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ANALYSIS OF MODERN METHODS OF ASSESSING THE QUALITY OF SAND FOUNDRY MOULDS

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Currently offered devices for the hardness measuring or indices of the mould strength, are presented in the hereby paper. The presented results allow to compare approximately the indications of individual devices of different types. The description of the author's own microprocessor tester for the quality assessment of the sand foundry moulds, is shown. On the bases of the measurements results it is possible, to evaluate indirectly, the mould apparent density in the selected points, as well as several other properties.

Key words: foundry, sand, moulds, mould hardness, mould strength

INTRODUCTION

The technology of green sand moulding still dominates in the casting production [1-4], especially for small and medium castings. A progress in the mechanisation and automatisation of production is decisive. The proper density of a moulding sand and its distribution in a foundry mould combined with good properties of this moulding sand favours the dimensional accuracy of the mould cavity, good reproduction of model shapes and thus decreases the casting defects number [1,5,6]. The proper compaction of the moulding sand is the most important task in the sand moulds production process. Various moulding methods are used currently. Each of them has its specific features and comparing their compaction effects is of a practical meaning. However, this comparison is difficult, due to various devices being used. In investigations of sand foundry moulds the direct as well as indirect methods are used in assessing the moulding sands compaction. To the direct methods belong, among others: determination of an apparent density of the compacted moulding sand (penetration test), surface hardness measuring and strength indices [1,5], while to indirect methods: ultrasound methods [6], computer tomography methods [4], mould permeability measurements [7]. Indirect methods require time-consuming laboratory measurements connecting the physical value measurement results with the apparent density. Special sensors for dynamic measurements during moulding should be mentioned [2]. Devices of the hardness measuring and recently the mould strength electronic testers have the fundamental meaning in the mould state determination [1,5,8,9]. Their merit constitutes the fast, multipoint and practically non-destructive measurement. Measurements in the determined points of the mould - Figure 1 - allow the foundryman to assess the mould quality and the applied compacting technique [1,5,10]. Measurements enable determining other parameters characterising the mould state. However, it requires supplementary laboratory experiments.

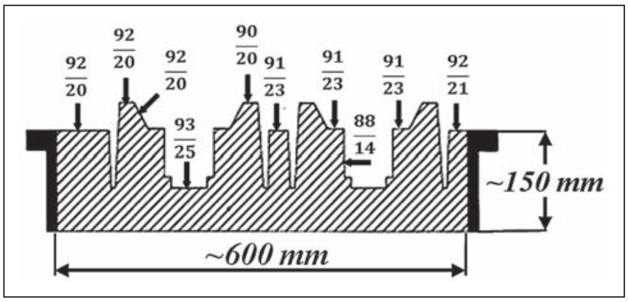

Figure 1 Measurements results of hardness (in the numerator) and strength (in the denominator) of the moulds. Compaction: gravitational and squeezing. Data from Loramendi [7]

The hardness measurements can be connected with the apparent density, compression strength or moulding sand permeability, etc. In the industry, at applying the determined moulding sand and automated systems of moisture stabilisations the proper operation of moulding machines and the proper selection of their operation parameters is essential [3,5,9,11]. At a variable casting assortment, it is possible to obtain various apparent densities and compaction degrees in different points of the mould.

GENERAL CHARACTERISTICS OF DEVICES FOR MEASURING THE MOULDS HARDNESS AND STRENGTH

Hardness testers are the most often applied in assessing the produced moulds state. Several such devices, which can be divided into two main groups: mechanical (Figure 2a) and electronic (Figure 2b,c,d), al-

