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# M.R.R. Optimization for Aisi 202 in Turning Using Taguchi Criteria and Productivity Enhancement Using Kaizen Approach

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**Abstract :**The present study applied Taguchi method through a case study in straight turning of AISI 202 steel bar using HSS tool for the optimization of MRR process parameter. The study aimed at evaluating the best process environment which could simultaneously satisfy requirements of both quality as well as productivity with special emphasis on maximizing material removal rate at various combination of cutting speed, feed, depth of cut. The predicted optimal setting ensured maximum MRR . Since optimum material removal rate is desired, so higher the better criteria of Taguchi signal to noise ratio is used --

$$\eta = -10\ln_{10}{}^{1}\sum{}^{n1}{}_{2}\ n\ i{=}1\ yi^{\wedge}2$$

The results have been verified with the help of S/N Ratios calculation and various graphs have been plotted to show the below mentioned observations.

a) MRR first increases with increase in cutting speed and then decreases.
b) With the increase in feed, MRR increases.
c) With the increase in depth of cut MRR first increases and then decreases.

## 1. INTRODUCTION

### Turning Operation

Turning is the removal of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the work piece will be turned so that adjacent sections have different diameters. Turning is the machining operation that produces cylindrical parts. In its basic form, it can be defined as the machining of an external surface:

1. With the work piece rotating.
2. With a single-point cutting tool, and
3. With the cutting tool feeding parallel to the axis of the work piece and at a distance that will remove the outer surface of the work.

### Adjustable Cutting Factors In Turning

The three primary factors in any basic turning operation are speed, feed, and depth of cut. Other factors such as kind of material and type of tool have a large influence, of course, but these three are the ones the operator can change by adjusting the controls, right at the machine.

### Speed

Speed always refers to the spindle and the work piece. When it is stated in revolutions per minute (rpm) it tells their rotating speed. But the important feature for a particular turning operation is the surface speed, or the speed at which the work piece material is moving past the cutting tool. It is simply the product of the rotating speed times the circumference of the work piece before the cut is started. It is expressed in meter per minute (m/min), and it refers only to the work piece. Every different diameter on a work piece will have a different cutting speed, even though the rotating speed remains the same.

### Feed:

Feed always refers to the cutting tool, and it is the rate at which the tool advances along its cutting path. On most power-fed lathes, the feed rate is directly related to the spindle speed and is expressed in mm (of tool advance) per revolution (of the spindle), or mm/rev.

### Depth of Cut:

Depth of cut is practically self explanatory. It is the thickness of the layer being removed (in a single pass) from the work piece or the distance from the uncut surface of the work to the cut surface, expressed in mm. It is important to note, though, that the diameter of the work piece is reduced by two times the depth of cut because this layer is being removed from both sides of the work.

**Taguchi method**

Taguchi Method is developed by Dr. Genichi Taguchi, a Japanese quality management consultant. The method explores the concept of quadratic quality loss function (Figure 3.1) and uses a statistical measure of performance called Signal-to-Noise (S/N) ratio. The S/N ratio takes both the mean and the variability into account. The S/N ratio is the ratio of the mean (Signal) to the standard deviation (Noise). The ratio depends on the quality characteristics of the product/process to be optimized. The standard S/N ratios generally used are as follows: - Nominal is Best (NB), Lower the Better (LB) and Higher the Better (HB), (Equations 10 to l2). The optimal setting is the parameter combination, which has the highest S/N ratio.

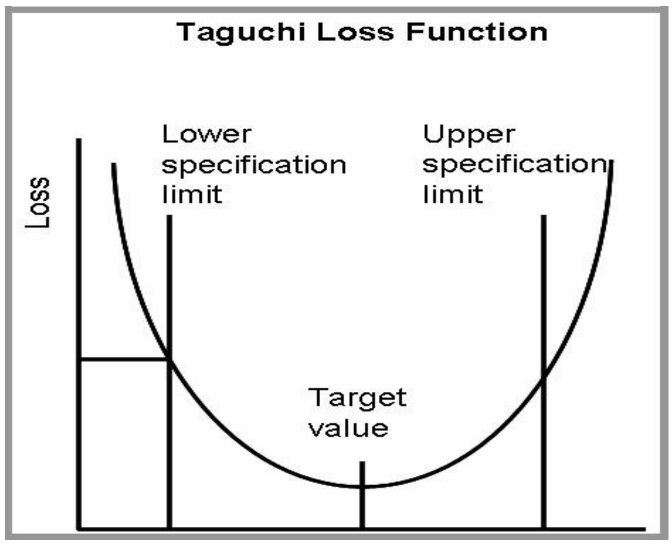


Fig.1: Taguchi's quadratic loss function

**Taguchi's S/N Ratio for (NB) Nominal-the-best**

(Quality characteristics is usually a nominal output, say Diameter)

