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Design, Fabrication, and Performance Evaluation of Coolant Delivery Systems for Under Water/Coolant Turning Operations

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Introduction

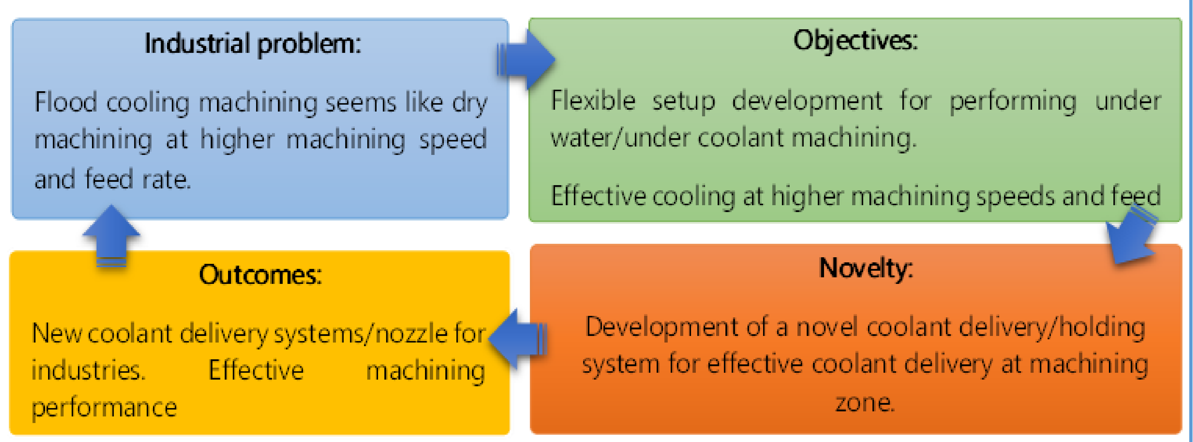
Machining process on the lathe generates high rates of heat which affect the surface finish, tool tip life, and chip shape and formation rates. Different techniques are used to cool down the working area.

This research aims at cooling the machining process by submerging the hot spot under water through two designs to deliver high coolant streams.

Objectives

- Design, Fabricate, and Experimentally Investigate Nozzles using 3D Printing.
- Design, Fabricate, and Evaluate a Box-Type Coolant Holding Setup Using 3D Printing.
- Conduct Machinability Studies at Higher Speeds and Feed Rates.

Study overview



Methodology

- The first design is the nozzle type which aims at delivering coolant through multi-inlets to fully cover the tool tip.
- The second design is the box type which encloses the whole machining process to submerge the hot spot under water which is supplied through the inlet with minimum leakage.

