6. CONCLUSIONS

6.1 Introduction:
In the present research work T42 HSS material is used for evaluating effect of turning process parameters on tool wear. Further the same tool material is used for evaluating effect of cryogenic treatment alongwith turning process parameters on tool wear.
Initially pilot experimentations are carried out in order to observe effect of cryogenic treatment on T42 HSS material. For the pilot experiments tool samples are subjected to different cryogenic temperatures and soaked for different timings. These tool samples are then used for turning operations using same process parameters. Wear of the tool samples is measured and tabulated. The results led to a conclusion that there is an improvement in wear resistance of cryogenically treated tools as compared to the conventionally treated tools. The results obtained from the pilot experiments are used to formulate a further plan of main experimentations. Also, these results helped in finalizing cryogenic treatment temperature levels and soaking time for main experimentations.
Thereafter, in order to study effect of turning process parameters on tool wear, scientifically planned experiments are carried out using conventionally treated T42 tools. Taguchi’s modified L$_{8}$ array is used for carrying out experiments. The response i.e. wear data obtained is analyzed using S/N ratio analysis and ANOVA. Based on S/N ratio analysis confirmation experiments are carried out for optimum conditions of the turning process parameters.
Further, to study effect of cryogenic treatment temperature alongwith turning process parameters on tool wear, experiments are carried out using cryogenically treated T42 tools. Taguchi’s modified L$_{16}$ array is used for carrying out experiments. In this case also the response i.e. wear data obtained is analyzed using S/N ratio analysis and ANOVA. Based on S/N ratio analysis confirmation experiments are carried out for optimum conditions of the turning process parameters alongwith cryogenic temperature.
The robustness of this parameter optimization is verified experimentally by carrying out experiments at one of the non optimum condition in both the non cryo as well as cryo treated tools experimentations.
The results obtained from non cryo tools and cryo treated experimentations are used to develop empirical mathematical models, comparison of wear etc.. The experimental results obtained in case of non cryo and cryo treated tools experimentations are used to plot nomographs for prediction of wear.

The conclusions derived out of the present research work are given in section 6.2. Future scope of the work carried out is discussed in section 6.3.

6.2 Conclusions:

- A mathematical model for tool wear as a function of turning process parameters is proposed.
- Also, a mathematical model for tool wear as a function of cryogenic treatment temperature alongwith turning process parameters is proposed.
- Pilot experiments carried out on T42 HSS proved that cryogenic treatment improves wear resistance i. e. improves tool life of T42 HSS material. As temperature of cryogenic treatment reduces, wear resistance of T42 tool steel improves.
- A regression model for evaluating tool wear of non cryo tools due to turning process parameters is evolved using non linear regression analysis. As the coefficient of determination $R^2$ for the developed model is 0.997522, it indicates a very good validity of the model developed.
- Out of the three process parameters cutting speed has highest effect on tool wear followed by feed and depth of cut.
- A regression model for evaluating tool wear of cryo treated tools due to cryogenic treatment and turning process parameters is also evolved using non linear regression analysis. In this case also very good validity of the model developed is indicated, as the coefficient of determination $R^2$ for the developed model is 0.951487.
- An empirical mathematical model to evaluate effect on tool wear of T42 tool material due to cryogenic temperature is evolved as a difference between the models developed for non cryo tools and cryo treated tools.
- The wear resistance improvement in case of T42 HSS material due to cryogenic treatment temperatures as calculated from the developed empirical mathematical model upto -80 °C amounts to 11.00233 %, for -140 °C wear improvement percentage
goes to 16.87794 % and for treatment upto -185 °C the improvement as high as 21.03457 % is obtained.

- The hardness and microhardness of the non cryo and cryo treated tools are almost similar indicating that the hardness is affected negligibly due to cryogenic treatment.
- According to the results obtained from cryo tools experimentations, it can be concluded that as temperature of cryogenic treatment reduces, wear resistance of T42 tool steel improves. This is in tune with pilot experimentation results.
- The improvement in wear resistance in case of the T42 HSS samples is initially due to conversion of retained austenite into martensite upto M_f temperature and there after due to refinement of carbide size, uniform distribution of carbides and precipitation of ultra fine carbides.
- Nomographs are plotted for both non cryo tools as well as cryo treated tools. These nomographs can be very well used as a ready reference for the prediction of the tool wear for different process parameters.

6.3 Future Scope:
The future scope of the present work is as follows

- Varieties of T- series tool steels can be tried for cryogenic treatment and mathematical models can be evolved for non cryo and cryo treated tools. The data obtained can be used to plot nomographs.
- Soaking time can be treated as one more variable so as to obtain optimum cryogenic treatment conditions.
- A study can be undertaken to study effect of cryogenic treatment on different properties of T42 HSS such as tensile strength, impact energy, red hardness etc.

6.4 Applications:
The mathematical model developed in this research work can be used to find out the improvement in wear resistance due to cryogenic treatment temperature, which ultimately is useful in determining the improvement in tool life due to cryogenic treatment. Also the nomographs plotted can be used as ready recknor on shop floor to find out tool wear due to process parameters as well as cryogenic temperature.
CONTRIBUTIONS

- The tool wear of conventionally treated T42 high speed steel single point cutting tools subjected to different values of the process parameters is measured and an empirical mathematical model is evolved.
- The cryogenically treated T42 high speed steel single point cutting tools are subjected to different values of the process parameters and the tool wear of the tools is measured and an empirical mathematical model is evolved.
- A comparison of the above developed model is useful in finding out the improvement in wear resistance due to cryogenic treatment for T42 tool steel tools.
- Microstructural analysis reveals that, as cryogenic treatment temperature with a constant soaking time reduces, the wear resistance of T42 tool steel gets improved.
- Nomographs for predicting tool wear of non cryo T42 tools due to different process parameters are plotted. Also, nomographs for cryo treated T42 tools due to cryogenic treatment temperature and process parameters are plotted.