A COMPARATIVE STUDY ON TRADITIONAL AND COMPUTERIZED METHOD OF BRINELL HARDNESS MEASUREMENT

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ABSTRACT

Technology transfer is not only a simple way of trading technology, but it can also be a useful information source. The purpose of conducting this comparative study is to identify the drawbacks and flaws in traditional Brinell hardness measurement system and compare the traditional hardness measurement with computerized Brinell hardness measurement system. Today in this modern world there are many advanced machines are available. Though the initial costs of those modern machines are high but there are lot of benefits on those modern machines. Thus this study reveals how the computerized Brinell hardness measurement is most efficient and reliable over traditional method of Brinell hardness measurement.

1. INTRODUCTION:

1.1 PROBLEM IDENTIFIED

The following are some of the drawbacks in traditional hardness measurement system

Reading man to man variation

- Error in the readings
- Accuracy not obtain
- Skilled labour required
- Labors affected by eye defect due to continuous measuring through microscope
- Prolonged measurement causes irritation to the labour.
- Customers satisfaction is affected
- Reading man to man variation

In this company hardness of a job is tested by Brinell hardness testing method. In this method an indentation is made on the job. That indentation is measured by the worker through a microscope. In this measurement the reading may differ from worker to worker due to their visibility level. This is an important problem found by us.

Error in the readings:

Due to the visibility problem the measuring values are incorrect. Such reading lead to error in hardness number calculation.

Accuracy not obtain:

These error readings give the incorrect Brinell Hardness number. So accuracy is greatly affected.

Skilled labour required:

To achieve the greater accuracy in measurement, skilled labour is needed.

Labours affected by eye defect due to continuous measuring through microscope:

During measuring the workers feel irritation in their eyes by the continuous concentrated focus. This leads eye defect to the workers. Prolonged measurement causes irritation to the labour. The prolonged measurement makes the worker feel fatigue physically and mentally.

More time required:

Entire inspection process consumes more time due to manual measurement.

For skilled labour, the company has to pay more:

Higher payment is offered to skilled labour which result the inspection cost more.

Due to the wrong measurement, the product might be rejected it causes to material wastage:

If the measured reading is not within the range of customer specification, then the product is rejected. So the wrong measurement increases the scrap loss.

Customers satisfaction is affected:

When the requirement of the customer is not fulfilled by the manufacturer, the company loses its credit, thereby damaging the reputation of the company.

1.2 OBJECTIVES OF THE STUDY:
PRIMARY OBJECTIVE:

- The primary objective of this research is to compare the performance of computerized hardness measurement over traditional method.

SECONDARY OBJECTIVES:
- To determine the Reliability of the successive readings and their corresponding BHN values for a same component.
- To determine the Return on Investment, Economic efficiency of the instrumen
- To determine the Replacement period (Economic life of the instrument)
- To identify the Time saving in hardness measurement and man power utilization also
- To compare the accuracy of computerized Brinell hardness measurement system over traditional Brinell hardness measurement system

1.3 EXPECTED DELIVERABLE:
The study will result in the following expected deliverables

- To determine how the computerized method is most efficient and reliable, cost effective.
- To determine the accuracy and speed of measuring.
- To reduce the human effort in hardness measurement.

LITERATURE SURVEY

2.1 HARDNESS MEASUREMENT
The hardness test is widely employed in materials research and quality control, because it is a less onerous and faster method to obtain some material mechanical properties. However, the results of the hardness measurements are subjected to the uncertainty of various parameters of the test method like test load applied, indenter, time of load application, device for indentation measurement and the operator's skill. Therefore, it is important to minimize the uncertainty relating to each parameter in the test method that can influence the final measurement, in order to assure the reliability of the resulting hardness value. Nowadays, the industry uses several methods for determination of the hardness indentation mark, and the selection of the indentation measurement method varies according to the size, the automation level of the industry and also the purpose of the test. The image analysis technique is a very useful tool in the measurement of hardness indentation, since its application allows the measurement of indentation characteristics that would be impossible with the employment of conventional techniques.