Design & 3D Printing of setups

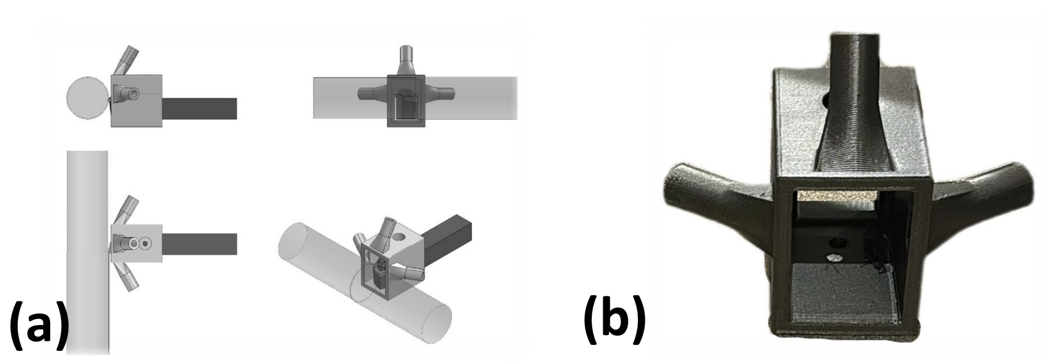


Fig. 1: (a)3D model, and (b)3D printed high flow nozzle

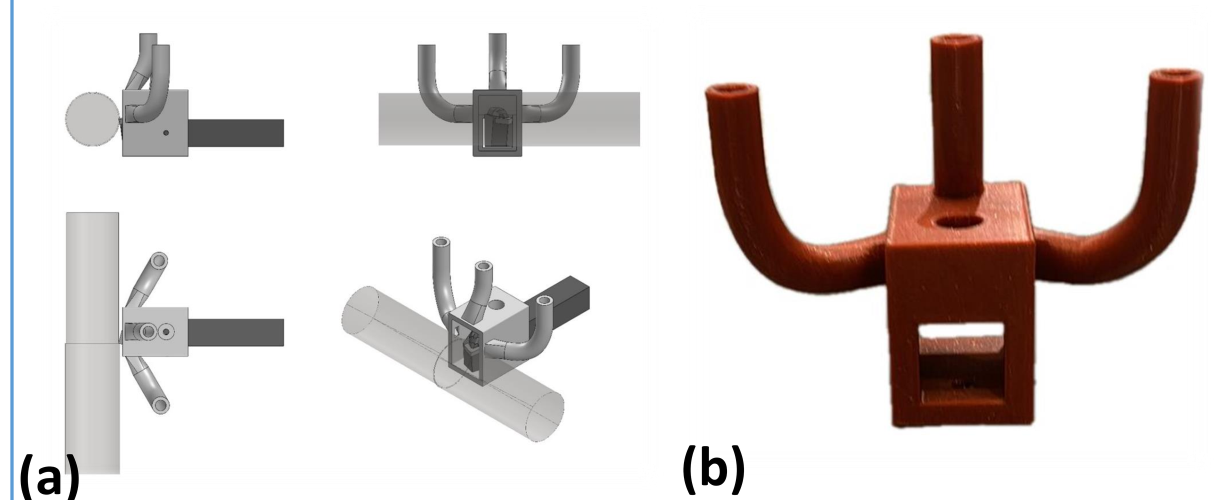


Fig. 2: (a) 3D model, and (b) 3D printed higher pressure nozzle

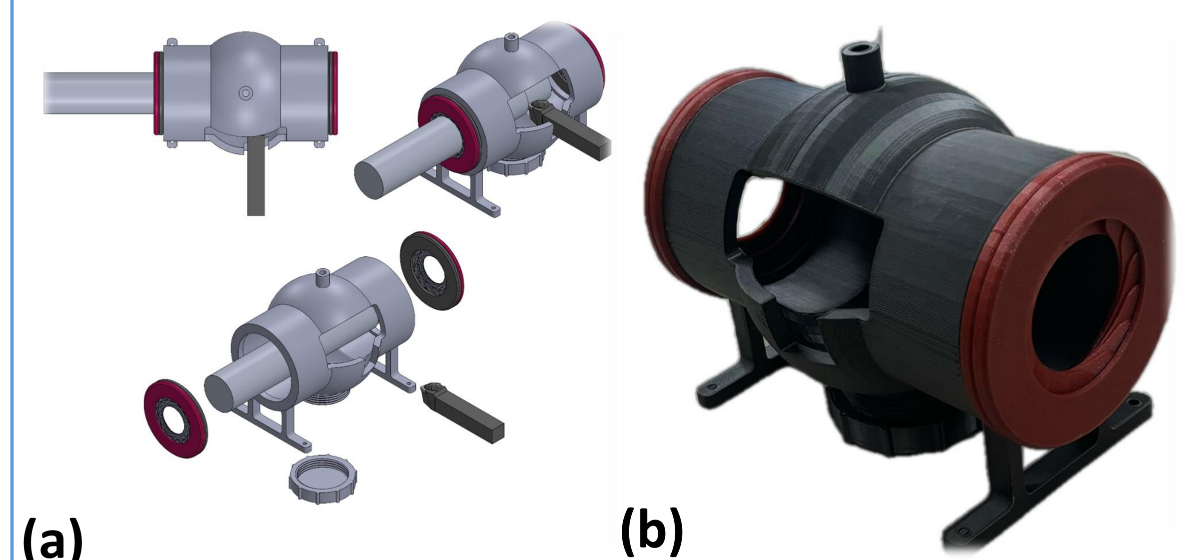


Fig. 3: (a) 3D model, and (b) 3D printed box type machining setup for realizing underwater machining

Experiments

Several experiments were conducted to test the performance of the prototypes. The chip formation process was observed at different feeds and cutting speeds.

