© April 2024 | IJIRT | Volume 10 Issue 11 | ISSN: 2349-6002

Experimental Examination of Coconut Oil Performance During Machining Of 1100- Aluminium Alloy with Minimum Quantity Lubrication

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Abstract— This study investigates the effectiveness of coconut oil as a lubricant in the machining of 1100 aluminum under minimum quantity lubrication (MQL) conditions, aiming to enhance machining performance by reducing tool wear, improving surface finish, and minimizing energy consumption. Experimental tests, conducted under controlled conditions with varied cutting parameters and lubrication techniques, analyze the influence of coconut oil on machining outcomes. The findings suggest promising implications for coconut oil as a sustainable lubrication solution in metal machining processes. Additionally, the challenges associated with machining aluminum alloys, including tool wear, surface integrity, and chip formation, are addressed through the investigation of Minimum Quantity Lubrication (MQL). The study evaluates the impact of MQL on various aspects of aluminum alloy machining, utilizing a CNC milling machine, aluminum alloy workpiece, and carbide cutting tool. Comparison between MQL and dry machining techniques reveals significant reductions in tool wear, improved surface finish, enhanced chip evacuation, and decreased cutting forces with MQL. Moreover, the implementation of MQL leads to reduced cutting zone temperatures, thereby enhancing tool longevity and machining effectiveness. Overall, Minimum Quantity Lubrication (MQL) demonstrates favorable outcomes for aluminum alloy machining, offering valuable insights for optimizing machining parameters and lubrication methodologies to improve performance in aluminum alloy machining operations.

Index Terms— Minimum Quantity Lubrication (MQL), Nozzle Stand Distance, Surface Bitterness, Temperature Variation, Aluminium alloy 1100, Coconut Oil.

I. INTRODUCTION

Aluminum alloys find widespread application across diverse industries owing to their favorable attributes, including lightweight nature, corrosion resistance, high strength-to-weight ratio, and exceptional machinability. [5]. Among these alloys, 1100-aluminium alloy stands out prominently due to its remarkable formability, high electrical conductivity, and ease of machining. However, the machining process of aluminium alloys poses challenges such as tool wear, built-up edge formation, and poor surface finish, thereby necessitating effective lubrication strategies to enhance machining performance and tool life. Traditional flood cooling methods have been widely utilized to address the difficulties encountered in machining aluminum alloys. Nevertheless, these approaches involve considerable drawbacks including environmental concerns, high consumption of coolant, and increased costs associated with coolant disposal and recycling. Within this framework, minimum quantity lubrication (MQL) has arisen as a compelling substitute lubrication strategy due to its capacity to reduce coolant consumption while providing sufficient lubrication and cooling throughout machining processes. Coconut oil, derived from the fruit of the coconut palm (Cocos nucifera), has gained attention in recent years as a potential bio-based lubricant due to its excellent lubricating properties, biodegradability, renewability, and low environmental impact. The unique chemical composition of coconut oil, predominantly comprising medium-chain fatty acids such as lauric acid and myristic acid, imparts favorable lubricating characteristics suitable for metalworking applications. The objective of this study is to examine the efficacy of coconut oil as a lubricant in the machining of 1100-aluminum alloy through the utilization of minimum quantity lubrication (MQL) methodology. The study seeks to evaluate various machining parameters, including cutting forces, surface roughness, tool wear, and chip morphology, to assess the effectiveness of coconut oil in improving machining efficiency and quality. Moreover, an assessment will be conducted regarding the environmental impacts and economic viability associated with the adoption of coconut oil as a sustainable substitute for lubrication. The selection of coconut oil as a lubricant for aluminum machining is driven by its intrinsic characteristics, including high lubricating properties, thermal stability, and compatibility with metal surfaces, all crucial factors for attaining optimal machining outcomes. Furthermore, the renewable nature of coconut oil aligns with the growing emphasis on sustainability and environmental responsibility in manufacturing processes. The experimental investigation will be conducted using a series of machining tests on a CNC milling machine under controlled conditions. Various combinations of cutting speeds, feed rates, and depths of cut will be examined to evaluate their impact on machining performance when utilizing coconut oil as a lubricant. Comparative analysis will be performed with conventional flood cooling lubrication to ascertain the efficacy of coconut oil-based MQL in enhancing machining efficiency and quality. Therefore, this research endeavors to contribute to the existing body of knowledge regarding sustainable lubrication practices in metal machining processes. By exploring the viability of coconut oil as a lubricant for aluminium alloy machining under MQL conditions, this study seeks to offer insights into environmentally friendly and economically feasible alternatives to conventional coolant-based lubrication techniques. The findings of this research could potentially pave the way for the adoption of coconut oil-based lubrication systems in industrial applications, thereby promoting sustainable manufacturing practices and reducing the environmental footprint of metalworking operations.

