ISSN 2347 - 3983
Volume 8. No. 10, October 2020
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter1438102020.pdf
https://doi.org/10.30534/ijeter/2020/1438102020

Study of material impact strength

Olga A. Sorokina[1], Daniil D. Melnikov[2], Marina N. Bulaeva[3], Anna V. Lapshova[4], Elena A. Chelnokova[5]
[1]Kumertau branch of Orenburg State University, Kumertau, Russia, e-mail: olya-sorokina@bk.ru
[2] Bashkir State University, Russia, Ufa, Russia, e-mail: meln-alena@yandex.ru
[3]Minin Nizhny Novgorod State Pedagogical University, Nizhny Novgorod, Russia, e-mail: bulaevamarina@mail.ru
[4]Minin Nizhny Novgorod State Pedagogical University, Nizhny Novgorod, Russia, e-mail: lapshova_av@mininuniver.ru
[5]Minin Nizhny Novgorod State Pedagogical University, Nizhny Novgorod, Russia, e-mail: chelnelena@gmail.com

ABSTRACT

When evaluating the service properties of structural and tool steels, it is of great importance to identify the characteristics of mechanical properties. Today there are a large number of impact testing methods, but the most widespread and relevant method is the method of measuring the impact strength. This method in dynamic impact bending tests serves as the main practical method for assessing the tendency of steel to brittle fracture. The article presents a study to determine the upper and lower critical temperatures of brittleness of carbon steel and the effect of temper brittleness on the impact strength of alloy steel.

Key words: toughness, alloy steel, carbon steel, brittle fracture, impact bending.

1. INTRODUCTION

Determination of the impact strength of materials is a significant process in many branches of life. For example, to determine the reliability resource of metal structures. The main requirements for metal structures put into operation at low climatic temperatures are to ensure the cold resistance of materials [1]. And this means preventing the appearance of destruction in structural elements. Impact toughness is important for welded structures as one of the parameters characterizing the cold brittleness of metals and alloys that protect against brittle fracture.

«The objectives of the study are to determine the upper and lower critical temperatures of brittleness of carbon steel, as well as to study the effect of temper brittleness on the impact strength of alloy steel. Appropriate equipment was used for the study:
- pendulum pile driver;
- samples from alloy and carbon steel for impact testing;
- vernier caliper;
- furnace for heating samples and a chamber for cooling them» [3].

The need to conduct research to determine the impact strength of materials is due to the interest in increasing the strength of structures and preventing their premature wear.

2. THEORETICAL FRAMEWORK

Pendulum impact testers are most often used for testing impact strength [2]. Figure 1 depicts an impact bending test setup.

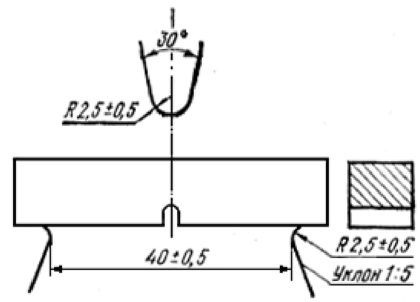


Figure 1: Impact bending test scheme (according to S.V. Matrenin)

External factors, under the influence of which the material becomes brittle, include:
- increasing the rate of deformation (increasing the number of shock loads);
- lowering temperatures;
- the appearance of biaxial and triaxial stress states;
- the formation of various cracks, notches - factors called stress concentrators.

Stress concentrators are increased local stresses in places of sharp changes in the shape of an elastic body or in areas of contact between parts.

«The increased content of phosphorus, which is concentrated along the grain boundaries (with a coarse-grained structure, if there are carbides along the grain boundaries and banding), the susceptibility of steel to brittle fracture increases» [3].

3. RESULTS AND DISCUSSION

To conduct the study, it was necessary:
- determine the critical temperatures of steel hardness;

- to investigate the effect of temper brittleness on the impact strength of steel.

For this:

- the parameters of the sample were measured (length and cross-sectional area at the notch);
- the pendulum was lifted and fixed over the latch;
- the sample was installed on the template supports;
- the scale determined the value of the work of destruction of the sample;
- the value of the impact strength of the material has been calculated.

Also carried out:

- impact tests of a series of samples made of carbon steel;
- for each temperature the impact strength of the material is set;
- the percentage of the viscous component on the fracture surface is determined for each test temperature;
- a graph of the temperature dependence of the impact toughness of the steel under study and the percentage of the fibrous component on the fracture surface was built;
- determined the upper and lower critical temperatures of steel brittleness according to the graphs;
- the results are compared.

«Research done for alloy steel:

- shock tests were carried out in the temperature range of temper brittleness of alloy steel specimens after quenching and tempering carried out with slow and fast cooling;
- the impact strength values are compared,
- summarized the results of research» [4] on the effect of temper brittleness on the impact strength of steel and the type of fractures.