**Taguchi's S/N Ratio for (LB) Lower-the-better**

(Quality characteristics is usually a nominal output, say Defects)

$\eta = -10\ln_{10}{}^{1}\sum^{n} y_i^{2n}$ i=1

**Taguchi's S/N Ratio for (HB) Higher-the-better**

(Quality characteristics is usually a nominal output, say Current)

$\eta = -10\ln_{10}{}^{1}\sum^{n1}{}_{2}$ n i=1 yi^2

**2. . SIGNAL-TO-NOISE RATIO -- S/N RATIO**

**Signal-to-noise ratio** (often abbreviated **SNR** or **S/N**) is a measure used in science and engineering that compares the level of a desired signal to the level of background noise. It is defined as the ratio of signal power to the noise power, often expressed indecibels. A ratio higher than 1:1 (greater than 0 dB) indicates more signal than noise. While SNR is commonly quoted for electrical signals, it can be applied to any form of signal (such as isotope levels in an ice core or biochemical signaling between cells).

Signal-to-noise ratio is sometimes used informally to refer to the ratio of useful information to false or irrelevant data in a conversation or exchange. For example, in online discussion forums and other online communities, off-topic posts and spam are regarded as "noise" that interferes with the "signal" of appropriate discussion

Signal-to-noise ratio is defined as the power ratio between a signal (meaningful information) and the background noise (unwanted signal):

$$\mathrm{SNR} = \frac{P_{\mathrm{signal}}}{P_{\mathrm{noise}}},$$

## 3. EXPERIMENTAL SETUP

**Case Study I-for optimizing material removal rate for AISI 202 in turning using Higher the better criteria of Taguchi Method**

The Taguchi method is applied to optimize material removal rate in turning operation of AISI 202 ,where cutting speed, feed, and depth of cut data is given below. Since optimum material removal rate is desired, so higher the better criteria of Taguchi signal to noise ratio is used --

$\eta = -10\ln_{10}{}^{1}\sum^{n1}{}_{2}$ n i=1 yi^2

MRR = Weight before machining - Weight after machining Time Taken

Nine nos samples of Material AISI 202 were taken for machining and their weight before machining and after machining were precisely recorded and time taken using a calibrated watch and following observations were recorded.

S.S. bars of diameter 32mm and length 40mm required for conducting the experiment have been prepared first.Nine no of samples of same material and same dimensions have been made.After that the weight of each sample has been measured accurately with the help of digital balance meter. Then using different levels of the process parameters nine specimens have been turned on lathe machine accordingly.Machining time for each sample has been calculated accordingly.

After machining weight of each machined parts have been again measured precisely with the help of digital balancemeter. The results of the experiments have been shown. Analysis has been made based on these experimental data .Optimization of Material removal rate has been made by Taguchi method & design of experiment which consists of nine different combination of spindle speed, feed, depth of cut .

**Data Related to Material Removal Rate (M.R.R)**

| **Sample No** | **Weight before** | **Weight after** | **Machining Time** | |
|---|---|---|---|---|
| **turning(kg)** | **turning(kg)** | **sec** | **Min** | |
| 1 | .256 | .240 | 18 | .3 |
| 2 | .292 | .264 | 10 | .167 |
| 3 | .231 | .208 | 8 | .134 |
| 4 | .232 | .210 | 16 | .267 |
| 5 | .241 | .217 | 9 | .15 |
| 6 | .251 | .214 | 7 | .116 |
| 7 | .240 | .209 | 13 | .216 |
| 8 | .226 | .216 | 8 | .133 |
| 9 | .254 | .233 | 6 | .1 |

| **Sample No** | **Cutting speed (m/min)** | **feed (mm/rev)** | **depth of cut (mm)** | **Material Removal rate (gm/sec)** | **S/N Ratio** |
|---|---|---|---|---|---|
| 1 | 115 | .07 | .6 | 0.92 | -0.51 |
| 2 | 115 | .14 | 1.2 | 2.91 | 9.1 |
| 3 | 115 | .21 | 1.8 | 2.72 | 8.7 |
| 4 | 130 | .07 | 1.2 | 1.31 | 2.34 |
| 5 | 130 | .14 | 1.8 | 2.65 | 8.48 |
| 6 | 130 | .21 | .6 | 5.28 | 14.4 |
| 7 | 145 | .07 | 1.8 | 2.38 | 7.53 |
| 8 | 145 | .14 | .6 | 1.25 | 1.93 |
| 9 | 145 | .21 | 1.2 | 3.67 | 11.27 |

The optimum parameters are corresponding to the highest S/N Ratio which is 14.4, So optimum cutting speed v=130m/min , feed=.21mm and depth of cut= .6 mm for material removal rate.

