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Study of Hot Turning Process Using 17ph4 Stainless Steel under Grey Analysis of Taguchi Method

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Abstract
Machining is the most important process for every industries to developed the product. The aim of every industries to low cost of machining by improving quality and productivity. This is demand for material of high strength, hardness and resistance to cutting. the machining process of these metal has always a challenge for every industries. The element of alloys and material required for high strength cutting, which sometimes is not efficient, and economical . Even the non-conventional processes are limited to the point of view of production in the hot working at a temperature of work piece is increased so as to reduce its shear strength. This paper will study on the hot working of 17PH4 stainless steel with LPG fuel.
Some parameter, such as cutting speed, feed rate, depth of cut, temperature of the work piece are taken in the machining process way stimulated in taguchi L9 based grey relational analysis method find corresponding deformation, rate of tool wear, cutting force, surface roughness and the temperature distribution of this paper.

KEYWORDS hot machining, 17ph4 stainless, lpg gas, tungsten carbide tools, pyrometer, force measurement dynamometer.

Introduction

Cutting remove undesired metals from the starting condition of work piece.These kind of process is always to} obtained finishing professional component of required shape, accuracy, surface finishing, and size. different cutting process such as for example milling, drilling, honing, milling, knurling and reaming are increasingly being used to removed are desired machining allowance. From the professional point of view. the main aspect is reducing of metal of machinability in addition to its particular influence of cheaply of the method machinability has received much attention out of every researcher. The main object of the technique could be the production of materials more economically. A incorrect decision can cause expensive production cost and reduce the quality of product. On this time the manufacturing industries having attempted to reduce operating cost while increasing the quality. every manufacturing process include some desire aspects of the process of reducing, in which there's the required to calculate quantity of technological performance of metal removing process, such as for example tool life, strength, power and surface finishing. this statement is compulsory for the performance of the selection and design of machine tools & cutting tools, in addition to the search engine optimization of cutting condition for the efficient & effective operation. It can be challenging to obtain a good surface finishing & tool life. While together with materials having high strength, corrosion resistance, toughness & wear amount of resistance in conventional process. Control of these metal need cutting tool high power that will be very cost effective and sometimes difficult non-conventional machining process, other practical means is generally restricted to lower range removal of material.To obtain removing large material, the growing interest in the process of hot working is developed in the industries. In the hot working process the work piece is softened by heating & consequently. The cutting power is necessary the hot machining process is a machining method conduct on conventional machine tools by which work pieces is preheated before machining procedure to become soft & there by to minimize its shear strength. The high temperature apply in hot turning process provide. soft on the materials. Which is not hard the engineering process the reduce high cost of changing reducing tools.Hot machining is a more effective the cold machining. for engineering of hard-to-cut steel, the cutting tool material must be harder they workpiece material.

1. 1 Result of hot machining are:
1 metal removing rate(MRR) are higher
2 Good surface finishing of workpices
3 Tool life is increase.
4 Much less power consuming of the lathe machine.

1.2 particular Material selection

The fabric which are basically machined by hot machining process. The research was done over a cylindrical job of 17ph4 metal steel. Which is known as precipiatation hardened steel. The workpiece on which the complete experiment was taken out with 70 millimeter a diameter and 200 millimeter length.

1.3 particular Heating system

The hot machining requires selecting a suitable method of heating. The region effected by the heat should be as enter very profound within the surface of the material in the hot machining. With this system high temperature metal surface change occur, then reaching extreme temperatures is always unexpected & should avoided the way of preheating of the workpiece to heat and flame heating, which is known as OXY-LPG.

