



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 9, Issue 9, September 2020

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512

9940 572 462

6381 907 438

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Investigation of MQL for Milling Operation of Aluminium 6061 Specimen using Taguchi Method

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ABSTRACT: This work intervenes some of the sustainability issues in machining by studying the cutting energy, surface finish and Minimum Quantity Lubrication (MQL). The minimum quantity lubrication in machining has been emerged as the sustainable manufacturing techniques and being widely explored for industrial applications since last few years. The aim of this paper is to explore the CNC milling performance while machining Aluminium 6061 plates rectangular shape (Dimension – 50*50*25) *40- height of work piece under two different Lubricant that is Flooded coolant and MQL. Taguchi L9 array was used to design the experiments, for three machining input parameters viz. cutting speed, feed rate and depth of cut; considering the efficient use of limited resources. A total of 4 experiments were performed for Flooded coolant and MQL. Average surface roughness was analyzed for each experiment and machining parameters for better surface finish were optimized. It was observed that MQL provides the best surface finish out of two lubricant.

KEYWORDS: Minimum Quantity Lubrication, TAGUCHI, Optimization, MRR.

I. INTRODUCTION

Machining is any of different procedures where a bit of crude material is cut into an ideal last shape and size by a controlled material-expulsion process. The procedures that have this normal subject, controlled material expulsion, are today by and large known as subtractive assembling, in differentiation from procedures of controlled material expansion, which are known as added substance producing. Machining is a piece of the assembling of many metal items, yet it can likewise be utilized on materials, for example, wood, plastic, artistic, and composites. Manufacturing by mechanical machining has traditionally benefited from the utilization of cutting fluid. Cutting fluids facilitate to cut back temperature, friction, flush away chips, and therefore prolong tool life and improve machining performance. However, uncontrolled use of cutting fluid raises concern in respect of price and environmental burden. For these reasons, dry machining is employed in conjunction with high speed machining to cut back cycle times and at the same time deliver a greener method. However, for a few work piece materials full implementation of dry machining isn't economically viable because of the absence of the essential cooling and lubricating functions delivered by cutting fluids. the foremost possible bridging technology is minimum quantity lubrication (MQL) wherever a awfully tiny rate of flow of coolant/lubricant is delivered to the cutting zones. In terms of machinability, the appliance of MQL is promising. However, most studies conducted on MQL targeted on the feasibility of MQL application and showcasing the technical advantages. No studies had been known in literature consistently work the link between cutting conditions and MQL with the goal of optimizing the method. In general, there square measure 2 kinds of MQL system. the primary kind is understood as an inside system. within the internal system, oil and air is mixed in an exceedingly intermixture chamber before being delivered to the cutting zone through one nozzle pipe. Meanwhile, the second kind, or external system, AN oil-air mixture is administered within the nozzle tip and therefore the air borne particles square measure shaped simply once the nozzle tip.

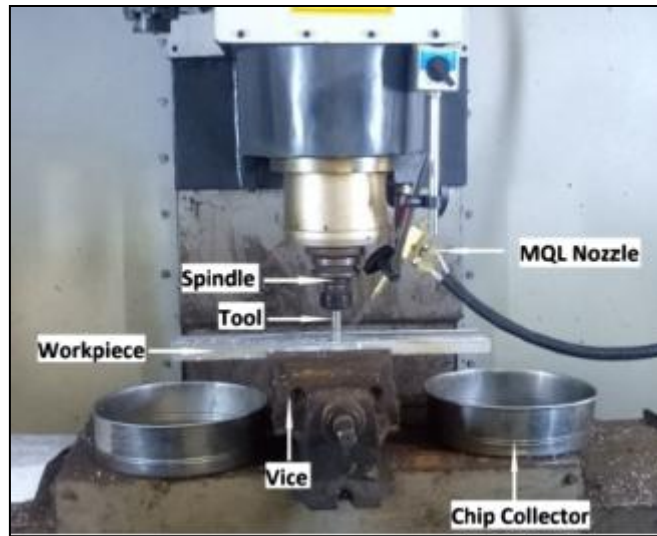


Fig. 1. VMC Setup.

