

## **Experimental Investigation on the Performance of Coconut oil Based Nano Fluid as Lubricants during Turning of AISI 304 Austenitic Stainless Steel**

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### **Abstract**

This research work presents the performance of nano cutting fluid in machining, one of the most fundamental process in manufacturing industries. The heat generated at the tool-chip interface during machining is critical for work piece quality. The cutting fluids which are widely used to carry away the heat generated at the tool-workpiece interface in machining process that do not possess a pathogenic clinical history and are relatively free from inherent hazards. Hence there arises a need to develop an eco-friendly and user friendly nano cutting fluid over conventional cutting fluids. Coconut oil has been used as one of the cutting fluids in this work because of its thermal and oxidative stability which is higher than that of other vegetable based cutting fluids used in machining industries. The present work investigates the application of nano Boric acid, solid lubricants suspension in coconut oil during turning of AISI 304 austenitic stainless steel with carbide tool. Where in nano boric acid solid lubricants of 50 nm particle size were suspended in coconut oil, base lubricant. So the variation of average tool flank wear, surface roughness of the machined surface and cutting tool temperature with cutting speed and feed are identify with nano solid lubricant suspensions in coconut oil.

**Keywords:** Turning; Nano solid lubricants; Boric acid; Coconut oil; Surface roughness; Tool wear.

## 1. Introduction

Coconut oil is being used as one of the cutting fluids in this work because of its higher thermal conductivity and oxidative stability. It has been found that coconut oil improves the tool life with a better surface finish for machining at low and medium cutting speed. This research work features a specific study on the application of nano solid lubricant suspensions in coconut oil, a base lubricant. Conclusively the cutting temperature, tool flank wear and surface roughness decreased significantly with nano lubricants suspended in coconut oil and this was attributed to the lubricating action of nano boric acid particles and the better lubricating properties of the base oil.

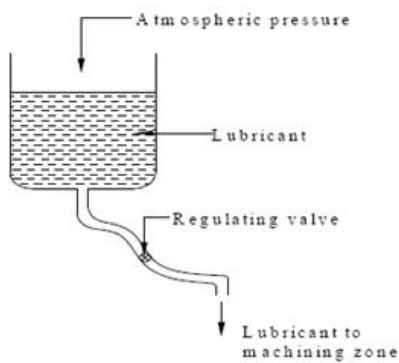
## 2. Nano Fluid Lubricants

### 2.1 Literature Review

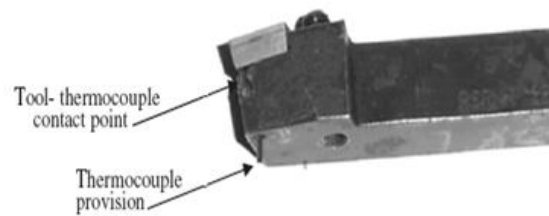
Noordin et al (2001) <sup>[1]</sup> determined that the surface roughness is dependent on the feed rate whereby the use of lower feed rate produced better surface finish. Higher surface roughness values at higher cutting speeds can be explained by the highly ductile nature of austenitic stainless steels. Jayadas and Prabhakaran (2006) <sup>[2]</sup> analyzed and compared the cooling behavior, thermal and oxidative stability of coconut oil with sesame oil, sunflower oil and a mineral oil. Krishna et al (2010a) <sup>[3]</sup>, Machining temperatures can be controlled by reducing the friction between tool-work piece and tool-chip interface with the help of effective lubrication. M. Anthony Xavier, M. Adithan (2008) <sup>[4]</sup> determine the influence of cutting fluids on tool wear and surface roughness during turning of AISI 304 with carbide tool.