In 1992, Horkos Enterprise [1] The semi-dry machining of cast press components was created through the integration of the outside strategy and outside spout, with a center on challenging machining errands, Broad investigate was conducted to investigate its appropriateness for requesting cutting operations.

Byrne and Scholta [2] The expenses associated with cutting fluids often surpass those linked to cutting tools. Therefore, eliminating the need for cutting fluids, whenever feasible, can present a substantial economic motivation.

Park K.E et al. [3] A consider was embraced to analyze bead dissemination for least amount grease in processing operations utilizing the CLSM procedure for 3D characterization and volume estimation of beads. The EDA calculation was connected to evaluate bead dispersion in processing operations utilizing least amount of oil. Test discoveries demonstrate that as the spout remove increments, the surface range secured by beads diminishes, and higher weights result in litter bead sizes compared to lower weights. The ponder approves that a spout separate of less than 50mm is ideal, and for higher weights, a shorter spout separate is required.

Hadad M.J et al. [4] An test examination was conducted on temperature and vitality parcel in least amount oil amid crushing operations utilizing 100Cr6 as the work fabric. Temperature estimations were taken utilizing implanted K-type thermocouples. The test comes about illustrate that MQL crushing with oil has decreased vitality utilization by 7-10% compared to dry pounding.

Sharma Vishal S. et al [6] MQL doesn't directly "cool" the machining process as traditional coolant systems do, it effectively manages heat generation and reduces friction, which indirectly helps in keeping the machining process cooler and more efficient.

Aluminum 1100 is a versatile metal, meaning it can be formed into different shapes and materials. These include chemical components, fins, dials, train tankers, and manufacturer names. This soft but strong alloy is also used in industries such as plumbing and lighting, as well as many other manufacturers, from cookware to construction rivets. [7].

Rao D. Nageswara [8] The examination centered on looking at the affect of strong and fluid oil molecule sizes on different machining parameters in turning, confronting, and cutting operations. The try concluded that the execution and effectiveness accomplished through the utilize of strong oils speak to a attainable elective to both dry and damp machining strategies. The particular preferences of strong greases were underscored within the study.

II. EXPLORATORY SETUP

Experiments were conducted on a capable and unbending machine (KIRLOSKAR, INDIA, HSTM 10HP) to step turn a 38mm distance across and 500mm long pole of 1100 aluminum amalgam beneath least amount oil (MQL) conditions. Diverse spout separations and temperatures were tried, and two diverse cutting liquids were utilized to examine their affect on surface unpleasantness. Cutting parameters were chosen based on instrument producer proposals and mechanical master counsel. Surface roughness was measured employing a Profound Gages harshness analyzer beneath different machining conditions and cutting fluids for comparison. The try comprised two stages: the primary stage compared surface harshness execution between dry cutting and MQL with coconut oil beneath consistent bolster rate and profundity of cut, whereas the moment stage compared diverse cutting liquid exhibitions beneath MQL conditions in surge cutting temperature. Points of interest of exploratory cutting conditions for both stages are given within the taking after table.

