Experimental Investigation on Cutting Force Analysis in LM6 Aluminium Nano-Composite Material

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Abstract:- A rotating dynamometer that can detect static and dynamic cutting forces utilizing a strain gauge and a piezo-electric accelerometer was invented and developed in this work. The alignment of octagonal rings and strain gauge sites has been chosen to enhance sensitivity while minimizing cross-sensitivity. A data collecting system is linked to the designed dynamometer. Cutting force signals were recorded, converted to numerical form, and processed utilizing a data collection system comprised of required hardware and software operatingon an MS-Windows-based personal computer. The results of machining experiments performed at various cutting settings demonstrated that the dynamometer could be used to reliably measure cutting forces. The dynamometer was designed primarily for turning activities, although it may also be used to measure cutting forces.

I. INTRODUCTION

Work pieces of various forms, dimensions, and materials are created in the metal working business, which is undergoing numerous changes owing to the endless wants of consumers for qualitative, dependable, and complex components and products in the modern and technological world. To address such demands, manufacturers all over the world are pursuing lower-cost solutions in order to preserve their competitiveness in machined components and produced items. Thus, the machining of components with the cutting tool set loaded on the machine tools is part of the production process. Thus, the creation of any part is dependent on the cutting tool's proper operation, which leads to meeting production deadlines and cost effectiveness. To fulfill such production needs, technology has played a significant role in improving the metal working sector and generating prospects for cost reduction and quality enhancement. To accomplish the above, the selection of a suitable material, cutting tool, and combination is more important in production components. Following the selection of an acceptable cutting tool for the work material, the manufacturing or production method is chosen. Turning on a lathe is considered the first and most fundamental process for metal removal using a single point cutting tool. The vibrational features and machinability performances of the turning process on LM6 Aluminium Alloy for various cutting settings are investigated in this study.

➢ *Turning:*

Turning is defined as the process of single-point cutting of component parts with hardness values more than 45 RC but commonly between 58 and 68 RC. It excels at cutting complicated geometries with delicate arcs, angles, and blended radii, and it avoids grinding, lapping, and other finishing procedures. Dry turning is a revolutionary method for machining hardened components produced by forging or casting that achieves excellent machining efficiency while being ecologically friendly. Turning has a machining cycle time that is up to three times quicker than grinding. It also uses one-tenth the energy per unit volume of metal removed as grinding and is more environmentally friendly. It produces extremely little scrap and rejects as few pieces as possible.

Fig 1 Measurement of Depth of Cut During Turning

This is an emerging technique with numerous potential advantages, but it is still the conventional finishing method for essential hardened steel surfaces. Cutting inserts composed of CBN (Cubic Boron Nitride), Carbide, or Ceramic are excellent for turning. The ability to generate contours and complicated shapes with the inherent motion capacity of current machine tools is a key benefit of this approach. High-quality turning applications need a correctly set machine tool as well as the necessary tools..

➢ *Commonly Processed Turned Materials Would Include Steel Alloys such as*

- Bearing steels
- Hot and cold-work tool steels
- High speed steels
- Die steels
- Case hardened steels.

II. WORKPIECE MATERIAL

This LM6 alloy has good fluidity, strength, and a low coefficient of thermal expansion. It has excellentmechanical qualities at both subzero and high temperatures. Even after exposure to subzero temperatures orextreme cold working conditions, the alloy retains its low magnetic permeability. The chemical composition ofthe workpiece material is shown in table 1, and the mechanical parameters of LM6 Alloy are shown in table 2.

Fig 2 LM6 Alloy Material

Table 1 Chemical Composition of LM6 Alloy

Element	**Content (%)**
Al	0.85
Si	10 – 13.0
Fe	0.1
Cu	0.1
Ni	0.1
Mn, Cr,Zn,Sn,Ti,Pb, Ca	0.15

Table 2 Mechanical Properties of LM6 Alloy

Tensile strength	**Yield strength**	**Elongation**	**Density**	**Hardness**
223 MPa	128 MPa	7.8	2.7 g/cm3	105VHN

Applications of LM6 Alloy steel includes such as pistons in automotive and aerospace engineering.