To determine the impact toughness of welded For the manufacture of samples, samples were prepared from the sheet steel of the joints, samples were made in the areas of the weld metal (MW), the heat-affected zone (ZTV) and the base metal [1].

The impact bending test is based on the failure of a specimen with a stress concentrator in the middle in one impact of a pendulum impact device. The ends of the sample are located on the supports. Figure 2 shows a sample (according to G.V. Klevtsov).

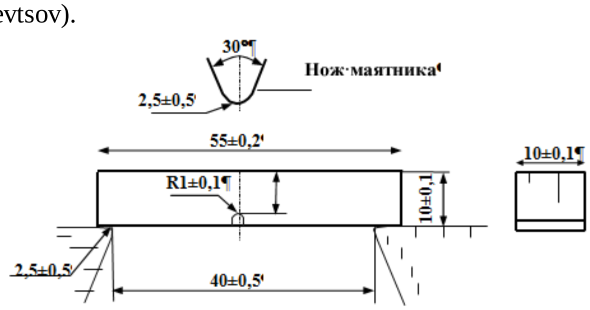


Figure 2: Impact test specimen shape and size

The tests are carried out on a pendulum impact machine of the MK type. Figure 3 shows a diagram of the M-30 pendulum headframe (according to G.V. Klevtsov).

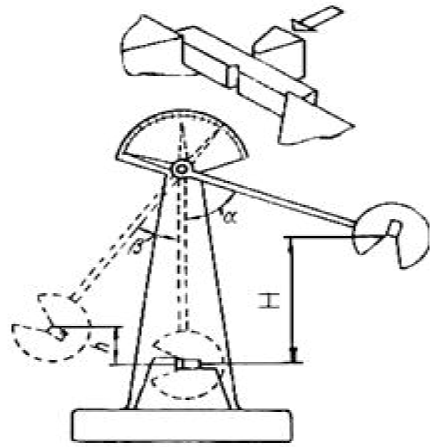


Figure 3: Impact bending scheme on a pendulum impact frame

The pile driver consists of a heavy pendulum, which swings freely on its axis, and a template, which ensures the installation of a notch in the middle of the pendulum knife span between its supports [4]. The pendulum swings freely and destruction is carried out [5]. The sample is installed on the lower supports of the copra. The pendulum strikes from the side opposite to the cut [6].

In dynamic tests, the principle of similarity is not implemented; therefore, these tests have a clear framework and unification both in terms of the parameters of the samples and in terms of the experimental conditions [7].

Cold brittleness is characterized by the transition of metals with decreasing temperature from a plastic state to a brittle one. The critical brittleness temperature is the most important factor in this process [8]. Cold-brittle materials include materials with a bcc lattice. Materials with an fcc lattice do not exhibit pronounced brittleness [9]. A large number of materials in the bcc lattice lose their plastic properties during the ductile-brittle transition [10]. On the surface of ductile-brittle fractures, the fraction of the brittle component increases.

There are two main groups of methods for assessing critical temperatures [11]. «The first group includes methods based on the study of the temperature dependence of the mechanical characteristics of the investigated materials under dynamic loading» [3]. To determine the critical temperatures of brittleness, the temperature dependence of the impact toughness of standard samples is used [13]. This curve has the shape of S and allows you to determine both the upper and lower critical brittleness temperatures as in Figure 4 (according to G.V. Klevtsov).

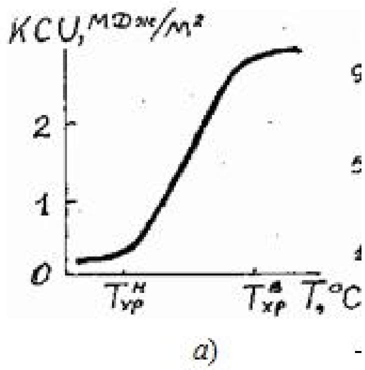
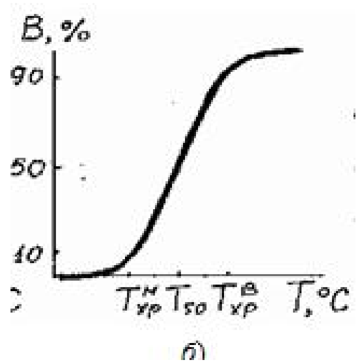


Figure 4: Temperature dependence of impact strength KCU

This method can be considered the most common in the current inspection of quality control of steel melting. The second group of methods includes fractographic methods based on macro and microfractographic analysis of fractures [14]. When using these methods, the proportion of the viscous component in the fracture is determined as in Figure 5 (according to G.V. Klevtsov).



. **Figure 5:** Temperature dependence of the viscous component at the fracture

Fractographic methods are also based on determining the length of the stable viscous zone [15].