The oil is equipped in tiny quantities through a pipe to the nozzle tip wherever the air, flowing from a distinct pipe, can force the oil to the cutting zone. the appliance of the MQL technique may be found in an exceedingly type of machining processes, particularly in primary processes like turning, drilling, milling, and grinding. additionally, cutting of wide sorts of work piece material, like metallic element, steel, hardened material likewise as hard-to-cut material may be done mistreatment the MQL technique.

PROBLEM STATEMENT

In the absence of garbage disposal facilities, the practice of dumping garbage into nearby water bodies has become quite common in recent years and has posed long-term negative impacts both on biodiversity of the area and as well as on the local environment.

II. RELATED WORK

Muhammed Muaz et al [1] The usage of practical assembling procedures to make machining forms all the more ecofriendly is a difficult theme that has pulled in noteworthy consideration from the modern division for a long time. As one of the predominant assembling forms, machining can have a significant effect as far as nature, society, and financial aspects. In specific territories, this effect is a consequence of utilizing certain cutting liquids, particularly during the machining of hard to-cut composites, for example, titanium, where a lot of slicing liquid is squandered to facilitate the cutting procedure. In such situations, recognizing reasonable machining conditions to flexibly cutting liquids utilizing eco-accommodating strategies is at present a significant focal point of scholastic and mechanical area research. In this examination, impacts of least amount grease with various groupings of hexagonal boron nitride nanoparticles on a superficial level unpleasantness and cutting power of opening processed titanium compound is explored utilizing investigation of fluctuation and reaction surface approach.

Ming Lia et al. [2] Minimum Quantity Lubrication has been generally utilized in the titanium combination processing process as a progressed and clean methods for cooling and grease. The Minimum Quantity Lubrication boundaries impact the processing attributes thus, deciding an ideal Minimum Quantity Lubrication boundary mix is indispensable to getting the best processing qualities. In this examination, Minimum Quantity Lubrication with graphene-scattered vegetable-oilbased cutting liquids was received in the processing of TC4 composite, where the cutting liquids were set up by scattering graphene nanoparticles into the vegetable-oil-based slicing liquid to improve the processing attributes of the TC4 compound. The incorporated Taguchi-Principal segment examination Gray social investigation improvement strategy was utilized to assess the impacts of the Minimum Quantity Lubrication boundaries on the processing attributes and acquire the ideal Minimum Quantity Lubrication boundary mix. The processing qualities of TC4 compound, to be specific, the processing power, processing temperature, surface small scale hardness, and surface unpleasantness were assessed and broke down, and the ideal Minimum Quantity Lubrication boundary mix was gotten.

ZhenjingDuan et al. [3] In this exploration, In nanofluid least amount grease (NMQL) processing of avionics aluminum amalgam, it is the bottleneck issue to alter the position boundaries (target separation, frequency point, and rise edge) of the spout to improve the surface harshness of processing, which has enormous and wild mistakes. In this paper, the impact law of processing shaper speed, helical point,

also, cavity shape on the stream field around the processing shaper was examined, and the ideal spout profile boundaries were gotten. Utilizing 7050 aluminum composite as the workpiece material, the processing trial of the NMQL cavity was directed by using cottonseed oil-based Al₂O₃ nanofluid. Results show that the high speed of the encompassing wind current field and the solid gas hindrance could be ascribed to high pivoting speeds of the processing shaper.

A. Duchosal1 et al [4] This paper centers around a numerical streamlining of the Minimum Quantity Lubrication (MQL) plan boundaries outside a turning apparatus with the Taguchi technique under completing conditions so as to get enough oil on the bleeding edge before expelling materials. This ecological well disposed strategy is reasonable for cleaner fabricating for a wide setting of creation. Boundaries as molecule sizes for various oil fog input gadget boundaries (channel pressures) as capacity of various canalization geometries have been resolved on a past test part. The assessed boundaries are: distinctive channel pressures, inward situated canalizations, cutting velocities and feed rates. The reenactments featured the impingement of the distinctive oil molecule sizes on the apparatus carbide embeds as capacity as these various boundaries.

Adhip Shukla et al. [5] The base amount oil in machining has been developed as the maintainable assembling strategies and being generally investigated for modern applications since most recent couple of years. The point of this paper is to investigate the CNC processing execution while machining Aluminum 6061 under three unique conditions viz. dry, flood and vegetable oil based least amount grease (MQL) procedure. Taguchi L9 exhibit was utilized to structure the tests, for three machining input boundaries viz. cutting rate, feed rate and profundity of cut; thinking about the proficient utilization of constrained assets. A new TiAlN covered carbide PVD embed was utilized in end processing of Aluminum 6061T6 for each trial run.

