COMPARATIVE STUDIES ON MACHINABILITY OF FORGED AND ANNEALED MCLA STEELS EN19 AND EN24 USING TAGUCHI OPTIMIZATION TECHNIQUE

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Abstract
Steels have wide application in industries and various to meet the demands of customer like surface finish and dimensional Accuracy of a component Machinability is required.EN19 and EN24 are the medium carbon low alloy steels. Medium carbon low Alloy steels and special steels are commonly used for manufacturing of components such as gears, spindle, shafts and aerospace components etc. To manufacture a component in forged condition is may not be acceptable because, it difficult to machining. To overcome this problem annealing is carried out, that provides good condition for working, machining. Machinability is the ability of material, with ease of removal. Machining of material effects on the Tool Forces, power consumption and Surface Roughness. The present work is about Comparative Studies on Machinability of Forged and Annealed EN19 and EN24 MCLA Steels, Using Taguchi Optimization Technique. To conduct Machinability Test, Design the experiments according to Taguchi L9 Experiment. Machinability Test is performed on Lathe. Cutting Speed, Feed and Depth of Cut are varied to study the effect those parameter on power and Surface Roughness. Optimize the Output value by using Taguchi's L9 Experiments to select optimum cutting parameters and best material for future application.
Keywords: MCLA Steels, Machinability, Surface Roughness, Taguchi Method.

I. Introduction

Steels have wide application in industries and various to meet the demands of customer like surface finish and dimensional basically a compound of iron and carbon, and other alloying components. .The steels with carbon content between 0.3 and 0.6% is named medium carbon steels [1]. EN19 (AISI 4140), EN25 (3430) are medium carbon low alloy steels under HSLA classifications. Typical Application includes Spindle of Machine Tool, Gears, Bolts, Shafts, Axels, Pinions, cams, Aero Space and Automobile Industries.

Fig (a) : Gear and Pinion, Shafts, Spindles

Medium carbon steels regularly does not meet the necessity for vehicle and mechanical applications where high quality and hardness required. Primarily because of their impediment in some mechanical properties. EN-19 is also known for high quality alloy steel, Due to its good ductility and shock resistance and resistance to wear properties. It is suitable for manufacturing of gears and penions, shafts, spindles. It contains alloying elements like 1% of Chromium and Molybdenum. EN24 is most suitable for manufacturing of heavy duty axels, bolts and studs. It provides good enhanced resistance properties. It is capable for retaining good impact value at lower temperature. It consisting of alloying elements like Nickel, Chromium and Molybdenum. The Specimens were forged and annealed. Forged steels is known for being stronger, more wear resistant and tougher. But manufacture of steel components is done in soft condition. Components in forged condition may reveal heavy distortion or cracking during hardening process. In that forged condition it is difficult to machine the components. To overcome this problem Annealing is carried out at different temperature. Annealing provides good condition for working, Machining and provides good grain structure for hardening [2].

Machinability is the ability of material, with ease of removal. Machinability can be accessed by Tool Forces, power consumption and Surface Roughness. If the power consumption is more, cutting forces is maximum and low machinability. Surface Roughness can be measured by Taly surf meter Instrument. Machinability Inversely proportional to instrument reading. A lower the reading a good surface finish and high machinability [3]. Aim of this work is to optimize the value of power consumed and Surface Roughness value, by using Taguchi factorial Analysis is performed by using MINI TAB software.

II. Materials and Methods

A. Selection of Material

Table a: Equivalent Specifications of Steels selected for the Study

EN Standa r d	Equivalent Grades			
	BS	DIN	IS	SAE/AIS I
EN19	709M 4 0	42Cr4Mo 2	40Cr4M o3	41,404,1 42
EN24	817M 4 0	34CrNiM o6	40NiCr4 M o3	4340

2.2 Chemical composition of Steels

Table (b) : Chemical composition of selected steel

%wt	Steels	
	EN19	EN24
C	0.43	0.27
Mn	1.1	0.45
P	0.035	-
S	0.04	--
Si	0.3	0.1
Ni	-	2.3
Cr	1.1	0.5
Mo	0.25	0.45

B. Methods

The steels from the material yard taken for forging. The temperature for hot working is 1100^0C at this temperature the rods are taken out and manually hammered Annealing is carried out different temperature given below.

sl no.	Heat Treatment temp	EN19	EN24
1	Annealing	845^0C-870^0C	800^0C-860^0C

Fig(b): Forged and Annealed Steels.

