II International Congress on Mechanical Metrology (CIMMEC)
Metrology 2011 - Natal, RN, Brazil - Sep. 27-30

INFLUENCE OF OPERATIONAL PROCEDURES ON THE TEST RESULTS OF CHARPY IMPACT TESTING MACHINES

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ABSTRACT: This work presents partial results of an interlaboratory comparison programme aimed at the evaluation of the performance of six CVN[1] . Factors which affected performance were found to be the conditions under which the machine were operated and calibrated. Programme was used as basis for technical experiences among the participating laboratories.

KEYWORDS: Charpy, impact testing, interlaboratory comparison, reference material, standardization.

1. INTRODUCTION

It's known for more than a century, the Charpy impact test is largely employed for the evaluation of mechanical strength of welded segments of metallic structures and pressure vessels.

The test is the most common technique to determine the toughness of a material and is based on measuring the absorption of the fracture energy of a specimen prismatic notched (Figure 1), bi-supported, subject to a coup a pendulum striker.

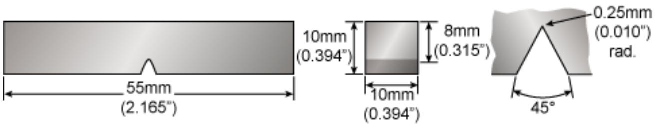

Fig. 1 – Charpy impact test specimen, standard size[3]

Typically, the test is performed at low temperature to determine the transition temperature of ductile-brittle material. Corresponding AWS [1] e ASME [2] standards prescribe the test, whose method is laid out by ASTM [3].

Figure 2 shows a schematic drawing of the principle of the test. The pendulum striker is released from a height (dimension "a") and specific angle going against the section of the specimen maintained between the gaps anvil's support.

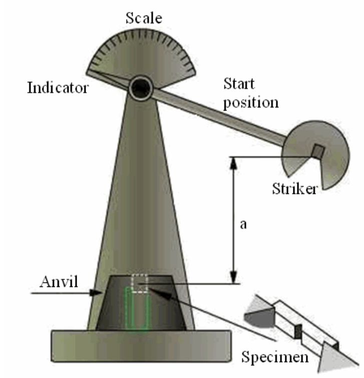

Fig. 2 – Energy measuring principles.

The machine used in the test and its auxiliary devices (indication system energy, temperature sensor and tongs) must have structural stability, dimensional and metrology to minimize its influence on the measurement results.

Figures 3 and 4 is showns a Charpy impact testing machine with indication system energy in analogic and digital modes and an ASTM standard tongs.

Fig. 3 – Instron-Satec Charpy impact testing machine. CETEC.

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[1] **CVN-Charpy V-notched- Charpy impact machines.**

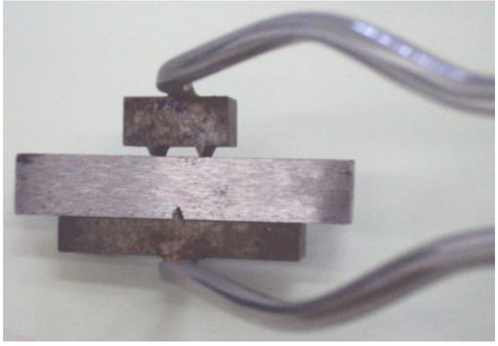

Fig. 4 – ASTM tongs for V-notched Charpy specimens.

The characterization of the metrological performance of a Charpy Impact Testing Machine (CITM) is based on its direct and indirect calibration [3-4]. The performance is affected by the widely harmonized methods employed for the installation, operation, and maintenance of the CITM. Performance is also affected by the system used for energy reading and recording, which is normally, based on analogic, digital, software-operated mass-velocity, energy measuring principles.

The direct verification of Charpy impact machines consists in the verification of dimensional geometric characteristic (pendulum, knife and support) and energy losses by friction in the bearings [3].

Figure 5 illustrates the verification of the distance between the support's gaps of a Charpy impact machine.

Fig. 5 – Direct verification, CETEC.

The indirect verification of Charpy impact machines requires Standard Reference Materials (SRM) with certified fabricated values by producing organisms (in this case NIST) to check the accuracy of the results indicated by the machine [4].

To found this verification, the test result must be in a range of acceptance associated with the certified value of SRM, whose scope is: ± 1.4 J or 5% of the certified value, whichever is the greater value.

