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# INSTALLATION AND METROLOGICAL CHARACTERIZATION OF ROCKWELL-BRINELL-VICKERS HARDNESS STANDARD MACHINE AT TÜBİTAK UME

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**Abstract:**
After successful implementation of two hardness standardizing machines at TSE (Turkish Standards Institution) in Rockwell and Brinell-Vickers hardness scales separately, it is aimed to combine them in a newer design and install in Hardness Laboratory of TÜBİTAK UME (National Metrology Institute of Türkiye). Design of such a national standard was made for Rockwell, Brinell and Vickers hardness scales within the scope of an internally funded project. In this paper installation and metrological characterization of the Rockwell-Brinell-Vickers hardness standard machine (RBVHSM) with dead weight force application system and laser interferometer developed by TÜBİTAK UME Hardness Laboratory is explained in detail.

**Keywords:** Rockwell-Brinell-Vickers hardness; hardness standard machine; indentation; measurement; dead weight.

## 1. INTRODUCTION

Improvements in quality assurance in the field of hardness testing and demand received from calibration and testing laboratories as well as hardness testing machine producers and other users made it inevitable to renew the National Hardness Standards at Hardness Laboratory of TÜBİTAK UME. After successful implementation of two hardness standardizing machines at TSE (Turkish Standards Institution) in Rockwell and Brinell-Vickers hardness separately and attaining good results with a newer design and automation of the systems it had been decided to renew the hardness standards present at TÜBİTAK UME Hardness Laboratory and develop the best design and widest measurement capability regarding the instrumented indentation test (IIT) to be embedded on the same machine. It is realized via designing [1] and developing a deadweight type Rockwell-Brinell-Vickers HSM with laser interferometer system within the scope of an internally funded project to provide traceability to all scales present between 3 kgf to 150 kgf within Rockwell, Brinell and Vickers hardness scales in accordance with the relevant ISO hardness standards [2] and [3] for Rockwell, [4] and [5] for Brinell, [6] and [7] for Vickers methods. In this newly installed RBVHSM the force application system was considered to comprise mass stacks realizing force under the gravitational acceleration and a frame to transfer the realized force to the tip of the indenter, a well-known deadweight force application principle. A picture of the RBVHSM is given in Figure 1 after its installation and activation.


Figure 1: Rockwell-Brinell-Vickers Hardness Standard Machine of TÜBİTAK UME

A laser interferometer system is equipped to be used for depth of indentation measurement for Rockwell hardness. An indentation measurement system is used for Brinell and Vickers hardness indentations designed and produced not in the scope of this project but another one beside the system present in TÜBİTAK UME Hardness Laboratory. Indenters are purchased from various companies and certified at TÜBİTAK UME in terms of geometric requirements and performances.

The measurement cycle is realized by making use of a force measurement device (force transducer) to which the whole force application system (the two frames and the mass stacks as a whole) is mounted. The laser interferometer systems is used for depth of indentation measurements as well as speed of intender during its penetration through the material.

## 2. PRODUCTION AND INSTALLATION

The machine body was designed to be rigid and sturdy to minimize side effects during force application and realization of indentation, and every component constituting Rockwell, Brinell and Vickers hardness is considered to have the highest accuracy for the best outcome quantity hardness.

### 2.1. Body of the Machine and Mass Stacks

It is very important to have a rigid and strong enough body that will not affect the measurement results. For this reason, the machine body were designed and produced to comprise the minimum number of parts and each part having precise dimensional measurements and tight tolerances, special material and production methods. It was mentioned to have long term stable material for the weights to be used for force application and stainless steel is used and the mass stack were produced with good surface quality. The mass stacks set mounted onto the machine is shown in Figure 2.