Literature view

Studies of metal cutting are as old as more than 100 years. Earlier studies have shown that the selection of an appropriate heating system eliminates the unwanted structural changes in the workpiece and reduces engineering cost (Kitagae et approach. 1990). Chen and lo (1974) presented the results associated by having an experimental investigation in to the factors affecting tool wear in an instantaneous current approach to hot machining alloy steels and considerable improvement in tool life was recorded. Wang et. al (2002) analyzed the parametric optimization of multi-objective precision turning using grey relational analysis and proposed optimum process guidelines of precision CNC making. The tool life can be improved by an external magnetic field in hot turning of materials which own challenges during machining. In hot engineering of manganese steel using liquid petroleum gas (LPG), the tool life is increased by selecting proper cutting speed and supply rate, whereas depth of cut and workpiece temperatures play minor roles on tool life (Ozler 2004). Tosun (2002) computed the tool life during hot machining of manganese metal using artificial neural network and regression analysis method and reported that the cutting speed, feed rate, and workpiece temperature around 600. C yield this individual longest tool life for carbide insert. Grey relational analysis based on gray system theory is the perfect solution for solving the process of complicated interrelationships among the multi-response. In grey-based Taguchi method, a multi-response process optimization problem may be converted to a single-response optimization problem where overall grey relational may be the single objective function or response function to be optimized(Amin et al. 2007). Venkatesh(1016) work uses oxy-acetylene heating approach for thermal enhancement to machine Inconel 718 with TiC coated carbide inserts. The machining parameters and responses were studied and analyzed with Taguchi structured grey relation technique. and analysis of variance (ANOVA) and confirmation test have been conducted to confirm the predicted values. this paper will study hot turning process (17-4ph metal steel) by using taguchi based grey relational research. and also study of surface cutting force, and temperature distribution etc.

2.1 Experimental setup

2.1.1 Lathe machine

A lathe machine is a mechanical device that revolves the job workpieces about an axis of rotation to performed such as, milling, drilling, cutting, turning, knurling, and facing with tools. Which have been applied to the work pieces to develop an object with symmetry about this axis. Most appropriate equipped metal working lathes can be produce most stable of revolution, plane surface &screw threads. The components is usually held in place by a single one or two centre, at least one of which can typically be moved side to side to support varying work bits length. Other work having method include clamping the work about the axis to rotation by using a chuck.

2.1.2 Workpiece Material Selection

The job piece done on a cylindrical job of a (17-4ph) stainless steel. Which is known as precipitation solidifying and also known as 630 is a chromium- copper precipitation hardening metal steel. It can be used for application requiring high power and moderate amount of corrosion resistance. This steel having high strength is managed to 316 degree C. The work piece on which entire experiment was carried out 70mm in diameter and 200mm in length.

Stainless steel
Fig.2.1

2.1.3 Oxyzen and lpg flame

Oxyzen and lpg flame is used for heating of the workpiece. Lpg is a flameable gas pure oxyzen, rather than air, is used to increase the flame temperature to permit localized heating of the workpiece fabric in a room temperature.

Lpg
Fig.2.2

2.3 Tool Material Selection

The machining was carried out using tungsten carbide tool inserts.

2.3.1 Properties of Tungsten carbide tool

These can be a listing of metallic element inorganic compound properties. very different grades of metallic element inorganic compound can deffer in strength, rigidity, and different properties, however all metallic element inorganic compound material falls in to the fundamental properties listed below.

2.3.1.1 Strength: Tungsten inorganic compound has terribly high strength for material thus exhausting and rigid. Compressive strength is higher than almost all liquified and value or solid metal alloys.

2.4.1.2 Thermal conduction: inorganic compound is within the vary of doubly that of alloy steel and steel.

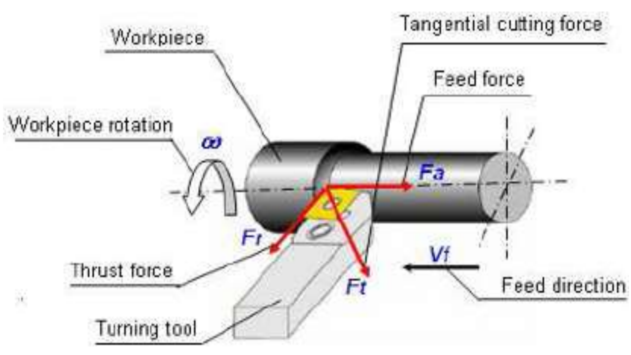
2.4.1.3 Electrical conduction: Tungsten inorganic compound is within the same vary as alloy steel and carbon

.2.4.1.4 heat: Tungsten inorganic compound vary from concerning five hundredth to seventieth as high as steel.