Participation in Interlaboratory Program (PI) provides laboratories evaluate their testing procedures to identify the strengths and weaknesses of the methodology, compare the results with those of other laboratories, and improve the quality of services.

The main objective of the related studies was to establish a technical basis for the harmonization of the preliminary and testing procedures adopted by six laboratories, participants of an interlaboratory comparison programme [5] co-ordinated by the Minas Gerais Laboratory Association[2] – RMMG. All six participating laboratories have their premises in or near the greater Belo Horizonte area. Two of these laboratories are linked to public institutions – CETEC and CNEN/CDTN – whereas the remaining four are private – SENAI/CETEF, ESAB S/A, USIMINAS, and Vallourec & Mannesmann.

2. METHODOLOGY

Before the series of measurements of PI, each laboratory received an identification code for monitoring and comparison of their results in relation to others. Were used the following codes: 30CP, 52N9, 5C8N, L2B1, T2CV and ZTVK.

Comparison experiments were conducted in two rounds. The first round was merely exploratory and the second round constituted the comparison proper.

In all rounds PI's measurements were discounted as a factor influencing the outcome of the analysis of energy consumption: the type of striker Charpy impact machine (type C or U) [3] and the direction of movement of specimens after receiving the blow of the striker [4]. In this paper, these factors were neglected because of the differences between the machines used (e.g. nominal range and the process of foundation/installation). However, the analysis of such factors is critical to aid the interpretation process of the absorbed energy and appearance of the fracture of the specimens, if any.

After second round, the results were analyzed and compared to the certified value for the SRM used.

2.1 First round of experiments

In the first round CITMs were previously evaluated and properly adjusted based on test results obtained with CETEC-manufactured reference specimens. These were V-notch broached SAE 4340 steel specimens, without any further treatment. Each laboratory tested two sets of five specimens, one at room temperature (25 ± 5 °C) and the other at -40 °C. Reference values were based on a technical publication Redemat[3] [6].

2.2 Second round of experiments

In the second round each laboratory tested two sets of V-notched certified standard-size specimens, respectively of low and high energy levels, both at -40 ° C. Employing the procedure prescribed by ASTM standard [3].

The value assigned by NIST for the group of SRM low energy level, between 13 J and 20 J, LL lot 104, consisting

[2] Rede Metrológica de Minas Gerais.
[3] Rede temática em engenharia de materiais (CETEC-UEMG-UFOP).

of four test items, was 14.1 J. Considering the acceptance range of ± 1.4 J, the energy values acceptable for the validation of the verification should be between 12.7 J and 15.5 J.

The value assigned by NIST for the group of reference materials, low energy was between 88 J and 136 J, HH lot 102, consisting of five test items, was 85.0 J. Considering the acceptance range of ± 5% of the assigned value, the energy values acceptable for the validation of the verification should be between 80.7 J and 89.3 J.

The low energy set was formed by 4 specimens and the high energy set by 5 specimens. A total of 54 specimens were thus tested, 9 by each of the 6 participating laboratories.

Impact energy results of the second round were analyzed for identifying and resolving laboratorial deficiencies laboratories in implementing the test.

Broken specimen parts were sent to NIST for the evaluation of possible causes of abnormal impact energy results, like machine geometry deviations, lack of control of the temperature conditioning bath, or procedural handling or testing mistakes.

3. RESULTS

The results of the first and second round of measurement were used to establish the harmony between the Charpy impact machines and identify points of failure and improvement of test procedures.

3.1 First round of experiments

Impact energy results of the first round were analyzed to the harmonization of machines (nominal range, type of knife and indicating equipment for the absorbed energy).

The results of the first round of measurement were used only as an indication of the functional characteristics of the machines. In this round, no SRM were employed.

3.2 Second round of experiments

The direct verification of the machines was carried out by the laboratory that reported the absence of deviations dimensional and structural instability in the devices (striker, support and knife) and the machine itself.

Table 1 and Figure 6 show the results obtained by laboratories for specimens low energy level.

Table 1 – Individual results: low-energy.