- *Cutting Tool Parameters:*

Cutting tool plays a very important role in the dry machining method. There are two types of cutting tools widely used in the turning such as ceramic and carbide cutting tools..

Polycrystalline Diamond (PCD) is diamond grit that has been fused together under high-pressure, high-temperature conditions in the presence of a catalytic metal. The extreme hardness, wear resistance, and thermal conductivity of diamond make it an ideal material for the cutting tools manufacturing.

Fig 3 Cutting Inserts

- *Cutting Parameters:*

Cutting parameters like as speed, feed, and depth of cut are critical for every machining process. The amount of material to be removed, surface roughness, tool materials, and the machining process or processes are all affected by machining conditions such as cutting force, power, and surface finish.

- **Cutting speed** (rpm) refers to the relative surface speed between tool and job, given in surface feet per minute. During cutting, the work, the tool, or both may move.

- **Depth of cut** (mm) relates to the cutting edge of the tool engages the work. One linear dimension of the cut region is determined by the depth of cut..

- **Feed** for the axial progress of the tool along the work during each evolution of the work is represented as inches per revolution (IPR) in lathe turning. The feed can alternatively be stated in terms of distance traveled in a single minute, or IPM (inches per minute).

Productivity, tool life, and machine tool needs are all affected by feed, speed, and depth of cut. As a result, these components must be carefully selected for each process.

- *Tool Vibration:*

A significant quantity of energy is wasted during cutting due to plastic deformation. Some of this energy is passed to the system's structural elements as induced vibration. Under adverse conditions, these vibrations should be reduced because they affect machining precision and the machined surface texture. The unsteadiness causes chatter, which causes tool wear, breakage, and damage to the machine tool and component. Chatter is determined by the machine's design and layout, as well as the tooling arrangement.

The investigation of the machine tool's vibration amplitude promotes the improvement of machining quality. Vibration in metal cutting operations reduces surface smoothness, generates excessive noise, and promotes premature tool failure due to edge chipping. Chatter is classified into two types: forced vibration and self-excited vibration. Forced vibration occurs as a result of a periodic excitation of force, which can be variable forces acting on the system as a result of intermittent or interrupted machining, the centrifugal force of inertia of unbalanced rotating masses, or impact force caused by faults or manufacturing errors on the component's work surface. This form of noise is first external to the metal removal process and the entire machine tool and should be thoroughly investigated.

➢ *Surface Roughness :*

The surface quality is critical; a well-machined surface enhances fatigue strength and corrosion resistance greatly. Surface roughness is measured by the deviations of an actual surface from its ideal form in the direction of the normal vector. The surface is rough if these variations are considerable; smooth if they are minimal.

- **Roughness Average, Ra** is the arithmetic average of the absolute values of the profile heights across the evaluation length.
- **RMS Roughness, Rq** is the evaluation length's root mean square average of profile heights.
- **Ten Point Height of Irregularities, Rz** is inside the assessment length, the average value of the absolute values of the heights of the five highest profile peaks and the depths of the five deepest troughs.

III. RESULT AND DISCUSSION

The optimization was carried out using the response surface approach in order to compute the best optimum values and significant factor among the specified input parameters and values. The optimum outcomes. The experiment was carried out to check the outcomes based on the optimized results. In addition, the lowest cutting force, tool vibration, and surface roughness were all observed.

The experiments were carried out on the LM6 alloy using the L18 orthogonal array. The turning process altered the cutting speed from 600 to 1045rpm, the feed rate from 0.06 to 0.12 mm/rev, and the depth of cut from 0.25 to 0.75 mm.

The optimization has been done with Box Behnken Design based Response Surface Methodology for optimizing turning parameters such as cutting speed, depth of cut, feed rate and inserts (Ti-6Al-4V) .