2.4.1.5 Hot Hardness: With temperature increase to 1400 degree f, metallic element inorganic compound retains a lot of its temperature hardness. At 1400 degree f, some grades equal the hardness of steel at temperature

2.5 Cutting Force

The cutting forces is critical parameter which impact the product and machining process. The cutting forces multiplied with increase in slicing pace which generated excessive device wear. The increase in tool put on interrupt in cutting potential and bring about growth of pressure. reducing pace is 100m/min or high completely plastic chips are fashioned which prevents coming into fluid into chip tool.cutting forces are typically solve into components in mutual perpendicular guidelines for convenience of size, analysis, estimation of electricity intake and for the design of machine-fixture-tool-work structures.

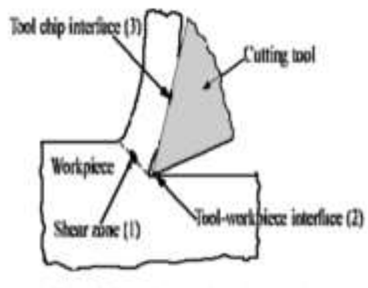


Cutting force
Fig 2.5

In turning with the aid of unmarried point gear like inserts, the unmarried slicing force generated is resolved into three components specifically; tangential pressure or principal reducing force, axial pressure or feed force and transverse pressure. each of those interrelated forces has were given be specific importance. under heating situations reducing force increase with increase in feed fee because feed rate boom the cutting location which brought about high forces. cutting forces lower with velocity underneath heating circumstance which is important impact on any machined additives. warm machining method lessen the reducing force because discount in friction because of direct split of heating on the operating region. slicing force and feed force elevated beneath warm turning procedure with increase in slicing velocity. The cutting forces beneath warm turning method had been barely higher than other machining .it's far observed that software hot turning procedure throughout slicing reduced the tangential reducing forces to a limit when machining is performed at low velocity.

2.6 Surface Roughness

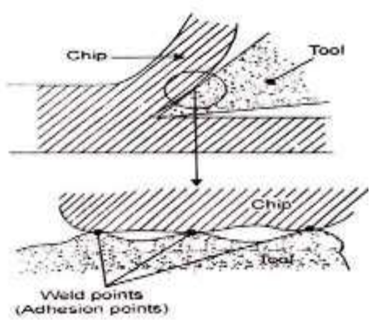
surface roughness is important parameter of hot turning technique. it's miles rely on decrease with growth velocity. in the hot turning technique floor roughness lower 20% to 30%. because the tiny particles of warm to the workpieces which decrease abrasion wear which make contributions to floor completing best of product is determined through surface roughness. decrease the surface roughness better dimensional accuracy of the product.



Surface roughness
Fig2.6

2.7 Temperature

Machining process associated with excessive velocity and feed rate generate huge quantity of heat in addition to reducing area temperature. The significance of this cutting temperature increases although in different degree with the growth of reducing cutting velocity, feed rate and depth of cut. The excessive temperature generated adversely influences at once or indirectly chip formation, reducing forces, tool life, dimensional accuracy and surface roughness of the workpiece. The process of machining entails a shearing mechanism to transform a workpiece to size. this essential mechanism creates a high friction among the cutting device and workpiece, which drastically increases the reducing temperature. similarly, friction dissipates electricity as a consequence generating warmth, which if it not managed might have impact the cutting device and device additives.the principle source of warmth are usually generated in areas called the primary or shear quarter and device-workpiece interface. furthermore, a 3rd zone warmth is generated where friction between the tool and the chip occurs.



