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Performance Evaluation of Dual Roller: Hydraulic Operated Roller Burnishing Tool

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Abstract: Conventional processes of finishing include grinding, lapping , super finishing etc., but in many cases they are found to increase the process cost and lead time of manufacture of components . Burnishing is an easy and efficient technique for enhancing surface quality and can be performed on standard machines like a lathe. Because of its high production rate, it reduces manufacturing costs compared to traditional finishing methods such as grinding, honing, and super-finishing. In addition, surfaces treated by burnishing exhibit improved wear resistance and longer fatigue life. Project work includes the design and development of the dual roller hydraulically operated tool head with The roller burnishing setup employs rollers manufactured from HCHCR material, while the tool holder is fabricated from EN-9 steel. The required force is applied through a hydraulic pressure adjustment system, in which pressure is generated and controlled using a hydraulic pump. The performance evaluation has been done by testing the tool head on EN 9 material and the effect of hydraulic pressure is varied is noted for surface finish and case hardness for the above said material.

Keywords: *Dual Roller, Hydraulic, Burnishing , Surface Finish , Case Hardness.*

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I. INTRODUCTION

Roller burnishing allows manufacturers to avoid additional finishing processes, leading to significant reductions in both production time and cost, while simultaneously enhancing product quality. This technique creates precise dimensions, smooth surface finishes, and a compacted surface layer with improved wear resistance. The process involves applying controlled pressure using hardened, highly polished steel rollers against a comparatively softer work piece. When the applied pressure surpasses the material’s yield strength, the subsurface material undergoes cold flow, causing permanent plastic deformation of the surface. A surface produced by burnishing is often smoother than one finished by abrasive processes, even when both show the same profile meter value. Since profile meters only evaluate surface height variations, they do not fully capture this difference. Abrasive finishing techniques primarily reduce surface roughness by removing material. However, these processes leave behind pointed surface asperities within the contact region of the machined surface. (Murthy R. L., 1981). Roller burnishing operates by redistributing material rather than removing it. During the process, the microscopic surface peaks formed by machining are plastically deformed and forced into adjacent valleys, resulting in a flattened, plate-like surface profile where sharp asperities in the contact zone are significantly reduced or completely removed. As a result, a burnished surface offers greater resistance to wear than an abrasively finished one under metal-to-metal contact conditions, such as a rotating shaft operating within a bushing. Burnishing processes are generally classified into two main categories: ball burnishing and roller burnishing. Ball burnishing employs elements made from materials such as hardened alloy steel, carbide, or diamond, while roller burnishing typically uses rollers manufactured from hardened alloy steel. In this paper, experiments with Roller burnishing tool are presented. Residual compressive

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stresses are induced on the surface of the burnished components, which results in fatigue resistance and improvement in wear resistance quality (Shneider, 1967). Figurer illustrates a schematic representation of the roller burnishing process, highlighting the residual stress states generated during the operation.

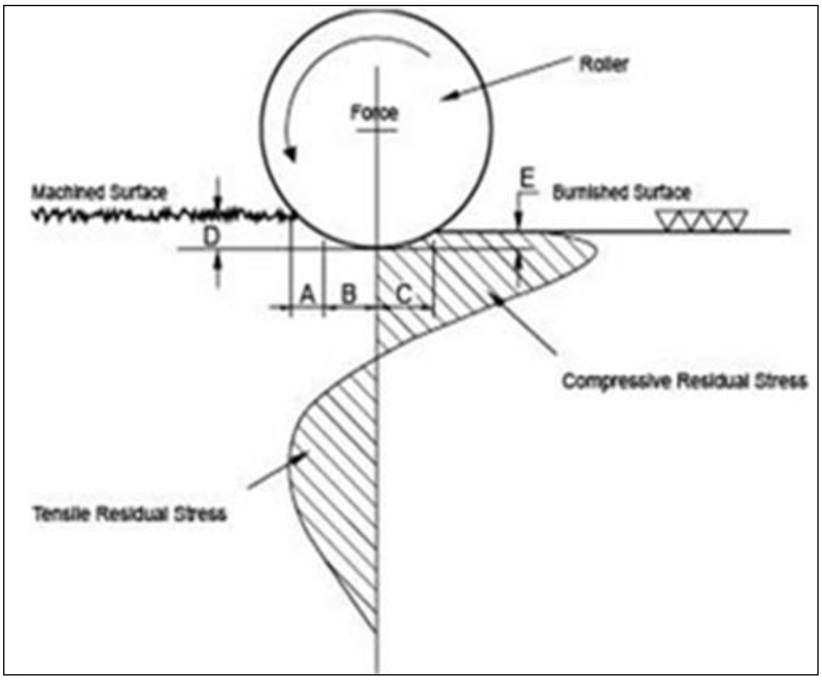

Fig 1 Roller Burnishing Process with Indication of Residual Stress Conditions Developed by the Process

