



## **EVALUATING THE PERFORMANCE OF PROCESS PARAMETERS IN ROLLER BURNISHING OF EN9 MATERIAL**

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### **Abstract:**

Burnishing is a surface finishing process which improves surface finish without removal of material. The burnishing process mainly includes the suppression of surface irregularities and thus smoothening of the work piece surface and giving it a shiny look. Roller burnishing is a cold rolling process which has a great effect on the surface finish of a work piece. In this paper, the effect of parameters on surface roughness in roller burnishing of EN9 material is determined. It is observed that the highest contributor in improvement of surface finish is depth of penetration followed by feed rate, burnishing speed and then number of passes. The design of experiment is done by Taguchi parametric design strategy for process parameters and then the optimization of results is carried out.

**Key Words:** Roller Burnishing, Taguchi, ANOVA, Surface Roughness & EN9 Material

### **Introduction:**

Burnishing is a surface finishing process which improves surface finish without removal of material. This process used to polish and harden the metal work surface. Roller burnishing process also used to smoothen and harden the surface. During burnishing, considerable residual compressive stresses are induced on the surface of the work piece and thus the fatigue strength and wear resistance of the surface layer is improved. Thus, in conjunction with giving finer surface finish it additionally enhances surface properties like hardness, wear resistance, fatigue life, corrosion resistance, etc. It involves rolling a hard, smooth object over the minute surface irregularities that are produced during machining or shearing. The hardened roller of burnishing tool suppresses the surface irregularities to a more flat surface. The improvement in surface finish takes place due to the application of dynamic loading on work-piece. [1]

### **Experimental Procedure:**

#### **Material and Method:**

Commercially available EN9 steel bars (dia., 32 mm) were machined on a CNC lathe machine to the required sizes. Work piece was cut to 60 mm length on a hacksaw machine using water emulsion as lubrication. Then facing operation was done and work piece was turned to 30 mm outer diameter on CNC lathe machine. Then the burnishing process was carried out using single roller burnishing tool made of D3 tool steel.

#### **Machines and Equipment:**

The proposed worked of roller burnishing was carried out on CNC lathe machine.



Figure 1: CNC Lathe Machine



Figure 2: Setup for burnishing process

The measurement of the output parameter, that is, surface roughness was done with the help of surface roughness tester Mitutoyo SJ-210



Fig. 3: Mitutoyo surf test SJ-210

**Design of Experiments:**

The design of experiment was done with the help of Taguchi's Approach for design of experiments. Taguchi method concentrates on design of experiment for product quality improvement. Taguchi method is used for intermediate number of parameters (3 to 50). It is a robust method of design of experiments. The process parameters and their levels selected for experimentation are shown in table below:

Table 1: Process Parameters and their levels

| Factors                    | Level 1 | Level 2 | Level 3 |
|----------------------------|---------|---------|---------|
| Spindle Speed (N)          | 500     | 800     | 1100    |
| Feed (f)                   | 0.08    | 0.10    | 0.12    |
| Depth of Penetration (DOP) | 0.1     | 0.2     | 0.3     |
| Number of Passes (NOP)     | 1       | 2       | 3       |

**Results and Discussion:**

The experimental combination of burnishing process parameters was done as shown in table 2.

Table 2: Experimental Results for surface roughness

| Experiment Number | Speed (rpm) | Feed (mm/rev) | Depth of penetration (mm) | Number of passes | Surface Roughness ( $\mu\text{m}$ ) |
|-------------------|-------------|---------------|---------------------------|------------------|-------------------------------------|
| 1                 | 500         | 0.08          | 0.1                       | 1                | 1.277                               |
| 2                 | 500         | 0.08          | 0.1                       | 1                | 1.28                                |
| 3                 | 500         | 0.08          | 0.1                       | 1                | 1.222                               |
| 4                 | 500         | 0.1           | 0.2                       | 2                | 1.306                               |
| 5                 | 500         | 0.1           | 0.2                       | 2                | 1.332                               |
| 6                 | 500         | 0.1           | 0.2                       | 2                | 1.372                               |
| 7                 | 500         | 0.12          | 0.3                       | 3                | 1.039                               |
| 8                 | 500         | 0.12          | 0.3                       | 3                | 0.933                               |
| 9                 | 500         | 0.12          | 0.3                       | 3                | 1.031                               |
| 10                | 800         | 0.08          | 0.2                       | 3                | 1.199                               |
| 11                | 800         | 0.08          | 0.2                       | 3                | 1.159                               |
| 12                | 800         | 0.08          | 0.2                       | 3                | 0.996                               |
| 13                | 800         | 0.1           | 0.3                       | 1                | 1.286                               |
| 14                | 800         | 0.1           | 0.3                       | 1                | 1.292                               |
| 15                | 800         | 0.1           | 0.3                       | 1                | 1.157                               |
| 16                | 800         | 0.12          | 0.1                       | 2                | 1.826                               |
| 17                | 800         | 0.12          | 0.1                       | 2                | 1.83                                |
| 18                | 800         | 0.12          | 0.1                       | 2                | 1.925                               |
| 19                | 1100        | 0.08          | 0.3                       | 2                | 0.757                               |
| 20                | 1100        | 0.08          | 0.3                       | 2                | 0.886                               |
| 21                | 1100        | 0.08          | 0.3                       | 2                | 0.874                               |
| 22                | 1100        | 0.1           | 0.1                       | 3                | 1.6                                 |
| 23                | 1100        | 0.1           | 0.1                       | 3                | 1.694                               |
| 24                | 1100        | 0.1           | 0.1                       | 3                | 1.73                                |
| 25                | 1100        | 0.12          | 0.2                       | 1                | 1.729                               |
| 26                | 1100        | 0.12          | 0.2                       | 1                | 1.704                               |
| 27                | 1100        | 0.12          | 0.2                       | 1                | 1.778                               |