The sources of heat in machining
Figure (2.7)

2.8 Temperature Measurement Setup

The temperature is measurement by means of pyrometer (fig3.8) . A pyrometer is a type of far off-sensing thermometer used to measure the temperature of a floor. A modern-day pyrometer has an optical device and a detector. The optical system focuses the thermal radiation onto the detector. Pyrometers are ideal in particular to the measurement of moving gadgets or any surfaces that can't be reached or cannot be touched. Temperatures can measured up to 1300 °C and are used for heat treatment. At very high operating temperatures with extreme heat transfer between the molten salt and the metal being dealt with, precision is maintained through measuring the temperature of the molten metal.

pyrometer
fig,2.8

2.9 Force measuring dynamometer

Dynamometers are devices used to degree cutting forces in machining operation. The cutting pressure cannot be detected or quantified at once but their impact can be sensed using Transducer. as an instance, a force which can neither be visible nor be gripped but can be detected and additionally quantified respectively via its impact and the amount of those effects like elastic deflection, deformation, stress, stress etc. those results, known as indicators, frequently want proper conditioning for clean, accurate and dependable Detection and size. In other words, dimension involves three stages Conversion into every other appropriate variable Amplification, filtration and stabilization analyzing or recording. metal machining are characterized mainly via brief modifications do no longer arise in isolation and that they impact each different. The analysis of changes require examine of the complicated systems in their real situation. The take a look at of slicing methods along with turning and facing from dynamics elements may be very vital. the fashion closer to the measurement of reducing forces in machining results in many theoretical and realistic problems.

2.10 Application of Dynamometer:

* for measuring cutting forces in milling, grinding, and turning.
* reliable force measurement device.
* ultra precision machining.
* excessive precision hard turning

2.11 Profilometer for surface Roughness measurement

A profilometer is a measuring instrument used to measure a surface's profile. In order to quantify its roughness. Critical dimensions as step, curvature, flatness, are computed from the surface topography.

3.1 Working process

The workpiece was connected between the head stock and the tail stock. Heating of the workpiece was done with assistance from oxygen + LPG flame. During heating the workpiece was made to rotate constantly to be able to avoid localization of heat. high heating may cause change in metallurgical properties of the work piece material. Metal can be hardened. It may also bring about melting of the material. And temperature measured by pyrometer to check on the workpiece temperature. The experiment should be conducted at particular temperatures for different readings. The temperature of the work piece must be maintained up to and including particular value for a single run. The work piece must certanly be heated until it reaches the desired temperature. Once it's attained the temperature, heating must be discontinued. Else there will be error in readings. In this experiment automatic heating arrangement was used. The flame torch was mounted on a shaft that has been connected to a servo motor. The actual movement of the torch (mounted on the shaft) facilitated the heating and discontinuation of heating of the workpiece. The specified temperature was set.

Torch heating the workpiece
figure (3.1)

When the required temperature was attained the torch automatically withdraws and again returns back when the temperature falls thus maintaining a constant temperature.

Torch withdrawn
figure(3.2)

As a result a steady heat source causing uniform heating was maintained by the LPG flame. The flame affected a region on 12 mm width along the circumference of the workpiece. Heating of the workpiece was done using LPG flame. The temperature of the heat affected zone was maintained using automated heating arrangement.

3.2 Experimental Design

The Experimental design was based on taguchi l9 orthogonal array for further optimization of result using grey relational analysis as shown in table 3.1 . the turning operation was carried out at a constant length of cut of 12 mm for all run to study the effect of variations of cutting velocity depth of cut, and feed. The cutting velocity was varied over three level: 49 m/mm,65m/mm, and 101 m/mm. the depth of cut was varied as 0.5mm, 10mm, and 1.5mm whereas the feed was varied as 0.07mm/rev,0.18mm/rev, and 0.45mm/rev.

