Optimization of Parameters In Hot Machining of Inconel 825 Alloys

B.Yogeswar[1], D.HarshaVardhan[2], A.Kiran Kumar[3]
[1]Dept of Mechanical Engineering
[2]Assistant. Professor & Head, Dept of Mechanical Engineering
[3]Asssistant. Professor, Dept of Mechanical Engineering
[1, 2] Sri Venkateswara Institute Of Technology, Anantapur, AP, India
[3]GITAM, Hyderabad, TS, India

Abstract*- The objective of the present work is to investigate the effect of hot machining on surface roughness. Inconel 825 has good mechanical properties from cryogenic temperatures to moderately high temperatures therefore it is widely used for many industrial applications. However, machinability of the material is considered to be poor due to its inherent characteristics. Hot Machining can be used to decrease tool wear, power consumed and increase surface finish. In Hot Machining the temperature of the work piece is raised to several hundred Celsius above ambient, which causes reduction in the shear strength of the material. We used furnace heating method for heating the work piece and surface roughness at different temperatures is measured using Taly surf and optimum temperature is chosen at which surface roughness is minimum. Bothe Flame Heating & Furnace heating compare this two Modules getting the result.*

Keywords- Cryogenic, Inherent characteristics, Shear strength, Surface roughness

I. INTRODUCTION

Hot machining is the process that is used for easy machining and to eliminate the problems of low cutting speeds, feeds and heavy loads on the machine bearings. This problem arises when machining process is being done on the new and tough materials. The basic principle behind this process is the surface of the work piece that is to be machined is to be pre heated to a temperature below the re-crystallization temperature. By this heating the shear forces gets reduces and machining process becomes easy.

Advantages of hot machining process are Easy formation of chip

- Lessened shocks to the tools
- Good surface finish of the work piece

On the other hand the main disadvantage of this process is the work piece‟s micro structure may get disturbed due to heating.
Precautions to be taken are

- Heat generated should be localized
- Heating is to be done just before the machining

The heat requirements for this process should satisfy the following conditions

- Heat input rate should be very high such that the work piece gets heated up in very short time
- The heat generated should heat only the shear zone. If heat generated penetrates to higher depths then there may be a problem of thermal damage.
- Constant temperatures over a wide range should be generated
- The installation cost and operating cost should be less
- It should be easy to set up and control.

Heat generation is done in various methods

1) Furnace heating,
2) Flame heating,
3) Arc heating,
4) Resistance heating,
5) Inductive heating,
6) Radio Frequency Resistance,

Electrical resistance heating is an intensive in situ environmental remediation method that uses the flow of alternating current electricity to heat soil and ground water and evaporate contaminants.

Disadvantages:

Temperature obtainable is limited to that which will not cause damage to the bulk material.

Inductive heating method:

Induction heating is a process of heating an electrically conducting object (usually a metal) by electromagnetic induction through heat generated in the objects by eddy currents (also called as Foucault currents).

Advantages:

1) Very clean and safe for operation purposes.
2) High specific heat input and quick temperature rise.
3) Induction heating is a process of heating an electrically conducting object (usually a metal) by electromagnetic induction through heat generated in the objects by eddy currents (also called as Foucault currents).

Disadvantages:

1) High equipment cost
2) Intricate work piece shapes are difficult to accommodate.
3) Work piece material must be magnetic
4) Depth of penetration is limited

Radio-frequency resistance: Radio frequency resistance involves theapplication of radio frequency devices, which is used to heat the material/ work piece.

Advantages:

1) Heating takes place over a small area.
2) Radio frequency resistance involves the application of radio frequency devices, which is used to heat the material/ work piece.
3) High specific heat input and quick temperature rise.

Disadvantages:

1) Work piece material must be magnetic.
2) High equipment cost.

Electric current heating: Electric heating is a process in which electrical energyis converted into heat.

Advantages:

1) Clean and easy to handle.
2) Electric heating is a process in which electrical energy is converted into heat.
3) Readily adaptable and control is easy.

Disadvantages:

Tool material must be conductive therefore cannot be used with ceramics.

Friction heating method: Friction heating is nothing but heat is produced in thematerial due to the friction between the surfaces.

Advantages:

1) Initial and operating costs low.
2) Friction heating is nothing but heat is produced in the material due to the friction between the surfaces.