Lab	Absorbed energy (J)				Result
30CP	15.7	16.6	15.6	16.2	NC
52N9	16.3	16.5	15.4	15.6	NC
5C8N	15.9	17.2	*	17.8	NC
L2B1	20.0	20.0	24.0	20.0	NC
T2CV	16.5	16.5	17.0	17.0	NC
ZTVK	16.0	16.0	16.0	14.0	CF

* lost test NC: Rejected CF: Accepted

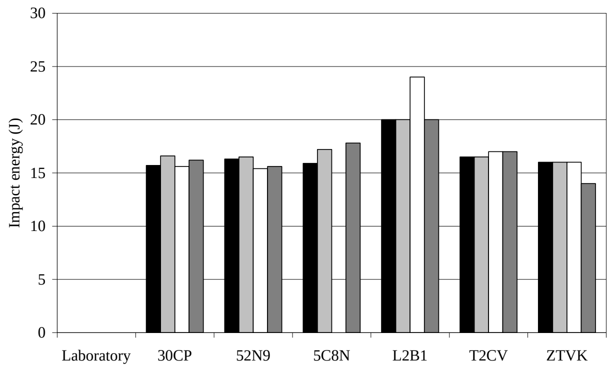

Fig. 6 – Graphic: low-energy, < 14,1 J

As it can be seen on Fig. 6 all laboratories presented means impact energy above 10% the NIST-certified value of 14.1 J.

Only the laboratory "ZTVK" (Table 1) results were in according to NIST range.

The laboratory "L2B1" (Table 1) presented dispersed results in relation to the others.

Table 2 and Figure 7 show the results obtained by laboratories for specimens high-level energy.

Table 2 – Individual results: high-energy.

Lab.	Absorbed energy (J)					Result
30CP	87.4	86.6	93.8	83.4	90.1	CF
52N9	91.1	90.3	89.9	89.6	90.1	NC
5C8N	89.0	88.3	97.4	92.5	96.6	NC
L2B1	94.0	98.0	92.0	94.0	96.0	NC
T2CV	99.5	91.0	90.0	88.5	87.0	NC
ZTVK	60.0	67.0	62.0	78.0	70.0	NC

CF: Accepted NC: Rejected

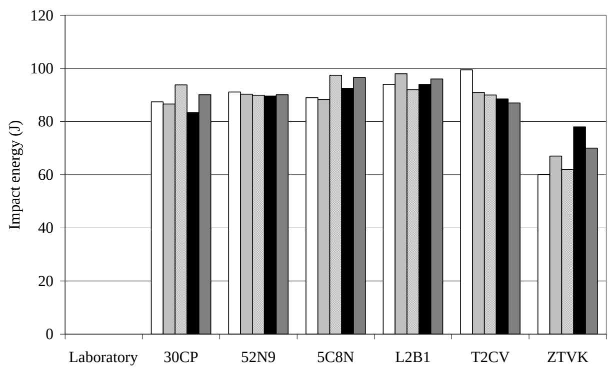

Fig. 7 – Graphic: high-energy, < 85,0 J.

On the other hand, for the high energy level (Fig. 7), one laboratory presented a mean result higher than 10% of the certified value, while another laboratory obtained a mean result 21% lower than the 85.0 J reference value.

The laboratory "30CP" (Tab.2) showed a result of compliance according to the discretion of NIST. There is also a large dispersion of the laboratory "ZTVK" results in relation to others.

NIST analysis of the broken specimen parts pointed to procedural mistakes and machine anvil wearing as the most probable causes of the verified deviations.

4. CONCLUSIONS

Results of the comparison programme have shown that the participating laboratories present a higher deviation for low-energy specimens, of up to 49% above the reference value. Causes attributed by NIST to the verified deviations lead to the conclusion that testing procedures and machine installation and maintenance are to be controlled to increase test results reliability, especially for low-energy specimens.

Standard reference specimens tenacity mean and dispersion values are certified by NIST or any other SRM purveyor [4] and are a way to performing indirect calibration of the machines. Nevertheless, the traceability of impact test results is strongly dependent on installation, operation and maintenance of the CITMs.

The interlaboratory comparison programme was the first step taken towards the harmonization of the procedures by the participating laboratories.

This work provided the laboratories to improve their ability to produce reliable results for items submitted to Charpy impact test.

ACKNOWLEDGEMENTS

Authors acknowledge the support given to intercomparison programme by the organizations to which the laboratories are sub-ordinated. Authors are also thankful to the Studies and Projects Funding Organisation – FINEP (Brazil) which provided the funds for the laboratory comparison programme. At last, authors acknowledge the competent co-ordination of the programme by its Consultative Committee on behalf of RMMG.

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