The principle of the Burnishing process is a cold forming finishing process based on the rolling movement of the tool on the peaks of the work piece's surface irregularities that are produced from the previous machining processes. Generally burnishing could be applied on both external and internal surfaces. The hardened rolls of the tool press against the surface causing cold working and residual compression stress formation. The tool pressure deforms the protrusions to a flat geometry by exceeding the yield point of the work piece's material. And as a result the wear and fatigue resistance is improved.

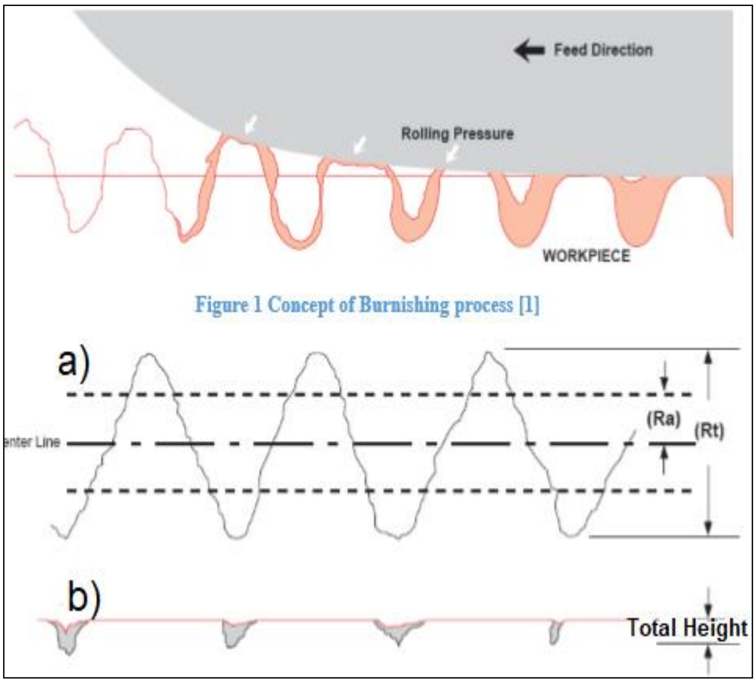

Fig 2 a) Before Burnishing Surface b) After Burnishing Surface.

II. CONVENTIONAL PROCESSES

Conventional processes of finishing include grinding, lapping, super finishing etc., but in many cases they are found to increase the process cost and lead time of manufacture of components. Burnishing is a straightforward and efficient technique for enhancing surface quality and can be performed on conventional equipment such as a lathe. Due to its high processing rate, it offers greater cost savings compared to traditional finishing methods like grinding, honing, and superfinishing. In addition, components treated by burnishing exhibit improved wear resistance and increased fatigue strength.

Considering that the roller burnishing has the possibility to eliminate the use of the hardening, grinding or lapping process for finishing of the wok piece it is recommended that the roller burnishing method be developed with more precision and more permutations through application of more robust tool head and through application of hydraulics.

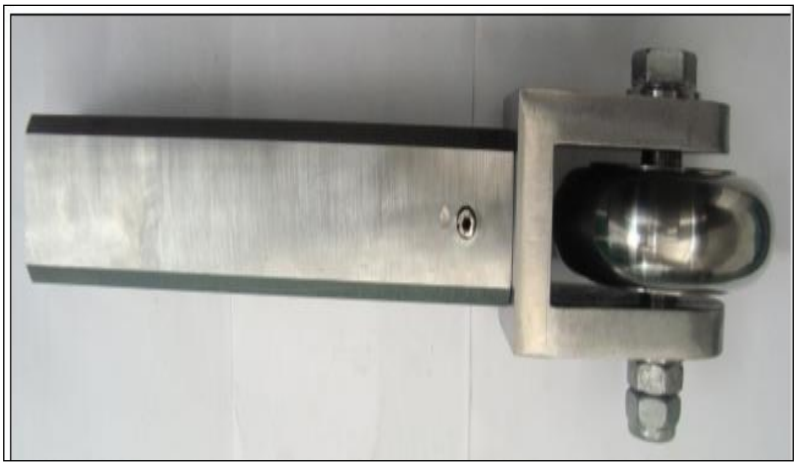

Fig 3 Actual Image to Existing Roller Burnishing Tool Actual Image to Existing Roller Burnishing Tool.