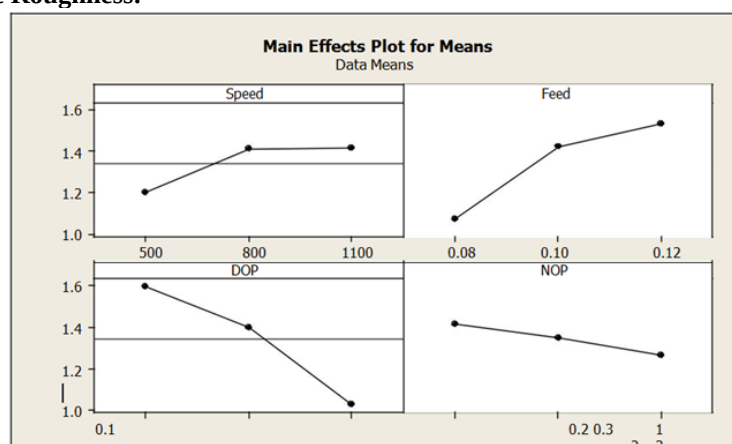
**Main Effect Plot for Surface Roughness:**

Figure 4: Main Effects Plot for Means of Surface Roughness Values

The main effect plot for means of surface roughness is plotted with the help of readings obtained after experimentation. From the above results and graphs, the effect of process parameters on surface roughness is found to be as follows:

- ✓ Effect of speed on surface roughness: With increase in speed the contact time between tool and work piece reduces resulting into reduced compression effect and thus the surface roughness value increases.
- ✓ Effect of feed on surface roughness: With increase in feed rate the tool passes over the work piece in less time, thus reducing the compression action and increasing surface roughness.
- ✓ Effect of depth of penetration on surface roughness: As depth of penetration increases the surface irregularities are pressed at larger extent, increasing the surface finish.
- ✓ Effect of number of passes on surface roughness: As number of passes increases, the irregularities go on suppressing and results into improvement in surface finish.

#### ANOVA:

Analysis of variance (ANOVA) tests the hypothesis that the means of two or more populations are equal. ANOVA assess the importance of one or more factors by comparing the response variable means at the different factor levels. The null hypothesis states that all population means (factor level means) are equal while the alternative hypothesis states that at least one is different. The analysis of variance is done with the help of Minitab 16 software and the results obtained are as follows:

Table 3: Analysis of Variance for Surface Roughness

| Source               | Degree of Freedom | Sum of Squares | Mean of Squares | Variance Ratio | % Contribution |
|----------------------|-------------------|----------------|-----------------|----------------|----------------|
| Speed                | 2                 | 0.27316        | 0.13658         | 33.06          | 9.14           |
| Feed                 | 2                 | 1.03562        | 0.51781         | 125.35         | 34.66          |
| Depth of Penetration | 2                 | 1.50376        | 0.75188         | 182.02         | 50.34          |
| Number of Passes     | 2                 | 0.10058        | 0.5029          | 12.17          | 3.37           |
| Error                | 18                | 0.07435        | 0.00413         | -              | 2.49           |
| Total                | 26                | 2.98747        | -               | -              | -              |

The highest contributor for the response of surface roughness is depth of penetration that is the compressive force has highest effect. The second contributor is feed rate followed by speed and number of passes.

#### Conclusions:

- ✓ Taguchi method concentrates on design of experiment for product quality improvement.
- ✓ Good surface finish has been obtained by the optimized parameters such as speed 500 rpm, feed 0.08 mm/rev, depth of penetration 0.3 mm and number of passes 3. The optimized parameter set obtained is as below
- ✓ The gradual increase in speed and feed increases surface roughness and with the increase in depth of penetration and number of passes surface finish increases.
- ✓ The depth of penetration of tool into work piece has a maximum contribution in improvement of surface roughness of the work piece.
- ✓ It is observed that the highest contributor in improvement of surface finish is depth of penetration followed by feed rate, burnishing speed and then number of passes.

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