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Development of Primary Vickers Hardness Testing Machine

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ABSTRACT - This paper describes a primary Vickers hardness standard, which was developed by National Institute of Standards (NIS), of Egypt. It is utilized synthetically the optics, precise mechanism, electronics, computer and automatic controlled technology. The CCD image system is employed, which makes the standard measuring of Vickers hardness value automatically and manually, so the indentation can be realized and accuracy can be improved. The machine has been evaluated through comparisons with the Physikalisch-Technische Bundesanstalt (PTB) Germany.

Keywords: Vickers hardness, hardness standard machine.

1. Introduction

The progress of engineering is greatly dependent on the development and correct use of newer and better materials. Thus, considerable attention has been given to the mechanical properties of such materials, which can be properly assessed. Their behaviour in service could be obtained from the results of laboratory tests and experiments. The accurate materials testing machines is an important and essential matter to the whole engineering and construction industries [1]. In Egypt, the Force

and Materials Metrology Department (FMMD) of the National Institute of Standards (NIS) has been responsible for this task. For many years, the department has extended the routine hardness test services and calibration of hardness testing machine is the NIS-PHVM machine is at the top of metrological chain way to guarantee minimum disturbance to the sensing element. Therefore, the designer where it has the best accuracy and uncertainty, so it is the national level. The primary hardness reference blocks for the calibration laboratory level can be calibrated using the primary hardness standard machine. Naturally, direct calibration and the verification of these machines should be at the highest possible accuracy [2].

2. NIS Primary Vickers Hardness Standard Machine

The PHVM was designed to achieve the development and modernization of the FMMD of the NIS. Intentions are to achieve two main features [3]. The first feature concerned with constructing primary Vickers standard machine to cover a range from HV10 to HV120 through HV (10, 20, 30, 50, 100, and 120) which are the most common in Vickers hardness scale to improve the calibration capabilities of FMMD for hardness.

The metrological characterization consists of the direct verification of the machine and a comparison with PTB primary hardness standard machine; in the direct verification, the main verified parameters are the forces generated by the PVHM, the geometry of indenters and indentation measuring system. In this paper the result of evaluating NIS standard machine through comparison with PTB will be presented.

3. Design concept

3.1 The Main Structure of the Machine

The machine consists of dead weights for the generation of the test forces which can be selected manually, a very flexible control unit that permits to set all the most important parameters involved in the test cycle (times and velocities) and separated image processing system measurements [3]. The main structure of the mechanical system of the machine includes see fig (1,2) ;

i) Load generation system (E): This system utilized to generate the required load values to obtain the desired thought four standard test loads HV (10, 20, 30, 50,100, and 120). This system includes the indenter's frame and the weights. Finite elements stress analysis of the indenter's frame was shown in fig (3).

ii) Load and unload system (G): Testing weights selection is designed to be manual. The main parameter which aimed to be controlled is the test time so it should be automated. The selection of the weights can be performed manually using a specified tools fixed on two column.

iii) Machine fixed used to support the machine. It should be rigid enough to resist the buckling or deflection due to the applied compressive load the main fixed frame includes two platens connected by four tie bars and other two bars

inserted to carry the pins used to select the desired weights manually. The fixed frame should be adjusted by levelling nuts utilized to adjust the machine frame (M): It's a frame vertically. Finite elements stress analysis of the fixed frame was shown in fig (4).



Fig.1.aphoto of the standard machine

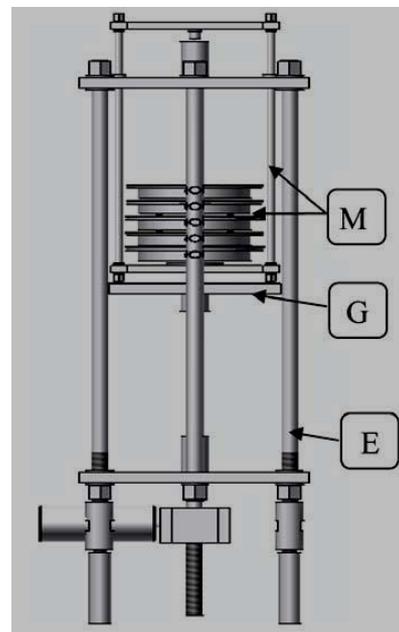


Fig. 2: Main components of the hardness standard machine (up to HV120).

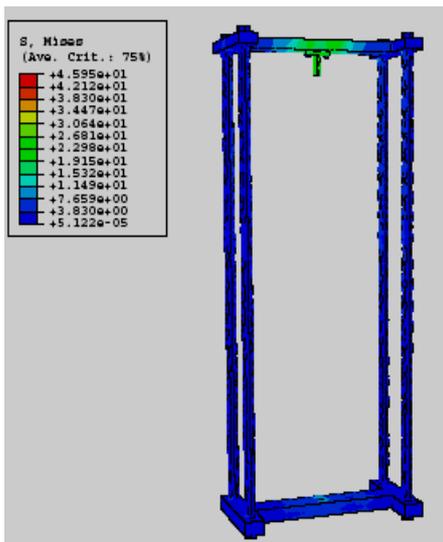


Fig.3 FEM stress analysis of the indenter frame

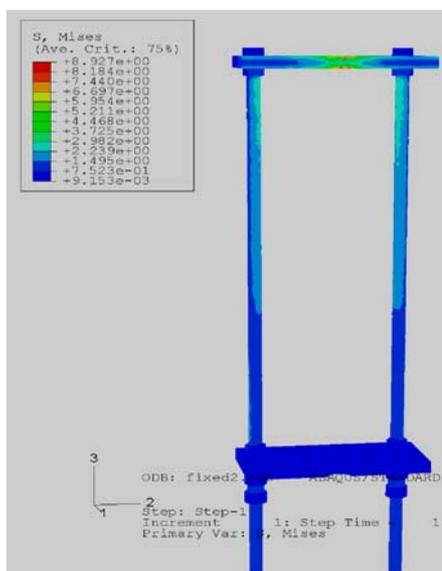


Fig.4 FEM stress analysis of the fixed frame

4. Comparison

NIS has recently commissioned of new hardness standard machines. In the key comparison Six sets of hardness reference blocks for the Vickers hardness scales HV10, HV20, HV30, HV50, HV100 and HV120 consisting each of three hardness reference blocks with different hardness levels.