Hardness which is a measure of a material's resistance to localized plastic deformation (e.g., a small dent or a stretch).
The various hardness testing methods are as described below.

2.2 TYPES OF HARDNESS TESTING METHODS:
1. Vickers hardness test.
2. Rockwell hardness test.
3. Brinell hardness test.

Scales and values:

There are several alternative scales the most commonly used being the "B" and "C" scales. Both express hardness as an arbitrary dimensionless number.

Various Rockwell scale

Scale	**Abbreviation**	**Load (kgf)**	**Indenter**	**Use**
A	HRA	60	120° diamond cone†	Tungsten carbide
B	HRB	100	1/16 in diameter steel sphere	Aluminium, brass, and soft steels
C	HRC	150	120° diamond cone	Harder steels

Table no 1 Various Rockwell scale

AUTOMATION METHOD:
System Design and Specifications:
Accessories:
1. Optical tube with CCD Camera
2. Video capture card with driver
3. Brinsys software package
4. Interface box
5. Minimum configured PC

Hardware Specifications:

- Scan head dimensions of 1.9" (48mm) diameter x 5.2" (132mm) tall with 1" footprint
- Resolution 0.01mm (standard lens #1)
- Accuracy ± 0.5%
- Video viewing system with solid state electronic camera
- Optional desktop, laptop or tablet PC – Windows® based operating system.

Software Specifications:

- Operating System: Windows 2000, XP, and Vista
- Fully automatic Image analysis software
- Readout given in Brinell hardness and diameter of measurement.
- Unlimited number of files for storing test results including image of the indentation and descriptive information.
- Each measurement is stored with its image which allows for re-evaluation of results
- Data sets can be freely selected and exported to Excel and other software for further analysis
- User friendly and fast calibration function
- Measures Brinell indentations for the following load range 3000kgf, 1500kgf, 1000kgf, 750kgf, 500kgf, 250kgf, 187.5kgf, 100kgf and 62.5kgf
- Measures Brinell indentations with the following indenter diameter: 10mm, 5mm and 2.5 mm

The following process flow chart represents the way doing brinell hardness test in computerized method**.**

Threshold selects ranges of pixel value in gray scale images. And the threshold values are automatically changed. According to the image, the thresh hold values are automatically changed.

Circle detection:

Circle detection which finds the center and radius of the circular particles in an image.

Spread sheet:

It doesn't have to be displayed as an image. It could just as well be displayed as a spreadsheet with groups of numbers in each cell representing the number of electrons produced at each pixel**.**

Path file:

In this sequence of operation we must to give the location where the file to be executed. And also the path is to be specified for complete execution of the program without error.

BHN Value:

Finally, Brinell hardness number is internally calculated by the ratio between the load applied and area of impression. Both the diameter and BHN value s displayed and stored in report.

BRINELL SOFTWARE FEATURES:

The brinell utility software is designed for measuring the ball impression diameter on the specimen for the brinell principle. Normally we use a brinell microscope to measure the impression diameter manually. To achieve more accuracy, and to avoid a human error-opinion difference, a CCD camera is placed on the microscope.

The magnification value is increased for gaining more accuracy. With the 20 x microscopes, we have a least count of 10 microns. So the measured value will have an accuracy of +/- 10 microns. The measurement of diameter by microscope is a conventional. There is no doubt about its reliability.

The use of CCD camera with microscope is just somewhat an adoption of higher technology. More over the oviality or deformation of the impression diameter can be taken into account. 'n' numbers of the readings can be taken on the same image.

1. It is possible to measure the diameter of a cord of the circle. Such measurement is not possible by any other means.
2. There is a provision to delete the maximum and the minimum measurement from 'n' numbers of the readings taken for the same image. It is presumed that for 'n' numbers of measurements, the max. and the minimum- measurement may be an error. (It may not be also.) By working with this logic, the error while taking measurement of an image is to eliminated.

To measure the diameter of an impression.

Bring the image on to the computer screen. Select the diametrical points on the circumference of the image (circle) in case of manual mode or Click inside the impression circle in semi-auto mode or Just press the button provided on the camera in auto mode. The readings are automatically saved in the predefined file location.

