10TH INTERNATIONAL CONGRESS ON MACHINING
7-9 NOVEMBER 2019
Kemer, Antalya, Turkey

INVESTIGATING THE EFFECT OF CUTTING CONDITIONS ON MACHINING PERFORMANCE OF AL 6061-T6 ALLOY

Ramazan Hakkı Namlu[a], Okan Deniz Yılmaz[a], Sadık Engin Kılıç[a], Barış Çetin[b]

a, Atılım University-Manufacturing Engineering Department

b, FNSS Defence Industry

PRESENTATION OUTLINE

- Introduction
- Literature research
- Material and Method
- Results about surface roughness and cutting forces
- Conclusions
- Ongoing projects and future works
- References

INTRODUCTION

- Aluminum 6061 – T6 is one of the most commonly-used aluminum alloy in **aerospace, defense and automobile industries** because of its good mechanical properties, high corrosion resistance and good weldability
- In these areas, machining operations have an important role in manufacturing chain.
- The machining cost has an unneglectable contribution to the overall cost of the final part. In that sense, cutting fluids serve a good implement to decrease manufacturing costs by eliminating the conventional coolant problems.
- On the other hand, the cutting fluids have a crucial drawback in terms of environmental issues.
- Therefore, **minimum quantity lubrication (MQL)** is an intensively-focused research area in machining in term of economy and ethics of environmental issues

- In this research, slot milling of Al 6061-T6 alloy is investigated in dry, wet and MQL conditions. The cutting force and workpiece roughness recorded in different cutting parameters in three different coolant conditions.

LITERATURE RESEARCH

- Recent researches in end milling and turning of Al6061 showed that tool wear and machining cost with MQL coolant machining is lower than conventional wet and dry machining [1,2]
- Another research reported that MQL coolant machining gives %20 better result than the dry condition of surface roughness of end milling of Al6061 [3].
- Kadirgama [10] reported that feed rate is the most significant factor for surface roughness but cutting speed is the least effective factor for the end milling of Al 6061 [4].
- Okonkwo [8] expressed that MQL coolant machining gives %32 better result than the dry condition of cutting forces of end milling of Al6061 [5]

- According to literature review, there is no consensus about the most important factor affecting the surface roughness. Furthermore, there is not sufficient study in cutting forces of Al6061 related to the use of in MQL coolant milling process. In this sense, our study will be effective in filling this research area.

MATERIAL AND METHOD

- Workpiece material was Al 6061 and cut in size of **135*270*15 mm** as shown in Figure 1
- The cutting tool was the MasterCut 81551 **HSS type** 30˚ helix angle 8 mm diameter with **two flute end mill**
- The workpiece is clamped tightly onto the dynamometer for prevent the chatter where the it can be seen in Figure 1
- The water soluble cutting fluid was **Force K 102 half-synthetic cutting fluid** which is commercial and non-toxic type cutting fluid.
- Selected ester based **MQL is Samnos ZM-22W**
- Its formation consisting of hydrous polyalkylene-glycol-solution.

Component	Wt. (%)
Al	95.8 - 98.6
Cr	0.04 - 0.35
Cu	0.15 - 0.4
Si	0.4-0.8
Mg	0.8-1.2
Fe	Max. 0.7