The comparison started with the initial measurements at NIS. Then at the same month these test blocks was tested at PTB then tested

at NIS again. It was shown that there is no big difference between the result obtained at NIS and PTB, the result of comparison between NIS and PTB are shown in the following figures (the results of three selected scale will be shown in this paper).

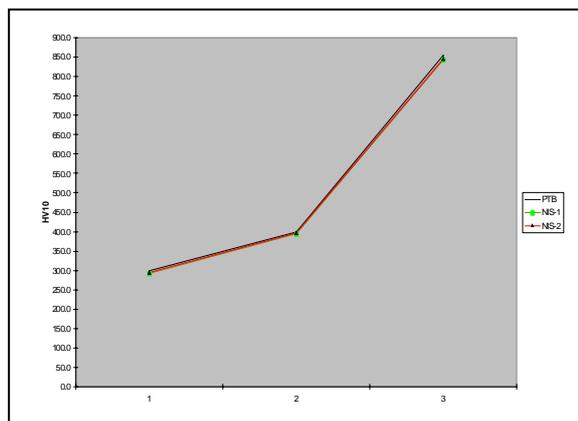


Fig. 5: Measurement results for the hardness scale HV10 for the participants

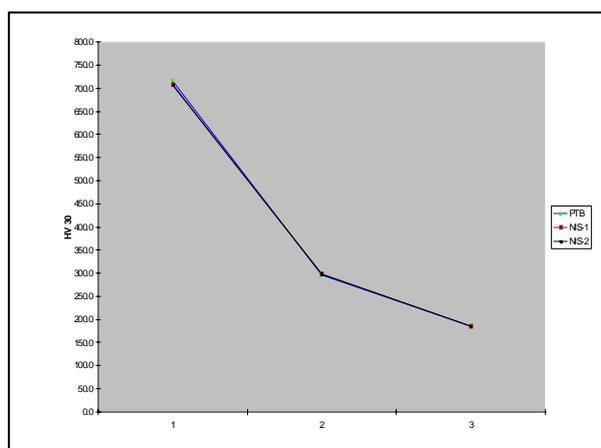


Fig. 6: Measurement results for the hardness scale HV30 for the participants

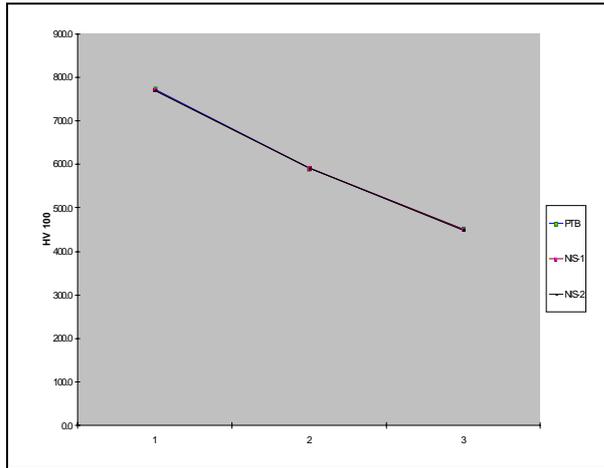


Fig. 7: Measurement results for the hardness scale HV100 for the participants

Finally, the coefficient E_n [4], which evaluates the agreement between the measurement deviations found in the comparison and the uncertainties stated by the participant it can be calculated from the following equation,

$$E_n = \frac{x_{lab} - x_{ref}}{\sqrt{U_{lab}^2 + U_{ref}^2}}$$

Where x_{lab} is the measurement result of the participating laboratory, x_{ref} is the reference value calculated by the weighted mean value, U_{lab} is the uncertainty stated by the participating laboratory and U_{ref} is the uncertainty of x_{ref} calculated by the uncertainty of the weighted mean value.

For the reference values only the measurement results with $E_n \leq 1$ are considered. The calculated E_n value will be presented through the following tables.

Table 1. Shows the E_n value for HV 10

Test Scale	Sample ID	PTB-(Xref)	NIS(1,2) (X lab)
HV10	292 HV10	298.42	1.02
	397 HV10	398.65	0.42
	854 HV10	855.20	0.52

Table 2. Shows the E_n value for HV 30

Test Scale	Sample ID	PTB-(Xref)	NIS(1,2) (X lab)
HV30	712 HV30	715.86	0.75
	294 HV30	295.96	0.76
	184 HV30	184.93	0.78

Table 3. Shows the E_n value for HV 100

Test Scale	Sample ID	PTB-(Xref)	NIS(1,2) (X lab)
HV100	772 HV100	773.03	0.40
	588 HV100	590.27	0.15
	452 HV100	450.94	0.25

5. Conclusion

In the framework of evaluating the new developed primary Vickers hardness testing machine belonged to National institute of Standard of Egypt it was covenant to perform a key comparison with another national standard such as PTB (Germany) to serve as the pilot laboratory. The comparison of the Vickers primary hardness standard machines was carried out with six sets of hardness reference blocks of the Vickers scales HV10, HV20 ,HV30,HV50,HV100 and HV 120 each with different hardness levels.

References

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