ,Erhan Budak en al.[7] The aim of the study is investigation and optimization of performance parameters for inspecting the machinability of Inconel600 alloys using Taguchi method .Inconel600alloys area type of material highly corrosion resistant (Nickel –Chromium super alloy) .As Inconel600 is highly brittle, this is not suited to be machined of traditional machine manufacturing .This paper utilizes vertical milling machine with ceramic tool are not affected by mechanical properties of materials . This experiment utilizes the Taguchi method and L9 orthogonal table to obtain the feed, depth of cut and tool rotational speed in order to explore the material removal rate, electrode wear rate and surface roughness. The influence of each variable and optimal processing parameter will be obtained through ANOVA analysis and verified through experimentation to improve process.

A comparison between silicon nitride- based ceramic and coated carbide tools in the face milling of irregular surface Anselmo Eduardo Diniz ,Jorge Antonio Giles Ferrer et al. [2] The research focuses on comparative study of silicon nitride based ceramic material to a carbide tool in the face milling operation of two irregular surfaces. the main conclusion was ceramic tool was longer tool life than carbide tool life even at a high speed ceramic tool wear due to diffusion whereas carbide tool wear occur due to chipping. Cutting speed of ceramic tool is higher than carbide tools by 2.2 times .Here EDS analysis is used to find surface topography and chatter analysis.

Growth of VMC on production line and its application – A review Mohd Sayuti ,Ooi Ming Erh, Ahmed A.D. Sarhan , Mohd Hamdi en al.[4] Globalization is making the manufacturers to invest and invent in the manufacture / production of sophisticated and quality products to meet ever changing needs of the customer in quick succession without idle manufacturing. Thus, the research in manufacturing has been concentrated towards the high speed machining involving CNC Machines, Robots and Automated Handling Systems with the emergence of computers in Engineering. Due to high manufacturing lead time and less precision in intricate cavity manufacturing and other surface defects in conventional milling process leads to vertical milling centre approach on production line aid in manufacturing a ductile to the hardest super alloys used in agriculture equipments, aerospace industries ,automobile bodies makes it a versatile machine.

Response surface modeling of VMC process. Nik Masmiaati ,Ahmed A.D. Sarhan ,Mohsen Abdel Naeim Hassan , Mohd Hamdi et al.[10] Vertical milling machine is used to produce complex shapes that would be difficult to produce in conventional milling machine appropriately and also good surface finish can be obtained in VMC. The work material extruded brass and lead alloy and inconel625 is machined by using high speed steel tool. The inconel contains nickel, chromium and it is used in automobile and aircraft transmission components whereas extruded brass- lead alloy also used for manufacturing of various items such as agriculture, nut, bolts, screws, locks bodies and so on .For this reason, the inconel625 and lead-brass alloy are experimentally investigated with the machining parameters for achieving maximum MRR, tool life and minimum tool wear rate , surface roughness, specific power consumption, machining time . The RSM is also used to identify the machining parameter responses on MRR, MT, TL and SR. The input parameters are feed, depth of cut and tool rotational speed. The experimental design is done using Box design of RSM. Regression equations are formulated based on the experimental results. The effects of input parameters are analyzed on MRR, MT, TL, SR.

V. RESEARCH GAP, PROBLEM AND CHALLENGE

Super alloys such as inconel625 and extruded brass-lead alloy are machined on the VMC.inconel625 and extruded-brass lead alloy on which optimization experiment can be performed in order to found out optimized performance parameters for them while machining on the VMC. No such optimization work is done taking account of multivariable performance parameters.

The objective of this article has been aimed to report the work carried out by various researchers in the field of VMC and to bridge the gap between the untouched areas. After an elaborate scrutiny of the published work, the following number of gaps in the literature has been observed from the existing published work.

- 1.In most of the research ,milling operation mainly done on aluminium, mild steel, titanium alloy . our research based on the optimization of process parameters on material extruded brass and lead alloy and inconel625 which is widely used in industry due to property of retaining hot hardness, corrosion, wear, creep, fatigue resistance ,machining performance and toughness.
- 2.A various surface property such as wear land, surface roughness which shows poor performance on conventional materials used in milling such as mild steel ,aluminium which might shows improved performance in extruded brass and lead alloy and also in inconel625 due to its predominant properties.
- 3.Most of the research based on single function optimization. our aim is to optimize multiple functions simultaneously.

VI. CONCLUSIONS

This article presents a review of research work carried out in the determination and optimization of the process parameters for VMC. A number of research works based on various optimization techniques were reviewed including RSM, Taguchi method. A review of research work on various optimization techniques indicated that there were successful industrial applications of Taguchi method, RSM. These are robust optimization techniques to make experimental design insensitive to uncontrollable factors such as environmental parameters to predict responses and optimize the VMC process conditions in accuracy level. Research work has been carried out in order to devise better ways for the machining of the extruded brass-lead alloy and inconel625 still there are shortcomings in the machining processes used for machining of the extruded brass-lead alloy and inconel625. Process parameters used in the VMC process are the one which play a key role in machining of super alloy and extruded brass-lead alloy . Using different process parameters performance parameters evaluated and concluding optimizing process parameters and compare it graphically.

REFERENCES

- [1] Dong Yang , Zhanqiang Liu, "Surface topography analysis and cutting parameters optimization for peripheral milling titanium alloy Ti-6Al-4V"Int. journal of refractory metals and Hard materials Elsevier-science direct(2015)

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- [2] Anselmo Eduardo Diniz ,Jorge Antonio Giles Ferrer, “A comparison between silicon nitride based ceramic and coated carbide tools in the face milling of irregular surfaces” journal of materials processing technology Elsevier-science direct(2008)
- [3] Yuan Ma ,Pingfa Feng , Jianfu Zhang ,Zhijun Wu ,Dingwen Yu, “Prediction of surface residual stress after end milling based on cutting force and temperature” journal of material processing technology Elsevier-science direct(2016)
- [4] Mohd Sayuti ,Ooi Ming Erh, Ahmed A.D. Sarhan , Mohd Hamdi, “Investigation on the morphology of the machined surface in end milling of aerospace AL6061-T6 for novel uses of SiO₂ nano lubrication system” journal of cleaner production Elsevier-science direct(2013)
- [5] Balkrishna Rao ,Chinmaya R. Dandekar, Yung C.Shin, “An experimental and numerical study on the face milling of Ti-6Al-4V alloy” journal of material processing technology Elsevier-science direct(2011)
- [6] Jie Gu , Gary Barber ,Simon Tung, Ren-Jyh Gu, " Tool life and wear mechanism of uncoated and coated milling inserts” Elsevier-science direct (1999)
- [7] Mehmet Emre Kara ,Erhan Budak, “Optimization of turn-milling processes” 9th CIRP conference on intelligent computation in manufacturing engineering-CIRP ICME 14 Elsevier-science direct(2015)
- [8] A. Jawaid ,S. Sharif , S. Koksai , “Evaluation of wear mechanisms of coated carbide tools when face milling titanium alloy” journal of material processing technology Elsevier-science direct(2000)
- [9] R. Arokiadass, K. Palaniradja , N. Alagumoorthi, “Prediction and optimization of end milling process parameters of cast aluminium based MMC” Elsevier -science direct(2012)
- [10] Nik Masmiaati ,Ahmed A.D. Sarhan ,Mohsen Abdel Naeim Hassan , Mohd Hamdi, “Optimization of cutting conditions for minimum residual stress, cutting force and surface roughness in end milling of S50C medium carbon steel” Accepted manuscript Elsevier- science direct(2016)