Table 1

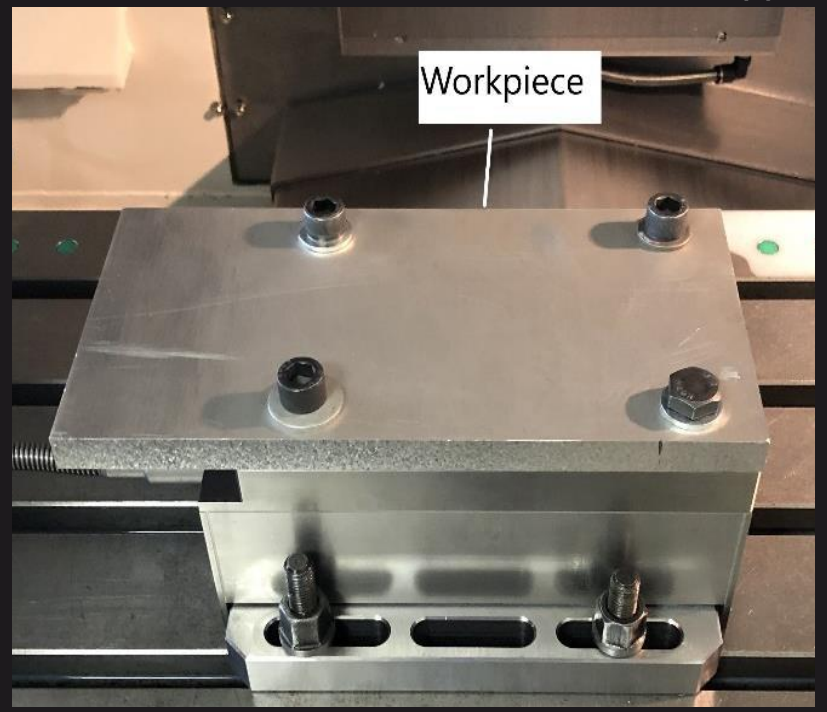

Figure 1

MATERIAL AND METHOD

- Nozzle of the MQL system has **10 mm diameter inside an it set 30 degrees from horizontal axis** as shown in Figure 2
- Cutting force measurements were done by **Kistler 9265B dynamometer with Dynoware software** and it can be seen in Figure 3
- Surface roughness values were measured by Mahr MarSurf PS1, surface roughness device which has resolution of the device is 1 nm.

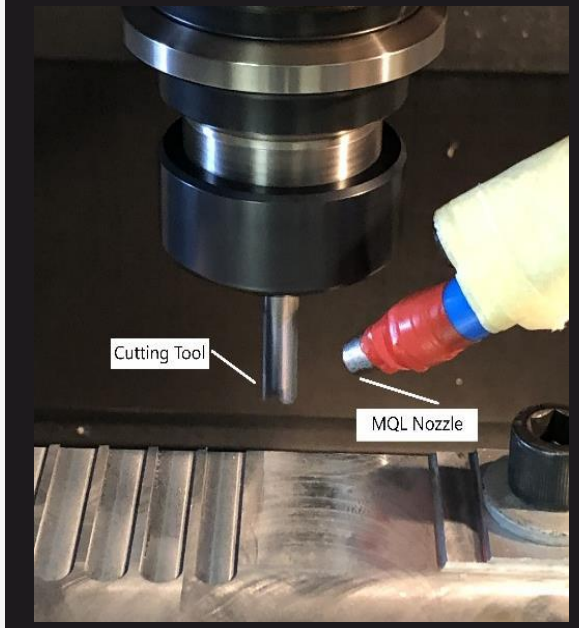

Figure 2

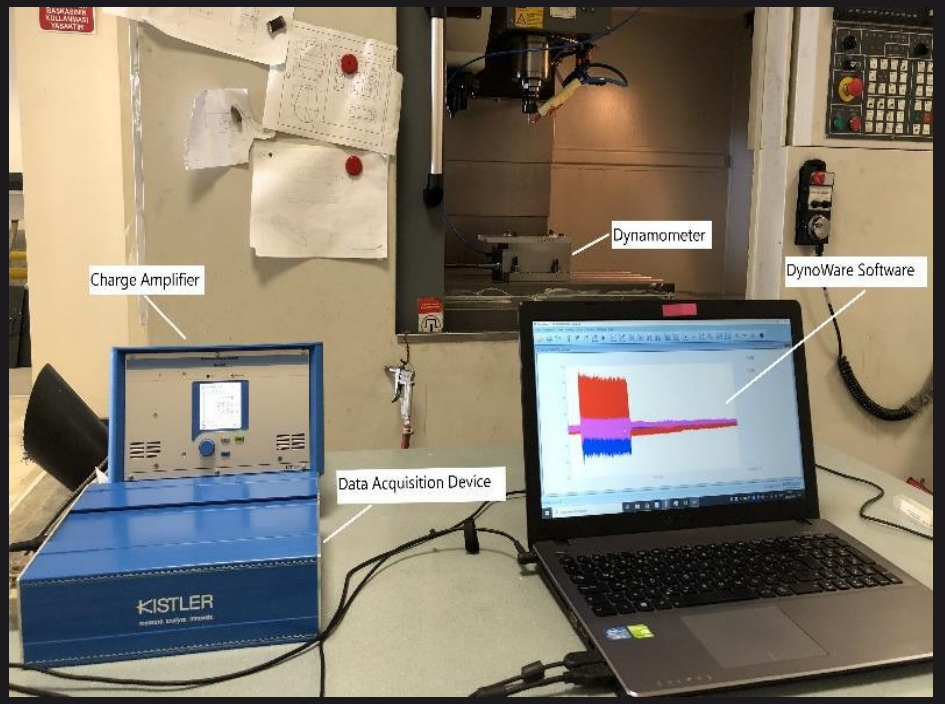

Figure 3

DESIGN OF EXPERIMENTS

- The three main machining parameters were selected in this experiments were **cutting speed, cooling of the cutting condition and feed rate**. Total of 18 experiments were done.
- Depth of cut was remaining constant in all experiments and it was 0,5 mm.
- Selected coolant conditions were **dry, wet (water soluble cutting fluid) and ester based MQL**

