ABSTRACT

AISI D2 steel has been widely used in modern manufacturing processes. It is one of the most advanced materials used in the manufacturing industry due to its excellent mechanical properties like high wear and abrasion resistant, high strength, high toughness, etc. With the advancement of heat treatment methods applied on the AISI D2 steel its properties get enhanced and thereby the range of its usability also gets increased. Machining of AISI D2 has been identified as one of the most important manufacturing processes because of its wide range of application in automotive industries, mould industries, sheet metal industries etc. But performing the hard turning (machining) operation on hardened AISI D2 steel is a great challenge due to the presence of hard chromium carbide particles and their high hardness value. During the machining of AISI D2, high cutting forces and high tool wear were recorded. Hence it is considered as a difficult material to machine. The present work is an attempt to improve the machining behavior of AISI D2 by using PVD TiAlN coated inserts under different cutting environments such as dry, wet, MQL with nano particles (Al2O3), and cryogenic (Liquid Nitrogen). Since a large number of factors affect machining of AISI D2, the process becomes very complex. The effects of turning parameters such as cutting speed, feed, depth of cut, and effective rake angle on surface roughness and cutting force are hence analyzed to evaluate the machining behavior of AISI D2 steel. Further, the significance of the process parameters on the selected responses has been evaluated using analysis of variance (ANOVA). In the current work, regression based models for cutting force and surface roughness have been developed under different cutting environments (dry, wet, nano MQL and cryogenic) and these models can be used by manufacturing industries to predict the value of output responses. After assessing the improvement in the machinability, a need arises to choose the optimum parametric combination which will yield good quality product. Therefore, various optimization methodologies are applied to determine the optimum value of parameters. The existing techniques such as grey relational analysis(GRA), principal component analysis(PCA) and response surface methodology(RSM) are adopted to determine the optimum parameters. Further residual stress of the turned specimens have been evaluated using X-ray diffraction method under different cutting environment conditions (dry, wet, nano MQL and cryogenic). For performing the residual stress analysis, optimum and worst parametric conditions are considered. These conditions are obtained after assessing the machinability of AISI D2 and the results from the optimization process. During residual stress analysis it was

found that thermal and mechanical effects favor the generation of tensile residual stress, and compressive residual stress respectively. And due to efficient cooling method employed such as cryogenic, and nano MQL, the thermal effects were found to be limited over the mechanical effects thereby producing high order of compressive residual stresses.

Key words: Hard turning, AISI D2, MQL, Cryogenic, GRA, PCA, Residual stresses,