Fig 4 Actual Image to Existing Roller Burnishing Process.

III. LITERATURE SURVEY

1) M. H. El-Axir & M. M. El-Khabeery, International Journal of Mechanical Engineering (IJME) ISSN (P): 2319-2240; ISSN (E): 2319-2259 Vol. 3, Issue 1, Jan 2014. worked upon the experimental techniques for studying the effects of milling roller-burnishing parameters on the surface integrity. They have used 6061-T6 Aluminum alloy work piece to investigate the effect of roller-burnishing upon surface roughness, surface micro hardness and residual stresses. They have used response surface method (RSM) with the Box and Hunter method to investigate the effect of the burnishing process parameters.

2) M. H. El-Axir, O.M. Othman & A.M. Abodiena, "Improvements in out-of-roundness and microhardness of inner surfaces by internal ball burnishing process", journal of materials processing technology 196 (2008) 120–128. published his work on experimental program to study the influence of different burnishing conditions on both surface micro hardness and roughness: namely, burnishing speed, force, feed, and number of passes.

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3) Zabkar B., Kopac J. (2013), “An investigation into roller burnishing process”, Journal of Production Engg., vol. 16, No. 2 stated that burnishing is a superficial plastic deformation process used as a surface smoothing and surface enhancement finishing treatment after some machining processes that eliminate secondary operations. In roller burnishing, a hard roller is pressed against a rotating cylindrical work piece and parallel to the axis of the work piece.

4) A. M. Hassan and A. M. Maqableh (2000), Effects of initial burnishing parameters on non-ferrous components,‖ J. Mater. Process. Technol., vol. 102, no. 1, pp. 115–121 studied the effects of initial burnishing parameters on non-ferrous components. They have used Carbon chromium as ball material and two non-ferrous work piece materials, namely free machining Brass and cast Al-Cu alloy and found that the initial burnishing parameters such as initial surface roughness and hardness of the work piece, the ball diameter of the burnishing tool, use of different lubricants have significant effects on the burnishing process.

IV. TWIN ROLLER, HYDAULIC OPERATED ROLLER BURNISHING TOOL

The roller burnishing tool has a single roller that tends to create feed marks on the surface more over the pressure is applied by hand which may not be applied uniform all along the length of job which will result in uneven surface finish and uneven hardness over the length of work piece.

➢ *Salient Features*

- Roller burnishing is applied to roller burnishing of EN9 material
- Pressure is varied to improve performance and then retest are conducted
- Case hardness and Surface finish are output parameters

➢ *Specifications*

- Twin roller system is used
- Maximum pressure 50 bar operating pressure
- HCCR material is used for rollers
- 7 Ft , Medium duty Centre lathe is used .
- Four speed Configuration is used for the test
- Motor specification = 12 V DC, 5 watts, 60 rpm

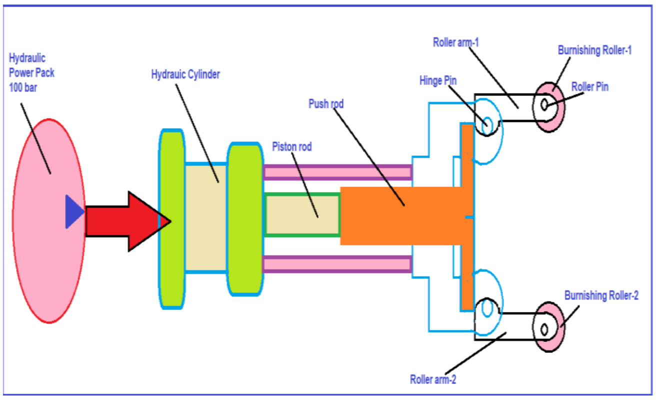

Fig 5 Schematic of Hydraulic Operated Twin Roller Tool Head for Roller Burnishing

➢ *Parts*

- Twin roller tool head: This is a special tool head with replaceable rollers held on two roller arms on a roller pin each. The roller arms are held in a hinge bracket that forms the body of the tool head and it also supports the push rod that is used to force the roller arms to apply the roller pressure on the work piece.

