A Review on Effect of Cutting Parameters in Hot Turning Operation on Surface Finish

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Abstract **- Hot machining is one of the popular technique mainly used for machining of difficult to cut materials. Machining of these materials is difficult because of very high hardness, less thermal conductivity, and abrasive wear resistance. Time and cost require less as compare to other conventional & non conventional machining processes. Hot machining is generally performed by providing external heat to the material it softens material & facilitates machining. Various Cutting parameters have effect on different performance Characteristics such as Surface Finish, metal removal rate, Tool life, Tool wear. This review paper focuses on the effect of hot turning process on the Surface Finish of material. Surface finish is an important & necessary requirement for proper functioning of machine parts, Tool life, fatigue life, aesthetic appeal, and tribological properties of machined material. By studying various research & experimental work this review will give information about effect of various cutting parameters in hot turning on surface finish of difficult to cut material.**

Index Terms **- Hot Machining, Difficult to Cut material ,Cutting parameters, surface finish**

I. INTRODUCTION

In today's world use of Advanced Engineering Material like Super alloys, High strength steel,M.M.C., Ceramics are highly demanding in various Manufacturing Sectors. The unique properties of these material such as High Tensile strength, High hardness, less heat sensitive, Resistance to wear, High shear strength attracts various manufacturing areas like Aerospace , Automobile ,Nuclear plants, electrical industries to meet the demands of extreme applications. The Machining of particular material is very difficult because the hardness of material is very high so that they are difficult to cut .When these materials are machined by conventional machining processes it find that they are very difficult to machine which causes rapid tool wear, poor surface finish, damage of work material, catastrophic tool failure, formation of chatter on surface so that requires costly tools for machining The advantages of Hot machining process comparing to conventional machining are lower machining cost (reduction around 30%),longer tool life (2-5 times) & better surface finish quality [9]. In which work piece is heated during or before machining by external heating source above or at recrystalization temperature which facilitates metal removing process.[12] There are various conventional methods for machining, but use of such methods reduces tool life with increase in tool wear and also increase in cost of manufacturing and require time for machining also increases results in decrease in rate of production. Life of tool is inversely proportional to the manufacturing cost. So we should have a Machining process which can help us to deal with the materials having high strength and which are hard to cut. [20].

Non conventional machining processes like Electro Discharge Machining, Abrasive Jet Machining, Electro Chemical Machining are also not useful because there metal removal rate is very low, High machining & capital cost.

other advanced techniques for machining of hard material are used include ramping technique, high pressure coolant supply technology, cryogenic machining, Ultrasonic assisted Turning[7].

Ultrasonic assisted Turning Technique is one of the new technique for machining of difficult to cut material in which material is removed by providing vibrations to tool which is costly & difficult the drawback of the machining process is vibrations induced are uncontrollable.

Cryogenic machining is also a new method in which liquid nitrogen (mostly) is delivered on cutting edge enabling faster processing for machining of difficult to cut material but is very costly & time taking as compare to hot machining.

Hot Machining is not a new method it was introduced by Tigham in 1889 the purpose of heating is to reduce the shear strength and enhance plastic deformation of the work piece material and thus to assist the cutting tool in the material removal process [6].

Hot Machining prevents cold working hardening by heating the work piece above the recrystallisation temperature & this reduces the resistance to cutting & consequently favours machining [15]

Hot Machining is the best option for machining of Hard to cut material. Hot machining is very easy & effective method for workshop process imparts softnesss on the material under investigation which eases the machining process & further reduces the high cost of changing & sharpening cutting tools .softening of the workpiece in hot machining is a more effective method than strengthening the cutting tool in conventional machining[22].

II. Hot Turning process overview

Turning is a very important machining process in which a single-point cutting tool removes material from the surface of a rotating cylindrical work piece. The cutting tool is fed linearly in a direction parallel to the axis of rotation. Turning is carried out on a Machine that provides the power to turn the work piece at a given rotational speed and to feed the cutting tool at a specified rate and depth of cut[4]. Turning perform with the help of external heat source is known as hot turning.