**MRR Vs Cutting Speed**

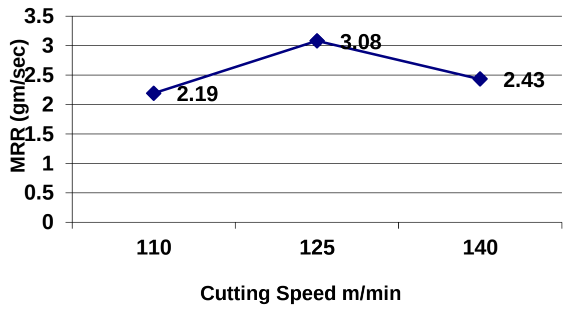


Fig.2

**MRR Vs Depth of Cut**

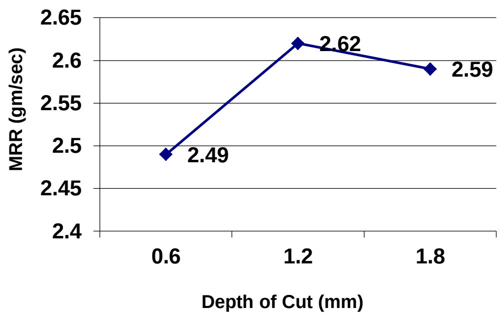


Fig.3

**Plot of MRR Vs Feed**

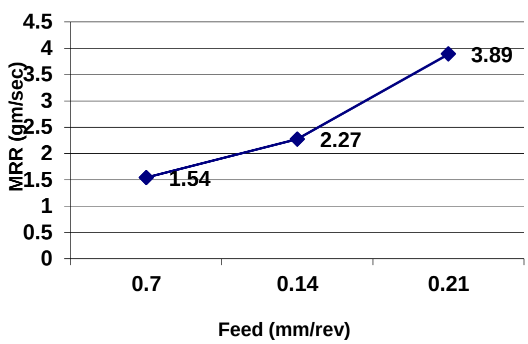


Fig.4

**S/N Ratio Plot for MMR Vs Cutting Speed**

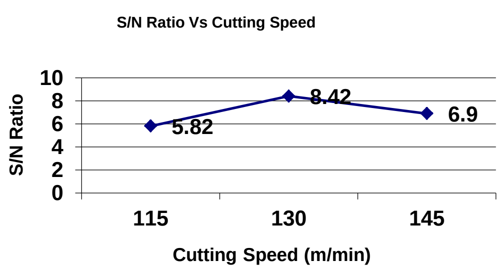


Fig.5

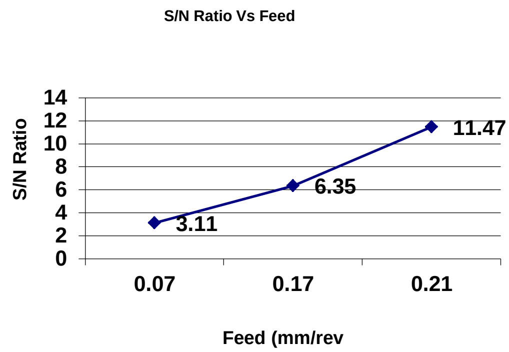


Fig.6

**S/N Ratio Plot for MRR Vs Depth of cut**

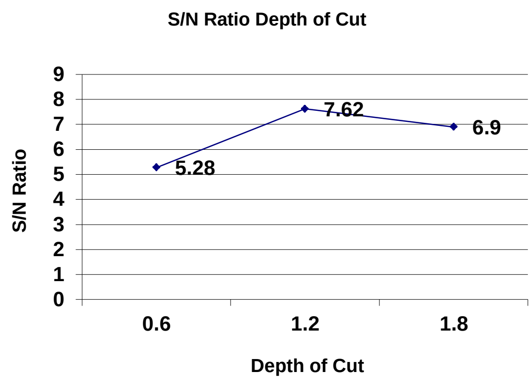


Fig.7

**Case Study-2**

**For enhancing industrial productivity using kaizen approach**

The research has been conducted in a Automotive industry which had complaints more rejections at customer end due to faulty transport.Workpiece distortion during transport. Because of wheels in trolly it hit the body of vehicle and the parts got damaged.