The software is unique programmed. It is user friendly.

The logic applied is to measure the diameter (ball impression) is deriving the area from the pixel occupied by the circle. An image is brought on the computer screen with the help of combination of a CCD camera. Then with the software application the diameter of the image is measured. Then selecting the weight applied and indenter ball diameter work out the BHN value. Following

options are available from the software Open project- to start with a particular project or a party name can be listed in this. Add to the project- the measurements of diameter i.e. Corresponding BHN value will be listed out to a particular project.
Q.C report- the quality control report can be generated from the software.
Q.C. Charts- Q.C charts also can be seen from the software.

Any brinell application is possible for measurement of ball impression diameter and BHN value can be known.

The weights ranging from 15.625, 31.25, 62.5, 125, 187.5, 250, 500, 750, 1000, and 3000 or any BHN weight.

THE SOFTWARE INCLUDES

1) Facility for Auto / semi Auto / Manual modes of operation.
2) Well managed database saves readings w.r.t., batch and certificate.
3) Report generation in the form of certificate and graph as per customer requirements.
4) Facility for calibration and check of calibration.

RESEARCH METHODOLOGY

3.1 Types of Research design:

The research design used in this study is Analytical type of research design. The Researcher used Analytical type of research design to analyze the existing data collected by conducting experiments on both Traditional & Computerized Brinell hardness method.

3.2 Source of data:

Secondary data was used for the study. Secondary data was collected from Quality & Inspection departments.

3.3 Determination of Sample and Sample size:

Different samples are taken from different lots and their hardness numbers are determined using microscope in traditional method of hardness measurement and also by using computerized Brinell hardness measurement system.

The below table represents the sample of Data collected for inspection of the components to find out the brinell hardness number of the component in traditional as well as in computerized brinell method.

No. of samples = 10 components

S.NO	NAME OF THE COMPONENT	LOT SIZE	SAMPLE SIZE PER HOUR
1	Pad back plate	1 lot = 800 qty	10 pcs
2	Copper shell	1 lot = 500 qty	20 pcs
3	Locating bracket	1 lot = 1000 qty	20 pcs
4	Floor support	1 lot = 600 qty	20 pcs
5	Sill plate	1 lot = 1000 qty	20 pcs
6	Side profile	1 lot = 1000 qty	10 pcs
7	Guide pillar	1 lot = 400 qty	20 pcs
8	Top bolster	1 lot = 300 qty	10 pcs
9	Die plate	1 lot = 600 qty	20 pcs
10	Front wall plate	1 lot = 800 qty	20 pcs

Table no 2 Determination of sample and sample size

DATA ANALYSIS AND INTERPRETATION

4.1 Determination of BHN using microscope in traditional Brinell hardness method & using CCD camera in computerized Brinell hardness method for different samples

4.1.1 COPPER SHELL:

Standard Value – 578 BHN

S.NO	BHN VALUE IN TRADITIONAL METHOD	BHN VALUE IN COMPUTERIZED METHOD
1	572	578
2	540	576
3	489	577
4	552	578
5	560	578
6	510	579
7	490	578
8	570	577
9	490	578
10	581	579

Table no. 3 Measured BHN values in Traditional & Computerized methods for copper shell

Inference: From table 4.1.1 it is found that there is difference in standard value of Brinell hardness number for copper shell and measured value of Brinell hardness number in traditional and computerized method, the variation is found to be more in traditional method compared to computerized method.

4.1.2 PAD BACK PLATE:

Standard Value – 293 BHN

S.NO	BHN VALUE IN TRADITIONAL METHOD	BHN VALUE IN COMPUTERIZED METHOD
1	292	293
2	252	292
3	280	291
4	210	293
5	287	292
6	224	294
7	308	293
8	292	292
9	287	293
10	256	293

Table no. 4. Measured BHN values in Traditional & Computerized methods for Pad back plate

Inference: From table 4.1.2 it is found that there is difference in standard value of Brinell hardness number for Pad back plate and measured value of Brinell hardness number in traditional and computerized method, the variation is found to be more in traditional method compared to computerized method