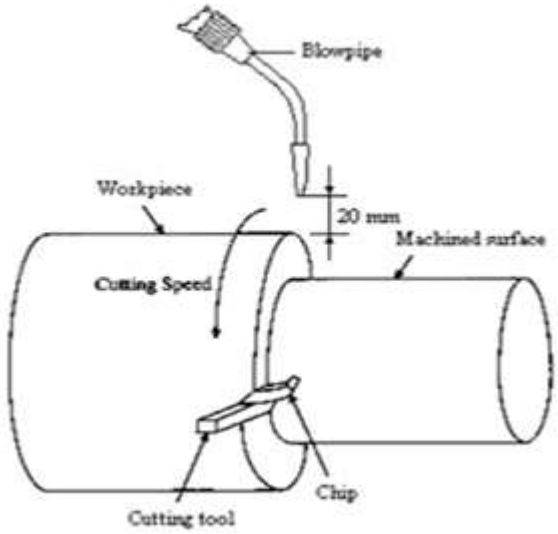

Fig.1 Schematic of Hot Turning Operation [8]

In hot machining a part or whole work piece is heated before or during machining In which the work piece is heated during or before machining by external heating source above or at recrystalization temperature which facilitates metal removing process.[18]. The heating causes an increase in the ductility of the material, indicate a better machinability of the hot turning[21]The Main Cutting parameters which will affect on performance characteristics in hot Turning are Cutting Speed, Feed rate, depth of Cut & temperature of Work piece. Many Research work were done to determine the effect of cutting parameters on performance characteristics like Metal Removal Rate & Surface Finish of Work piece. Materials with resistance to wear are frequently utilized in industry and these materials are comparatively difficult to machine. One of the methods of softening the work piece is hot machining. The temperature rise at the shear zone reduces the yield strength and work hardening of the work piece, which makes the plastic deformation of hard to machine materials easier during machining. Hot machining prevents cold working hardening by heating the piece above the recrystallization temperature and this reduces the resistance to cutting and consequently favours the machining. Hot Machining can be used to decrease tool wear, power consumed and increase surface finish. It was found by various experiments that the power consumed during turning operations primarily due to shearing of the material & plastic deformation of the metal removed .since both the shear strength & hardness values of engineering materials decreases with temperature it was thus postulated that an increase in work piece temperature would reduce the amount of power consumed for machining & tool life. The Heating of work piece reduces hardness & yield stress of material which helps in machining. the heating temperature was able to reduce the yield strength limit of the material.[21]. The Heating of work piece reduces hardness & yield stress of material which helps in machining.

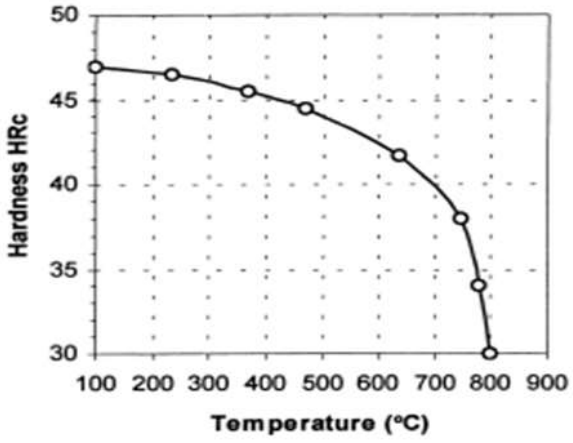

Fig.2 Effect of Temperature on Hardness [8]

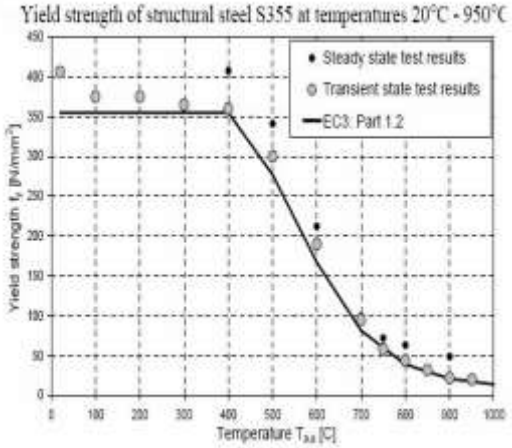

Fig.3 Effect of Temperature on yield stress [25]

Hot machining is potential workshop process for easing metal cutting problems has been under consideration metals deform more easily when heated & facilitates machining [3]. Various experiments in hot machining performed by researchers by using different heating techniques. Selection of proper heating method is very important otherwise it can damage the work piece & required results will not obtain. Various heating methods have been developed for hot machining such as electric current, flame, induction heating, arc heating, plasma arc, high frequency, laser etc. Every heating method has some advantages but later studies based on laser assistance hot machining. From the past experiments it was found the power consumed during turning operations is primarily due to shearing of the material and plastic deformation of the metal removed. Since both the shear strength and hardness values of engineering materials decrease with temperature, it was thus postulated that an increase in work piece temperature would reduce the amount of power consumed for machining and eventually increase tool life. (20).

