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Hardnessand Elemental Test Analysis Of 5 Tonne Hydraulic Jack

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ABSTRACT: *The research submitted presents detailed hardness and elemental test analysisfor production of 5tonne hydraulic jack. The main task is to perform hardness and elemental test for the specimen of the selected material needed in constructing the jack, the jack was purchased at the market and dismantled in order to study the parts and produce a prototype with the available local materials. The test was carried out using Rockwell hardness test scale for each and every part involves in production of the jack. Procedures of carrying out the testand results are hereby presented in this report.*

KEYWORDS: *Rockwell mechanical test and hardness test, Hydraulics*

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I. INTRODUCTION

The study of hydraulic deals with the use and characteristics of the liquid, earlier recorded history shows that devices such as pumps and water wheels were known in very ancient times [17]. It was not, however until 17th century that the branch of hydraulics with which we are to be concerned first came in use.Hydraulics now could be defined as a means of transmitting power by pushing on a confined liquid, the input component of the system is called pump while the output is called an actuator [16]. Hydraulic jack is a device that lifts an object from one point to the other by the use of hydraulic system [15].

II. SIGNIFICANCE OF WORK

The significance of this work is to perform elemental and hardness analysis and performance evaluation test of selected components that could be used in producing the jack which would go a long way in producing 5 tonne hydraulic jack for the increase in output of locally fabricated equipment, decrease in price of these equipment and jobs creation for our numerous unemployed graduates, which at the end will generally improve the economy of the country.

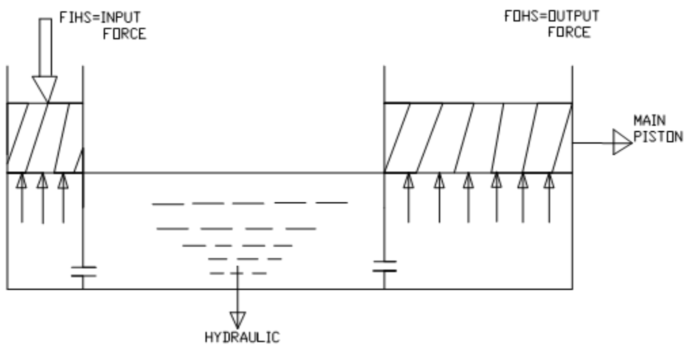

Figure 1: Schematic diagram of 5 tonne hydraulic jack

III. MECHANICAL (HARDNESS TEST)

Hardness test was performed on the samples of the material used to produce the model and the prototypes. Hardness is a measure of a material's resistance to localized plastic deformation, e.g. a small dent or scratch [10]. The Rockwell tests constitute the most common method used to measure hardness because it is easy to perform and require no special skills [6]. The resistance of material to penetration by a pointed tool is called hardness. Hardness largely determines the resistance to scratching, wear, penetration, machinability and the ability to cut.

Hardness is a commonly used property; it gives a general indication of the strength of the material. More specifically, hardness is usually defined as resistance to permanent indentation [9]. Hardness is not, however, a fundamental property, because the resistance to indentation depends on the shape of the indenter and on the load applied. Surface preparation is very important for Rockwell test, because of the small sizes of the indentations and allows correct measurement of the impression's dimensions. For a hardness test to be meaningful and reliable, the zone of deformation under the indenter is allowed to develop freely. In this report all measures have been taken to make the test and to ensure that the selected parts are fully tested for effective performance of the jack.

3.1 ROCKWELL HARDNESS SCALE

There are several alternative scales, the most commonly used being the "B", and "C" scales. Both express hardness as an arbitrary dimensionless number[7] . The B-scale is used for softer materials (such as aluminum, brass, and softer steels). It employs a hardened steel ball as the indenter and a 100 kg weight to obtain a value expressed as "HRB". The C-scale, for harder materials (cast iron and hardened steels), uses a diamondcone known as Brale indenter and a 160-kg weight to obtain values expressed as "HRC" [1].