4.1.3 LOCATING BRACKET:

Standard Value – 778 BHN

S.NO	BHN VALUE IN TRADITIONAL METHOD	BHN VALUE IN COMPUTERIZED METHOD
1	792	778
2	740	778
3	731	779
4	690	778
5	782	778
6	790	778
7	778	778
8	785	779
9	778	778
10	782	778

Table no. 5 Measured BHN values in Traditional & Computerized methods for Locating bracket

Inference: From table 4.1.3 it is found that there is difference in standard value of Brinell hardness number for Locating bracket and measured value of Brinell hardness number in traditional and computerized method, the variation is found to be more in traditional method compared to computerized method

4.1.4 FLOOR SUPPORT:

Standard Value – 311 BHN

S.NO	BHN VALUE IN TRADITIONAL METHOD	BHN VALUE IN COMPUTERIZED METHOD
1	308	310
2	310	311
3	292	310
4	298	310
5	325	310
6	307	311
7	283	312
8	379	310
9	236	311
10	357	310

Table no. 6 Measured BHN values in Traditional & Computerized methods for Floor support

Inference: From table 4.1.4 it is found that there is difference in standard value of Brinell hardness number for floor support and measured value of Brinell hardness number in traditional and computerized method, the variation is found to be more in traditional method compared to computerized method.

4.1.10 FRONT WALL PLATE:

Standard Value – 765 BHN

S.NO	BHN VALUE IN TRADITIONAL METHOD	BHN VALUE IN COMPUTERIZED METHOD
1	770	765
2	690	765
3	765	766
4	680	765
5	740	765
6	825	764
7	752	765
8	750	767
9	762	765
10	710	766

4.2 Z TEST FOR TWO DIFFERENT SAMPLES FROM THE SAME LOT:

Hypothesis: To test there exist any significant difference between accuracy of BHN tested values in traditional and computerized method of hardness measurement.

H_0: There is no difference in accuracy of BHN values between Traditional and computerized method.

$H_{0:}\ \mu_1 = \mu_2$

H_1: There is difference in accuracy of BHN values between Traditional and computerized method.

H_1: $\mu_1 \neq \mu_2$

COMPONENT 3 – LOCATING BRACKET

μ =778

S.No	Traditional Method			Computerized Method		
	X_i	X_i-X	$(X_i-X)^2$	X_i	X_i-X	$(X_i-X)^2$
1	792	4	16	778	0	0
2	740	-38	1444	778	0	0
3	731	-47	2209	779	1	2
4	690	-88	7744	778	0	0
5	782	-6	36	778	0	0
6	792	4	16	778	0	0
7	740	-38	1444	778	0	0
8	731	-47	2209	779	1	2
9	690	-88	7744	778	0	0
10	782	-6	36	778	0	0

Table no. 7 Z test for Locating bracket BHN Values in traditional and computerized method

$\sum(X_i-X)^2$ = 30886 (Traditional)

$\sum(X_i-X)^2$ = 8 (Computerized)

Std.Deviation = √ 11449/4

Std.Deviation = √ 2/4

= 53.5

= 0. 70

Variant = 936.25

Variant = 0.5

$$Z_{cal}=\bar{X}_1-\bar{X}_2 / \sqrt{((\sigma_{s1}^2/n1+\sigma_{s2}^2/n2))}$$

= 747-778 / √ ((936.25/10 + 0.5/10))

= -3.2

Z_{tab} =1.65

RESULT: Since Z calculated value is greater than Z table value. Null hypothesis is rejected and alternative hypothesis is accepted. There is difference in accuracy of BHN values between Traditional and computerized method. The accuracy of BHN values is higher in computerized method than traditional method.

$\mu_1 \neq \mu_2$. H_1 is accepted.