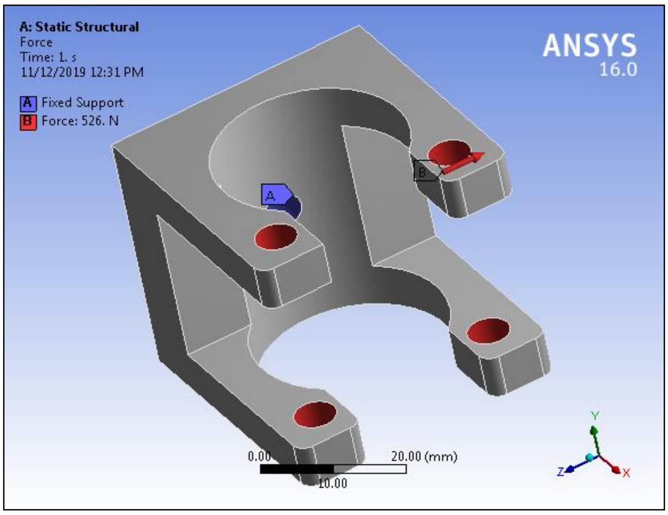

Fig 6 Twin roller head

- The Hydraulic actuator: This is a specially designed face mounted hydraulic cylinder that can hold up to 60 bar pressure. The design of the hydraulic cylinder is short boy which gives maximum force in minimum area.

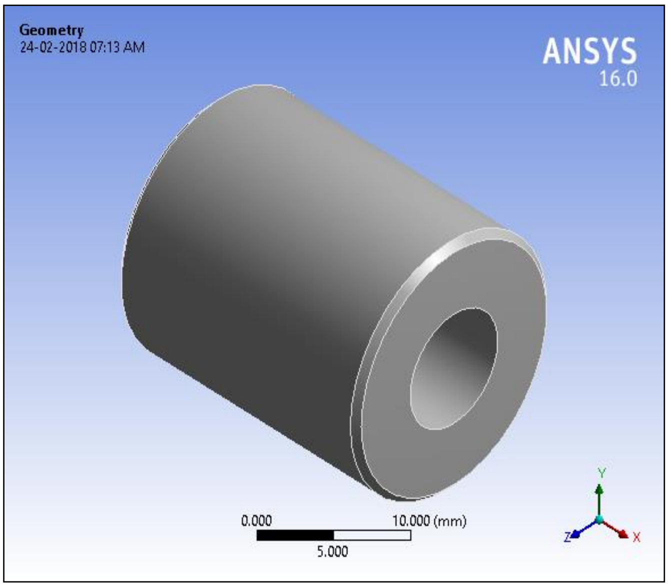

Fig 7 Rollers

V. TESTING METHDOLOGY

The experiment will be performed on EN24 material using a twin-roller burnishing tool mounted on a lathe, under the conditions outlined below.

- Variable pressure (p bar)
- Variation of cutting speed (v m/min)

- Variation of feed (f mm/rev)

In this experiment, a twin-roller burnishing tool is mounted on the lathe's tool post and connected to a hydraulic actuator system, allowing adjustable pressure to be applied on the rollers. Experimentation was carried out for different sets of pressure viz 50 bar, 40 bar, 30 bar and 20 bar. Also the values of Speed Feed combinations were changed for different pressure. The SPEED values are 750 m/min, 500 m/min, 350 m/min, 275 m/min and FEED values are 0.3 mm/rev., 0.25 mm/rev., 0.20 mm/rev., 0.15 mm/rev. respectively. Expected results to study –

- Theoretical and Ansys analysis of critical parts of the assembly
- Case hardness & Case depth after roller burnishing process.
- Surface finish after roller burnishing process.

➢ *Graphs*
- Surface finish Vs Speed, Feed and Pressure
- Case Depth Vs Speed, Feed and Pressure

Based on the experimental layout depicted , the experiments were performed in random order Three characteristics namely surface roughness (Ra), Case depth and Case hardness were measured. Ra has been expressed as a value which was observed from machine tool monitor screen. SR value (in µm) was measured in terms of mean absolute deviation (Ra) using the digital surface tester Mitutoyo Portable Surface Roughness Tester Surftest SJ-210. The Case hardness and Case depth were measured on a hardness testing machine.