III.Surface Finish

Surface Finish is an important parameter in manufacturing engineering. It is a characteristic that could influence the functional attributes of Mechanical Parts and the production costs [9].Surface finish is directly depends upon application of machined part. Surface finish reduces friction, reduces wear which is considered important in various mechanical application such as speed, gear, bearing, seal, shaft, machine ways. Hot machining is proved method which effective in machining of hard to cut material & for better surface finish as compare to other methods used. The important cutting parameters that affects on surface finish are cutting speed, feed, depth of cut & Work piece temperature. Feed rate had the strongest influence on surface roughness followed by cutting speed & Workpiece, temperature depth of cut. Higher surface temperature gives better surface roughness the feed rate had the strongest influence on surface roughness followed by cutting speed and last by depth of cut[10] preheating temperature have a significant influence on surface roughness and micro-hardness during hot machining of Al/SiC ,MMCs[23].

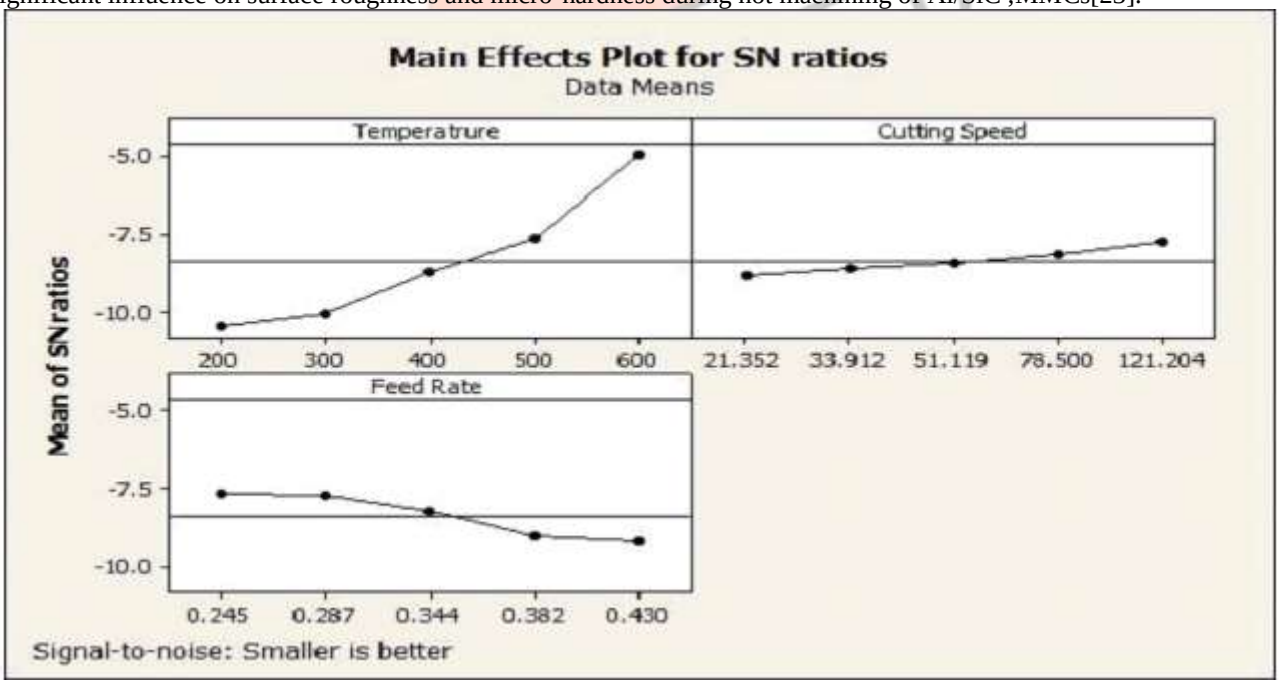

Figure 4: Effect of Cutting parameters on Surface Roughness [10]

higher ductility obtained at high temperatures makes improvement of surface roughness, because cutting force variations are reduced .[14].The temperature is chosen as per recrystallization temperature of material which decreases the yield stress of

material consequently Cutting force , power consumption , & tool wear rate decreases in this high integrity of surface with low cost could be obtained.