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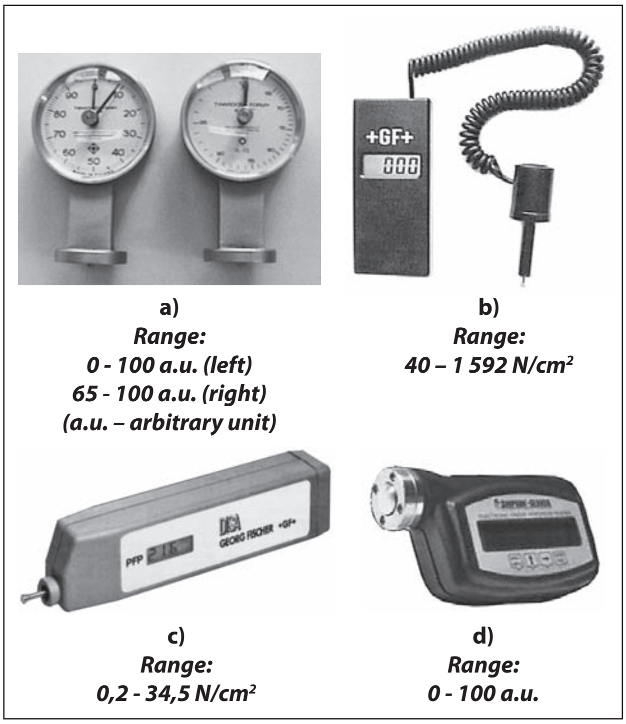

Figure 2 Testers for mould hardness or mould strength [5,7]: a) hardness tester: A type (left) and C type (right)- Multiserw- Morek, b) mould strength tester PVP type- Georg Fisher, c) mould strength tester PFP type- DISA Georg Fisher, d) electronic hardness tester- Simpson Gerosa

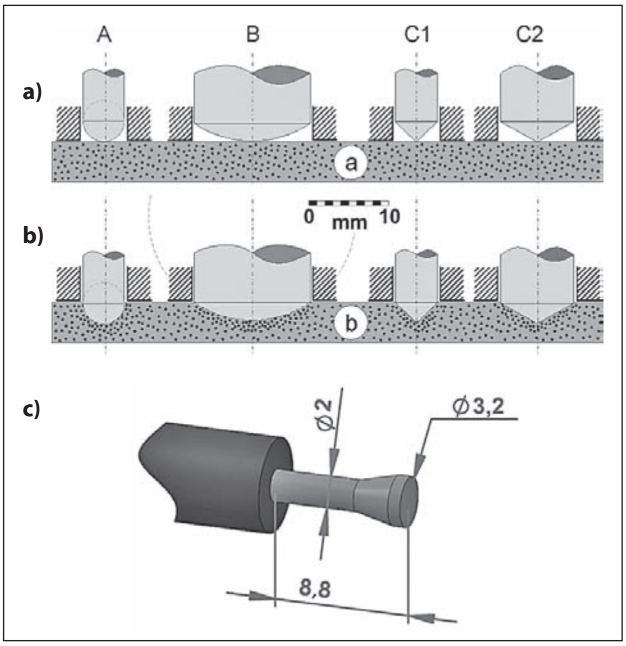

Figure 3 Indenters (penetrators) of different mould hardness tester (A, B, C- types)- a), b) and mould strength tester (Figure 2b,c)-c). Schemes of location of indenters in extreme positions (relative to the tester body): a) hardness ~ 100 a.u., b)hardness ~ 0 a.u

ready exist. Displacing of the indenter cooperating with an elastic element - in hardness testers - is reflected either in the clock scale or in the digital display. In dependence on the indenter shape and dimensions (Figure 3) the range of measured hardness values and accuracy of the device indications changes.

The indenter shape determines the hardness tester type (A, B or C). The hardness is expressed in arbitrary units (a.u.). Mechanical devices - at a changed indenter shape – Figure 3c and at adequately selected characteristic of an elastic element were also scaled in strength units (e.g. N/cm²). The indications range corresponded with the compression strength range of classic moulding sands [1,5]. The second group of devices (Figure 2b,c) is the one in which mechanical values (e.g. force) are changed into electric signals, which after transformation are displayed (and stored). In practice none intender displacement occurs.

The good point of these devices is a small size of the indenter. Individual solutions have similar principles of operations, while quite different appearance. The device PVP of the Georg Fisher Company (Figure 2b) scaled in strength units was their precursor. It can be applied for assessing the states of the moulds (cores) made of moulding sands with binders [1,5]. A variety of the applied devices render difficult comparing the moulding results. They are often presented by producers of moulding machines (e.g. Figure 1).