C. Machinability Test

The Forged and Annealed EN19 and EN24 are 50mm diameter rods were taken for conducting machinability test, which is done on the lathe machine. Cutting Speed, Depth of cut and Feed were three parameters selected. As given in the table.

Cutting Speed, rpm	150	250	420
Feed Rate, mm	0.05	0.11	0.22
Depth of cut, mm	0.25	0.5	0.75

Table (c): Machinability Test Parameters.

During machining operation, the forces in all three direction (F_x, F_y, F_z) were measured using lathe tool dynamometer. Carbide brazed cutting tool inserts were used for machining.

Fig(c) : Conducting Machinability Test

Fig(d): Carbide insert brazed Tool

Facing is done on both side of the work piece. The work piece is held between the live and dead centers. carbide tool is mounted on the tool post. Carrying out machining using carbide insert for a length of cut of 10mm. Record the different cutting forces components. Determining the power required for the machining operation.

D. Surface Roughness Test

The Forged and Annealed EN19 and EN24 steel rods were taken for conducting Surface Roughness test after conducting machinability test, which is done by Taly Surf meter.

Fig(e):Conducting Surface Roughness test on the specimen.

III Result and Discussion

A. Machinability Test Results for EN19

Table (d) :Taguchi design for different speed ,feed and DOC

Sl no.	Speed (rpm)	Depth of cut(mm)	Feed (mm)
1	150	0.25	0.05
2	150	0.5	0.11
3	150	0.75	0.22
4	250	0.25	0.11
5	250	0.5	0.22
6	250	0.75	0.05
7	420	0.25	0.22
8	420	0.5	0.05
9	420	0.75	0.11

Table (e) : Cutting forces observed and calculated power.

Fx (kg)	Fy (kg)	Fz (kg)	V= πDN/60	Power(watt)
5	2	6	392.699	23.09
-73	7	11	392.699	42.332
-77	6	22	392.699	84.665
-14	8	24	654.4984	153.938
-12	9	36	654.4984	230.907
-68	12	27	654.4984	173.1802
-7	2	42	1099.557	452.577
-27	5	35	1099.557	377.148
-13	2	34	1099.557	366.372

a. Analysis of Variance (ANOVA) for EN19

Source	DOF	Adj SS	Adj MS	F value	P value
Cutting Speed	2	185298	92649.2	331.03	0.003
DOC	2	127	63.7	0.23	0.815
Feed	2	8919	4459.4	15.93	0.059
Error	2	560	279.9		
Total	8	194904			

After computing and analyzing the result, value of P smaller than significance level for cutting speed. Hence we conclude that Cutting Speed have a significance effect on the power value and DOC. Feed does not have significance effect on power value.

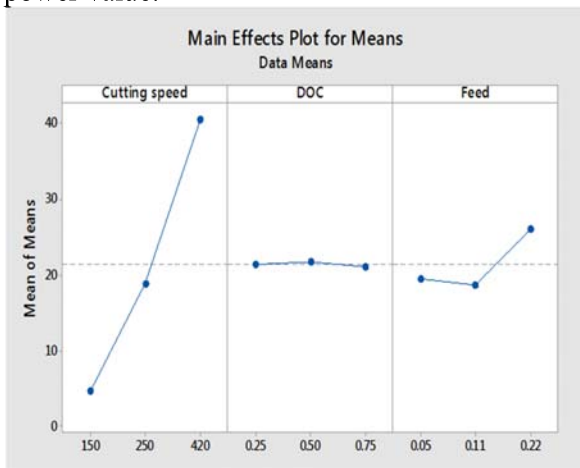

Fig (f) : Mean Effect Plot for Power consumed

From above discussion, the graphs are represents that at a speed of 150 rpm , Depth of cut of 0.75 and Feed of 0.11optimum power consumed 22.488 watts.