Table 3.1: Experimental design using taguchi l9 orthogonal method

Run no	Cutting velocity (m/mm)	Feed (mm/rev)	Depth of cut (mm)
1	49	0.07	0.5
2	49	0.18	1.0
3	49	0.45	1.5
4	65	0.07	0.5
5	65	0.18	1.0
6	65	0.45	1.5
7	101	0.07	0.5
8	101	0.18	1.0
9	101	0.45	1.5

The turning of 17-4ph stainless steel was carried out under the following experimental conditions as summarized in table 3.2

Table(3.2)

Workpiece material	17-4ph stainless steel
Tool insert	Tungestun carbide insert
Cutting velocity(m/min)	49,65,101
Feed (mm/rev)	0.07,0.18,0.45
Depth of cut (mm)	0.5,1.0,1.5
Length of cut (mm)	12
Environment	Hot turning process

During the operation the cutting forces were measured as the output. The cutting forces were measured with the help of dynamometer as shown in figure 3.3

Dynamometer
Figure 3.3

After machining the workpiece surface roughness both measured using a profilometer As shown in figure 3.4. surface roughness for each length of cut was measured by mounting the profilometer on the workpiece by using horizontal support. For each run chips were collected and chips thickness was measured to calculator chip-reduction coefficient with of digital vernier calipers.

Profilometer
Fig 3.4

3.3 Grey Relational analysis

The grey relational anaylsis is a multi- response optimization technique. A black system means a system with no information whereas a white system represent availability of all the related information. Grey system is one which is in between black and white system as all information are not available. To optimize a system using grey relational analysis (GRA) following steps are followed;

3.3.1 Normalisation of output

All the output responses were normalised between 0 and 1. Normalisation was done according to higher the better characteristic' for responses which needed to maximize and 'Lower the better' for the output responses which needed to minimize . But here cutting forces , surface roughness and coefficient of friction need to be minimize so ' lower the better' normalization system will be used .

$$Xi(K)=maxYi-Yi(k)/maxYi(k)-minYi(k) \qquad (1)$$

Where I = 1,2,3…………..m, k = 1,2,3,………..n , m is the total number of experiments and n is number of output ,maxyi(k) and minyi(k) are the maximum and minimum values of output responses.
Where Xi(k) is the normalized value.

3.3.2 Grey Relational Grade

Grey relational grade is calculated as sum of grey relational coefficient per number of output. Higher the value of grey relational grade high is the effect of parameter on the original experiment and vice-versa . therefore, the combination with higher value of grey relational grade of grey relational grade is the optimal combination to carry out experiment. It is following relation

$$yi=(1/n)\Sigma\xi i(k) \quad (2)$$

The grey relational analysis is verified by conducting experiment with the corresponding optimal parameters

4.1 Result and Discussion

Output Response for under cold turning process

Experimental data table no:4.1

SR NO	Cutting Velocity (Vc) (m/mm)	Feed rate (f) mm/rev	Depth of cut (t) mm	Feed Force (Fx) N	Radial Force (fy) N	Cutting Force (fz) N	Surface roughness (Ra) (μm)	Temperature of w/p (Degree Celcius)
1	49	0.07	0.5	103	135	221	1.866	150
2	49	0.18	1.0	245	195	256	1.93	175
3	49	0.45	1.5	385	210	525	1.99	225
4	65	0.02	0.5	125	165	285	2.03	150
5	65	0.18	1.0	233	185	330	2.356	175
6	65	0.45	1.5	367	280	545	2.50	225
7	101	0.07	0.5	109	188	295	2.88	150
8	101	0.18	1.0	255	210	365	3.00	175
9	101	0.45	1.5	345	220	630	3.129	225

Output response for under hot turning process

Experiment data table 4.2:

Sr No	Cutting Velocity (Vc) mm	Feed rate mm/rev	Depth of cut mm	Feed force (fx) N	Radial force (fy) N	Cutting force (Fz) N	Surface roughness (RA) (μm)	Temperature Of w/p Degree celcius
1	49	0.07	0.5	100	130	210	1.246	250
2	49	0.18	1.0	241	185	239	1.360	350
3	49	0.45	1.5	376	182	512	1.504	550
4	65	0.07	0.5	121	160	280	1.590	250
5	65	0.18	12.0	226	170	306	1.629	350
6	65	0.45	1.5	355	208	515	1.909	550
7	101	0.07	0.5	97	165	290	2.096	250
8	101	0.18	1.0	246	200	337	2.863	350
9	101	0.45	1.5	339	210	618	2.919	550

It was found that almost in all cases chips formed are continuous. But in the cold machining process the chips produced under high depth of cut and feed found to be discontinuous and 'C' type.

4.6 Grey Relational analysis (GRA)

Table 4.5: Result table for hot turning process

Process No	Cutting velocity	Depth of Cut	Feed rate	Cutting Force	Surface Roughness	temperature
1	49	0.5	0.07 .	210	1.246	250
2	49	1.0	0.18	239	1.360	350
3	49	1.5	0.45	512	1.504	550
4	65	0.5	0.07	280	1.594	250
5	65	2.0	0.18	306	1.629	350
6	65	1.5	0.45	515	1.909	550
7	101	0.5	0.07	290	2.096	250
8	101	1.0	0.18	337	2.863	350
9	101	1.5	0.45	618	2.919	550

From the analysis of above graphs, it is clear that hot turning cutting environment is producing better result by minimising cutting forces, surface roughness and temprature. The output table of the cutting conditions is shown in Table 4.4.

Table 4.5 normalization of output response

Process no	Cutting force	Surface roughness	temperature
1	.1689	0	250
2	0.3987	0.1628	350
3	0	0.1326	550
4	0.5876	0	250
5	0.2364	0.14660	350
6	0.4683	0.13290	550
7	0.5927	0.2096	250
8	0.9329	0.2826	350
9	0.2469	0.2919	550

From the normalised table grey relational grade are evaluate using equation 2 and 3 in Table 4.6. After calculating grey relational grade they are ranked according to their values. The combination which give highest value of grey relational grade is the optimal set of parameter for machining

Table 4.6: Grey Relational analysis

Process No	Cutting force	Surface roughness	Temperature	Grey relational Grade	Rank
1	1	0	250	0.12566	4
2	0.3987	0.1628	350	0.3453	7
3	0	0.1326	550	0.53411	2
4	0.5876	0	250	0.26765	6
5	0.2364	0.14660	350	0.3425	8
6	0.4683	0.13290	550	0.6325	9
7	0.5929	0.2096	250	0.75876	1
8	0.9329	0.826	350	0.51325	3
9	0.2469	0.2919	550	0.65678	5

From grey relational analysis it is cleared that the highest grey relational grade is obtained for run no.7. Whose Vc = 101m/min, f=0.07mm/rev, temperature 350, and t=0.5mm.The output corresponding to this run are Fz = 290, Ra =2.09

Conclusion

The present research work was taken out to analyze of engineering of 17-4PH stainless steel. The effect of various cutting parameters (cutting speed, feed and depth of cut and temprature) on different process parameters analyzed by making use of column graph using Taguchi L9 orthogonal method.

After analysis pursuing conclusions are drawn:

(a). In the analysis cutting makes increase with increase in cutting velocity and give rate. None the less it was found that there were face changes in cutting forces in hot turning process compare to cold turning process.

(b). The surface roughness lower with increase of range of cut and cutting velocity. Hot turning techniques obtained better result regarding cold working.

(c). The area roughness increases in increase of feed rate. With this condition hot turning method is better compare to cold turning process.

(d). The temperature also increased with the increases of cutting force, feed force and depth of cut in both turning process. Yet hot turning process the temperature is higly {made} in the environment..

(e) taguchi based grey research improved the grey relationship grade by 24%, thus {increase the} hot turning techniques.

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