THE DYNAMIC CALIBRATION PROBLEMS IN INSTRUMENTED IMPACT TESTING

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Four different calibration methods for instrumented impact test were investigated. These methods are: static calibration with different load induction, comparing the calculated and measured energy, dynamic calibration with a strain rate insensitive material and with low-blow test on a high strength steel. On the basis of our experiences these methods are compared.

INTRODUCTION

In the existing standard recommendations different calibration methods are proposed for calibration of the instrumented tup. The ASTM recommendation (1) proposes dynamic calibration with a strain rate insensitive material having known maximum load or with a known total absorbed energy standard material. The DVM-001 (2) recommends static calibration with the tup built into the hammer assembly. In practice another dynamic calibration procedure is widely used:equating the measured energy to the energy calculated from the apparent load-time or load-displacement curve (Ireland (3), Winkler (4)). In reference (3) the low-blow test is mentioned as a posssible dynamic calibration method of instrumented tup.

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EXPERIMENTS AND RESULTS

The calibration experiments were performed on instrumented tup of PSD 300/150 type impact pendulum at Material Testing Laboratory at University of Miskolc (machine 1) and some comparative experiments was performed on a similar machine at Research Centre Rossendorf (machine 2).

1. Static calibrations

1.1. Loading the demounted instrumented tup with a continuously increasing load on a servohydraulic testing machine, measuring the load of the servohydraulic machine (P_s) and the voltage signal of the tup instrumentation (U_t) through their own amplifier, a static calibration factor can be calculated:

$$C_{s1} = \frac{P_s}{U_t} \quad \text{(N/V)} \qquad (1)$$

1.2. Loading the built-in instrumented tup with a given load, another static calibration factor can be determined (C_{s2}) similarly as above mentioned.

2. Dynamic calibrations

2.1. Supposing, that the energy calculated from the load-time record is equal to the measured energy, a dynamic calibration factor can be calculated taking into account the changing in hammer velocity during impact (4):

$$C_{d1} = \frac{mv_o}{T_f} \cdot \left[1 - \sqrt{1 - \frac{E_d}{\frac{1}{2}mv_o^2}}\right] \qquad (2)$$

2.2. With a maximum load calibration procedure on strain rate insensitive Al alloy 6061-T651 specimens, according to Recommendation ASTM E24.03.03 (1), at first an average maximum load was determined by static slow-bend test: $P_{max} = 6086 \pm 50$ N. Then the maximum voltage value of the load cell during impact was measured (U_m, V) and the dynamic calibration factor can be calculated:

$$C_{d2} = \frac{P_{max}}{U_m} \qquad (3)$$

2.3. Low-blow tests with different impact velocities (up to 0.71 m/s) were performed on a high strength steel unnotched Charpy specimen ($\sigma_{yS} \approx 2000$ MPa). In case of only elastic deformation of the specimen the kinetic energy of the hammer before impact is equal to the elastic energy calculated from the area under load-time curve up to maximum load. Supposing, that the average velocity of the hammer is equal to $v_o/2$, the dynamic calibration factor is:

$$C_{d3} = \frac{\frac{1}{2} m \cdot v_o^2}{\frac{v_o}{2} \cdot T_m} \qquad (4)$$

The calibration factors determined by the above mentioned procedures are presented in Table 1 for the two different machines.

TABLE 1 - Calibration Factors for Instrumented Impact Machines

	C_{s1} (N/V)	C_{s2} (N/V)	C_{d1} (N/V)	C_{d2} (N/V)	C_{d3} (N/V)
machine 1	9511	-	10880	9746	10042
machine 2	-	22250	-	-	23500

CONCLUSIONS

The dynamic calibration factors determined with different methods are always higher than the static calibration factor. The difference between the static and dynamic calibration factors depends on the dynamic calibration method and is between 2.5% and 14% of the static calibration factor. The differences of the calibration factors of two machines is caused by the different instrumentation characteristics. These results show that further experiments and round-robin tests have to be performed and evaluated for the reliable determination of the dynamic material properties.

SYMBOLS USED

E_d = dial energy (J)

m = mass of the impact hammer (kg)

T_f = integral of the voltage-time record of the instrumented impact test (Vs)

T_m = integral of the voltage-time record up to maximum voltage value in case of low-blow test (Vs)

v_o = velocity of the hammer before impact (m/s)

REFERENCES

(1) Recommendation ASTM E 24.03.03., "Proposed Standard Method of Test for Instrumented Impact Testing of Precracked Charpy Specimens of Metallic Materials", 1980.

(2) DVM-001, "Messtechnische Anforderungen beim instrumentierten Kerbschlagbiegeversuch", Deutscher Verband for Materialprüfung, Berlin, September 1986.

(3) Ireland, D.R., "Procedures and Problems Associated with Reliable Control of the Instrumented Impact Test", Instrumented Impact Testing, ASTM STP 563, American Society for Testing and Materials, 1974. pp. 3-29.

(4) S. Winkler, "Dynamische Kraftkalibrierung von Pendelschlagwerken", Fraunhofer-Institut für Werkstoffmechanik, Freiburg, Januar 1988.