This concerns also compaction effects presented often in publications related to investigations of moulding processes [5,7,8,9]. In order to compare, approximately, the measurement results obtained by means of the classic hardness testers (type A) and by new testers (Figure 2c), the data originated from various sources are shown in Figure 4.

The results of own investigations, where parameters were determined on cylindrical specimens of various compaction degrees (moulding sand with bentonite), are presented in Figure 5.

CONCEPT OF THE PROTOTYPE DEVICE FOR ASSESSING THE QUALITY OF SAND FOUNDRY MOULDS

The prototype device developed in the Faculty of Foundry Engineering of AGH is presented in Figure 6.

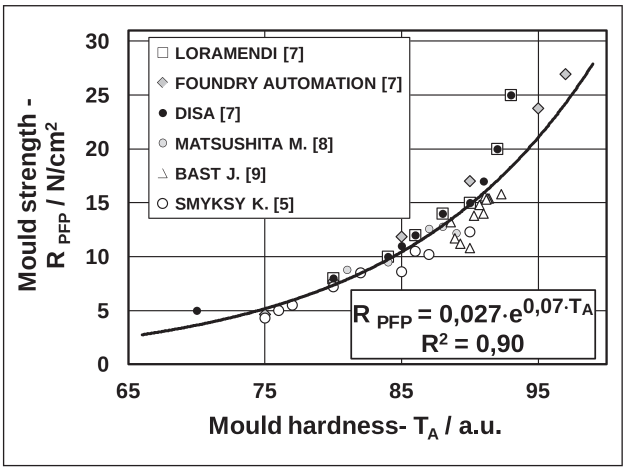

Figure 4 Dependence between mould hardness T_A (hardness tester of Georg Fisher company- indenter A type) and mould strength- R_{PFP} (tester PFP – Figure 2c)

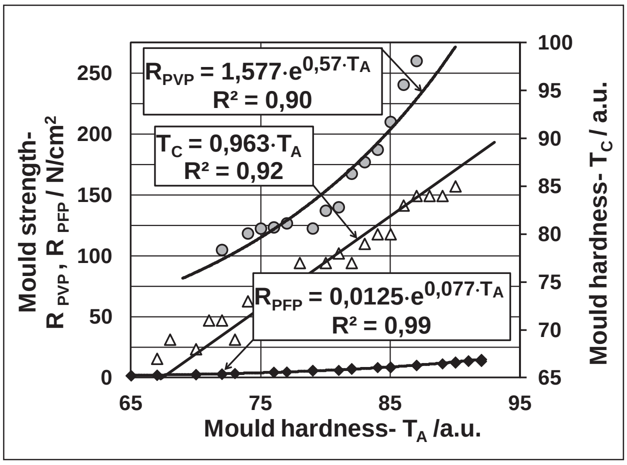

Figure 5 Comparison of indications of different testers from Figure 2a,b,c. (T_A, T_C - hardness testers of Multiserw-Morek company- indenter A and C2 type) (R_{PVP}, R_{PFP} - strength testers of Georg Fisher company)

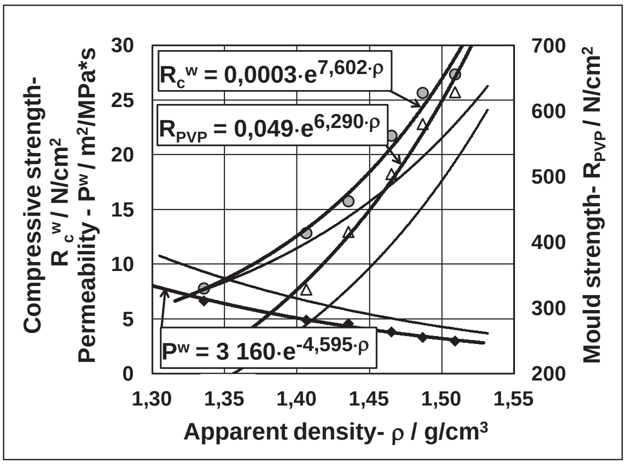

Figure 7 Correlations between basic parameters of moulding sand and apparent density. Continuous lines- industrial moulding sand, dashed lines- laboratory moulding sand; coefficient- R^2 for all trend lines ~ 0,99

Figure 6 View of prototype digital hardness tester: 1- main unit with display and keypad, 2- exchangeable measuring head, 3- supply unit, 4- connector, 5- cover

Due to the additional functions of the microprocessor central unit, the variant similar to the version from Figure 2b (PVP, +GF+) was selected. In contrast to this version, the device has the possibility of exchanging measuring heads (with different indenters- Figure 3) and the computer cooperation. The intender dislocation is transformed and recorded.