B. Machinability Test Results for EN24

Table (f) :Taguchi design for different speed ,feed and DOC

Sl no.	Speed (rpm)	Depth of Cut (mm)	Feed (mm)
1	150	0.25	0.05
2	150	0.5	0.11
3	150	0.75	0.22
4	250	0.25	0.11
5	250	0.5	0.22
6	250	0.75	0.05
7	420	0.25	0.22
8	420	0.5	0.05
9	420	0.75	0.11

Table (g) : Cutting forces observed and calculated power.

Fx (kg)	Fy (kg)	Fz (kg)	V= πDN/60	Power(watt)
5	2	4	392.699	15.393
-73	7	8	392.699	30.7876
-77	6	27	392.699	103.908
-14	8	35	654.4984	224.492
-12	9	42	654.4984	269.391
-68	12	36	654.4984	230.907
-7	2	52	1099.557	560.334
-27	5	43	1099.557	463.353
-13	2	42	1099.557	452.577

b. Analysis of Variance (ANOVA) for EN24

Source	DOF	Adj SS	Adj MS	F value	P value
Cutting Speed	2	294860	147430	240.29	0.004
DOC	2	231	116	0.19	0.19
Feed	2	11238	5619	9.16	0.098
Error	2	1227	614		
Total	8	307556			

After computing and analyzing the result, value of P smaller than significance level. Hence we conclude that Cutting Speed have a significance effect on the power value. DOC, Feed does not have significance effect on power value.

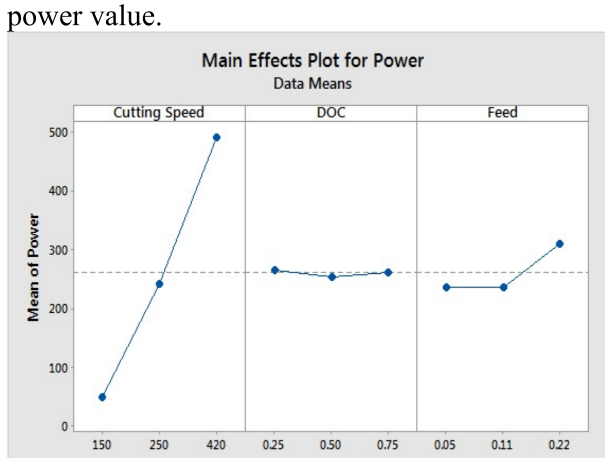

Fig (g) : Mean Effect Plot for Power consumed

From above discussion, the graphs are represents that at a speed of 150 rpm , Depth of cut of 0.5 and Feed of 0.05 optimum power is obtained is 18.014 watts

C Surface Roughness Test Results for EN19

Table (h) : Different R_a value obtained for EN19 at different speed, Feed and DOC

Sl no.	Speed (rpm)	Depth of cut(mm)	Feed (mm)	Surface Roughness (µm)
1	150	0.25	0.05	3.5
2	150	0.5	0.11	3.34
3	150	0.75	0.22	4.6
4	250	0.25	0.11	3.3
5	250	0.5	0.22	2.09
6	250	0.75	0.05	2.85
7	420	0.25	0.22	3.96
8	420	0.5	0.05	4.28
9	420	0.75	0.11	2.77

a. Analysis of Variance (ANOVA) for EN19

Source	DOF	Adj SS	Adj MS	F value	P value
Cutting Speed	2	2.011	1.00543	0.83	0.548
DOC	2	0.184	0.0919	0.08	0.93
Feed	2	0.336	0.16813	0.14	0.879
Error	2	2.435	121763		
Total	8	4.966			

After computing and analyzing the result, value of P greater than significance level. Hence we conclude that Cutting Speed, DOC, Feed does not have a significance effect on the R_a value.