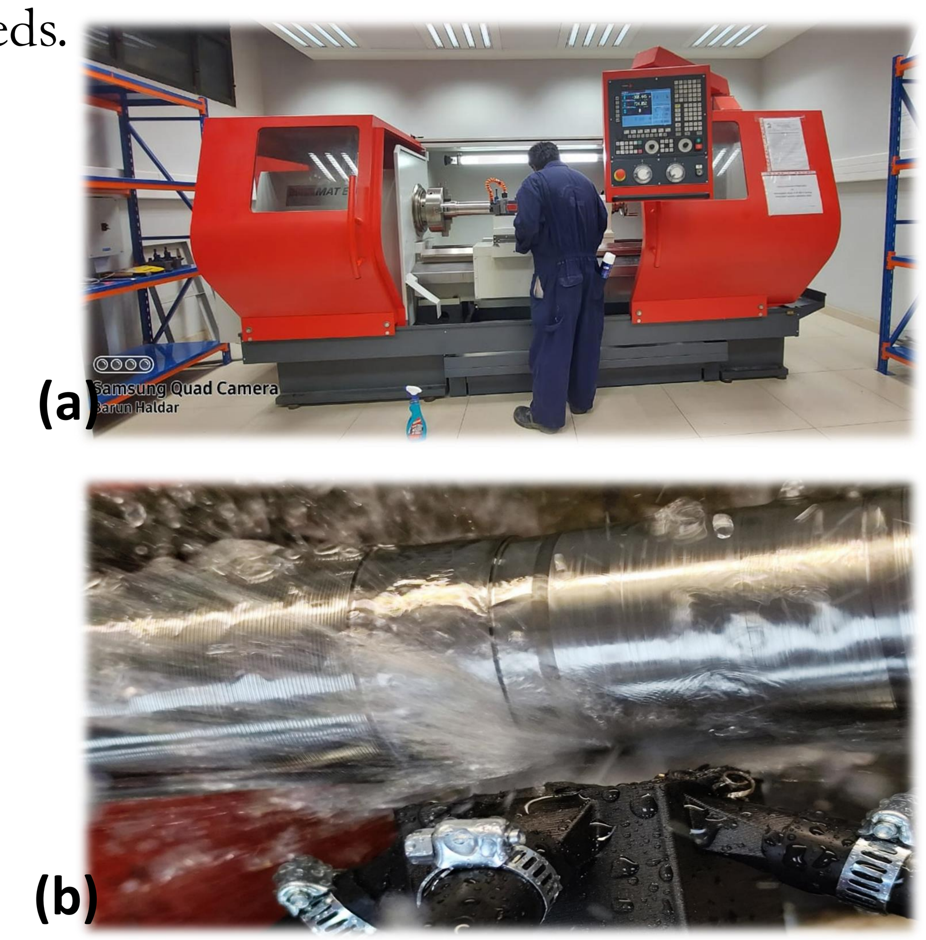