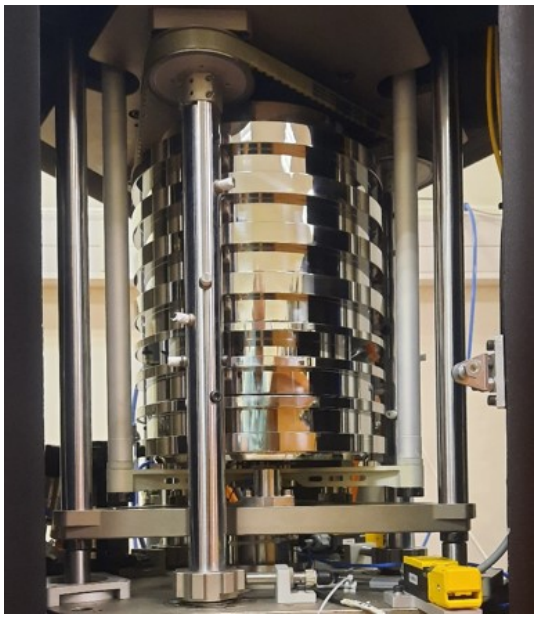

Figure 2: Rockwell-Brinell-Vickers HSM Mass Stacks

### 2.2. Force Application System

To realize the force with the highest accuracy and stability, deadweight type force application principle is preferred. It comprises mass stacks made up of stainless steel and an Aluminium frame to constitute one of the preliminary loads (the 3 kgf) and transfer the other loads to the tip of the indenter. The mass stacks are used in summation order such that all scales can be realized.

### 2.3. Measurement Cycle

The measurement cycle is realized with application of force with a predefined indenter approach speed and force application rates with respect to time. To figure out the measurement cycle of force application, a force measurement device is equipped onto the machine and data from this device is recorded and instantaneous force application is plotted as the force is applied. The laser interferometer system if used for speed of the indenter during its penetration to the material as well as depth of indentation. The force measurement unit with the frame mechanism is mounted and shown in Figure 3.

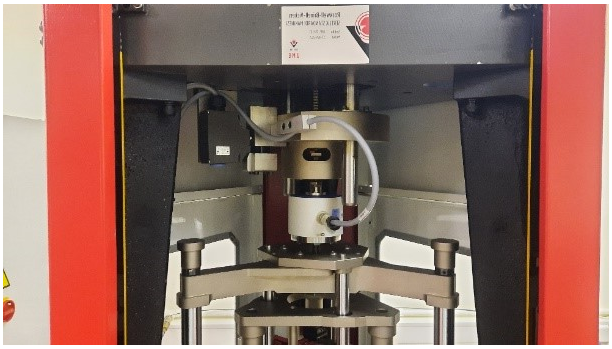

Figure 3: Rockwell-Brinell-Vickers HSM Force Measurement Device Mounted with the Frame

### 2.4. Indentation Measurement

Indentation measurements in Brinell and Vickers are performed as mentioned with an independent system designed and produced by TÜBİTAK UME Hardness Laboratory. The depth of indentation is managed by making use of a laser interferometer system with the highest possible accuracy. The moving corner cube is mounted to the indenter and it is supposed to move as far as the indenter moves. In this case movement of the indenter inside the material is figured out as shown in Figure 4. The indenter speed is also calculated with the displacement received from the laser interferometer.

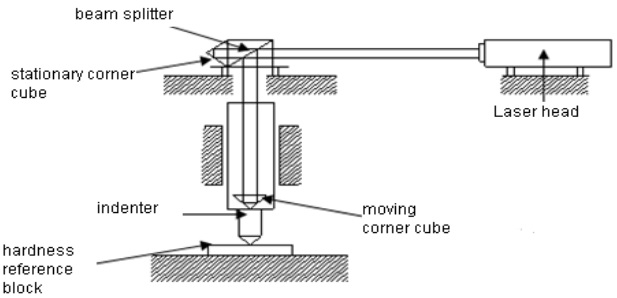


Figure 4: Rockwell-Brinell-Vickers HSM Indentation Depth Measurement Principle Scheme

## 3. AUTOMATION OF THE MACHINE

The machine is equipped with servomotors for selection of the relevant mass according to the scale and realization of indentation. Other automation sensors are the force transducer to manage the force application time as well as dwell time, the laser system for all displacement and speed management and other sensors are used to manage the automatic calibration algorithms. A user-friendly software is specially prepared for activating the machine and performing all measurement stages automatically. The picture of the user interface is shown in Figure 5.

Figure 5: User interface software of the RBVHSM

With the user interface software it is possible to set all measurement parameters like approach speed of the indenter, force application and removal speeds, information belongs to the hardness reference block subject to calibration etc. At the end of the realization of indentation, a list of the realized values of the parameters set before the measurement is listed. For instance the force application and dwell times of the measurement cycle is measured and given on the screen.