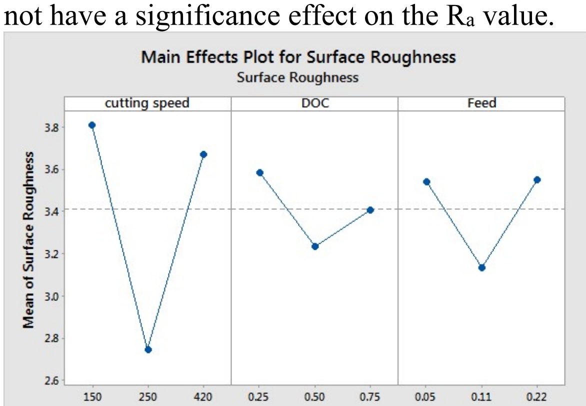

Fig (h) : Mean Effect Plot for Surface Roughness for EN19

From above discussion, the graphs are represents that at a speed of 250 rpm, Depth of cut of 0.5 and Feed of 0.11 optimum surface roughness is obtained is 2.301 µm

Where DOF: Degrees of freedom, Adj SS: Adjacent Sum of square, Adj MS : Means Square.

D Surface Roughness Test Results for EN24

Table (i) : Different R_a value obtained for EN19 at different speed, Feed and DOC

Sl no.	Speed (rpm)	Depth of cut(mm)	Feed (mm)	Surface Roughness (µm)
1	150	0.25	0.05	6.25
2	150	0.5	0.11	2.89
3	150	0.75	0.22	3.7
4	250	0.25	0.11	5.97
5	250	0.5	0.22	2.77
6	250	0.75	0.05	2.29
7	420	0.25	0.22	3.14
8	420	0.5	0.05	3.91
9	420	0.75	0.11	2.66

a. Analysis of Variance (ANOVA) for EN24

Source	DOF	Adj SS	Adj MS	F value	P value
Cutting Speed	2	1.646	0.8231	0.35	0.742
DOC	2	8.822	4.4108	1.87	0.349
Feed	2	1.398	0.6988	0.3	0.772
Error	2	4.73	2.3648		
Total	8	16.595			

After computing and analyzing the result, value of P greater than significance level. Hence we conclude that Cutting Speed, DOC, Feed does not have a significance effect on the R_a value.

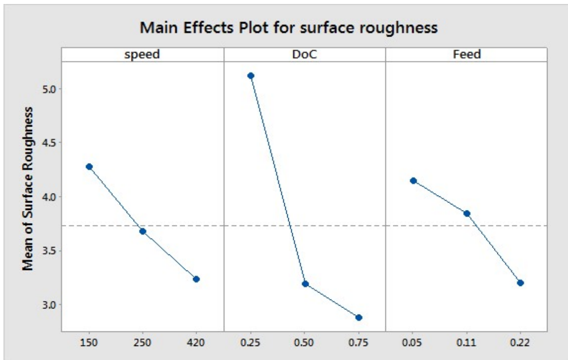

Fig (i) : Mean Effect Plot for Surface Roughness for EN24

From above discussion, the graphs are represents that at a speed of 420 rpm , Depth of cut of 0.75 and Feed of 0.22optimum surface roughness is obtained is 1.862 µm

1V Conclusions

1. After machining good surface smoothness obtained for Forged and Annealed EN24 than EN19 of Surface roughness about 1.86 µm and 2.3 µm respectively.
2. After machining the lower power is obtained for Forged and Annealed EN24 than EN19 and is about 18.015 watts and 22.488 watts respectively.
3. For the manufacture of components like Crank shaft, Axels, Gears, Spindles and pinion, Forged and Annealed EN24 steel is undoubtedly optimum than EN19.
4. Forged and Annealed EN24 steels provides good surface finish so that we can consider it exhibits good Tribological property and Machinability properties.

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