AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Design and Production Engineering

Suppression of Boring Bar Vibrations

A Thesis submitted in partial fulfilment of the requirements of the degree of

Master of Science in Mechanical Engineering

(Design and Production Engineering)

by

Ahmed Abd El Monem Barakat Mosaad

Bachelor of Science in Mechanical Engineering

(Design and Production Engineering)

Faculty of Engineering, Ain Shams University, 2010

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Associate Prof. Mostafa Rostom Ahmed Atia

Cairo - (2015)

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Date: 19 August 2015

Statement

This thesis is submitted as a partial fulfillment of the requirements for the degree of Master of Science in Mechanical Engineering (Design and Production Engineering).

The author carried out the work included in this thesis, and no part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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Date: 19 August 2015

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Thesis Summary

Boring bars are considered the most flexible element in the Machine-Fixture-Tool-Workpiece (MFTW) system in the boring process. Their flexibility originates from their nature of being long enough for deep holes and thin enough to enter the hole to be enlarged. The boring bars flexibility causes lower accuracy, worse surface finish and the occurrence of chatter at small width of cut.

Several authors have investigated factors affecting the boring bar tendency to chatter occurrence that include cutting conditions and system parameters. The increase of system inherent damping was not applicable due to size limitations, while the increase of system stiffness or the use of vibration absorbers had more significant effects. The variation of cutting conditions can be beneficial if they are available for the required process.

The present work was conducted to propose a newly developed boring bar design that is concerned with increasing the system stiffness. The proposed design concept depends on adding an extra support for the boring bar inside the workpiece itself during the cutting process. As the cutting tool proceeds in the cutting process, the added support lies behind the cutting tool to support the boring bar with respect to the workpiece. This is applied through pressing circumferentially distributed balls between the boring bar body and the workpiece inner surface using a hydraulic piston-cylinder assembly.

The proposed design was modeled mathematically to determine its static properties, and modeled numerically using the Finite Element Method to obtain both static and dynamic properties. The improvement of static and dynamic properties while applying the hydraulic pressure was clearly observed theoretically.

Experimental investigation was carried out to determine the improvement of static and dynamic performance of the proposed design and compare it to the theoretical calculations. Then, the chatter tendency was measured through the limiting width of cut- cutting speed ($b_{lim} - v$) relation and compared to the chip compression ratio- cutting speed ($\lambda_c - v$) relation in the case of no added support.

At the cutting speed having the minimum limiting width of cut (the worst condition) the proposed design concept is applied by pressing the supporting balls between the boring bar and the workpiece using the hydraulic mechanism. Furthermore, two other cutting speeds are investigated for the improvement caused by the proposed design, thus, the improvement in chatter tendency is investigated at 3 cutting speeds and 4 pressure levels.

To study the effect of the added support on the vibration level in stable cutting process, the vibration level at 3 different cutting speeds and 5 pressure levels were investigated.

The proposed design concept was found to increase the system stiffness to values that are in a good accordance with the theoretical values. Considering the dynamic properties, the receptance of the system was found to decrease significantly while using the hydraulic pressed support, but also other natural frequencies for the system were found to be not matching the theoretical values.

The proposed design was found to increase the limiting width of cut significantly at all speeds but with a variation of improvement percentage due to the effect of damping factors other than the effect of increased stiffness. At the contrary, the vibration level was found to give unsatisfactory results and have higher values as the value of hydraulic pressure increases.

From the results obtained through the study, it can be concluded that the proposed design had a positive effect in the resistance of chatter phenomenon, and therefore increase the allowable depth of cut and material removal rate. Furthermore, it is recommended to use the proposed design concept at the least effective pressure level to decrease its effect on the system vibration level.

Further future work should be carried out to study the effect of

the balls-workpiece contact on the system vibration level, and also to study the change of the proposed design parameters for the sake of obtaining higher practicality.

Keywords: Boring Bar, Chatter, Stiffness, Limiting width of cut, Vibrations

Acknowledgment

All thank and gratitude is for ALLAH almighty, for he is the source of all knowledge from which he supplied me and taught me all what I know.

I would like first to thank Dr.Mohammed Alaa ElDin El Hakim for his continuous valuable support and sincere concern through all the phases of preparing this work starting from criticizing literature and through my experimental work in the Metal Cutting Research lab.

I would like to thank Dr.Mohammed Abd El Salam, Dr.Taher Gamal ElDin Abu ElYazid and Dr.Mostafa Rostom (my professors and supervisors) for their essential support in supplying me with the needed knowledge and guidance, because of their sincere efforts I have learned much and was able complete my presented work.

I would like to thank Dr.Moataz El Qenawy for guiding me through the design of the hydraulic system of my proposed boring bar design.

Also, I would not forget the role of my colleagues in helping me through out this work, I would specify Dr.M.M.Hedaya, Eng.Weam El Sahhar, Eng.Bahi ElDin Bakeer and Eng.Julia Raafat, as their efforts in my experimental work and theoretical studies had a great impact on the quality of the work.

Finally, I would like to thank Mr.Hassan Abd El Rahman and Mr.Hamed for their continuous help through my work in the lab.

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