INVESTIGATIONS ON CUTTING PERFORMANCE PREDICTION DURING TURNING OF HARDENED AISI4340 STEEL WITH MINIMAL FLUID APPLICATION USING MULTICOATED CARBIDE INSERTS

a thesis submitted by

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in partial fulfillment for the award of the degree of

DOCTOR OF PHILOSOPHY

under the supervision of

Dr. A. S. VARADARAJAN

SCHOOL OF MECHANICAL SCIENCES

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DECLARATION

I, P.SAM PAUL hereby declare that the thesis, entitled “Investigations on cutting performance prediction during turning of hardened AISI4340 Steel with minimal fluid application using multicoated carbide inserts”, submitted to the Karunya University, in partial fulfillment of the requirements for the award of the Degree of Doctor of Philosophy in Mechanical Engineering is a record of original and independent research work done by me during the period 2008 – 2013, under the Supervision and guidance of Dr.A.S.Varadarajan, Professor, NSS college of Engineering, Palakkad, kerala. The work contained in this thesis has not been previously submitted to meet the requirements for a degree or diploma at this or any other higher education institution.

P.SAM PAUL
Signature of the candidate
BONAFIDE CERTIFICATE

Certified that this Thesis titled “Investigations on Cutting Performance Prediction during Turning of Hardened AISI4340 Steel with Minimal Fluid Application using Multicoated Carbide Inserts” is the bona fide work of P. SAM PAUL who carried out the research under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other scholar.

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ABSTRACT

Conventionally when parts requiring high hardness as functional requirement are to be machined, the work piece is turned to the near net shape, hardened to the required hardness and ground to the final dimension. This lengthy process cycle can be avoided if the hardened work piece is directly turned to the final dimension. This is possible by hard turning. But hard turning involves very large quantities of cutting fluid. Procurement, storage and disposal of cutting fluid involves expenses and it has to comply with environmental legislation such as OSHA as well.

Pure dry turning is a solution to this problem as it does not require any cutting fluid at all. But pure dry turning requires Ultra Hard cutting tools and extremely rigid machine tools and it is difficult to implement in the existing shop floor as the machine tool may not be rigid enough to support hard turning. In this context, turning with minimal fluid application is a viable alternative where in, extremely small quantities of cutting fluid are introduced at critical contact zones as high velocity pulsing slugs, so that for all practical purposes it resembles pure dry turning and at the same time free from all the problems related to large scale use of cutting fluid as in conventional wet turning.

Since a very small quantity of cutting fluid is doing cooling and lubrication, there must be some performance enhancers to improve the efficiency of utilization of the cutting fluid and also some condition monitoring system to monitor the status of the cutting tool and its wear characteristics to facilitate uninterrupted turning operations. The performance can be improved further if some schemes are introduced that can reduce tool vibration. This research work aims at developing schemes to reduce tool vibration during hard turning of AISI
4340 steel with minimal fluid application using a high velocity narrow pulsing slug of cutting fluid with multicoated hard metal inserts.

In this research work fluid application parameters (frequency of pulsing and rate of fluid application) that characterize the minimal fluid application scheme were optimized. An effort is made to investigate the effect of semi solid lubricants on tool vibration and cutting performance during hard turning of AISI 4340 steel with minimal fluid application. Effect of Impact damper and magnetorheological fluid damper on tool vibration and cutting performance was also investigated.

A tool was developed with in-built sensors to measure symptoms of tool wear such as average cutting temperature, main cutting force and tool vibration signals. An attempt was made to assess the wear status of the cutting tool using ANN and regression models by fusing the average cutting temperature, main cutting force and tool vibration signals.

The schemes developed in this investigation are economically viable and can be easily adopted on the existing machine tool without any major modifications. The findings of this research work are to be offered as a package of measures to predict cutting performance and monitor tool condition during hard turning of AISI 4340 steel with minimal fluid application using multi coated hard metal inserts with sculptured rake face.
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