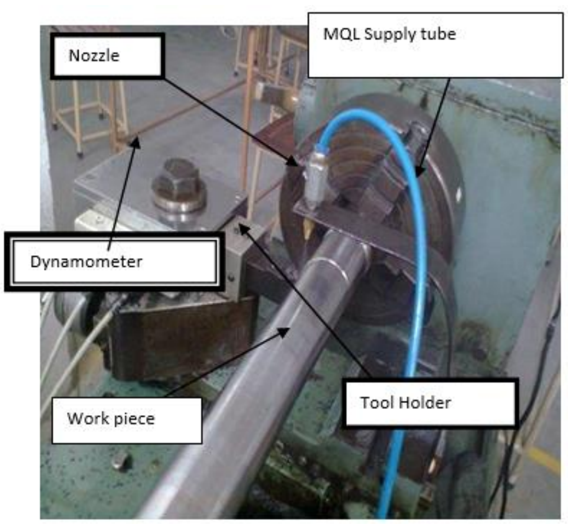

Fig-1: Photographic view of Experimental set up

Table-1: Details of Experimental Set up

Sr. No.	Components	Description
	Machine Tool	Lathe Machine (Hindustan Machine Tool, INDIA)10 hp
	Work Specimen	1100 Alloy Aluminium, Size: φ90X 900 mm
	Cutting tool (insert):	SNMG120408
	Tool holder	PSDNN 2525M12
	Working tool geometry	-80, -80, 80, 80, 550, 550 degree and0.8 mm
	Cutting velocity (Rpm)	152, 360, 550, 640, 900 and 1200
	Feed rate	0.073 and 0.098mm/rev
	Depth of cut	1 and 1.5mm
	MQL supply	Coconut oil 120ml/hr at 6 bar
	Distance of nozzle(mm)	20,30 and 40
	Thermocouple	N- type (-25 to 1260C)
	Air Compressor	Single phase motor driven

Table-2: Experimental condition for different Position of Nozzle

Sr. No.	Cutting Speed (Rpm)	Feed Rate (mm/rev)	Nozzle distance in1st case(mm)	Nozzle distance in 2nd case(mm)	Nozzle distance in 3rd case(mm)
	152	0.073	20	30	40
	200	0.073	20	30	40
	360	0.073	20	30	40
	550	0.073	20	30	40
	640	0.073	20	30	40
	900	0.073	20	30	40
	1000	0.073	20	30	40
	1200	0.073	20	30	40
	152	0.098	20	30	40
	200	0.098	20	30	40
	360	0.098	20	30	40
	550	0.098	20	30	40
	640	0.098	20	30	40
	900	0.098	20	30	40
	1000	0.098	20	30	40
	1200	0.098	20	30	40

Table-3: Surface Bitterness in different cutting condition

S No.	V rpm	Feed Rate mm/rev	Surface roughness in dry cutting at 1 mm	Surface roughness in flood cutting at 1mm	Surface roughness in MQL cutting at 1mm	Surface roughness in dry cutting at 1.5 mm	Surface roughness in flood cutting at 1.5 mm	Surface roughness in MQL cutting at 1.5 mm
1	152	0.073	1.98	1.87	1.8	2.26	2.24	2.2
2	200	0.073	1.79	1.69	1.69	2.12	2.1	1.92
3	360	0.073	1.68	1.57	1.58	1.92	1.91	1.81
4	550	0.073	1.46	1.47	1.39	1.85	1.8	1.75
5	640	0.073	1.38	1.32	1.27	1.78	1.69	1.62
6	900	0.073	1.3	1.2	1.17	1.65	1.5	1.48
7	1000	0.073	1.1	1.14	1.1	1.5	1.39	1.32
8	1100	0.073	0.99	1.1	0.98	1.35	1.25	1.22
9	1200	0.073	0.97	0.94	0.87	1.24	1.15	1.12
10	152	0.098	1.94	1.86	1.8	2.13	2.1	2.08
11	200	0.098	1.64	1.69	1.59	2.01	1.92	1.9
12	360	0.098	1.42	1.39	1.47	1.92	1.81	1.78
13	550	0.098	1.37	1.27	1.35	1.81	1.69	1.63

14	640	0.098	1.26	1.17	1.22	1.72	1.57	1.5
15	900	0.098	1.15	1.05	1.14	1.61	1.43	1.39
16	1000	0.098	1.03	0.99	1.07	1.5	1.35	1.3
17	1100	0.098	0.92	0.86	0.87	1.32	1.26	1.21
18	1200	0.098	0.82	0.78	0.75	1.25	1.18	1.1

Table-4: Temperature during different cutting condition

Sr. No.	V (RPM)	Feed Rate (mm/rev)	Temperature during dry cutting (deg. C)	Temperature during Flood cutting (deg. C)	Temperature during MQL (deg. C)
	152	0.073	165	145	131
	200	0.073	160	150	144
	360	0.073	195	185	182
	550	0.073	233	210	208
	640	0.073	275	245	252
	900	0.073	320	265	264
	1000	0.073	340	273	275
	1200	0.073	360	290	287
	152	0.098	169	140	141
	200	0.098	185	168	145
	360	0.098	225	208	200
	550	0.098	270	221	214
	640	0.098	298	250	237
	900	0.098	345	278	268
	1000	0.098	399	299	288
	1200	0.098	405	305	295