COMPONENT 4 – SILL PLATE

μ =745

S.No	Traditional Method			Computerized Method		
	X_i	X_i-X	$(X_i-X)^2$	X_i	X_i-X	$(X_i-X)^2$
1	690	-55	3025	745	0	0
2	745	0	0	744	-1	1
3	724	-23	529	745	0	0
4	745	0	0	745	0	0
5	758	13	169	745	0	0
6	690	-55	3025	745	0	0
7	745	0	0	744	-1	1
8	724	-23	529	745	0	0
9	745	0	0	745	0	0
10	758	13	169	745	0	0

Table no. 8 Z test for Sill plate BHN Values in traditional and computerized method

$\sum(X_i-X)^2$ = 30886 (Traditional)

$\sum(X_i-X)^2$ = 8 (Computerized)

Std.Deviation = √3723/4

Std.Deviation = √ 1/4

= 30.5

= 0.5

Variant = 930.5

Variant = 0.25

$$Z_{cal}=\bar{X}_1-\bar{X}_2 / \sqrt{((\sigma_{s1}^2/n1+\sigma_{s2}^2/n2))}$$

= 732.4-744.8 / √ ((930.5/10 + 0.25/10))

= -1.92

Z_{tab} =1.65

RESULT: Since Z calculated value is greater than Z table value. Null hypothesis is rejected and alternative hypothesis is accepted. There is difference in accuracy of BHN values between Traditional and computerized method. The accuracy of BHN values is higher in computerized method than traditional method.

$\mu_1 \neq \mu_2$. H_1 is accepted.

4.3 To find out the Correlation between BHN values of Traditional and Computerized brinell hardness measurement

Component - 1

	X	Y	XY	X^2	Y^2
1	572	578	330616	327184	334084
2	540	576	311040	291600	331776
3	489	577	282153	239121	332929
4	552	578	319056	304704	334084
5	560	578	323680	313600	334084
6	510	579	295290	260100	335241
7	490	578	283220	240100	334084
8	570	577	328890	324900	332929
9	490	578	283220	240100	334084
10	581	579	336399	337561	335241

Table no9 Correlation between BHN values for component 1

$\sum XY = 3093564$

$\sum X^2 = 2878970$

$\sum Y^2 = 3338536$

$r = \sum XY / \sqrt{(\sum X^2 * \sum Y^2)}$

$= 0.99$

Result: So, there will be high positive correlation between Traditional and Computerized method of Brinell hardness for Component 1

Component – 2

	X	Y	XY	X2	Y2
1	292	293	85556	85264	85849
2	252	292	73584	63504	85264
3	280	291	81480	78400	84681
4	210	293	61530	44100	85849
5	287	292	83804	82369	85264
6	224	294	65856	50176	86436
7	308	293	90244	94864	85849
8	292	292	85264	85264	85264
9	287	293	84091	82369	85849

Table no.10 Correlation between BHN values for component 2

$\sum XY = 786417$

$\sum X^2 = 731846$

$\sum Y^2 = 856154$

$r = \sum XY / \sqrt{(\sum X^2 * \sum Y^2)}$

$= 0.99$

Result: So, there will be high positive correlation between Traditional and Computerized method of Brinell hardness for Component 2

4.4 COST JUSTIFICATION AND ECONOMIC ANALYSIS

MANUAL METHOD:

Fixed Cost
=Rs.3000

Wages paid to labour / day = (7000+6000+6000) / 26

= Rs. 730

Unit inspected / day
= 500

Inspection cost per component = 730/500

= Rs. 1.46

AUTOMATION METHOD:

Fixed cost:

Cost of CCD Camera = Rs. 75,000

Video Card with interface box= Rs. 5,000

Cost of PC
= Rs. 20,000

Brinsys Software Package = Rs. 25,000

Total Fixed Cost= Rs. 1, 25,000

Variable cost:

Wages paid to labour / day= (7000+6000) / 2

= Rs. 500

Power consumed / day= 120W * 24

= 2.88 Kw-Hr

Cost of Power consumed / day= 2.88* Rs.5

= Rs. 15

Total Variable cost
= Rs. 515

Unit inspected / day
= 1000

Inspection cost per component= 515/1000

= Rs. 0.515

4.4.1 ECONOMIC EFFICIENCY:
Economic Efficiency (%)= (Cost saved / Expenses)*100

= (1.46 – 0.515) / 0.515

= 0.945 / 0.515 *100

= 183%

4.4.2 PROJECT JUSTIFICATION:
EXPENSE COST:
Present worth of annual Maintenance cost:
A1= Rs. 10000 n= 7 years
G = Rs. 5000 i= 12%
Annual Equivalent maintenance cost
A = A1 + G (A/G, 12%, 7)