Summary of Literature Review on Surface Roughness:-

Author's Name	Workpiece Material	Method Used	Highest Affecting Factors on S/F	Optimal Surface Roughness Value	Findings
S.Basu Mukherjee (1973)	Nickel Chromim Steel	D.O.E.	Temperature Cutting Speed	0.32 µm	• Hard to cut material areeasily machined by Heating. • Increasing Temp Reduces S/F Roughness & increases Tool Life.
T.Kitagawa K.Maekawa A.Kubo (1988)	18%Mn Steel 2.25% Cr Cast Iron	Comparison	Temperature	-	• Decrease in cutting forces, less tool corner & flank wear at lower cutting spped. • Improvement in Surface Roughness • 50% reduction in cutting Cost.
N.Tosun-L.Ozler (2004)	High Mangenese Steel	Taguchi Method	Cutting Speed,Feed Rate	0.73µm (prediction) 1.04µm (experiment)	• Tool life increases by 2.34 times. • S/F Roughness decreases by 2.34
S.Rangnathan T. Senthilvelan (2011)	Stainless Steel	Taguchi Method Grey Analysis	Feed Rate Cutting Speed	4.2µm 3.6µm(optimal)	• Cutting Speed, Feed, D.O.C are primary factors. Depth of cut is secondary factor.
LSanchez H Mello & R. Neto & J.Davim (2014)	HeatResistant Austenitic Alloy Steel	Experiment	Temperature & Speed rate Feed Rate	1.14 µm	• Reduction of 205% on w/p Surface Roughness. Increase in Tool Life. • The heating produced by the resistances clearly causes an increase in the ductility of the material
N.ModhG. Mistry,K.Rathod ()	Bearing Steel	D.O.E. Annova Analysis	Temperature & Speed rate Feed Rate	1.44 µm	• Optimal Results obtained at high Temp. • Low feed, Highest Speed gives good S/Finish.
V.Ganta D.chakrdhar (2014)	15-5PH Martensitic Stainlesssteel	Anova Analysis, S/N method	Feed Rate Cutting Speed	0.49 µm	• Small Surface Roughness. • Highest M.R.R.
M.Davami M.Zadshakoyan (2008)	1060 Steel	Experiment	Temperature Cutting Speed	0.6µm	• Reduction of yield stresses at high temperature. • Heating material can improve surface quality.
Patel	EN 24	Taguchi Method	Temperature	0.876 µm	• Increasing Temp Reduces Surface Roughness & Tool Wear Rate.
D.Przestacki M.Jankowiak (2014)	M.M.C. Si3N4	ANNOVA Analysis Grey Relational Analysis	Temperature	0.39 µm	• Machine surface roughness is reduced in Hot machining as compare to conventional machining.
M.Baili (2011)	Ti-5553	Experiment	Temperature	0.8-1.6 µm	• Surface Roughness Improves around 50%.
Xavierarocki 2014	Tool Steel SKD 11	Experiment	Cutting Speed Feed Rate	0.2-0.6 µm	• 50 % improvement in Surace Roughness. • Temperature is an effective factor.
V.Ganta D.Chakradhar (2014)	15-5PH Stainless Steel	Annova Analysis Taguchi Method Grey	Cutting Speed Feed Rate	2.58 µm 4.30µm (experimental)	• Cutting Speed, Feed, Depth of cut are primary factors . • Temperature is secondary factor have effect on Surface Finish

		Relation Analysis			
U.Dabade M Jadhav(2016)	Al/Sic M.M.C.	Taguchi Method	Temperature Feed Rate	0.776 µm	• Increase in feed increases surface roughness. • increase in temperature reduces s/f roughness
N.Kamdar V.Patel (2012)	EN-36	Annova Analysis	Temperature	1.95 µm	• Surface Roughness decreases with increase in Temperature, with increases in Cutting speed &decreases in Feed rate. • Temperature is the most significant control factor on Surface Roughness. • Hot machining gives good surface finish at high temperature, high cutting speed and low feed rate.
Chi-Wei chang Chun pao-kao(2006)	Al_2o_3	Taguchi Method	Rotational Speed	2.98µm	• LAM had a surface roughness of 2.98 mm, much better than that from conventional machining. • Moreover, the reduced cutting resistance as temperature increased implies thermal softening of the material.
K.trivedi J desai K patel (2014)	4030 Steel	D.O.E. Method	Cutting Speed Feed, Temperature	0.678 µm	• At Highest Temp Yield strength decrease. • Minimum s/r obtain at highest temp.& feed
A.Shah B.Gelot(2014)	EN31 Steel	D.O.E. Method Taguchi Method	Cutting Speed, Temperature, Feed	3.05 µm	• Hot machining gives good surface finish at high temperature, high cutting speed and low feed rate.

SWOT Analysis of hot machining

Strength:-It is Effective in machining of difficult to cut material. Hot machining increases Tool life, decreases tool wear rate, takes very short time to perform operations. It also improves Metal Removal Rate, Surface Finish.