III. RESULT AND DISCUSSION

The exploratory examination pointed to evaluate the affect of Least Amount Oil (MQL) on the machining execution of 1100 aluminum amalgam. By utilizing a efficient test setup, parameters such as cutting speed, bolster rate, oil stream rate, and profundity of cut were methodicallly balanced and observed to analyze their impact on the machining handle. The discoveries yielded important experiences into the elements between MQL and the 1100 aluminum combination amid machining.

Regarding surface quality, it was famous that utilizing MQL brought about in noteworthy upgrades compared to dry machining conditions. The presentation of a little sum of oil successfully diminished contact and warm buildup at the cutting interface, driving to smoother surface wraps up and diminished surface harshness. This advancement in surface quality is credited to the lubricant's part in supporting chip expulsion and lessening tool-workpiece attachment, thus diminishing surface abandons and irregularities.

Moreover, the affect of MQL on device wear and life span was inspected. The think about uncovered that MQL brought about in diminished device wear rates and amplified apparatus life in comparison to dry machining scenarios. By relieving contact and warm, the grease served as a defensive shield, moderating intemperate apparatus wear and drawing out the life expectancy of cutting devices. This disclosure emphasizes the potential of MQL as a attainable approach for making strides apparatus productivity and bringing down machining costs in aluminum combination machining endeavors.

Apart from exploring surface quality and apparatus wear, the ponder moreover surveyed the impact of MQL on machining strengths and vitality utilization. It was famous that executing MQL driven to diminished cutting strengths and control utilization in differentiate to conventional surge cooling methods. This lessening in machining powers not as it were upgrades machining productivity but moreover brings down the probability of workpiece distortion and instrument avoidance, subsequently progressing dimensional precision and generally handle stability.
In outline, the test discoveries emphasize the considerable preferences of utilizing MQL within the machining of 1100 aluminum amalgam. By conveying productive oil whereas decreasing coolant utilization, MQL presents a maintainable and eco-friendly approach to improving machining proficiency. In any case, extra inquire about is required to explore the ideal collaboration between handle parameters and grease compositions to completely abuse the preferences of MQL in aluminum combination machining endeavors.