Disadvantages:

Cannot be used for intricate work shapes

Flame Heating Hot Machining Method

Flame heating employs a torch, which is usually fitted to the lathe machine. The flame from the torch heats the work piece. One important point is that the flame heats the work piece locally i.e.; at the location where the operation is performed rather than the whole work piece which is not possible in furnace heating method. In this process oxyacetylene (or) propylene (or) town gas is employed. Multi-jet head is employed when high concentration of heat is required. The equipment required for this method is relatively inexpensive and is very effective in milling narrow jobs. But when it is employed for wider jobs problem of localization of heat arises. Another problem, which may arise due to this process, is oxidation. If this happens post machining is required. The production of super alloys, high hard and smart materials has become extremely essential to satisfy the robust design requirements for critical equipment's, aerospace and defense industries. The machining of such materials has always been a great challenge before the production engineering. These alloys and materials can be machined by cutting tools of vary high hardness and strength, but is sometimes neither economical nor practical. Apart from this the non-conventional machining methods are generally restricted due to productivity viewpoint.The beneficial manufacturing of the components of excessive hard materials can be substantial in terms of reduced cost of machining and lead time as compared to the traditional way which involves metal machining in annealed state followed by Heat Treatment, and then finishing operations like grinding and polishing operations, which in turn consumes lots of Effort, time and workspace. Machining of high hard materials through conventional processes is restricted due to excessive tool wear of cutting tools and undesired surface finish quality. So for a qualitative and productive process, the positive interest for hot machining process is being moderately developed in production technology. The basic of hot machining operation is to first soften the work piece is by preheating and thereby shear strength gets reduced in the vicinity of the shear zone. The use of hot machining has become very useful in the machining of high strength temperature-resistant (HSTR) alloys. Hot machining has two functions to perform, one, to machine some HSTR alloys which are unmachinable in the conventional machining method. Second, to improve tool life this eventually improves the production rate.There are various techniques of hot machining which are subjected to requirements. The penetration of heat should be such that the shear zone is appreciably affected. Input rate of heat must be commendably high, so as to temperature sufficiently and quickly. Thermal damage done to work piece through distortion should be minimum. The installation and operation cost should be minimum. The operators in the operation should take safety measures into account. Temperature control should be quickly obtained.

II. LITERATURE SURVEY

Chin-Wei Chang, Chun-PaoKuo (2007) Conducted an experiment on laser-assisted machining (LAM) as an economical process for manufacturing precision aluminium oxide ceramic parts. Because it is locally heated by an intense laser source prior to material removal, LAM leads to higher material removal rates, as well as improved control of work piece properties and geometry. To assess the feasibility of the LAM process and better understand its governing physical phenomena, experiments were conducted to obtain different measures of surface roughness for Al2O3 work pieces machined by laser-assisted Cutting using an Nd: YAG laser. The experimental results were analyzed using the Taguchi method, which facilitated identification of optimum machining conditions. The findings indicate that rotational speed, with a contribution percentage as high as 42.68%, had the most dominant effect on LAM system performance, followed by feed, depth of cut, and pulsed frequency. LAM"s most important advantage is its ability to produce much better work piece surface quality than does conventional machining, together with larger material removal rates (MRR) and moderate tool wear.

D.K. pal and S.K. Basu (1969) Hot Machining of austenitic Manganese steel by shaping, In this paper they analysis the effects of various cutting parameters while machining austenitic high manganese steel at an elevated temperature in a Shaping machine. This investigation makes an evaluation of the tool life and studies its dependence on work piece temperature and relative cutting speed. Empirical relationships are also suggested for calculating the values of the cutting forces. For Hot hardness test for high manganese steel was carried out in a Rockwell hardness tester with water-jacketed carbide tipped in dentor. For the measurement of cutting forces, the authors used a three-dimensional strain gauge type dynamometer Tool life does not go on increasing with the increase in the temperature of the work piece. Thus there is an optimum value of cutting speed when the tool life curve, plotted against speeds, gets a sudden break-back. From the measurement of forces, it was found that both cutting and thrust force were independent of speed in hot machining. This, so far as the effect of cutting speed is concerned, is quite similar to the conventional machining process at room temperature.

