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Evaluation of minimal quantity lubrication effects on surface roughness in milling with coated and uncoated tools using kurtosis quantification method approach

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ABSTRACT –The present work's main contribution is applying kurtosis quantification to analyse complicated or random type of milling vibration signals under dry and minimal quantity lubrication (MQL) to achieve good surface quality. The milling process is carried out using coated and uncoated cutting tools on ductile iron under the selected MQL volume flow rate parameter. The results obtained from kurtosis and skewness measurement are then verified with average surface roughness measurement (Ra). From the experimental work, it was found that kurtosis demonstrate the effectiveness on feature extraction. The dry milling using uncoated tools contributes high values of vibration signals and surface roughness. Meanwhile, the Ra values improvement, which reduces by 70% when MQL is applied.

1. INTRODUCTION

At present, manufacturing and other industries compete to achieve high-volume production. MQL has the advantage of producing good machining quality and minimal tool wear. Zhang et al. [1] studied the performance of different types of MQL system used in milling H13 steel, which evidently, MQL increased the tool life, contributed to economical cutting speed and generally improved the efficiency of the production rate. MQL is more preferable than dry cutting because of less heat generated due to friction between surfaces and considerably better surface finish results [2]. It is difficult to measure directly because the vibration mode is frequency-dependent. Hence, related parameters are derived from the raw data. Cuka and Kim [3] demonstrated acceleration signals could provide an earlier indication of approaching cutting failure than the force signals besides low cost, ease of use and adaptability [4]. Cao et al. [5] applied statistical indicators, such as kurtosis and skewness, to monitor the milling process. The high noise level further complicated the milling process analysis picked up by the accelerometer and the low level of energy associated directly with the milling parameters. Therefore, milling process with coated and uncoated tools are conducted under dry machining and MQL condition where signals are quantified using the feature extraction method in the present work. Meanwhile, the milling process is verified by surface roughness measurement to observe the reliability of data analysis.

2. METHODOLOGY

The experiment was carried on a CNC Makino KE55 milling machine (Figure 1). The workpiece material used was ductile iron FCD450 and meanwhile 20 mm diameter cutting tools of coated (TiAlN) and uncoated type end mill carbide-based were used. The milling parameters are concluded in Table 1. Unist Coolubricator with six pumps for individual outputs was used for MQL machining. It provided up to 0.03 ml/stroke for standard one-drop displacement metering pump and equipped with the pulse generator, which allows for automatic repeat cycling of the lubricant pumps with 5–200 pulse/min air output. The best volume of lubricant and air could be manually achieved to produce perfect spray.

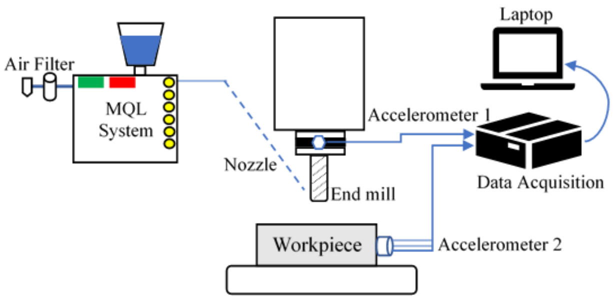

Figure 1 Schematic of experimental.

Table 1 Milling process parameters.

Machining parameter	Value
Rotation speed, n (rev/min)	1000, 1487, 2015, 2495, 3026
Feed rate, v_f (mm/min)	120, 165, 375, 520, 720
MQL nozzle spraying angle (°)	135°
MQL volume flow rate (ml/h)	0, 9, 18, 36

Meanwhile, kurtosis (K) equation labelled as in Equation 1, the fourth central moment and a measure of the peak for acceleration data (α), where μ is the mean and σ is the standard deviation of size n.

$$K = \frac{1}{n}\frac{\sum_{i=1}^{n}(a_i-\mu)^4}{\sigma^4} \quad (1)$$

3. RESULTS AND DISCUSSION

The acceleration signals from different rotation speeds (Figures 2 and 3) and feed rate (Figures 4 and 5) were quantified using kurtosis approach and compare with average roughness measurement (Ra). Figures 2 and

3 illustrates that maximum K and Ra values measured at the highest speed of 3026 rev/min. The best one was obtained at 2015 rev/min whereby all K values were below 0.7. Ra values gradually increase when spindle speed increase excepts surprisingly under dry cutting. At low speed, friction between tool-workpiece is high due to discontinuous chip. Therefore, when MQL is applied, milling at 36 ml/h produces lower Ra values due to both output and air blown off to clear chip and friction.

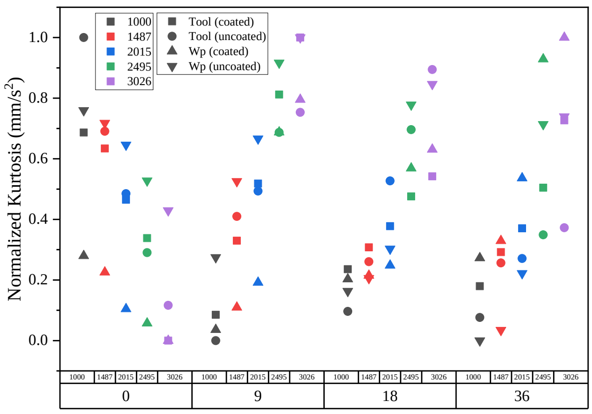

Figure 2 MQL and rotation speed to kurtosis values.