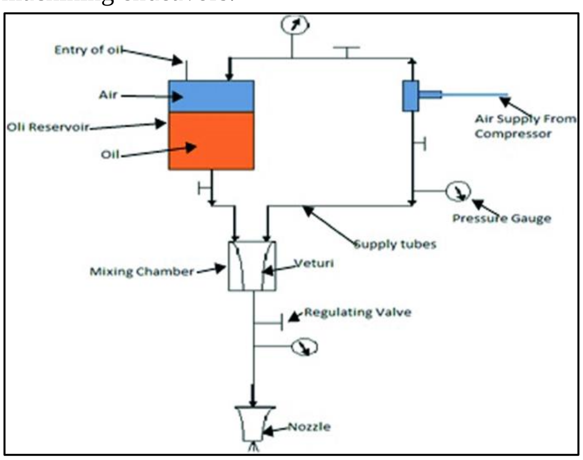

Fig-2: Schematic diagram of experimental set up

Fig-3: Photographic view of experimental set up

Fig-4: Photographic view of digital temperature indicator

3.1 EFFECT OF NOZZLE DISTANCE ON DIFFERENT CUTTING CONDITION AT FEED 0.073

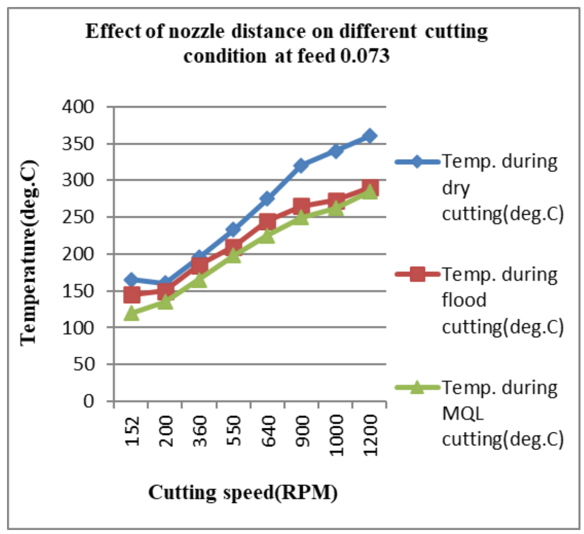

Fig-5: Effect of nozzle distance on different cutting condition at feed 0.073

3.2 EFFECT OF NOZZLE DISTANCE ON DIFFERENT CUTTING CONDITION AT FEED 0.098

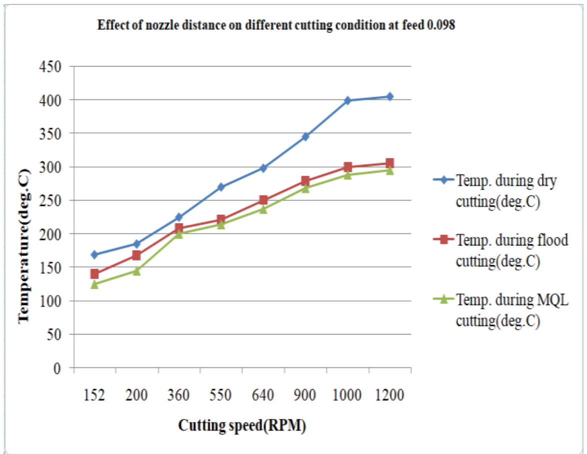

Fig-6: Effect of nozzle distance on different cutting condition at feed 0.098

As evident from figures 5 and 6, temperatures during dry cutting conditions were higher compared to those during flood cutting and MQL cutting conditions. This discrepancy could be attributed to several factors, including evaporative cooling by the air-assisted jet, the cutting and healing action of MQL fluid, and other potential causes. However, observations indicate that MQL with coconut oil jet, in its current application method, reduced average cutting temperatures by approximately 4% to 10%, contingent upon the levels of cutting parameters and nozzle distance from the cutting zone. Notably, maximum cutting temperatures were recorded at a 40mm nozzle distance, while the lowest temperatures were observed at a 30mm distance. Interestingly, when the nozzle was positioned 10mm away from the cutting zone, temperatures recorded were higher than those at the 30mm distance.

Here in, several implications are discussed:

1. Chip Formation and Evacuation: Nozzle distance affects lubricant application, potentially hindering effective chip formation and evacuation. Improper lubrication may lead to chip adherence, tool wear, and inferior surface finish.
2. Tool Wear: Nozzle distance influences cooling and lubrication on the cutting tool. Inadequate lubrication due to nozzle positioning could escalate tool wear rates, especially at higher feed rates, impacting tool longevity and machining efficiency.
3. Heat Generation: Effective cooling and lubrication are vital for dissipating machining-generated heat. Nozzle distance affects cooling efficiency; thus, improper positioning might escalate temperatures at the cutting interface, risking thermal damage to the workpiece and tool.
4. Surface Finish: Machined surface quality can suffer due to improper nozzle distance, potentially resulting in inferior surface finish, including roughness, edge buildup, and defects.
5. Machining Forces: Nozzle distance can influence cutting forces, affecting machining stability and accuracy. Improper lubrication may lead to force variations, impacting overall performance.
6. Machining Efficiency: Efficiency, encompassing material removal rates and energy consumption, can be influenced by nozzle distance. Inadequate lubrication due to improper positioning might lower machining efficiency, stemming from increased tool wear, breakage, and machine downtime.

To comprehensively grasp nozzle distance effects across diverse cutting conditions, systematic experimental exploration is essential. Such investigation can aid in parameter optimization for improved performance, encompassing tool longevity, surface quality, and machining efficiency, while mitigating adverse effects associated with inadequate lubrication.