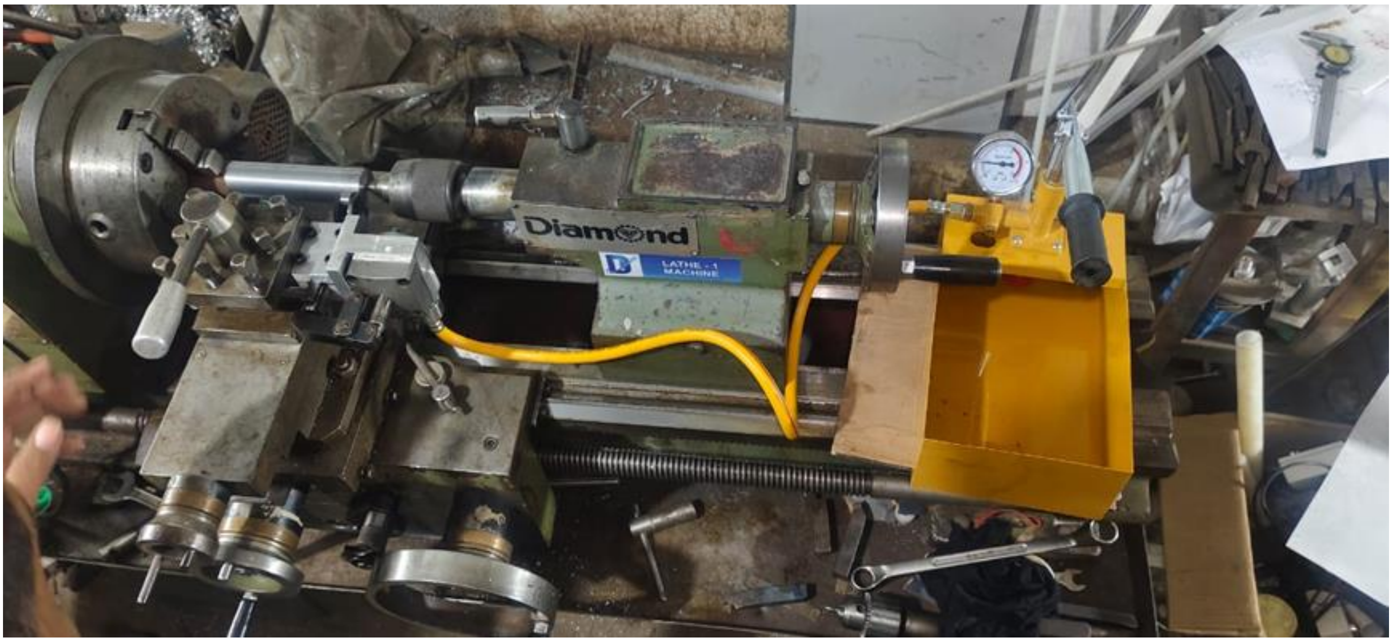

Fig 8 Experimental Setup

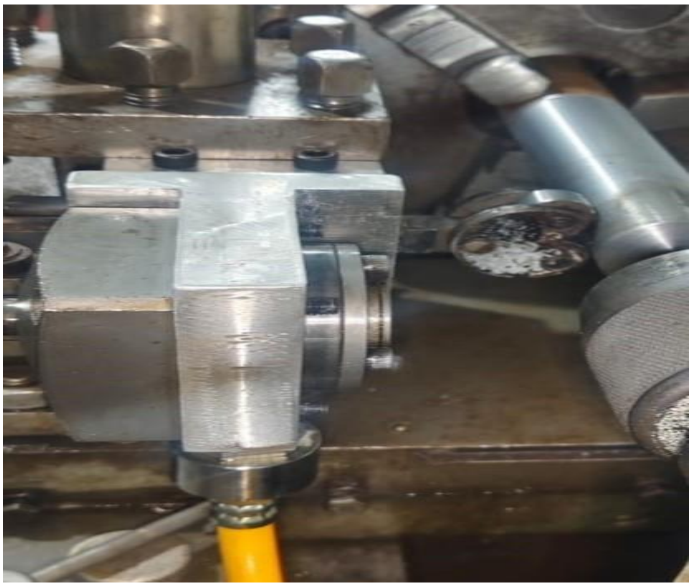
Fig 9 Tool setup

Table 1 Observations for Case Depth and Case Hardness at Maximum Pressure 50 Bar Condition