## 4. PERFORMANCE OF THE MACHINE

Rockwell-Brinell-Vickers hardness standard machine is used only for realization of indentation for Brinell and Vickers scales, but measurement of all Rockwell scales. With the measurements made so far repeatable results were attained in terms of force application and measurement cycle parameters such as force application and dwell times as well as indenter penetration speeds. The software gives the possibility to figure out the force application and comparison of force with the reference value as well as the tolerances requested. With the laser interferometer depth of indentation with respect to time is also figured out. At the end of measurement of the Rockwell hardness number and depth of indentation is given as the result of measurement for Rockwell scales. The realized measurement cycle parameters are listed on the measurement page for Brinell and Vickers measurements as well. Below in Figure 6 to Figure 8 you can see force application cycle, indentation depth and the information extracted from the force measurement device during realization of indentation.

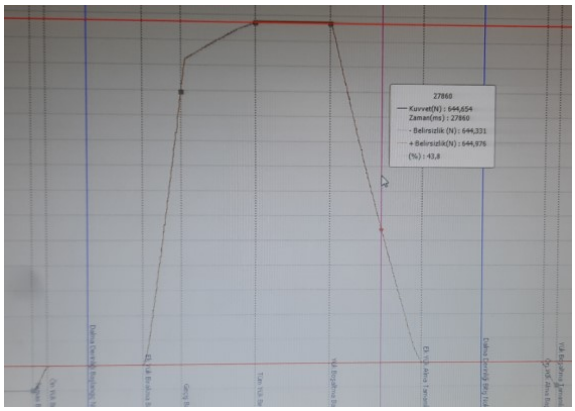

Figure 6: Force application with RBVSSM

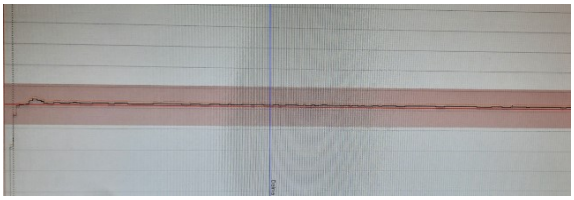

Figure 7: Force application with RBVHSM

The force applied, time, the reference force value with the tolerances requested (grey area) and the uncertainty of the force measurement information can be seen as a label at any instant. As shown in Figure 6 and Figure 7 visual interpretation of the force applied being within the tolerances is demonstrated on the graphical interpretation of measurement cycle.

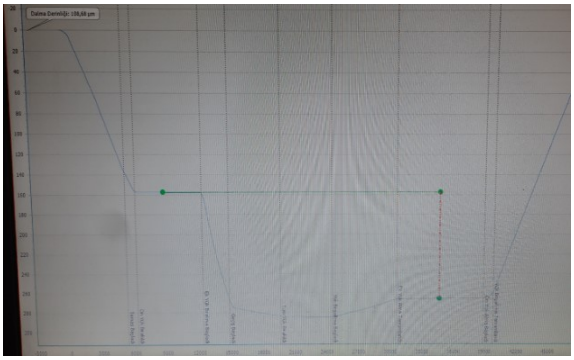

Figure 8: Depth of indentation measurement

The depth indentation is calculated from the depth – time graph of the indenters movement inside the material. Then this value is used to calculate Rockwell hardness number with the very well-known Rockwell equation.

## 5. SUMMARY

At the end of this project a deadweight type Rockwell-Brinell-Vickers hardness standard machine with laser interferometer optic system is designed, produced, installed and activated with the ultimate design having better metrological properties then the present one in TÜBİTAK UME Hardness Laboratory. It comprises all Rockwell scales, Vickers

scales between 3 kgf - 100 kgf (also 120 kgf is possible) and Brinell scales between 5 kgf the 125 kgf. Very good results were attained in terms of force application and testing cycle realization functioning properties, and user-friendliness from design and automation point of view. Very good repeatability in terms of force application as well as measurement cycle parameters were attained. The system can also be used for Instrumented Indentation Test and the calibration of the force transducer used for calibration/verification of measurement cycle parameters.

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