Experiment No	Feed [mm/min]	Spindle Speed [RPM]	Coolant Condition
1	600	8000	Dry/ Water Soluble Cutting Fluid/Ester Based MQL
2	600	10000	Dry/ Water Soluble Cutting Fluid/Ester Based MQL
3	600	11000	Dry/ Water Soluble Cutting Fluid/Ester Based MQL
4	500	10000	Dry/ Water Soluble Cutting Fluid/Ester Based MQL
5	700	10000	Dry/ Water Soluble Cutting Fluid/Ester Based MQL
6	800	10000	Dry/ Water Soluble Cutting Fluid/Ester Based MQL

Table 2

RESULTS AND DISCUSSION- SURFACE ROUGHNESS

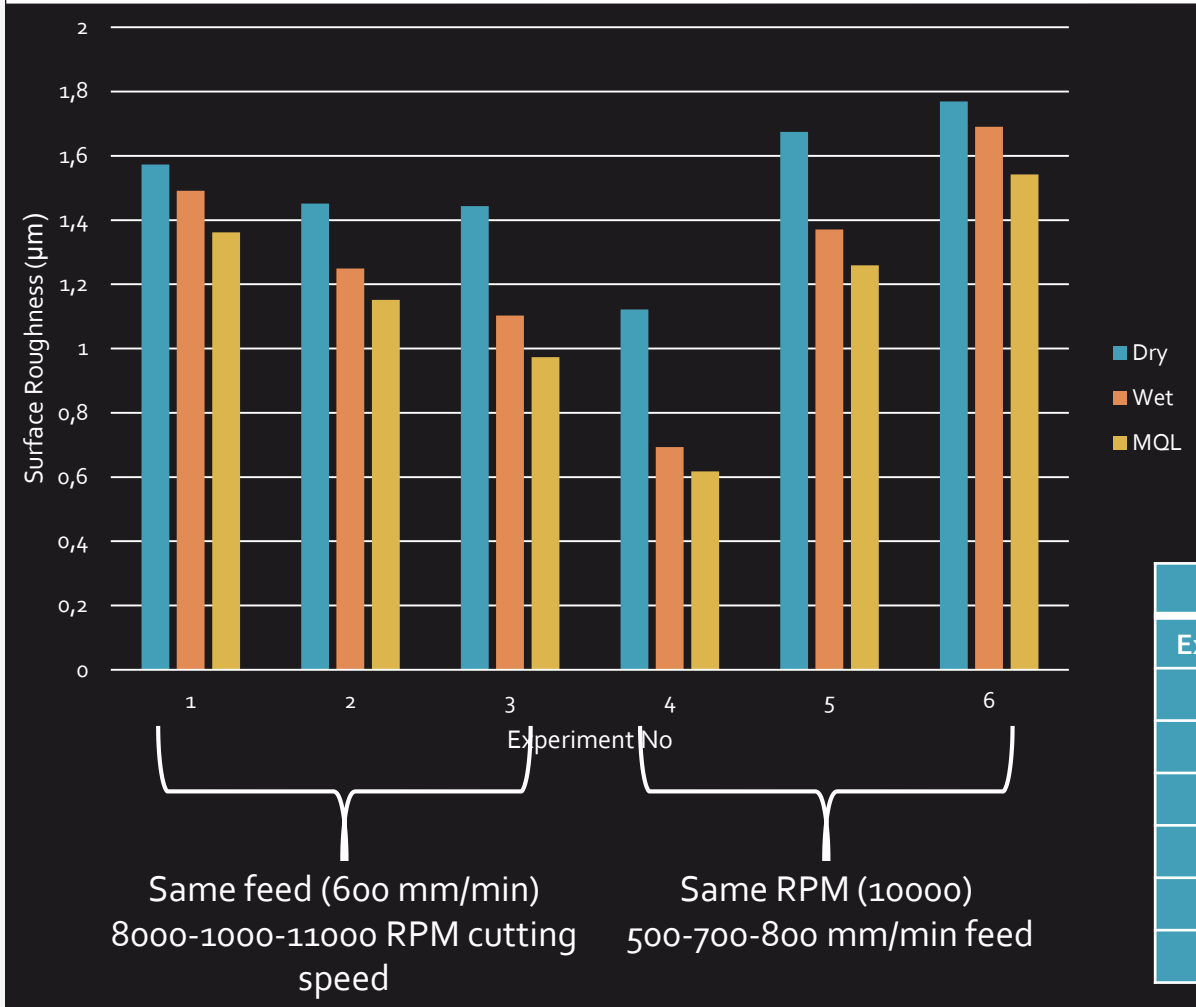

Figure 4

- There was a significant improvement in the surface finish of about a maximum of 81% compare to dry condition and 13% for wet condition.
