Productivity Improvement in Hardness Testing Activity

V. Deshmukh[1] M. Gaikwad[2] A. Jadhav[3] K. Shitap[4] D. Gadsing[5]
[1,2,3,4]B.E Student [5]Professor
[1,2,3,4,5]Department of Mechanical Engineering
[1,2,3,4,5]Dr. D. Y. Patil Institute of Technology, Pimpri, Pune/Savitribai Phule Pune University, India

Abstract— Brinell hardness test is carried out to determine the hardness value of material. This test has been largely used for research development and quality control analysis due to its several applications. However, a problem associated with this technique is the influence of the human operator which consumes extra lead time. In order to reduce the lead time of hardness testing activity, this work proposes to design and development of automatic hardness testing system.

Key words: Hardness Testing Machine, Automation, Material handling equipment, Productivity improvement

I. INTRODUCTION

The project focuses on improving productivity of the hardness testing activity by process optimization and layout modifications [6]. The present system needs to be redesign by fully automated system. This mainly includes automatic material handling, firm clamping and automatic grinding operation.

II. CURRENT APPROACH

The hardness testing activity is mainly associated with the different passenger car crankshafts.

The activity mainly consists of following operations:

1) Manual grinding - Currently grinding operation is done manually, which is less accurate and consumes more time.
2) Manual loading and unloading - Currently Crankshaft is loaded manually with help of hoist.
3) Indentation and hardness evaluation - Crankshaft is held under the BHN machine and the indentation is taken. The corresponding hardness value is measured with the help of microscope and software.

Fig. 1: Indentation and hardness evaluation.

III. EXPERIMENTAL DATA

The dimensions of different crankshaft is measured from the engineering drawing and data is recorded in the table form as shown below,

Crankshaft Specifications.				
	Overall Length (mm).	Length On Plate (mm)	Overall Height (mm).	Weight (Kg).
Range	410-625	250-465	130-210	14-45

Table 1: Crankshaft specifications.

IV. WORKING

In automation the different stations will be arranged on the periphery of the circular indexing plate:

1) Loading and Unloading station.
2) Grinding station.
3) Indentation and Hardness Evaluation station.

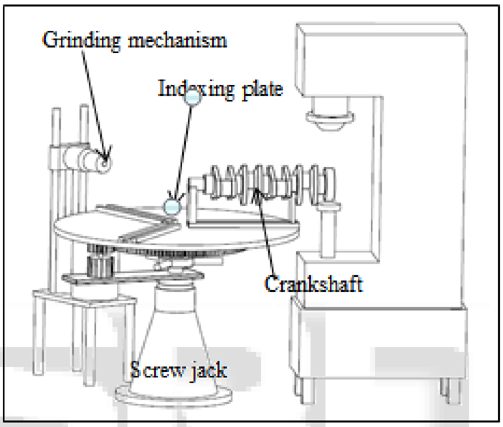

Fig. 2: Sequence of operations

The very first step is to set the screw jack height and V-block position as per the crankshaft size and the location of hardness checking. Then operator will start the Brinell hardness machine (auto cycle mode). Crankshafts from the forging shop will be loaded on the V-block. Then there will be first indexing (indexing plate will rotate by 120^{o}) and crankshaft will come under grinding machine [2]. Here with the help of pneumatic actuator grinding machine will perform grinding operation at required location. Then there will be second indexing, crankshaft will come under indenter (Brinell hardness machine) and indentation will be done [8]. Then there will be last indexing and crankshaft will come at beginning station, where operator will unload the crankshaft. Here operator's job is only to load-unload crankshaft.

V. MATERIAL SELECTION

1) The indexing plate and V-blocks are made of Mild Steel.
2) The frame of the screw jack has complex shape. It is subjected to compressive stress. Grey cast iron of grade - FG200 (Sut = 200 MPa) is selected as the material for the frame. [1]
3) The screw is subjected to torsional moment, compressive force and bending moment. From strength consideration, Plain carbon steel of grade - 30C8 (Syt = 400 Mpa and E = 207 GPa) is selected as material for the screw. [1]

4) The handle is subjected to bending moment. The yield strength is the criterion for the selection of material. Plain carbon steel of grade - 30C8 (Syt = 400 MPa) is selected as the material for the handle. [1]

VI. DESIGN CALCULATION

A. Indexing Plate,

Dia. of plate = 2×Length of Crankshaft on plate + Allowance.

= 2×465+120

= 1050 mm.

Thickness of Plate = 25mm + Depth of T-slots (20mm).