III.PROBLEM STATEMENT

Consequently the selection of milling parameters such as spindle speed, feed rate and depth of cut are important for improving the productivity and part quality. In previous work study RSM Methodology used but in this project we concentrated Taguchi method for optimize the process parameter

IV.OBJECTIVES

The objective of the work discussed is to investigate surface finish of Aluminium 6061 plates specimen in Flooded coolant and MQL environment. The impact of cutting parameters such as cutting speed, feed and depth of cut (DOC) at a constant flow rate and pressure of MQL and Flooded coolant during end milling were discussed.

V.EXPERIMENTATION

The experiments were performed on Aluminium 6061 plates rectangular shape (Dimension – 50*50*25) *40- height of work piece to investigate trends between surface roughness and different machining parameters i.e. cutting speed, feed rate and depth of cut. The different cutting environments were applied including the Flooded coolant and MQL. For MQL environment, 1. Carol coolant 2. Mist (carol coolant + compressed air) are used. The experiments were conducted on VMC machine.

The experiments were performed on Aluminium 6061 plates to investigate trends between surface roughness and different machining parameters i.e. cutting speed, feed rate and depth of cut.

Mechanical Properties of aged aluminum 6061-T6

Properties	AA6061-T6
Yield stress (σ_y), MPa	276
Ultimate stress (σ_u), MPa	310
Fatigue limit (σ_f), MPa	96.5
Rupture strain, %	17
Elasticity Modulus (E), GPa	68.9
Poisson's ratio (ν)	0.33
Density (ρ), g/cm ³	2.7

Taguchi's design of experiments is a robust experimental design technique which helps in reducing the total number of experiments to be carried out using the orthogonal array to find out the most optimum level of each performance parameter. Taguchi's orthogonal arrays are widely used to investigate the effect of input process parameters on the process responses.



Fig. 2 .VMC machine

TECHNICAL SPECIFICATION

Work piece material – Aluminium 6061 plates

Total No. of workpiece – 4 block rectangular shape (Dimension – 50*50*25) *40- height of workpiece.

Tool – Solide Carbide – cutter coating -TLTAIN

Tool diameter – 12

Lubricant use -1. Carol coolant 2. Mist (carol coolant + compressed air) also known MQL

Surface roughness tester- SJ-410 Mitutoyo



VI. EXPERIMENTATION RESULTS

Trial first

Table 1: Process parameters with their levels

Factor	Designation	Level		
		Level 1	Level 2	Level 3
SPEED (rpm)	N	1500	1800	2200
FEED (mm/m)	F	600	800	1000
DEPTH OF CUT (mm)	D	0.1	0.2	0.3

Test number	N	F	D	Ra Values (µm)	
				Flooded coolant	MQL
1.	1500	600	0.1	1.053	0.635
2.	1500	800	0.2	2.323	1.094
3.	1500	1000	0.3	1.922	0.769
4.	1800	600	0.2	1.802	0.642
5.	1800	800	0.3	2.147	0.31
6.	1800	1000	0.1	1.482	0.435
7.	2200	600	0.3	0.873	0.355
8.	2200	800	0.1	0.628	0.56
9.	2200	1000	0.2	0.904	0.495

Taguchi Design

Taguchi Orthogonal Array Design

L9(3³)

Factors: 3

Runs: 9

FOR FLOODED COOLANT:

Response Table for Signal to Noise Ratios

Smaller is better

Level	N	F	D
1	1.7660	1.2427	1.0543
2	1.8103	1.6993	1.6763
3	0.8017	1.4360	1.6473
Delta	1.0087	0.4567	0.6220
Rank	1	3	2