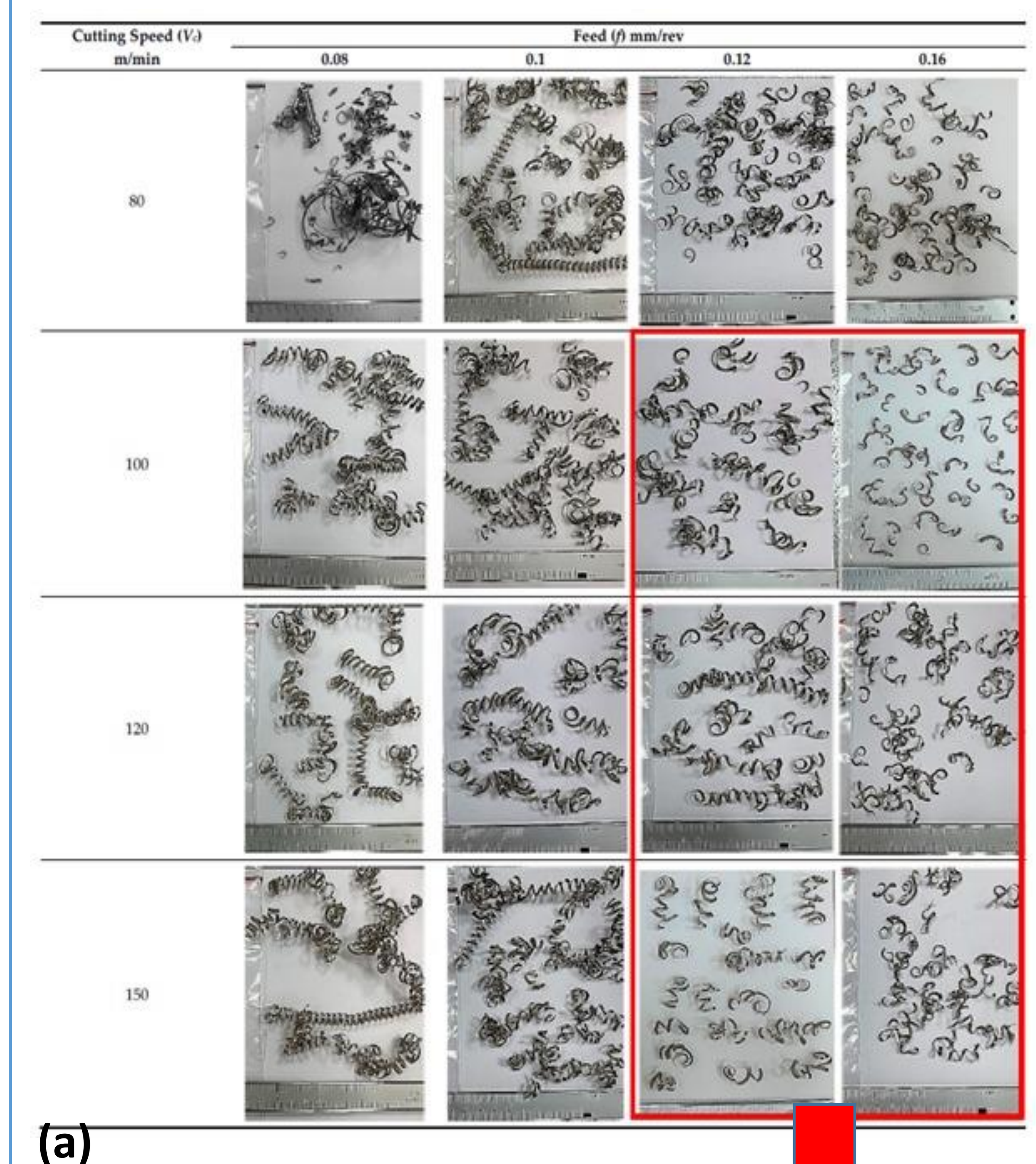