Several investigations of the device operation were performed. The selected results of measurements with the first head variant with the conical intender, type C2 (Figure 3), are presented below. Two kinds of moulding sands were applied: industrial of quartz matrix with bentonite and coal dust and the one prepared in the laboratory - also of quartz matrix with bentonite. Moulding sands were tempered to the working moisture content and standard cylindrical specimens were made (ϕ - 50mm, h - 50 mm). Specimens were compacted by various moulder's rammer strokes (from 1 to 6) obtaining different apparent densities.

Hardness measurements were made by various devices on the upper and bottom surface of shaped samples and then their strength was determined. The average values, representative for the sample of the given density, were calculated. Also measurements of the compression strength - R_c^w and permeability - P^w, were performed. The typical pathways of these [1,6] features were obtained – Figure 7. The industrial moulding sand was treated as the basic one - continuous trend lines. Dashed lines were used for the laboratory moulding sand. The analysis of data from Figure 7 indicates the essential linear dependence between parameters: R_c^w and R_{PVP} (or R_{PFP}). Coefficients must be determined for each moulding sand. The dependence of the hardness on apparent density of the moulding sand formed into shaped samples is presented in Figure 8. The hardness - T_A and T_C was measured by mechanical devices (Figure 2a), while T_S by the prototype device (Figure 6). The trend lines were described by power functions, according to data [5,6]. Linear functions provide also good descriptions, within the measured ranges.

The sensitivity of the hardness tester- S can be defined as:

$$S = \frac{dT_i}{d\rho}$$

where:

dT_i - differential hardness increase,

dr - differential density increase.

In case of linear dependencies the device sensitivity constant is determined by the directional coefficient.

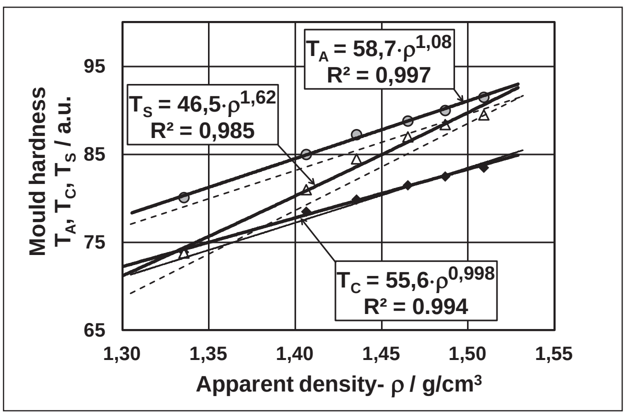

Figure 8 Correlations between hardness- T_A, T_C, T_S and apparent density. Continuous lines- industrial moulding sand, dashed lines- laboratory moulding sand

The sensitivity ratio: T_C, T_A, T_S can be expressed by the number ratio: 1 : 1.2 : 1.7. Thus, in this sense, the less sensitive is the type C tester and the most sensitive the prototype tester (T_S).

CONCLUSIONS

The prototype tester of the moulding sand compaction has several merits as compared with other devices. It is functional, cooperates with the computer and has additional functions: automatic switch-off, recounting of measured values into other ones (e.g. T_A, T_C) according to the defined - by the user - regression equations, signalisation of threshold values, storing large measurement series results. Operating of this tester is intuitive. The device can be calibrated according to indications of the standard hardness tester. Further studies concerning the device miniaturisation and new measuring heads are carried out.

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Note: The responsible translator for English language: “ANGOS” Translation Office, Krakow, Poland.