

Analysis of Surface Hardness, Surface Roughness and near Surface Microstructure of AISI 4140 Steel Worked with Turn-Assisted Deep Cold Rolling Process

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Abstract : In the present study, response surface methodology has been used to optimize turn-assisted deep cold rolling process of AISI 4140 steel. A regression model is developed to predict surface hardness and surface roughness using response surface methodology and central composite design. In the development of predictive model, deep cold rolling force, ball diameter, initial roughness of the workpiece, and number of tool passes are considered as model variables. The rolling force and the ball diameter are the significant factors on the surface hardness and ball diameter and numbers of tool passes are found to be significant for surface roughness. The predicted surface hardness and surface roughness values and the subsequent verification experiments under the optimal operating conditions confirmed the validity of the predicted model. The absolute average error between the experimental and predicted values at the optimal combination of parameter settings for surface hardness and surface roughness is calculated as 0.16% and 1.58% respectively. Using the optimal processing parameters, the hardness is improved from 225 to 306 HV, which resulted in an increase in the near surface hardness by about 36% and the surface roughness is improved from 4.84 μm to 0.252 μm , which resulted in decrease in the surface roughness by about 95%. The depth of compression is found to be more than 300 μm from the microstructure analysis and this is in correlation with the results obtained from the microhardness measurements. Taylor Hobson Talysurf tester, micro Vickers hardness tester, optical microscopy and X-ray diffractometer are used to characterize the modified surface layer.

Keywords : hardness, response surface methodology, microstructure, central composite design, deep cold rolling, surface roughness

Conference Title : ICMAME 2015 : International Conference on Mechanical, Aeronautical and Manufacturing Engineering

Conference Location : New York, United States

Conference Dates : June 04-05, 2015