K.M. Rao, Padmini. R, Vamsi Krishna. S (2008) <sup>[5]</sup>, focuses on application of eco-friendly nano fluids in machining. And they represent the performance of nano solid lubricant suspensions in vegetable oils in turning of AISI1040 steel in minimum quantity lubrication (MQL). Krishna et al (2010b) <sup>[3]</sup> investigated the performance of boric acid in coconut oil as base lubricant and boric acid solid lubricant of 50 nm particle size as suspensions. P. Vamsi Krishna, D. Nageswara Rao (2008) <sup>[6]</sup> presents the work on the application of solid lubricant in turning process. N.S. Kumar Reddy, P.V. Rao (2005) <sup>[7]</sup> state the solid lubricant assisted machining is an environmental friendly clean technology for desirable control of cutting temperature. Rao and Singh (2007) <sup>[8]</sup> studied the use of solid lubricants during hard turning while machining bearing steel with mixed ceramic inserts at different cutting conditions and tool geometry. Results showed 8–15% improvement in the surface finish with the use of solid lubricants. Reddy and Rao (2006) <sup>[9]</sup> reported that graphite and MoS<sub>2</sub> assisted end milling process showed considerable improvement compared to machining with a cutting fluid in terms of cutting forces, surface quality and specific energy.

Based on available literature, it can be concluded that suspensions of nano boric acid solid lubricants particle in coconut oil provides better lubrication as compared to the conventional cutting fluids. Boric acid of 50 nm particles size is used as suspensions in coconut oil with varying proportions, i.e. 0.25%, 0.5%, 1.0% by weight.



**Fig. 1:** Lubricant supply system



**Fig. 2:** Tool holder with provision for thermocouple.

Experiments were conducted at CIPET, Ahmedabad, Gujarat to evaluate the performance of nano boric acid suspensions in coconut oil during turning of AISI 304 on CNC Lathe. Design of experiments was selected based on Taguchi’s DOE. The temperature is sensed by the embedded thermocouple (K type), placed at the bottom of the tool insert as shown in Fig.2. Cutting tool was analyzed under Tool maker’s microscope to measure tool flank wear. Talysurf with stylus radius 0.002 mm and cut-off length 0.08 mm was employed for measuring average surface roughness (Ra).

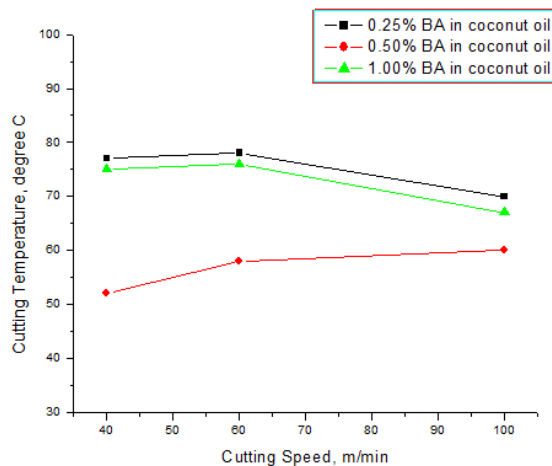
**2.2 Experimental condition**

**Table 1**

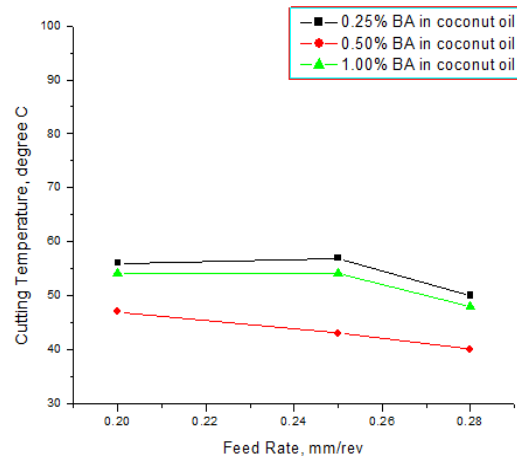
<b>1) Work Specimen</b>		<b>3) Machine Tool</b>	
Material	AISI 304 Steel (C = 0.05487%, Mn = 1.66%, Si = 0.64%)	Machine Type	CNC Lathe, Tornodo-300
Size	Ø50 x 400 mm	Motor Capacity	35 hp, 26 kW
Hardness	82 HRB, Bright annealed	Cutting tool (Insert)	Carbide, SNMG 120408 QM H-13A, (ISO specification)
<b>2) Process Parameters</b>		Tool Holder	PSDN 2525M12 (ISO specification)
Cutting Speed	Vc = 40, 60, 100 m/min	<b>4) Cutting Tool Geometry</b>	
Feed rate	f = 0.20, 0.25, 0.28 mm/rev	Inclination angle	-6°
Depth of cut	d = 0.5, 1.0, 1.2 mm	Orthogonal rake angle	-6°

