Design and fabrication of ball burnishing tool for surface finish

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Abstract. In the recently growing trends among the different fabrication processes, it is necessary to produce the compressive residual stress for the various components. Burnishing process improves the physical and mechanical properties and also the surface finish of the products to be manufactured. Due to the advantages like simple in operation and chip less process after manufacturing this ball burnishing method is considered to be the attractive process. It is a method applied for providing residual stresses at the surface layer and also to reduce the machined surface roughness. There are different methods available for producing surface finish of the components which includes burnishing method also. This process is mainly used in industries in order to increase the quality of the parts produced and also to have a fatigue resistance. This paper presents about the different ball burnishing methods and tools available in the recent trends. By controlling the different parameters, the methods of performing burnishing process is studied in the paper.

Keywords: Burnishing, Surface quality, Residual stress, Hardness.

1. Introduction:
The process of high surface finishing is to be concentrated more nowadays in the growing technology. The product when reaching the finishing stage should be in a condition which will satisfy the needs of the end customers which is turn has an adverse effect on the company’s reputation which may solve the problems of people working in the design and quality. The surface which is machined by the turning and also the milling process doesn’t have a surface which is smooth but has few inherent layers because the initial layer would be teared by the tool which is also dependent on the tool material [1]. So the process of finishing was considered of more importance after the process of machining being done. Burnishing offers simplicity and economy in tooling. It reduces production cycle time, increases service life and reliability of components in assembly because of improvement in their surface finish, hardness, dimensional accuracy. Burnishing is the finishing operation which involves plastic deformation of the layer in the surface to increase the quality and even the practical usefulness of the pieces. Basically burnishing is the secondary operation, which follows a primary finishing operation [2]. Burnishing is performed either with ball or roller burnishing tool. The process is classified as normal vibratory in impact type burnishing. In burnishing process, surface pressure of the hardened steel ball acts on the component and displaces metal plastically from crest to valley of surface irregularities. Thus the process improves the surface quality. Further the burnished surface also gets work hardened because of plastic deformation. Burnishing generates beneficial
compressive stress in the surface layers, which are responsible for wear and corrosion resistance and for increase in fatigue strength of the layers surface of each component.

The process of burnishing is favourably applied for most of the ductile and malleable metals. Pre-burnishing processes such as milling, turning are desirable, because surface texture so obtained is suitable for metal flow from crests to valley. Burnishing is generally carried out as separate operation following turning and grinding. To increase output and reduce the machining cycle time, two operations namely turning and burnishing were combined.

The burnishing process of finite element analysis requires few input and output parameters. The speed of the tool, burnishing force and feed are the main input parameters whereas the surface roughness, residual stresses, micro hardness are some of the output parameters. As soon as the turning operation is over the surface roughness generated helps to create a pattern that is used for simulating the ball burnishing process [3]. The surface roughness with a low value and highly to be used in practical conditions is the most important features to be maintained in the product being made in the current situation. The burnishing speed, feed, force and even the width has a capability to provide a low surface roughness [4]. The product design and the mould to be produced is also a vital factor in the forming and also in the shaping processes. The mould produced should have a high quality of surface finish and it plays an important role in the aesthetic of the products [5]. The process of ball burnishing may be done by placing the sphere to roll on the surface by a force that is controlled by an electrical means. For the AISI specimens the ball burnishing process helps to improve the lifespan which is explained by the rotating bending tests. The ball burnishing when done with a ball of 6mm with a force of 120N with a 7 passes the AISI material properties are increased in a more nominal value [6]. Nano finishing of the component with high precision and dimensional accuracy is a critical necessity in modern industries [7]. The R-MRH process is mainly used for producing the internal surface finish for the cylindrical work pieces [8]. The objective of the paper to process improves the physical and mechanical properties and also the surface finish of the products to be manufactured.