B. Screw Jack,

Total weight acting on screw jack, W =3924N

Maximum height to be lifted, H=300mm

1) Dimensions of screw,

Compressive stress in screw,

$$\sigma_{c\ per(screw)} = \frac{Syt(screw)}{fos} = \frac{420}{3}$$

$$\therefore \sigma_{c\ per(screw)} = 140\ N/mm$$

$$\sigma_{c\ per(screw)} = \frac{W}{\frac{\pi}{4}(dc)^2}$$

$$140 = \frac{3924}{\frac{\pi}{4}(dc)^2}$$

$$\therefore d_c = 5.97mm$$

Diameter of screw, d = 60mm

Pitch of thread, p = 9mm

Number of start, n = 1

Lead of screw, l= $n \times p$ = 9mm

Mean diameter of screw, $d_m = d - \frac{p}{2}$

$$= 60 - \frac{9}{2}$$

$$\therefore d_m = 55.5mm$$

Core diameter of screw, $d_c = d - p$

$$= 60 - 9$$

$$\therefore d_c = 51$$

Check screw body for stresses,

Force required to raise the load under thread friction, Pr = W× $\tan(\emptyset + \alpha)$

$$= 3924 \times \tan(10.2039 + 2.9549)$$

$$\therefore Pr = 917.3895N$$

Torque required against thread friction,

$$Tr = Pr \times \frac{dm}{2}$$

$$= 917.3895 \times \frac{55.5}{2}$$

$$\therefore Tr = 25457.5586\ N\text{-}mm$$

$$= 25.4575\ N\text{-}m$$

$$\sigma_{c\ (screw)} = \frac{W}{\frac{\pi}{4}(dc)^2}$$

$$= \frac{3924}{\frac{\pi}{4}(51)^2}$$

$$\therefore \sigma_{c\ (screw)} = 1.9208\ N/mm^2$$ [1]

2) Dimensions of handle,

Bending Moment of Screw Handle

Mb = F × (H+70 mm) = 400 × (300+70)

$\therefore$ Mb = 148000 N-mm

$\therefore$ Mb = 148 N-m

$$Zxx = \frac{Ixx}{y} = \frac{\pi}{32}(dc)^3$$

$$= \frac{\pi}{32}(51)^3$$

$$= 13022.98\ mm^3$$

$$\sigma_{b\ (screw)} = \frac{Mb}{Zxx} = \frac{148\times10^3}{13022.98}$$

$$\therefore \sigma_{b(screw)} = 11.36N/mm$$

$$\tau_{(screw)} = \frac{Ttr}{\frac{\pi}{16}(dc)^3} = \frac{25.4575\times10^3}{\frac{\pi}{16}(51)^3}$$

$$\therefore \tau_{(screw)} = 0.9774\ N/mm^2 \qquad (1)$$

$$\sigma_{max\ (screw)} = \sigma_{c\ (screw)} + \sigma_{b\ (screw)} = 1.9208 + 11.36$$

$$\therefore \sigma_{max\ (screw)} = 13.2808\ N/mm^2 \qquad (2)$$

According to maximum shear stress theory,

$$\tau_{max(screw)} = \sqrt{\left(\frac{\sigma\ max(screw)}{2}\right)^2 + \tau(screw)^2}$$

From equation (1) and (2)

$$= \sqrt{\left(\frac{13.2808}{2}\right)^2 + (0.9774)^2}$$

$$\therefore \tau_{max\ (screw)} = 6.7119\ N/mm^2 \qquad (3)$$

$$\tau_{per\ (screw)} = \frac{0.5\ syt(screw)}{f.o.s.}$$

$$= \frac{0.5 \times 420}{3}$$

$$\therefore \tau_{per\ (screw)} = 70\ N/mm^2 \qquad (4)$$

$$\therefore \tau_{max\ (screw)} < \tau_{per\ (screw)}$$

From equation (3) and (4)

$\therefore$ Design of Screw is safe. [1]

VII. ANALYSIS OF INDEXING PLATE

The analysis for stress and deflection of Indexing plate can be done by finite element analysis (HyperMesh).

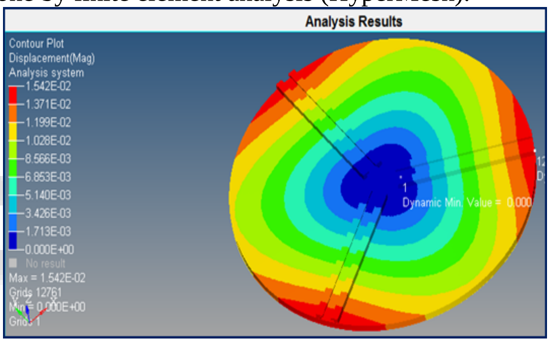

Fig. 3: Elemental displacement

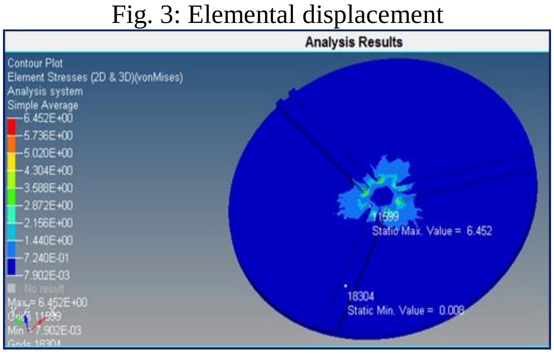

Fig. 4: Elemental stress

Summary of analysis,

1) Elemental displacement = 0.01542 mm.
2) Elemental stress = 6.452 MPa.

VIII. CONCLUSION

This paper studies design and analysis of automatic material handling system for hardness testing of passenger car crankshaft. Automation results in minimum lead time and manpower required. Hence productivity can be improved by implementing above system. Furthermore above system can be used for horizontal deployment on other hardness testing areas.

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