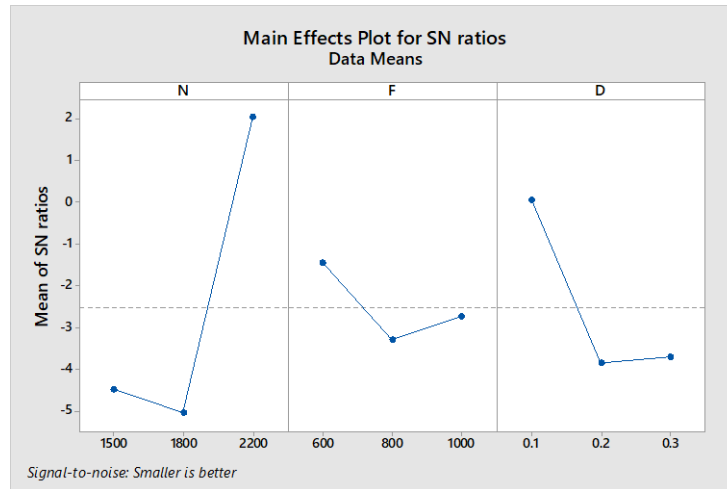


Fig.3 S/N Ratio analysis for Flooded coolant

Analysis of Variance(ANOVA)

FOR MQL :

Response Table for Signal to Noise Ratios
Smaller is better

Level	N	F	D
1	1.815	5.596	5.404
2	7.084	4.810	3.059
3	6.713	5.207	7.150
Delta	5.269	0.787	4.091
Rank	1	3	2

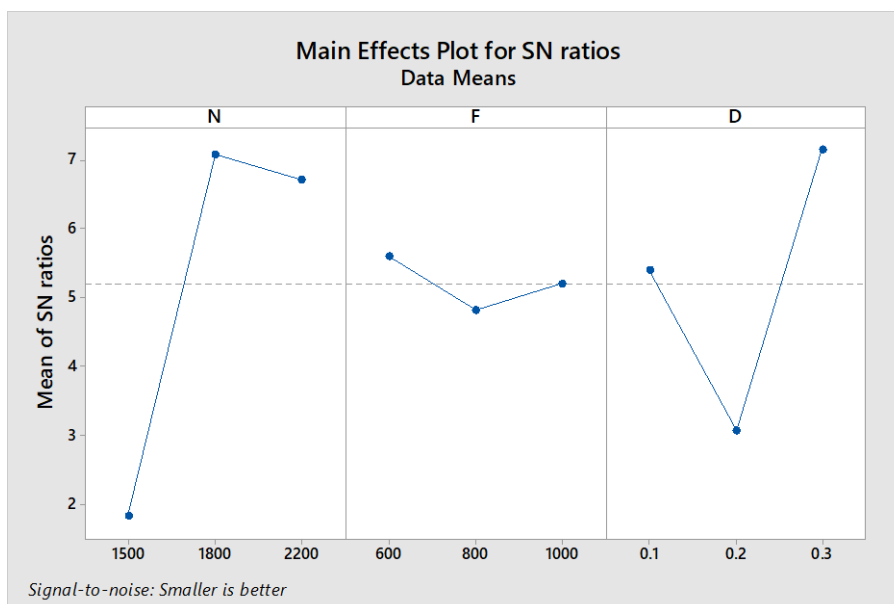


Fig. 4 S/N Ratio analysis for MQL



Fig. 5 Taguchi Specimen For MQL

From 1st trial it conclude that surface roughness value of aluminum 6061-T6 specimen during MQL was better than flooded coolant.

as per 1st trial 3 more trial was conducted and it observed that MQL was better than flooded coolant

ROUGHNESS TESTER

The milled surface roughness for each experimental combination was measured with a roughness tester (SJ-410 Mitutoyo). The measurement was taken in the feed direction and width of cut direction. An example of surface roughness measuring is shown in Figure



Fig. 6 Surface roughness measurement

VII.CONCLUSIONS

In MQL (Minimum quality lubrication) system, the soluble lubricant with mist air will be provide bet result of surface finish and temperature reduction during milling machining of a steel materials. The Taguchi method and ANOVA will optimize the MQL condition for surface roughness and optimize milling process parameters may show significant effect on surface finish and tool life.

Trial	N	F	D	Ra Values (µm)	
				Flooded coolant	MQL
1	1800	800	0.3	2.147	0.31
2	2200	900	0.12	1.440	0.362
3	2100	700	0.21	0.77	0.338
4	2000	800	0.20	0.891	0.150

From all trial it conclude that surface roughness value of Aluminium 6061 plates specimen during MQL was better than flooded coolant.



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