3.1.1. AIM:To determine the strength and machinability of the samples of the materials selected.

3.1.2 EQUIPMENT USED:BS 6407 Rockwell hardness testing machine "C" Scale.

3.1.3 PROCEDURE: The specimens selected for the test were materials used to produce components of the model obtained from the market which include Specimens; A1- Minor Piston, B1- Minor Cylinder, C1-Base, D1-Main Cylinder, E1-Adjustable Carriage and FI- Main Piston. The other specimens were the materials adapted to develop the components of the prototype of the jack which include Specimens; A2- Minor Piston, B2- Minor Cylinder, C2-Base, D2- Main Cylinder, E2-Adjustable Carriage and F2- Main Piston.
In this report the depth of penetration of Rockwell test was measured by the instrument, and this was shown directly on a dial as a hardness value. No subsequent measurement of the indentation was involved.The tester has a base plate where the part is located, directly below the indenter (diamond). It also has a spooked wheel, designed to raise and to lower the base plate, and a ridged wheel, to zero the scale on the display. Other important parts are the trigger (a flat area pushed to start the test) and a lever in the front position to supply the load.
First, the specimen was put on the base plate. Slowly the spooked wheel was turned until specimen was in contact with the indenter supplied with a load of 160 Kg. On the display, there was a short indicator with a dot at the 12 o'clock position. The turning of the spooked wheel was continued until the indicator pointed to the dot. When the short indicator pointed to the dot, the ridged wheel was turned until the long indicator pointed to the zero on the scale. The trigger was pressed. After waiting for about 30 seconds, the lever moved backwards slowly as the indenter lowered. After the time was up, the lever was flipped to the front and the reading (measurement) was taken from the position of the long indicator. The test was performed on C scale. The procedure was repeated for all the specimens.

3.1.4RESULTS: -The hardness values obtained from the tests conducted on the 6
Specimens of the materials of the components of the model obtained from the market
(A1, B1, C1, D1, E1and F1), 6 specimens of materials of the components of the
Prototype produced (A2, B2, C2, D2, E2, and F2) and the hardness values of the materials with closer chemical
Properties obtained from engineering materials tables respectively are presented in the table 1, 2, 3 and 4 below.

3.2HARDNESS TEST RESULTS PRESENTATION

3.2.1 HARDNESS TEST RESULTS (ROCKWELL "C" SCALE)

Table 1: Average Hardness Values of Specimens of the Materials Used to Manufacture the Model Jack Obtained from the Market in HRC

SPECIMEN	1	2	3	AVERAGE
A1	27.00	27.50	27.50	27.33

B1	23.50	23.50	23.50	23.50
C1	39.00	39.00	39.50	39.20
D1	29.50	30.00	29.50	29.67
E1	31.00	31.50	31.50	31.33
F1	30.50	30.00	30.50	30.33

Table 2: Average Hardness Values of Specimens of the Materials Used to Develop the Prototype in HRC

SPECIMEN	**1**	**2**	**3**	**AVERAGE**
A2	20.50	20.50	20.50	20.50
B2	27.00	27.00	27.00	27.00
C2	34.50	32.50	33.50	33.50
D2	31.50	31.50	31.50	31.50
E2	28.00	28.00	28.00	28.00
F2	26.50	26.00	26.50	26.33

Table 3: Hardness Values (HRC) of Materials of Model Jack Obtained from the Market and Closer Chemical Properties as Obtained from Engineering Materials Table (Callister, 2003 and PIM International, 2009)

SPECIMEN	**TESTED HARDNESS VALUES**	**CLOSER HARDNESS VALUES OBTAINED FROM TABLE**
A1	27.33	23.00
B1	23.50	23.00
C1	39.20	26.90
D1	29.67	18.60
E1	31.33	26.80
F1	30.33	25.00

Table 4: Hardness Values of the Materials of the Prototype and Closer Chemical Properties as Obtained from Engineering Materials Table (Callister 2003 and PIM International, 2009)

SPECIMEN	**TESTED HARDNESS VALUES**	**CLOSER HARDNESS VALUES OBTAINED FROM TABLE**
A2	20.50	19.40
B2	27.00	23.00
C2	33.50	18.70
D2	31.50	25.50
E2	28.00	23.00
F2	26.33	28.00

Note: The minimum hardness values recommended in the texts were adapted for the analysis.

3.3.1Discussion of Hardness Test Results

The values obtained from the Hardness test results for the materials used to produce the components of the model obtained from the market is compared favorably to the materials adapted to develop the components of the prototype. The results also compared well to the values of materials with closer chemical properties in Engineering Materials Tables (Callister, 2003 and PIM International, 2009). This therefore indicates that the materials selected for the development of the components of the Hydraulic Jack is appropriate for its production because the hardness values is higher than the least specifications recommended. The results are shown in Figures 1 and 2 below.

