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# EXPERIMENTAL INVESTIGATION OF LUBRICATION SYSTEM OF MILLING OPERATION ON ALUMINUM ALLOY 6060

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## ABSTRACT

In this project work an investigation into Minimum Quantity Lubricant (MQL) and wet machining in milling processes of AISI 6060 Aluminum work material has been carried out with the main objective is to determine the effect of lubrication conditions on the surface roughness. Three other parameters were also consider in this study; feed rate (FR), depth of cut (DOC) and cutting speed(CS).The levels each parameter had been selected is four levels. The ranges of feed rate 0.05mm/min,0.15mm/min,0.20mm/min and 0.25mm/min depth of cut used were 0.2mm, 0.4mm, 0.6mm and 0.8mm whereby the cutting speed values were 600mm/min,800mm/min,100mm/min and 1200mm/min.

## INTRODUCTION

**Machining aluminum and aluminum alloys:** Traditional machining operations such as turning, milling, boring, tapping, sawing etc. are easily performed on aluminum and its alloys. The machines that are used can be the same as for use with steel, however optimum machining conditions such as rotational speeds and feed rates can only be achieved on machines designed for machining aluminum alloys.

The specific properties of aluminum alloys must be considered:

1. Their density allows high speeds of rotation and translation as the inertia of aluminum alloy swarf is less than that of steel,
2. Their modulus of elasticity - one third that of steel - requires appropriate chucking and clamping arrangements that avoid deformation and distortion,
3. Their thermal conductivity assists heat dissipation. Given the high rate of chip removal, the heat generated by the machining process is taken away with the swarf without having the time to diffuse into the metal,
4. A coefficient of linear expansion that is twice that of steel makes heating undesirable if criteria of dimensional stability are to be satisfied.

Unlike steel, there is no need to provide heat treatment of the “stress-free annealing” type during machining.

**Cutting force:** The specific cutting force needed to machine aluminum alloys is far less than is required for steel. For the same section of swarf, the force is one third of that required for aluminum than for low-carbon steel, so it follows for the same cutting force, chip removal is three times higher with aluminum alloys such as 2017A whose level of mechanical properties is on a par with that for low-carbon steel.

**Tooling:** The geometry of tools must be specially designed for use with aluminum alloys. Edges must be very keen and cutting tool faces must be highly polished so as to remove swarf efficiently and prevent it from bonding to the tool. Cutting angles will depend on the alloys. The rake angle of the cutting edge must be greater than $6^{o}$ and can attain $12^{o}$.

The use of tools tipped with TiN or TiCN by PVD deposition only is highly advisable for machining alloys that contain no more than 7% silicon. (Angle of $15^{o}$ for diamond coated carbide (CVD Diamond) tools and polycrystalline diamond (PCD) tools.) Provided tooling is designed for aluminum alloys, tool life is much longer than for machining steels, all other factors being equal.

All wrought alloys can be machined very rapidly. With special machines (high speed spindles) the machining speed can attain (and exceed) 2 to 3000 m/min with 2000 and 7000 series alloys. Thus for a 12 mm diameter tool the cutting rate can be as high as 50,000 r.p.m. for a feed rate of 10 m/min. With very high cutting rates it is possible to obtain very thin sheet and much lighter components.

**Rate of advance and depth of cut:** Given the low modulus of aluminum alloys, high rates of advance are not advisable, even for rough machining. The feed rate should be limited to 0.3mm per revolution. For finishing operations the rate of advance will be determined by the specified surface roughness for the finished product. The depth of cut will depend on the specified accuracy.

## MILLING

**Definition:** Milling is the process of machining the flat, curved or irregular surface by feeding the work piece against a rotating cutter containing a number of cutting edges. The milling machine consist of basically of a motor driven spindle which mounts and revolves the milling cutter and a reciprocating adjustable work table , which mount and feeds the work piece. Most of the milling machine have self-contained electric drive motors, coolant systems, variable spindle speeds and power operated table feeds.

**Types of milling machine:** Basically, Milling machines are classified as vertical and horizontal machines. These machines also classified as

1. Knee type machine
2. Ram type machine
3. Manufacturing or bed type machine
4. Planner type machine

**Milling cutters:** Milling cutters are usually made of high-speed steel available in a great variety of shapes and sizes for various purposes. You should know the names of the most common classifications of cutters, their uses, and, in a general way, the distance between like or sizes best suited to the work at hand

**Classification of milling cutters:**

1. Helical milling cutter
2. Metal slitting saw milling cutter
3. Side milling cutter
4. End milling cutter
5. Angle milling cutter
6. T-slot milling cutter
7. Gear hob
8. Woodruff key slot milling cutter
9. Concave & convex milling cutter
10. Corner rounding milling cutter
11. Special shaped formed milling cutter

## LUBRICATION

**Definition:** Lubrication is the process, or technique employed to reduce wear of one or both surfaces in close proximity, and moving relative to each other, by interposing a substance called lubricant between the surfaces to carry or to help carry the load (pressure generated) between the opposing surfaces. The interposed lubricant film can be a solid, (e.g. graphite, $MoS_2$)[1] a solid/liquid dispersion, a liquid, a liquid-liquid dispersion (a grease) or, exceptionally, a gas.