Suspended solid lubricants	Boric acid	Auxiliary cutting edge angle	45°
Solid lubricant particle size	50 nm	Principle cutting edge angle	45°
Lubricating oil	Coconut oil	Nose radius	0.8 mm
Flow rate	100 ml/min	6) Surface Roughness Tester	
5) Thermocouple		Stylus material	Diamond
Designation	K-type, Shielded thermocouple	Stylus Tip radius	2 $\mu$ m
Element outside diameter	1.0 mm	Stylus Tip angle	60°
Element length	30 mm	Cut of length	0.08 – 2.5 mm
Element type	Duplex	Accuracy	$\pm$ 3% of reading
Sheath material	Recrystallised alumina	7) Sonicator	
Temperature range	-200°C to 1250 °C	Ultrasonic frequency	20-25 kHz
Tolerance	$\pm$ 2.2°C or $\pm$ 0.75% (whichever is greater)	Maximum Power	0-150 W
		Sonicating Capacity	10-200 ml
		Probe Length	20 mm

### 2.3 Results and discussion



**Fig. 3:** Variation of Cutting temperature with Cutting speed.



**Fig. 4:** Variation of Cutting temperature with Feed Rate.

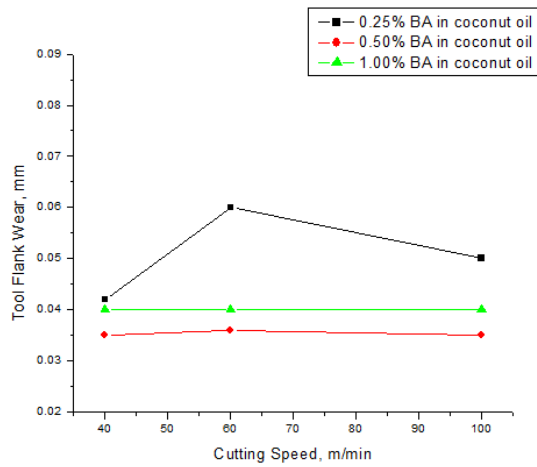


Fig. 5: Variation of Tool flank wear with Cutting speed.

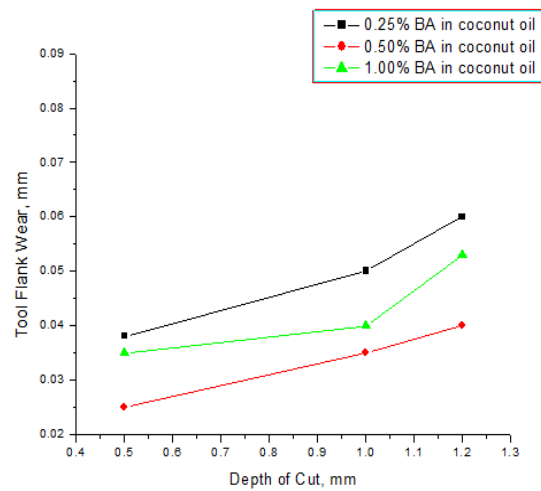


Fig. 6: Variation of Tool flank wear with Depth of cut.