Fig.8

Spacer rod added in transport vehicle to avoid the damage of parts in future.

The other common customer complaint was poor quality surface finish .Research has been conducted in a Automotive industry which had complaints more rejections at customer end due to poor surface finish. So to avoid such rejections deflashing / shot blasting of components was recommended to deal with such a problem.

Fig.9

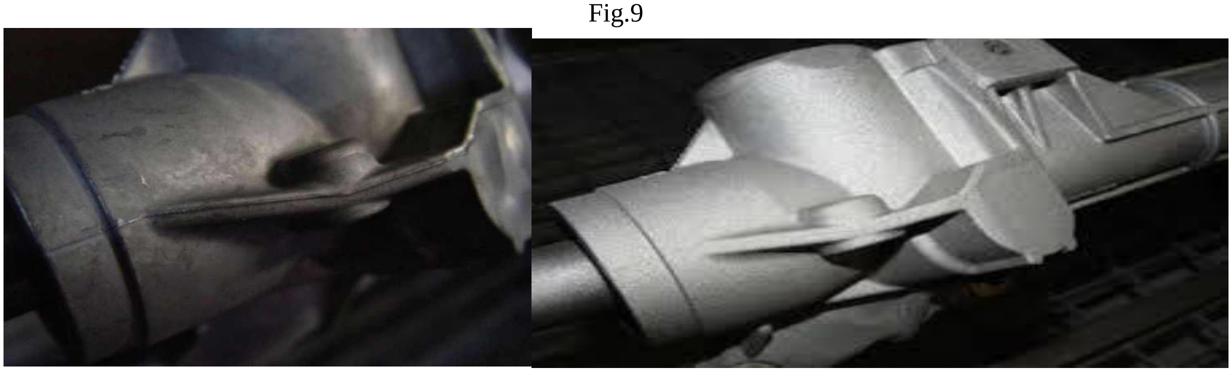

Fig.10

1) The cost to society in case of deviation from target value could be quantified using Taguchi loss function. More the deviation more is the fall in customer brand reputation, market size .
2) Idle, non-productive time was minimized and the time to complete a test job was reduced.

**Case study- Time estimation for a job in Process Layout**

| | Average Time to Perform job (Seconds) |
|---|---|
| 1 Straight Turning and Facing on lathe | 600 |
| Idle time to move job in next shop | 300 |
| 2 Hole drilling using drill machine | 350 |
| Idle time to move job in next shop | 200 |
| 3 Slot cutting using Shaper | 500 |
| Idle time to move job in next shop | 320 |
| 4 Grinding using Grinder machine | 400 |
| Idle time to move job in next shop | 200 |
| 5 Finish Machining (Honing &laping) | 650 |
| Total Time | 3200 sec |

Fig.11

**Case study- Time estimation for a job in Product Layout**

| | Average Time to Perform job (Seconds) |
|---|---|
| 1 StraightTurning and Facing on lathe | 600 |
| Idle time to move job to next machine | 100 |
| 2 Hole drilling using drill machine | 350 |
| Idle time to move job to next machine | 110 |
| 3 Slot cutting using Shaper | 500 |
| Idle time to move job to next machine | 120 |
| 4 Grinding using Grinder machine | 400 |
| Idle time to move job to next machine | 125 |
| 5 Finish Machining (Honing &laping) | 650 |
| TOTAL TIME | 2995 Sec |

Fig.12

## 4.CONCLUSIONS

**For case study 1**

a) The optimum value of process variables for material removal rate are cutting speed – 130m/min, feed - .21mm/rev And depth of cut - .6mm.
b) MRR first increases with increase in cutting speed and then decreases.
c) With the increase in feed, MRR increases.
d) With the increase in depth of cut MRR first increases and then decreases.
e) For MRR
   - S/N Ratio first increases with increase in cutting speed and then decreases.
   - With the increase in feed S/N ratio increases.
   - With the increase in depth of cut S/N Ratio first increases and then decreases.

**For case study2**

1) Time to complete a workpiece was reduced from 3220sec to 2995 sec from switch over to product layout from type.
2) Preventive Maintenence approach was adopted instead of breakdown Maintenence
3) Productivity increased as rejections were reduced to great extent.
4) Root causes of defects were uncovered.
5) Annual profit and turnover of the company increased.
6) Employees became more Quality consciousness.
7) Timely delivery commitments of finished product with customers and job schedules were obeyed.
8) Best method of doing a job among various available alternatives were uncovered.
9) Proper and timely calibration of instruments was made possible.

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