**Function of lubrication:** Lubrication is a very important factor in the machining of aluminum alloys, and has three main functions:

1. Cooling to dissipate the heat generated by cutting and friction,
2. Preventing swarf from bonding to the tools,
3. Removing swarf from the point of machining.

Although three types of lubrication are available- spray mists, full cutting oil, and oil emulsions- the latter option is the most common because this method dissipates more calories per kilo of lubricant, of the order of 200 kg/J. Cutting fluids reduce friction and aid tapping operations. Lubricant spray mists are not advisable where a lot of heat has to be dissipated.

**The composition of cutting fluids must meet other requirements:** They must be compatible with aluminum alloys, they must not cause stains or surface corrosion (no chlorine or sulfur compounds, They must have an anti-bacterial action to prevent fungal growth, They must be environmentally friendly.

**Lubricants:** A lubricant is a substance introduced to reduce friction between moving surfaces. It may also have the function of transporting foreign particles. The property of reducing friction is known aslubricity. (Slipperiness)

**A good lubricant possesses the following characteristics:**

- High boiling point
- Low freezing point
- High viscosity index
- Thermal stability
- Hydraulic Stability
- Demulsibility
- Corrosion prevention
- High resistance to oxidation

## EXPERIMENTAL WORK

The objective the experimental work is to investigate the Minimum Quantity Lubricant (MQL) and wet machining in milling processes of aluminum alloy 6060.Aluminum work material with the main objective is to determine the effect of lubrication conditions on the surface roughness. Three other parameters were also consider in this study are as follows:

- Feed rate (FR),
- Depth of cut (DOC)
- Cutting speed (CS).

**Experimental Setup:** Based on observation, figure.1.(a) shows the MQL machining using a very small amount compared to the wet lubricant using higher amount. Figure b shows the condition of wet machining. The ways to control the MQL and wet machining are adjust the valve to minimum.

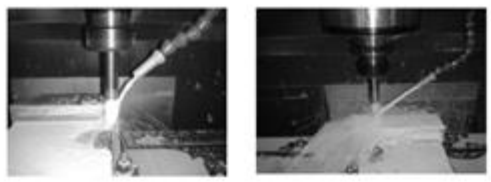

**Figure.1.(a) MQL Machining (b) Wet Machining**

MQL refers to the use of cutting fluids of only a minute amount typically of a flow rate of 50 500 ml/h which is about three to four orders of magnitude lower than the amount commonly used in flood cooling condition. (MQL) in machining is an alternative to completely dry or flood lubricating system, which has been considered as one of the solutions for reducing the amount of lubricant to address the environmental, economical and mechanical process performance concerns. Wet machining refers use a large quantities of lubricants. The wet machining can reduce the heat between the material surface and tools surface. In wet machining, the role of cutting fluids is transports the chips away from the cutting zone, at the same time cooling the chips and keeping dust and small particulates in liquids rather than in the air .

**Design of Experiments:** Taguchi Method was proposed by Genichi Taguchi, a Japanese quality management consultant. The method explores the concept of quadratic quality loss function and uses a statistical measure of performance called signal-to-noise (S/N) ratio, Antony, 2001). It is the ratio of the mean (Signal) to the standard deviation (Noise). The ratio depends on the quality characteristics of the product/process to be optimized (Peace, 1993). The optimal setting is the parameter combination, which has the highest S/N ratio. Based on the signal-to-noise (S/N) analysis, the signal-to-noise (S/N) ratio for each level of process parameters are computed. Larger S/N ratio corresponds to better performance characteristics, regardless of their category of performance. It means that the level of process parameters with the highest S/N ratio corresponds to the optimum level of process parameters.

Taguchi method is usually used in an analysis that uses a lot of factor low than two will use the factorial design. When the total factors have been more than two, the number of experiment also will increase, and then the solution will be used Taguchi method. The flow of process when analysis by using Taguchi method.

The first step before using the technique Design of Experiment (DOE) knew how many factors and level. Table 3.1 shown the factor and level had been decided. Actually, method of Taguchi has been be used if the factor has more than two to beable to reduce the number of the experiment.

**Table 2.1 Factors and Levels**

| **Factors** | **Levels** | | | |
|---|---|---|---|---|
| | **1** | **2** | **3** | **4** |
| **CS** | 600 | 800 | 1000 | 1200 |
| **DOC** | 0.05 | 0.15 | 0.20 | 0.25 |
| **FR** | 0.1 | 0.2 | 0.3 | 0.4 |

After identifying the number of factors and level, orthogonal array of methods used for the experiment to knew the total of experiment. The total should be known in two ways, namely using a table or MINITAB software. In this experiment L16 has been used after recommended by orthogonal array based on the three factors and four levels.