2. Methodology

2.1 Design of spring

| Parameter                  | Value       |
|----------------------------|-------------|
| Outside diameter           | D = 10 mm   |
| Wire diameter              | d = 2 mm    |
| Maximum load applied       | F = 70 kgf  |
| Maximum deflection of the spring | y = 25 mm |
| Number of turns            | i = 24      |
| Modulus of rigidity        | G = 88930 N/mm² |
| Spring stiffness           | F₀ = F/y    |
|                           | F₀ = (70 x 9.81)/25 |
|                           | F₀ = 2746 N/mm²   |

Spring stiffness,

\[ i = \frac{d^4 \times G}{8 \times F_0 \times D^3} \]
\[ i = 24 \times 88930 / 8 \times 2746 \times 103 \]
\[ i = 7 \]

Hence, the design is safe as the obtained number of turns is less than the total number of turns used. The ball Burnishing tool diagram is shown in Fig 1:

![Ball Burnishing Tool Diagram](image)

**Fig 1:** Ball Burnishing Tool Diagram
Fig 2: Shows the tool assembly of the burnishing process. Tool parts, brushing ball, spring, cap, stem, body and assembled tool.

2.2 Burnishing effect on the surface hardness

Normally in the burnishing process [9], high specific forces are generated in the contact zone between the rolling tool and work surface, form defects as a result of plastic deformation [10]. It increases the stiffness and generates compressive stresses on the layer and due to the reason the wear resistance and corrosive resistance is improves along with the fatigue life of the components. [11] The properties of material like strength, toughness and workability contribute to the results of burnishing process in a large amount. The brittle materials when burnished have low values when compared to the materials which have high workability. In present work
the surface hardness of the ball burnishing effect of different components are discussed and given in fig.3

![Fig.3: Forces generated during burnishing](image)

3. Result and Discussion

**Table: 1 - Surface hardness of different materials**

|        | Mild Steel | Brass | Copper |
|--------|------------|-------|--------|
| Burnishing (BHN) | Turning (BHN) | Burnishing (BHN) | Turning (BHN) |
| 72     | 60         | 73    | 72     |
| 74     | 68         | 83    | 76     |
| 88     | 73         | 87    | 83     |
| AVG=78 | AVG=67     | AVG=81| AVG=77 |

Table 1 shows the surface hardness of different materials with lubricant – white grease. When low burnishing speed with more number of passes were given it led to increase in the value of burnished [12] surface roughness. When there is an increase in plastic deformation the deflection of spring also increases which in turn reduces the surface finish. Within local yielding there is an increase in burnishing pressure when the coefficient of friction [13] reduces. The value of plastic strain will be low when the material flows easily as there is no friction and also it receives the compression stress of the material. When a larger value of plastic strain is required it can be done by increasing the friction value which makes the material to flow in front of the ball and makes the work easier. The burnishing force and feed rate are the two main properties to be considered while doing the burnishing process. It is observed that when the white grease was used as a lubricant for mild steel material the penetration value is about 0.5mm there was an increase in surface roughness of about 2.34 microns and as the penetration value increases...
there is a fluctuation in the values of surface roughness. Similarly for brass and copper also the average surface hardness was about 4.32 microns and 0.65 microns respectively.

| Material          | Lubricant          | Depth Of Penetration (S) Mm | Surface Roughness (Ra) Microns |
|-------------------|--------------------|-----------------------------|--------------------------------|
| Mild Steel        | white grease       | 0.50                        | 2.34                           |
|                   |                    | 0.75                        | 1.8                            |
|                   |                    | 1.00                        | 2.1                            |
| Brass             | white grease       | 0.50                        | 1.94                           |
|                   |                    | 0.75                        | 1.5                            |
|                   |                    | 1.00                        | 1.93                           |
| Copper            | white grease       | 0.50                        | 0.43                           |
|                   |                    | 0.75                        | 0.34                           |
|                   |                    | 1.00                        | 0.25                           |

Table 2: Surface hardness of different materials with Lubricant

4. Conclusion:

As a result of burnishing the surface hardness increases. It is primarily due to greater plastics deformation with burning intensity of micro irregularities. After when there is sufficient penetration depth, feed and also the speed there is a decrease in the hardness value. Different parameters like speed and feed along with the force acting and also the number of passes were identified and the influence of those variables on hardness as well as surface roughness was studied. To conclude the depth of penetration had greater effect on the different materials which was selected for testing.

5. References

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