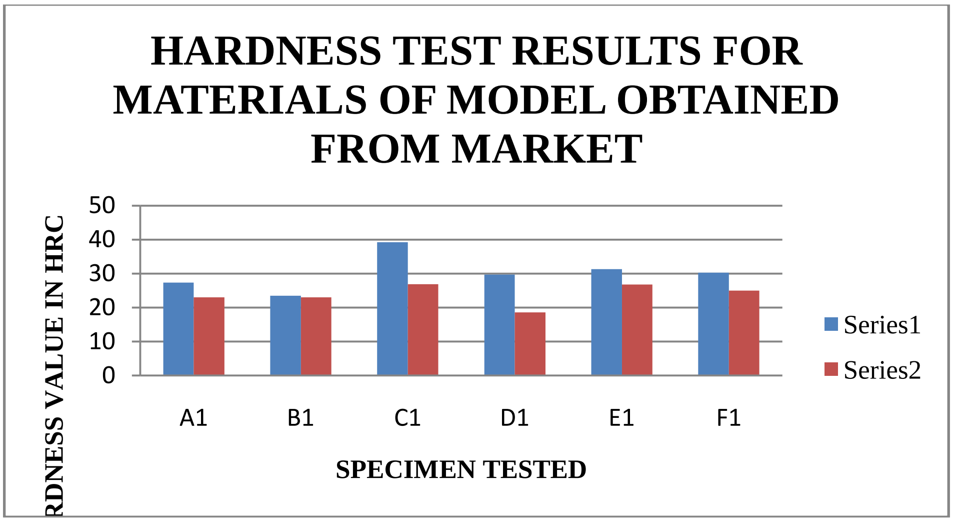

Figure 1: Hardness values of materials used to manufacture the model obtained from themarket and hardness values obtained from engineering materials table.
Note: Series 1: Hardness value of material tested series
2: Hardness value of closer material from engineering materials table.

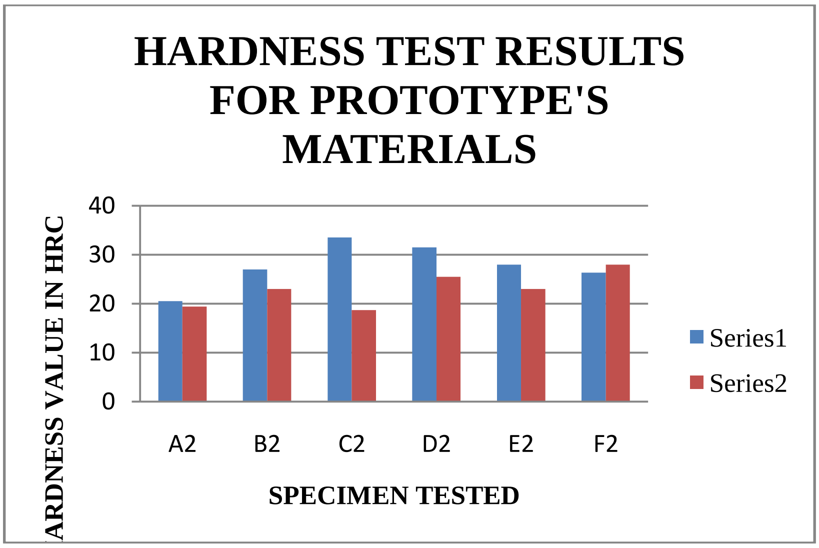

Figure2: Hardness values of materials used to develop the prototype and hardness values obtained from engineering material Table

Note: Series 1: Hardness Value of Material Tested
Series 2: Hardness Value of Closer Material from Engineering Materials table.

3.4 ELEMENTAL ANALYSIS TEST

Elemental analysis of the selected materials that would be adapted in the development of the components of Hydraulic Jack prototype and the materials used to develop the model obtained from the market was carried out and their constituents were determined.

3.4.1 AIM:-To assess the percentage concentration of the elements in the samples of materials selected.

3.4.2 EQUIPMENT USED: Minipal 4 Energy Dispersive X-ray Fluorescence Spectrometer (EDXRF)

3.4.3 SAMPLE PREPARATION:- Each of the Specimens of materials selected was cut and machined into a metal disc of (40 x 10) mm. The discs were polished to obtain smooth substrates using a grit emery paper.

3.4.4 PROCEDURE:-The EDXRF is software driven spectra photometer which gives accurate spectra of polished substrates using its database. Specimen A was put inside one of the cups of the magazine of the spectrometer. Precaution was taken to ensure that the specimen fully occupied the cup to avoid the escape of the X-ray particles. The condition set for the analysis was the XRF power rating was 30kV, Al-Thin filter was used, maximum counts per second was 46258 cps, measuring time was 60 seconds and the medium of experiment was air. The neutron of the X-ray particles bombarded the metal and the initial bombardment is called Raw Intensity (Iraw). After some series of bombardments, the average energy intensity i.e. Net Intensity (Inet) were recorded and measured in counts per second (cps). The measurement of the percentage concentration of the elements in the metal disc was done automatically and the result was displayed on the computer screen and then printed out.
The procedure was repeated for the other Specimens i.e. Specimens B to J respectively and the results were displayed and printed out.