3.3 SURFACE BITTERNESS IN DIFFERENT CUTTING CONDITION AT FEED 0.073 AND 1MM DEPTH OF CUT

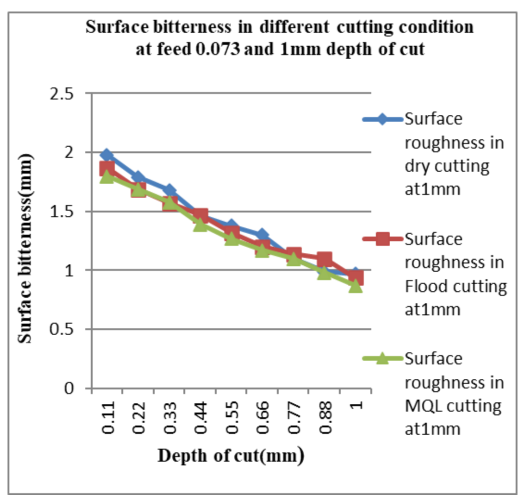

Fig-7: Surface bitterness in different cutting condition at feed 0.073 and 1mm depth of cut

3.4 SURFACE BITTERNESS IN DIFFERENT CUTTING CONDITION AT FEED 0.073 AND 1.5 MM DEPTH OF CUT

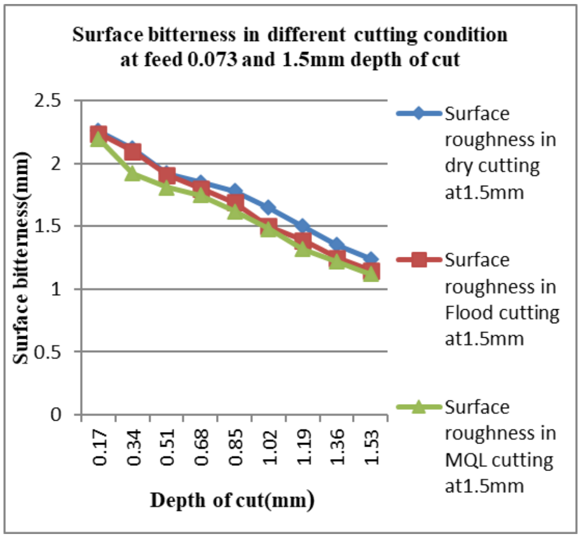

Fig-8: Surface bitterness in different cutting condition at feed 0.073 and 1.5mm depth of cut

3.5 SURFACE BITTERNESS IN DIFFERENT CUTTING CONDITION AT FEED 0.098 AND 1 MM DEPTH OF CUT

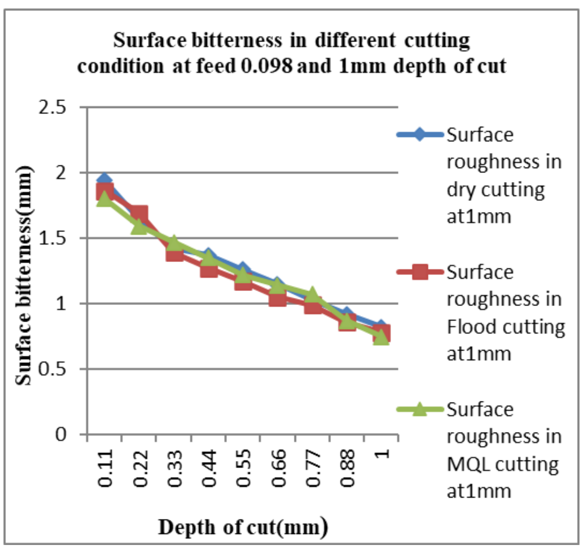

Fig-9: Surface bitterness in different cutting condition at feed 0.098 and 1mm depth of cut

3.6 SURFACE BITTERNESS IN DIFFERENT CUTTING CONDITION AT FEED 0.098 AND 1.5 MM DEPTH OF CUT

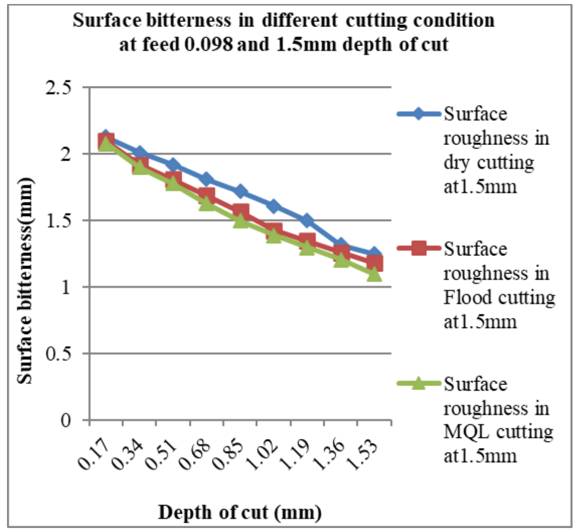

Fig-10: Surface bitterness in different cutting condition at feed 0.098 and 1.5mm depth of cut