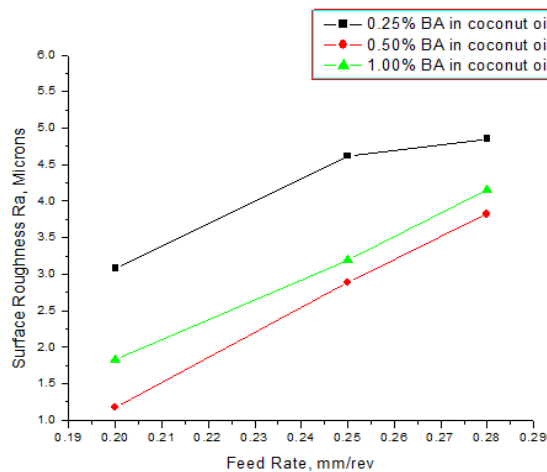


Fig. 7: Variation of Surface roughness with Feed rate

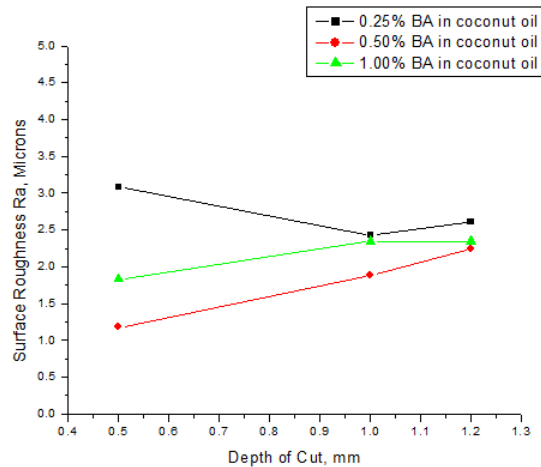


Fig. 8: Variation of Surface roughness with Depth of cut

### 3. Conclusion

The Nano fluid lubricants were prepared by suspensions of Nano Boric acid in coconut oil so thermal conductivity and heat transfer coefficient increased and specific heat decreased with percentage increase in Nano boric acid. So cutting temperatures, tool flank wear and surface roughness were decreased significantly with Nano lubricants compared to base oil, due to the better lubricating properties of it. In all the cases, coconut oil with 0.5% Nano Boric acid suspensions showed better performance compared to other Nano fluid in terms of cutting temperatures, tool flank wear and surface roughness.

## References

- [1] Noordin M.Y., Venkatesh, V.C., Chan, C.L., Abdullah, A. (2001), Performance evaluation of cemented carbide tools in turning AISI 1010 steel, *J. Mater. Process. Technology*, **116**, pp. 16–21.
- [2] Jayadas, N.H., Prabhakaran Nair K. (2006), Coconut oil as base oil for industrial lubricants—evaluation and modification of thermal, oxidative and low temperature properties, *Tribology. Intl*, **39**, pp. 873–878.
- [3] P. Vamsi Krishna, R.R. Srikant, D. Nageswara Rao (2010), Experimental investigation on the performance of Nano boric acid suspensions in SAE-40 and coconut oil during turning of AISI 1040 steel, *International Journal of Machine Tools & Manufacture* **50**, pp. 911–916.
- [4] M. Anthony Xavier, M. Adithan, (2009), determines the influence of cutting fluids on tool wear and surface roughness during turning of AISI 304 austenitic stainless steel, *Journal of materials processing technology* **209**, pp. 900–909.
- [5] Krishna Mohan Rao. G, Padmini. R, Vamsi Krishna. S (2008), Performance evaluation of eco-friendly nano fluids in machining. *Recent Advances in Robotics, Aeronautical and Mechanical Engineering*.
- [6] P. Vamsi Krishna, D. Nageswara Rao (2008), Performance evaluation of solid lubricants in terms of machining parameters in turning, *International Journal of Machine Tools and Manufacture* **48**, pp. 1131–1137.
- [7] N. Suresh Kumar Reddy, P. Venkateswara Rao (2006), Experimental investigation to study the effect of solid lubricants on cutting forces and surface quality in end milling, *International Journal of Machine Tools & Manufacture* **46**, pp. 189–198.
- [8] Dilbag Singh, P.V. Rao (2007), Performance improvement of hard turning with solid lubricants, *International Journal of Advanced Manufacturing Technology* **32**, pp. 170–177.
- [9] N. Suresh Kumar Reddy, P. Venkateswara Rao (2006), Experimental investigation to study the effect of solid lubricants on cutting forces and surface quality in end milling, *International Journal of Machine Tools & Manufacture* **46**, pp. 189–198.