= 10,000 + 5,000 (2.5515)

A = 22,757.50 /-
Present worth of annual maintenance cost
= 22,757.50 (P/A, 12%, 7)

= 22,757.50 (4.5638)

= Rs. 1, 03,860.67 /-
Present worth of annual operating cost
= 1, 60,680 (P/A, 12%, 7)
(0.515*1000*26*12= 1, 60,680)
= 1, 60,680 (4.5638)

= Rs. 7, 33,311.38 /-
Total present worth cost= Initial cost + Present worth of annual Operating and maintenance cost
= 1, 25,000 + 1, 03,860.67 + 7,33,311.38
C_p= Rs. 9, 62,172.05 /-
BENEFIT COST:
Total present worth of inspection cost savings: (B_P) Cost Savings
= [(1.46-0.515)*1000*26*12]

= Rs. 2, 94,840 /-

= 2, 94,840 (P/A, 12%, 7)

= 2, 94,840 (4.5638)

= Rs. 13, 45,590.80 /-

4.4.3 BENEFIT COST RATIO:
Benefit Cost Ratio =
Benefit cost/Expense cost = {B_P / (P+C_P)}
= 13, 45,590.80 / 9, 62,172.05
= 1.398

Since, Benefit Cost Ratio is more than 1, the project financially profitable and can be implemented.

4.4.4 RELIABILITY ANALYSIS:

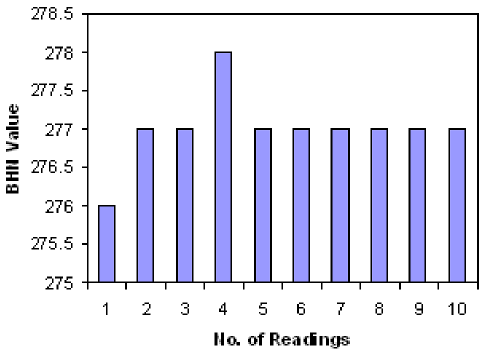

Fig 1 Successive Reading attempt and their corresponding BHN Values for a same component in Computerized Method of Brinell hardness measurement

SUMMARY
5.1 Findings:

- In all components Z calculated value is greater than Z table value. Null hypothesis is rejected and alternative hypothesis is accepted. There is difference in accuracy of BHN values between Traditional and computerized method. The accuracy of BHN values is higher in computerized method than traditional method.
- In Computerized method the Inspection per component is low when compared to traditional method of Brinell hardness measurement.
- BHN value is more reliable in computerized method when compared to traditional method of Brinell hardness measurement.
- Benefit Cost Ratio is more than 1, the project financially profitable and can be implemented.
- Economic efficiency of computerized Brinell hardness measurement method is more.

5.2 SUGGESTIONS:

In traditional Brinell hardness measurement some of the problems has found out like,

- Error in the readings
- Accuracy not obtain
- Skilled labor required
- Labors affected by eye defect due to continuous measuring through microscope
- Prolonged measurement causes irritation to the labor.
- Customers satisfaction is affected
- Reading man to man variation

These problems are eliminated in computerized method of Brinell hardness measurement. Hence, computerized method is suggested for the better output of Brinell hardness measurement.

5.3 CONCLUSION

In the existing Brinell hardness tester the indentation created is measured by microscope manually, which is a tedious and time consuming process. In this project, manual method is eliminated.

In this method indentation is captured by CCD camera and dedicated BRINSYS software installed in pc to analyze and measure the image taken from the camera which is also connected to pc.

This method of measurement is appreciated by the industry (KONE Elevators India Pvt Ltd.) because of its accuracy and speed of measuring. It also reduces human effort.

The usage of pc makes this system to be remote from the workplace. The future scope of the project is to implement our system in the workplace.

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