- There is more efficient diffusion of coolant into the cutting area with MQL.
- MQL also reduces the cutting zone temprature.
- Efficient lubrication allows the chips to slide more easily over the tool's surface, resulting in a better surface finish

				% Reduction in Ra	
Experiment No	Dry (Ra)	Wet (Ra)	MQL (Ra)	Dry vs MQL	Wet vs MQL
1	1.573	1.491	1.362	15.49	9.47
2	1.451	1.249	1.152	25.95	8.42
3	1.443	1.103	0.973	48.30	13.36
4	1.122	0.693	0.617	81.85	12.32
5	1.675	1.371	1.259	33.04	8.90
6	1.769	1.691	1.542	14.72	9.66

Table 3

RESULTS AND DISCUSSION – CUTTING FORCES

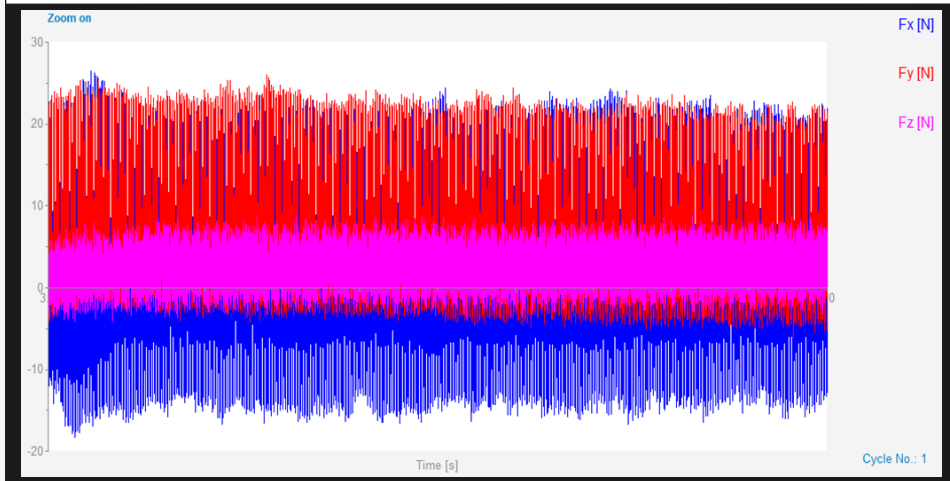

Figure 5:Cutting force measurement sample (feed: [600 mm/min], Spindle speed: 11000 [RPM], MQL