3.4.5RESULTS: - The results obtained from the tests conducted on the 10 Specimens of material (A to J) are hereby presented below in table 5. Sample A is material used for base of the model obtained from the market, Sample B is material for base of the prototype to be developed, Sample C is material for main piston of the prototype to be developed, Sample D is material for main piston of the model obtained from the market, Sample E is material for main cylinder of the model obtained from the market, Sample F is material for main cylinder of the prototype to be developed, Sample G is material for adjustable carriage of the model obtained from the market, Sample H is material for adjustable carriage of the prototype to be developed, Sample I is material for minor piston of the model obtained from the market and Sample J is material for minor piston of the prototype to be developed.

3.5 ELEMENTAL ANALYSIS TEST RESULTS PRESENTATATION

Table 5: Percentage Concentration of Constituents of Materials Selected in (%).

SPECIMEN	Fe	C	Si	Mn	P	S	N
A	93.99	3.21	1.83	0.92	0.10	0.010	-
B	94.79	3.43	2.74	0.50	0.12	0.023	-
C	97.56	0.30	0.31	0.51	-	-	-
D	92.89	0.20	0.66	1.92	-	-	0.009
E	96.66	0.43	0.33	0.20	-	-	-
F	98.89	0.51	-	-	-	-	-
G	97.69	0.32	0.23	1.25	-	-	-
A	-	0.14	0.16	-	0.010	-	0.726
B	-	0.19	0.09	-	0.064	0.036	0.590
C	-	0.29	-	-	-	-	0.060
D	-	0.12	0.12	0.14	-	0.043	0.290
E	-	-	0.65	-	0.250	0.043	0.214
F	0.51	-	0.02	-	-	0.049	0.410
G	-	0.28	0.00 1	-	0.210	0.036	0.034
H	0.15	0.11	-	-	-	-	0.021
I	-	0.18	-	-	0.210	0.080	0.030
J	-	0.13	-	0.28	0.210	-	0.410

Note: Only major elements recommended by the texts (Callister, 2003 and PIM International, 2009), were considered for the analysis. Other constituents such as Rubidium Rb, Lanthanum La, Europium Eu, Osmium Os and Ytterbium Yb were not considered. Elemental analysis results of all the constituents in the samples of selected materials are tested and presented.

3.6 DISCUSSIONS ON ELEMENTAL TEST RESULTS

From the results of the elemental analysis stated above, Specimen A and B were ascertained as Cast Iron because of the presence of iron and 3.1 and 3.4 percent carbon respectively and other impurities like silicon, manganese, phosphorus and sulphur. The inclusion of chromium, nickel and copper improved the hardness, strength and machinability of the materials. Considering the percentage concentration of carbon in the material, they are determined as Gray Cast Iron of grade SAE G4000 and SAE G1800 respectively [8].

Specimen C contained 0.3 percent of carbon and other alloying elements such as 1.55 manganese, 0.31 silicon and 0.29 copper. From this result, the material is High Strength-Low Alloy Carbon Steel AISI A440. Specimen D has in percent 0.2 carbon and other alloying elements like 0.12 copper, 0.043 vanadium, 1.92 manganese, 0.66 silicon and 0.14 aluminum. This indicates that the material is a High Strength-Low Alloy Carbon Steel AISI A633 [13].

Specimen E contained in percent 0.43 carbons, 0.65 chromium, 0.25 nickel and 0.2 manganese. This shows that the material is Medium Carbon Steel AISI 4340. Specimen F results revealed that there is in percent 0.51 carbon, 0.02 chromium and 0.51 molybdenum. From the result, the material is Medium Carbon Steel AISI 4605 (PIM international, 2009). Sample G contained in percent 0.32 carbon, 1.25 manganese, 0.23 silicon and 0.28 copper. The result however stated that the material is High Strength-Low Alloy Carbon Steel AISI A440. In the same vein Specimen H contained in percent 0.18 carbon, 0.91 silicon and 0.021 nitrogen. This indicates that the material is High Strength-Low Alloy Carbon Steel AISI A656. Similarly, Specimen I contained 0.19 carbons, 0.84 silicon, 0.08 vanadium and 0.02 nitrogen. The material was determined to be High Strength-Low Alloy Carbon Steel AISI A656. Finally, Specimen J contained in percent 0.36 carbon, 0.27 silicon and 1.12 manganese. This indicates that the material is Low Carbon Steel AISI A516 (Callister, 2003).

IV. CONCLUSION AND RECOMMENDATIONS

After trouble shooting, it was observed that when pumping the hydraulic oil into the line, the oil is not retained due to poor operation of the valves. To address this, the valve seating was chamfered to allow the valves to be properly seated on the orifice. The jack was reassembled and retested under load and found working well without leakage.

It is recommended that further research should be carried out using different specimen and technique to justify the performance of the selected material. And the jack should be not be used outside the range of ambient temperature as recommended by the manufactures.

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