Table 3 Test Results

Type of Insert	**PCD**	**PCD**	**PCD**
Cutting Speed(rpm)	726	939	1152
Feed (mm/rev)	0.03	0.45	0.6
Depth of cut (mm)	0.5	1.0	1.5
Sl.No	**Output Parameters**	**Confirmation Test Results**	
1	Fx (N)	94.38 %	
2	Fy (N)	98.10%	
3	Fz (N)	91.12%	
4	Ra (microns)	98.39%	
5	Rq (microns)	91.70%	
6	Rz (microns)	96.78%	

IV. CONCLUSION

The current study has investigated the enhancement of machinability characteristics and tool vibration of the LM6 alloy steel, as well as the influence of machining settings on output reactions.

The experiments were carried out on the LM6 alloy using the L18 orthogonal array. The turning process altered the cutting speed from 726 to 1152 rpm, the feed rate from 0.03 to 0.6 mm/rev, and the depth of cut from 0.5 to 1.5 mm.

The Box Behnken Design-based Response Surface Methodology was used to optimize turning parameters such as cutting speed, depth of cut, feed rate, and inserts (Ti-6Al-4V)..

The regression coefficients for displacement, velocity, acceleration, Fx, Fy, Fz, Ra, Rq, and Rz are 94.38%, 98.10%, 91.12%, 98.39%, 91.70%, 96.78%, 97.5%, 96.6%, and 95.09%, respectively, according to the Analysis of Variance.

To obtain better results, a confirmation test was done, and from that optimization, the best ideal values were predicted out of eighteen tests using an Artificial Neural Network.

REFERENCES

[1]. **Mehmet AlperSofuoglu ,2015; “**Prediction of stable cutting depths inTurning operation using soft computing methods”,Applied Soft Computinghttp://dx.doi.org/doi:10.1016/j.asoc.2015. 10.031**47**

[2]. **G. Totis n,2010; “**Development of a modular dynamometer for triaxial cutting force measurement in turning”,International Journal of Machine Tools & Manufacture 51 (2011) 34–42 **9**

[3]. **KannanA ,2020; “**Experimental Investigation On Surface Roughness, Tool Wear And Cutting Force In Turning Of Hybrid (Al7075+sic+gr) Metal Matrix Composites”, *Journal of Materials Research and Technology*https://doi.org/10.1016/j.jmrt.2020.11.07 4**27**

[4]. **Su¨leymanYaldız ,2005;** “Design, development and testing of a turning dynamometer for cutting force measurement”,Materials and Design 27 (2006) 839–846 **8**

[5]. **Yahya Isik,2006; “**Investigating the machinability of tool steels in turning operations”, Materials and Design28 (2007) 1417–1424**8**

[6]. **[6]R.K.BharilyaRitesh ,2015; “**Study of optimised process parameters in turning operation through Force Dynamometer on CNC Machine”, Materials Today: Proceedings 2 (2015) 2300 – 2305**6**

[7]. **MecheriSandeepKumar , 2016; “**A 3-D Simulation and Experimental Study of Cutting Forces in TurningInconel-718”,Materials Today: Proceedings 4 (2017) 9942–9945 **4**

[8]. **N ShivarajS ,2018; “**Static and Fatigue Analysis of Lathe spindle for Maximum Cutting Force”, MaterialsToday: Proceedings 5 (2018) 4438–4444 **7**

[9]. **A Mahamani,2014;** “Influence of Process Parameters on Cutting Force and Surface Roughness During Turning of AA2219-TiB2/ZrB2 In-situ Metal Matrix Composites”, Procedia Materials Science 6 (2014) 1178-1186**9**

[10]. **DarshitShah ,2020; “**Effect of Tool Nose Radius and Machining Parameters on Cutting Force, Cutting Temperature and Surface Roughness – An Experimental Study of Ti-6Al-4V (ELI)”, Materials Today: Proceedings 22 (2020) 1977–1986**10**