Weakness: - To maintain Temperature is somewhat difficult but by using Laser, induction coil or any other good quality heating source can overcome this problem but it makes process somewhat costly. During turning already heat is generate & again by providing external heat might cause quality on work piece.

Opportunities :- By using Different Heat Sources, various technical equipments improvement can be possible in Hot Machining. We can also use Automation in Hot machining process by incorporating it with sensors for Temperature & microcontroller for controlling process.[20]

Threat: - Use of other methods like ultrasonic machining, cryogenic machining may give better results. Many researchers used combination of ultrasonic and hot machining.

Result & Discussion

So Hot Machining is efficient machining process for difficult to cut materials[20].Surface Finish of work piece increases as compare to conventional machining in Hot machining. After Studying 18 Journal papers related to hot turning & effect of cutting parameters on surface roughness the graph below will give information about higher effective factor in hot machining .

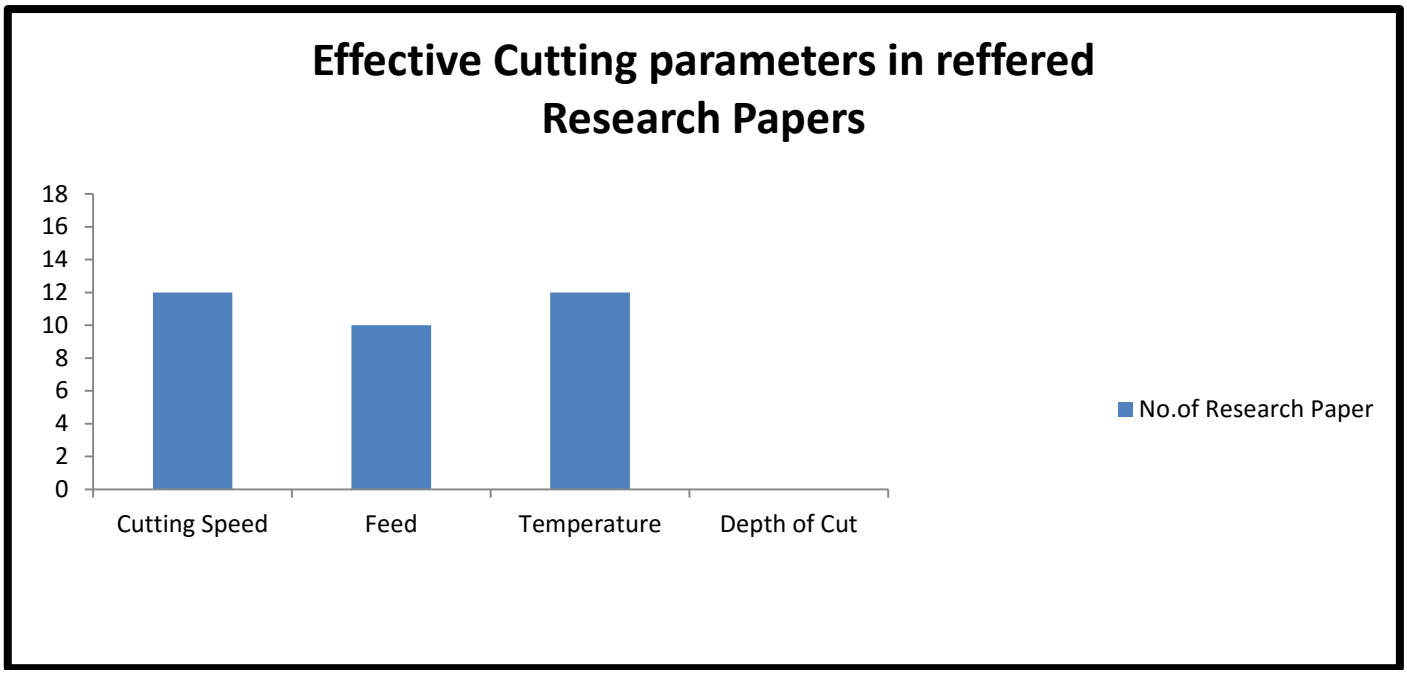

Fig.5 Study of Significant Cutting Parameter on Surface Roughness

Conclusion

- Hot machining is the most effective method in machining of hard to cut material.
- By Heating material its Shear strength decreases, brittle material becomes ductile and provides ease in machining
- Preheating the material gives good Surface Finish.
- Cutting Speed, Feed Rate &Temperature are the most significant parameter which have effect on surface finish.

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