**Optimization:** Process optimization is the discipline of adjusting a process so as to optimize some specified set of parameters without violating some constraint. The most common goals are minimizing cost, maximizing throughput, and/or efficiency. This is one of the major quantitative tools in industrial decision making. When optimizing a process, the goal is to maximize one or more of the process specifications, while keeping all others within their constraints

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Table 2.2 Taguchi's L-16 series of Experiments

| Sl.No | CS | DOC | FR | Sl.No | CS | DOC | FR |
|---|---|---|---|---|---|---|---|
| 1 | 600 | 0.2 | 0.05 | 9 | 1000 | 0.2 | 0.2 |
| 2 | 600 | 0.4 | 0.15 | 10 | 1000 | 0.4 | 0.25 |
| 3 | 600 | 0.6 | 0.2 | 11 | 1000 | 0.6 | 0.05 |
| 4 | 600 | 0.8 | 0.25 | 12 | 1000 | 0.8 | 0.15 |
| 5 | 800 | 0.2 | 0.15 | 13 | 1200 | 0.2 | 0.25 |
| 6 | 800 | 0.4 | 0.05 | 14 | 1200 | 0.4 | 0.2 |
| 7 | 800 | 0.6 | 0.25 | 15 | 1200 | 0.6 | 0.15 |
| 8 | 800 | 0.8 | 0.2 | 16 | 1200 | 0.8 | 0.05 |

## SURFACE ANALYSIS

## SURFACE FINISH DEFINITIONS

- **Ra:** Ra is the arithmetic average of the absolute values of the roughness profile ordinates. Also known as Arithmetic Average (AA), Center Line Average (CLA). The average roughness is the area between the roughness profile and its mean line, or the integral of the absolute value of the roughness profile height over the evaluation length
- **Rz:** is the arithmetic mean value of the single roughness depths of consecutive sampling lengths. Z is the sum of the height of the highest peaks and the lowest valley depth within a sampling length.
- **Cutoff λc:**of a profile filter determines which wavelengths belong to roughness and which ones to waviness.
- Sampling Length: is the reference for roughness evaluation. Its length is equal to the cutoff wavelength.
- Transversing Length: is the overall length travelled by the stylus when acquiring the traced profile. It is the total of Pre-travel, evaluation length and post travel
- Evaluation Length: is the part of the traversing length from where the values of the surface parameters are determined.
- Pre-Travel: the first part of the traversing length.
- Post-Travel: The last part of the traversing
- length.

## TYPES OF SURFACE ANALYSIS

1. Contact angle analysis
2. Light microscopy
3. X-ray Photoelectron Spectroscopy(XPS)
4. Fourier-Transform Infrared Spectroscopy(FTIR)
5. Electron microscopy – TEM , SEM
6. Scanning probe/ Atomic force microscopy (SPM/AFM)

## CONCLUSION

Finally the AISI 6060 aluminum material had been investigated into MQL and wet machining process.The other three parameters feed rate (FR), depth of cut (DOC) and cutting speed(CS) also considered for the investigation process.

## REFERENCES


Bogusława Adamczyk-Cieślak, Jarosław Mizera, & Krzysztof Jan Kurzydłowski, Microstructures in the 6060 Aluminium Alloy After Various Severe Plastic Deformation Treatments" Original Research Article Materials Characterization, 62(3),2011, 327-332

T. Kayser, B.Klusemann, H.-G.Lambers, &H.J.Maier, B. Svendsen, Characterization of Rain Microstructure Development in the Aluminum Alloy en aw-6060 During Extrusion"Materials Science and Engineering: A, Volume 527, Issues 24–25, 25 September 2010,

D. Apelian, Worldwide Report Aluminum Cast Alloys:Enabling Tools for Improved Performance, NADCA , 2009

Influence of Annealing and Deformation on Optical Properties of Ultra Precision Diamond Turned and Anodized 6060 Aluminium Alloy, Surface and Coatings Technology, 204, 16–17, 15 May 2010, 2632-2638.

Marcel Mandel, Lutz Krüger, Determination of Pitting Sensitivity of the Aluminium Alloy Enaw-6060-t6 in a Carbon-fibre Reinforced Plastic Aluminium Rivet Joint by Finite Element Simulation of the Galvanic Corrosion Process"Original ResearchArticleCorrosion Science, Volume 73, August 2013, 172-180

N. Coniglio, C.E. Cross, I. Dörfel, W. Österl "Phase Formation in 6060/4043 Aluminum Weld Solidification, Materials Science and Engineering: A, Volume 517, Issues 1–2, 20 August 2009, Pages321-327