Fig. 4: (a) High power CNC lathe used in the machining study, and (b) 3D Printed nozzles under higher pressure coolant delivery tests at machining zone

Results



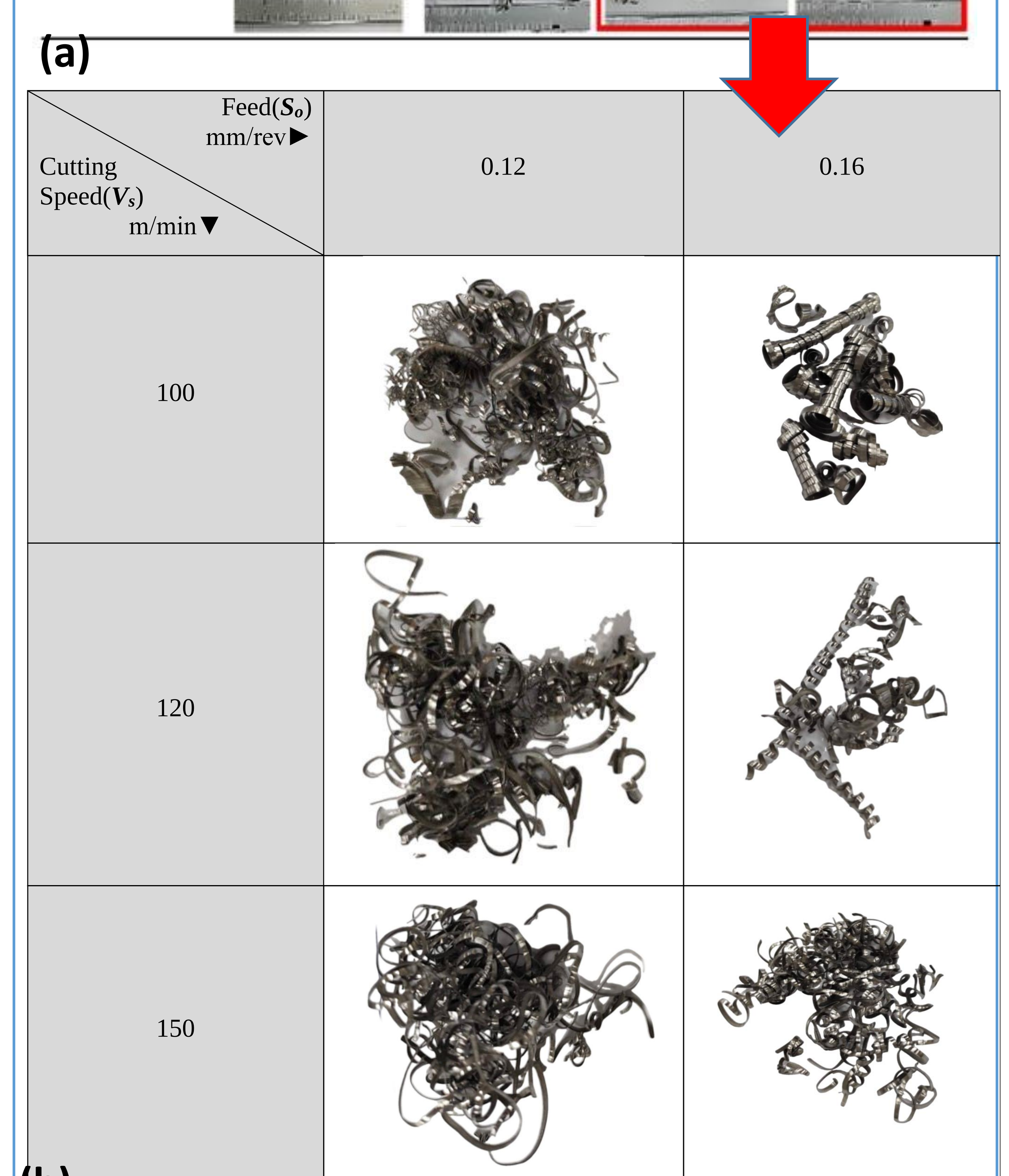


Fig. 5: (a) Machining chips under flood cooling conditions, and (b) machining chips under higher pressure coolant conditions

Discussion

From the previous investigation by B. Haldar et al. (2023), it was evident that under dry, flood coolant, and micro-jet conditions, the machining performance of SS304 was almost similar to dry conditions at higher feed rates (0.12, 0.16 mm/rev) and higher cutting speeds (100, 120, 150 m/min). This suggests that at higher feed rates and cutting speeds, the coolant may not effectively reach the cutting zone.

The present investigation, using a high-pressure coolant supply with a 3D-printed nozzle arrangement, demonstrates the formation of long chips, indicating that the coolant effectively reaches the machining zone. This confirms that the designed and 3D-printed coolant supply nozzles significantly improve the machinability of SS304.

Conclusion

- Design Achievement: The study successfully designed solid models for both nozzle-type and box-type coolant delivery systems using SolidWorks software.
- 3D Printing Compatibility: Both designs are compatible with 3D printing technology, facilitating rapid prototyping and enabling easy adjustments and iterations to improve performance based on experimental results.

References

[1] Haldar B, Joardar H, Louhichi B, Alsaleh NA, Alfozan A. A Comparative Machinability Study of SS 304 in Turning under Dry, New Micro-Jet, and Flood Cooling Lubrication Conditions. Lubricants 2022;10.
[2] Umesh K. Mishra JS. Semiconductor Device Physics and Design. vol. 53. 2013. https://doi.org/10.1017/CBO9781107415324.004.

Acknowledgments

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