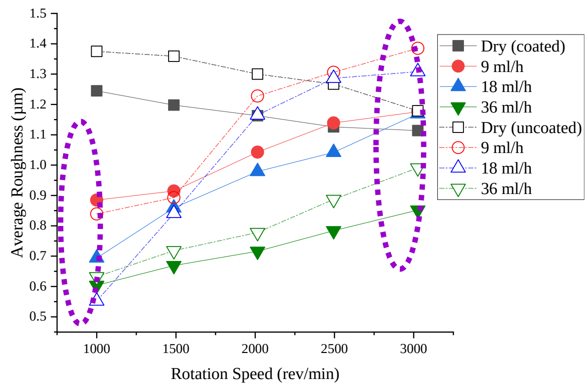

Figure 3 Rotation speed effect on surface roughness.

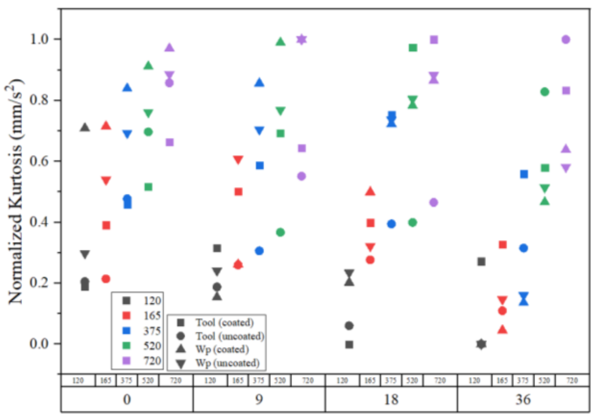

Figure 4 MQL and feed rate to kurtosis values.

Meanwhile, the maximum K (Figure 4) and Ra (Figure 5) values measured are at the highest feed rate applied, 720 mm/min. However, the minimum K values surprisingly were conducted using the uncoated tool. Besides, the lowest Ra values measured under 36 ml/h of MQL. From the graph, both K and Ra value gradually increase when the feed rate increase. It is also visible that the coated tool has lower Ra values compared to the uncoated one. At a low feed rate, the cutting process has less interruption leading to friction between interfaces also decrease. As the feed rate is increased, the coefficient of friction increases resulting in high average Ra values.

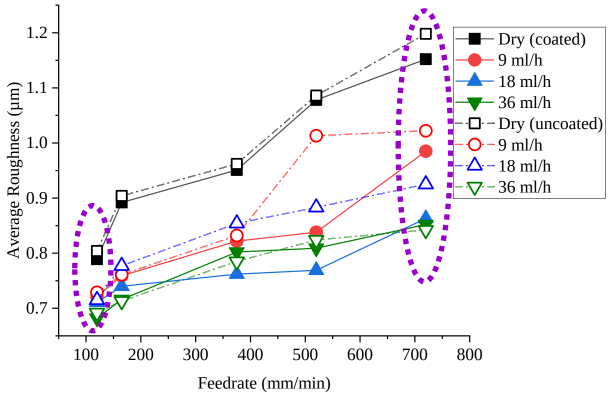

Figure 5 Feed rate effect on surface roughness.

4. CONCLUSION

The present work shows that quantification data using the kurtosis approach enhances in acquiring and analyse data. Besides, K and Ra values measured mostly perform better when the MQL system was applied.

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REFERENCES

[1] Zhang, C., Zhang, S., Yan, X., & Zhang, Q. (2016). Effects of internal cooling channel structures on cutting forces and tool life in side milling of H13 steel under cryogenic minimum quantity lubrication condition. *The International Journal of Advanced Manufacturing Technology*, *83*(5-8), 975-984.

[2] Xu, X., Feng, B., Huang, S., Luan, Z., Niu, C., Lin, J., & Hu, X. (2019). Capillary penetration mechanism and machining characteristics of lubricant droplets in electrostatic minimum quantity lubrication (EMQL) grinding. *Journal of Manufacturing Processes*, *45*, 571-578.

[3] Cuka, B., & Kim, D. W. (2017). Fuzzy logic based tool condition monitoring for end-milling. *Robotics and Computer-Integrated Manufacturing*, *47*(C), 22-36.

[4] Palanisamy, P., Subramanian, M., & Manojkumar, N. P. (2018). An analytical method of prediction of stability and experimental validation using FFT analyzer in end milling process. *International Journal of Applied Engineering Research*, *13*(7), 5260-5264.

[5] Cao, H., Yue, Y., Chen, X., & Zhang, X. (2018). Chatter detection based on synchrosqueezing transform and statistical indicators in milling process. *The International Journal of Advanced Manufacturing Technology*, *95*(1-4), 961-972.