Sr No.	Speed	Feed	Case Depth	Case hardness HRC	Surface finish
1.	750	0.2	0.08	56	0.6
2.	500	0.2	0.06	54.3	0.54
3.	350	0.2	0.09	52.1	0.65
4.	275	0.2	0.10	50.9	0.68

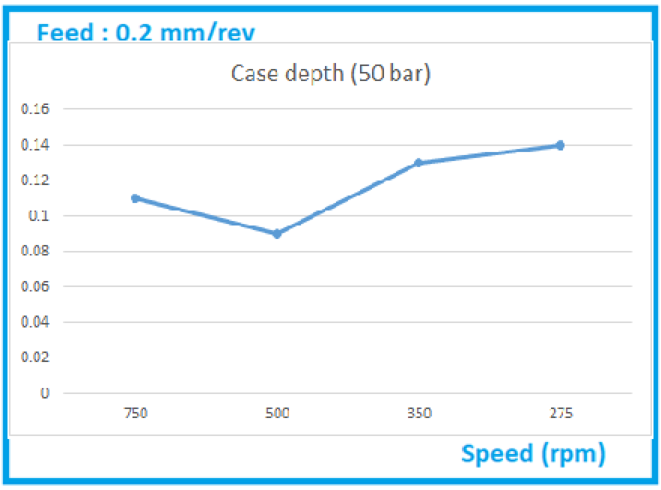

Fig 9 Graph of Case Depth VS Speed at 50 bar pressure

The graph Machine time Vs Speed for maximum feed and 50 bar pressure shows that maximum case depth is obtained at lower speed of 275

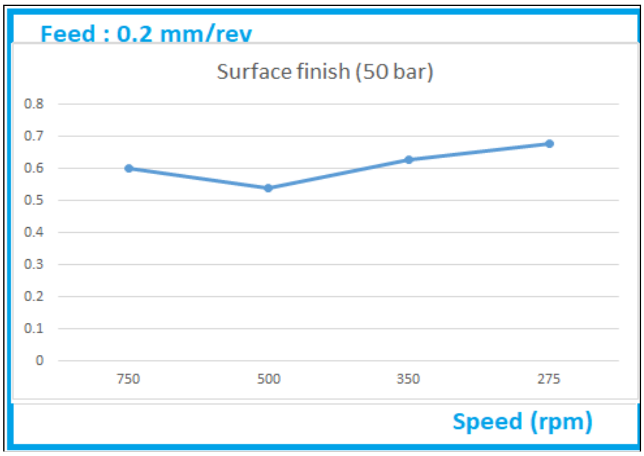

Fig 10 Graph of Surface Finish VS Speed at 50 bar pressure

VI. CONCLUSIONS OF EXPERIMENT

The Twin roller burnishing was designed and fabricated to apply the stand alone system.

The experiment was carried out by varying pressure.

The Surface finish is observed to improve with application of higher pressure and optimal speed was found to be 500 rpm

The graph of case depth Vs Speed for maximum feed and maximum pressure, it is observed that the speeds of 500 rpm are in the optimal range and the recommended speed for better case depth

The graph Case hardness Vs Speed for maximum feed and maximum pressure, it is observed that the speeds of 750rpm recommended speed for better case hardness

The Roller burnishing system shows better overall results and it is recommended for use in maximum pressure condition for 500 rpm.

Speed of 500 rpm for best results of Surface finish.

VII. ADVANTAGES

- Maximum pressure can be used.
- Lower power consumption
- Compact in size
- Low weight
- Low production cost
- Clean work place
- Very low maintenance cost
- Better surface finish
- Lesser machining time
- Better tolerances achieved.

VIII. APPLICATIONS

- Automobile industry
- Machine tool industry
- Lifting machinery and material handling equipment manufacture
- Earth moving equipment manufacture

IX. FUTURE SCOPE

- Pressure regulator can be developed for applicator
- Auto lubrication can be applied
- Higher pressures can be employed.

X. MARKET POTENTIAL & COMPETITIVE EDGE

- No such device is available in market which is so small an offers so high oil saving capacity.
- Compact size makes it useful in any machine where big tool system is not permitted
- Automobile industry can make full use of the technique to bring down the surface finish application overheads in machining.

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