When comparing surface bitterness across various cutting conditions (dry cutting, flood cutting, and minimum quantity lubrication (MQL) cutting) at different feed rates (0.073 and 0.098) and depths of cut (1 mm and 1.5 mm), several notable findings emerge. Dry cutting, characterized by the absence of lubrication, typically results in the highest surface bitterness due to heightened friction and heat buildup at the cutting interface. This often leads to the formation of built-up edges, microcracks, and surface irregularities, resulting in a rough and bitter surface finish. Flood cutting, involving continuous coolant or lubricant application, partially alleviates surface bitterness by dissipating heat and reducing friction. However, excessive coolant application may impede chip evacuation and lead to coolant-induced defects, adversely affecting surface quality. Conversely, MQL cutting, which applies a minimal amount of lubricant directly to the cutting zone, strikes a balance between lubrication efficacy and reduced environmental impact. MQL cutting notably reduces surface bitterness compared to dry cutting by providing adequate lubrication to minimize friction and heat without excess fluid application. Evaluation across different feed rates and depths of cut indicates that higher feed rates and deeper cuts generally exacerbate surface bitterness due to increased tool engagement and heat generation. Nonetheless, the specific impact varies depending on the cutting condition.

CONCLUSION

The essential objectives of this consider were to survey the impacts of utilizing coconut oil as a oil on the execution of Aluminum-1100 amalgam, especially in terms of surface intensity, over different cutting situations and with distinctive cutting embeds beneath shifting cutting parameters. Furthermore, the impact of spout remove situating in numerous cutting temperature conditions was inspected. The test discoveries approve the taking after results, summarized underneath:

1. The most extreme cutting temperature has been recorded at 20mm spout stand-off separate, which is dry cutting condition. This is often 8-12% more than 30mm spout stand-off remove.
2. When Spout has been set at 30mm stand-off remove at that point the cutting temperature is 4-8% more than 40mm spout stand- off separate.
3. The impact of spout stand-off is about break even with to the impact speed rate on cutting temperature amid more than 30mm stand-off separate.
4. The least temperature has been recorded amid 40mm stand of remove since of uniform dispersion of MQL jet drops conveyance to the cutting zone, which may be not conceivable amid other stand of separations and subsequently more temperature.
5. MQL by coconut oil moreover secures environment contamination by releasing diminished sums of fumes, mist, erosion and oxides during cutting conjointly diminish wellbeing hazards.
6. We will moreover discover that when we increments cutting speed the surface severity of alumimium combination diminishes. Thus MQL in show examination has decreased the surface severity as compare to dry cutting condition.
7. The usage of coconut oil as a grease come about in eminent varieties in surface intensity over distinctive cutting situations and with unmistakable cutting embeds at shifting cutting parameters.
8. Adjusting the position of the nozzle distance in different cutting temperature conditions yielded significant impacts on the observed outcomes.
9. The experimental results underscored the intricate relationship between lubricant application, cutting conditions, and surface quality, offering valuable insights into optimizing machining processes for enhanced performance and surface finish in Aluminum-1100 alloy machining applications.

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ACKNOWLEDGMENTS

We would like to specific our true appreciation to Chandigarh University for giving me a extraordinary openings, which made this inquire about conceivable. Also, we expand our appreciation to our extend Administrator Er. Ajay Kumar Faculty of Chandigarh College for their important direction and back all through the length of this think about. We are profoundly grateful to the educators of Chandigarh University Research facility, where the exploratory work for this inquire about was conducted. Their expertise and assets were instrumental within the fruitful completion of this ponder. Moreover, we would like to thank MQL setup laboratory assistance for their help with information collection, investigation, and composition arrangement. Their commitments altogether upgraded the quality and meticulousness of this investigate. At long last, we are thankful to the members who volunteered their time and participation for the exploratory strategies. Without their inclusion, this think about would not have been conceivable.