Maity.K.P, Swain.P.K, (2008) Conducted an experimental investigation of Hot-machining to predict tool life an experimental investigation had been carried out for hot-machining operation of high manganese steel using a carbide cutting tool. The heating of the work-piece was carried out by burning a mixture of liquid petroleum gas and oxygen. An expression of tool life as a Function of cutting speed, feed, depth of cut and temperature was developed using regression analysis. The adequacy of the model was tested. The effects of cutting conditions on tool life were also investigated. The functional relationship of the tool life *T* and variables cutting speed *V*C, feed *s*, depth of cut *t* were assumed the chip-reduction coefficient reduces with increase in temperature. Hence the machinability of the material improves with increase in temperature. The variation of average non-dimensional tangential cutting force *F*C and effect of cutting parameters the effects of different cutting parameters on tool life are analyzed and represent tool lives corresponding to low and high level of cutting velocity, feed, depth of cut and temperature It is evident from that tool life is greatly influenced by work piece temperature and cutting speed. The significance of feed on tool life is more than the depth of cut. There is increase in tool life with decrease of cutting speed, feed and depth of cut but tool life increases with increase in work-piece temperature. The limiting highest temperature will be the recrystallisation temperature of work piece, as higher heating temperature beyond that may induce unwanted structural changes in the work-piece material. A tool life equation is developed for machining hardened high manganese steel for hot-machining operation. The model adequacy is tested using test. The tool life is influenced by work-piece temperature, cutting speed, feed and depth of cut in that order. So the effect of temperature of work-piece is found to be the most significant on tool life. However the recrystallisation temperature of work- piece limits the maximum value of temperature. The chip-reduction coefficient decreases with increase in temperature. NihatTosun, LatifOzler (2002) study of tool life in hot machining using artificial neural networks and regression analysis method, In this study, the high manganese steel specimens heated with liquid petroleum gas flame were machined on a lathe under different cutting conditions of feed rates, depth of cuts, cutting speeds and surface temperatures. A mathematical model for tool life was obtained from the experimental data using a regression analysis method. In addition, the tool life was estimated using artificial neural network (ANN) with back propagation (BP) algorithm. Then, this program was trained and tested. Finally, the experimental data are compared with both the regression analysis results and the estimations the experiments illustrate that the tool life has increased much in hot machining of the manganese steel specimens with respect to that of the room temperature machining. The longest tool life has been obtained at 600ºC machining. The tool life obtained at 600ºC machining is approximately same as the tool life obtained at 400ºC machining. Consequently, 400ºC machining is the optimum heating temperature if we consider the microstructure of the work piece and the cost. The tool life has decreased when the cutting speed Has been increased. And the results indicate that ANNs were giving better result with respect to regression analysis method. In addition, it is shown that ANNs can be used as an effective and anAlternative method for the experimental studies that‟s the mathematical model cannot be formed.

III. EXPERIMENTAL STUDIES

In this process a furnace is employed for heating the work piece. The work piece material is placed in the furnace and is heated till the surface temperature gets equal to furnace temperature. Then the work piece is taken out and is machined. This process is economical when the required furnace is already there. The machine on which machining operation will be done should be placed near to the furnace such that the temperature loss of the work piece is very less.

Fig 1. Electric furnace

We use this method for hot machining because of the availability of an electrical furnace, which is located close to the lathe machine, hence minimizing the losses encountered generally and overcoming the limitations.

Material Removal Rate (MRR)

Material Removal Rate (MRR) Measurement From the initial and final weight of job MRR is calculated and the relation is given below:

$$MRR = v*f*d \text{ cm}^3 / \text{min}$$

Where

V = cutting speed in m/min
F = feed rate in mm/rev
D = depth of cut in mm

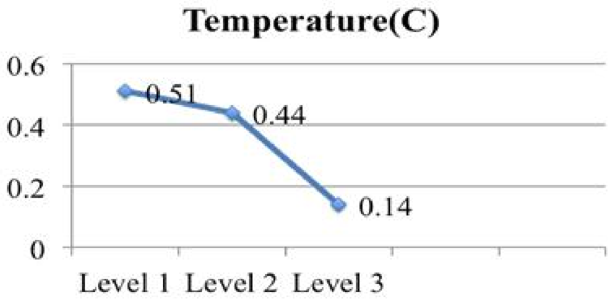
Surface Roughness

Surface roughness is a component of surface textureit is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small, the surface is smooth. Roughness is typically considered to be the high frequency, short-wavelength component of a measured surface. However, in practice it is often necessary to know both the amplitude and frequency to ensure that a surface is fit for a purpose. Rough surfaces usually wear more quickly and have higher friction coefficients than smooth surfaces. Roughness is often a good predictor of the performance of a mechanical component, since irregularities in the surface may form nucleation sites for cracks or corrosion. On the other hand, roughness may promote adhesion.

Fig: 2 surface roughness indicator

The response graph for the grey relational grade values. Delta is the difference between the maximum and minimum grade values of the each input parameter and the significance row give the order of influence of the process parameter. The results obtained from the analysis it is observed that the order of influence of process parameters for obtaining the best possible channel.

Graph 1: Average grey grade Speed



Graph 2: Average grey grade Temperature

The larger grey relational grade means the comparability sequence exhibits a stronger correlation with reference sequence.

IV. CONCLUSIONS

- The grey relational analysis based on Taguchi method‟s response table was conducted as a way of studying the optimization of process parameters of INCONEL 825.
- The speed, feed, temperature were selected to be the quality targets. From the response table of the average grey grade, the largest value of grey relational grade for the parameters was found.
- Feed is the strongest factor among the other parameters used on the multiple performance characteristics.
- Finally we found out optimal setting (A3B1C2) in conditions. The study indicated that clearly that the gray relational analysis accomplished effectively the optimization of responses in INCONEL 825.
- Surface roughness obtained in hot machining was observed to be less than that of conventional cutting.
- Surface finish was improved remarkably in hot machining. About 25% reduction in surface roughness was observed in hot machining (at 400^0c) compared to conventional cutting.

- Effect of hot machining was observed to be predominant at lower values of speed and feed due to the efficient transfer of heat to the cutting zone.

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