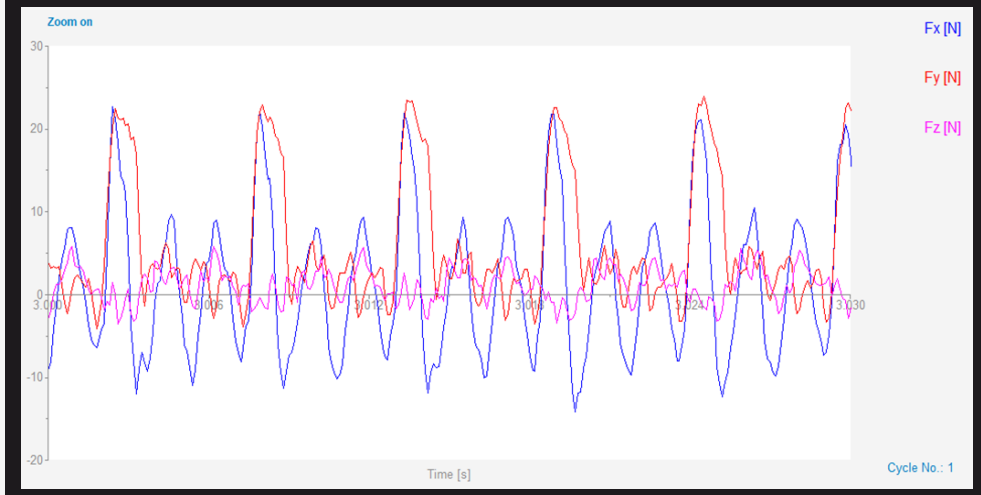

Figure 6: Detailed view of cutting force measurement sample

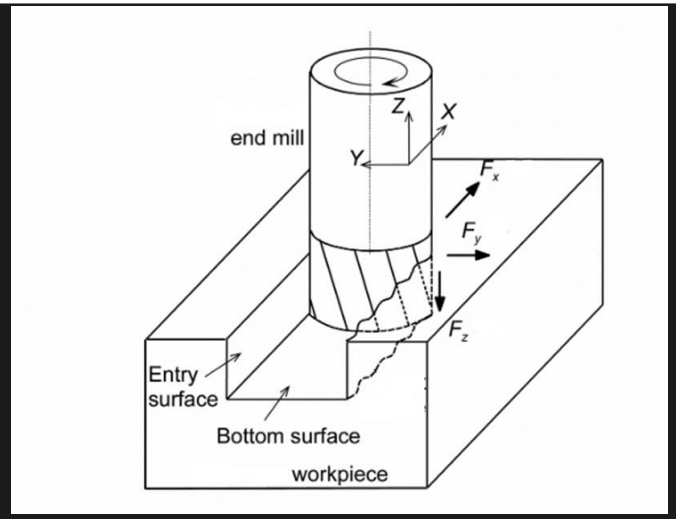

Figure 7: Directon of cutting forces

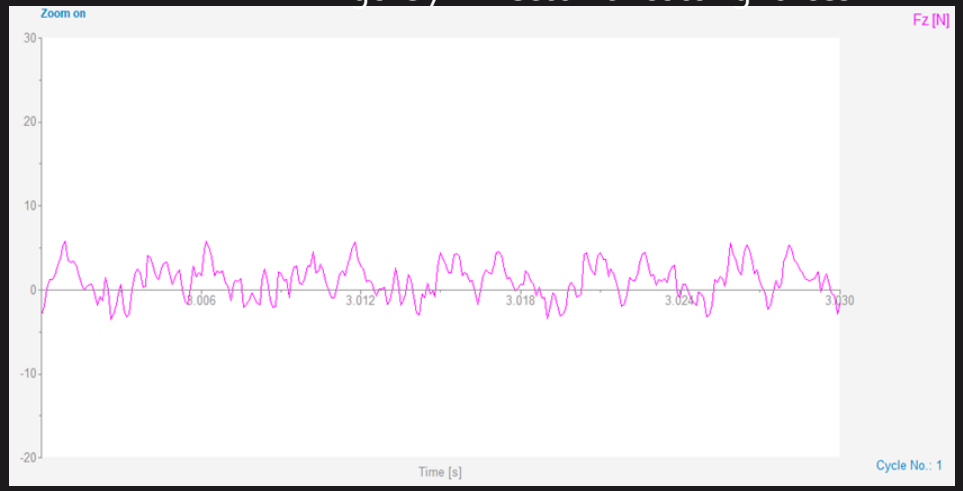

Figure 8: Z direction cutting forces

RESULTS AND DISCUSSION- CUTTING FORCES

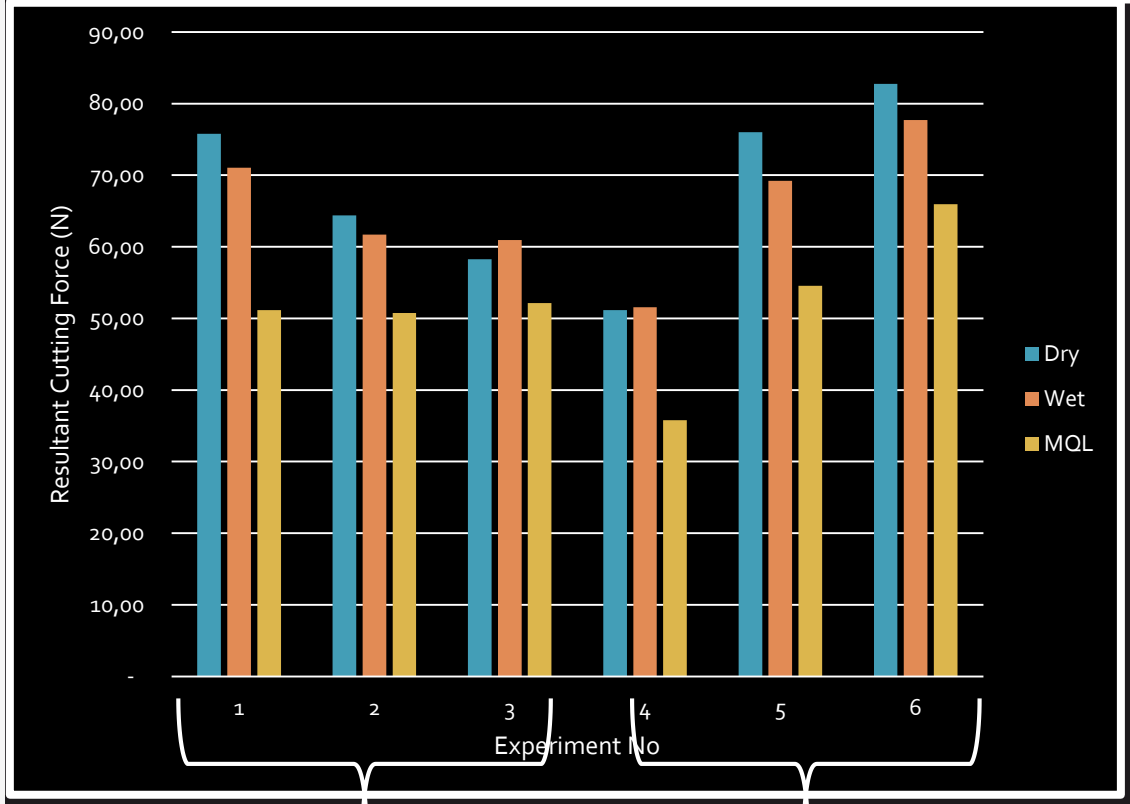

Figure 9

- The cutting force of MQL was reduced by up to 48% compared to dry cutting. Compared to wet cutting, the use of MQL reduced the cutting force by up to 44%.
- The aeresol coolant with **high pressure and high velocity** are able to reach the everywhere of the cutting zone where it performed its lubrication effect and minimized the friction to a remarkable amount.
- The cooling effect of the low temprature compressed air could reduce temprature of the cutting zone.
- With that better lubrication and cooling, MQL reduce cutting forces.

	Resultant Force			% Reduction	
Experiment No	Dry	Wet	MQL	Dry vs MQL	Wet vs MQL
1	75.78	71.05	51.15	48.15	38.91
2	64.40	61.72	50.77	26.85	21.57
3	58.27	60.94	52.15	11.74	16.86
4	51.15	51.57	35.77	42.97	44.16
5	76.01	69.20	54.56	39.30	26.81
6	82.77	77.71	65.93	25.54	17.86

Table 4

CONCLUSIONS

The important conclusions drawn from the research are summarized as follows:

•Spindle speed and feed as independent factors have influence on the surface roughness. However, while **increase in the spindle speed decreases the surface roughness, that of the feed increases it.**

•In the surface roughness results, **the use of MQL has always yielded better results than dry and wet conditions**. Up to 81% less surface roughness than dry condition and up to 14% less than wet condition.

•In the results of cutting forces, it was observed that the **increase in speed** had a positive effect in general and **decreased the cutting forces**. However, **the increase of feed parameter adversely affects and increases cutting forces**.

•According to the results of cutting force experiments, **the use of MQL has always had a positive effect**. The resultant cutting forces were 48% lower than the dry condition and 44% lower than the wet condition.

ONGOING PROJECTS AND FUTURE WORKS

- Ultrasonic Assisted Milling of Ti-6Al-4V with MQL (Ongoing Project)
- Simulation of MQL process (Ongoing Project)
- Using different kinds of MQL oils (Future Work)
- Using more than one nozzle for MQL system (Future Work)
- Investigating the tool wear after machining with MQL (Future Work)

ACKNOWLEDGEMENT

The authors wish to express their appreciations for the financial support by **UNF Makina Company**

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QUESTIONS?