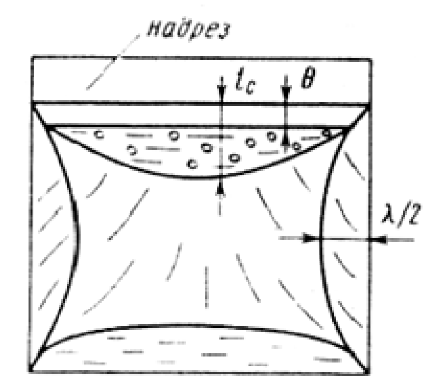


Figure 6: Structure of a fracture resulting from shock loading (according to G.V. Klevtsov)

Figure 7 shows the temperature dependence of the length of the viscous zone.

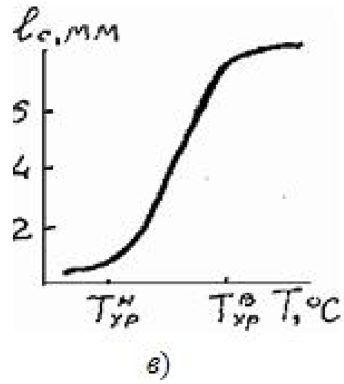


Figure 7: Temperature dependence of the length of the viscous zone (according to G.V. Klevtsov)

Under some tempering conditions, the embrittlement of steel is called temper brittleness. In this case, two types of temper brittleness are observed. The first type of brittleness is irreversible, the second - reversible, which were determined by impact bending tests at room temperature. In this case, the impact strength does not change monotonically. Figure 8 shows that the impact toughness changes nonmonotonically (depending on how fast the cooling occurs).

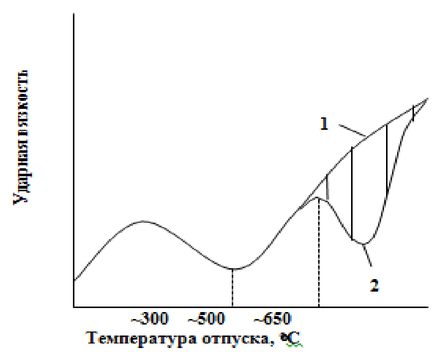


Figure 8: Diagram of the dependence of the impact strength of steel on the tempering temperature (according to G.V. Klevtsov)

Steel tempered in the temperature range of the order of 300-350 ° C has the minimum impact strength. This phenomenon arises due to the volumetric stress state, which is obtained during the homogeneous decomposition of martensite.

The fracture of steel is fibrous, which is characteristic of the tough state. After slow cooling from temperatures of 500-650 C °, the steel acquires a brittle metal fracture. Repeated tempering at temperatures of 600-650 C °, followed by rapid cooling, eliminates fragility of the second kind. Such brittleness occurs in steels alloyed with magnesium, silicon, chromium, which contain an increased amount of P and As, or with the simultaneous introduction of chromium, nickel or manganese into the steel.

4. CONCLUSION

Conducted impact bending studies are one of the most sensitive control methods that can detect the smallest changes in the state of metals. The resulting carbide particles do not have time to acquire a granular structure. The residual austenite is transformed into tempering martensite. And steel, having a state of irreversible temper brittleness, has a shiny intergranular fracture.

Brittleness of the second kind occurs in steels alloyed with carbide-forming elements, when cooled in a furnace or in air after tempering at temperatures of 500-550 C ° or with a sufficiently long exposure at these temperatures.

Tempering brittleness of the second kind reduces the work of initiation and propagation of cracks in steel. This type of brittleness does not appear upon rapid cooling. Impact testing is an important addition for the study of low and medium carbon steels.

REFERENCES

1. I.I. Sannikov, D.F. Kovrova, E.P. Ustinov Research of impact strength constructional steel and the welded joints which are operated in the conditions of far north. International research journal. No. 6 (37). 1.P. 71-74. 2015.
2. S.V. Matrenin Impact strength tests: Method. decree. by execution lab. works on the course "Mechanical and physical properties of materials" - Tomsk: Ed. TPU, 11 p. 2009.
3. G.V. Klevtsov. Fractodiagnostics of the destruction of metallic materials and structures: textbook. allowance / G.V. Klevtsov [et al.]. - M.: MI-CC, 2007, pp. 264.
4. Erofeev V.V., Sharafiev R.G., Kulnevich V.B. Ensuring fire safety of technological equipment of agricultural facilities based on the use of new fire retardant materials. Bulletin of the Chelyabinsk State Agroengineering Academy. 57.2010.77-84.
5. O. A. Andrienko. Network educational technologies and their use when working with students. *Humanitarian Balkan Research 2019*, 1(3), 5-7. 2019.
6. Z.V. Smirnova, O.I. Vaganova, S.N. Kuznetsova, O.V. Golubeva, M.S. Mikhailov. Kinematic calculation of gear reduction gear. **International Journal of Emerging Trends in Engineering Research**. 2020. 8. № 6. C. 2422-2425.
7. O.T. Cherney, Zh. V. Smirnova, M.L. Gruzdeva, E.A. Semakhin, O.I. Vaganova The tendency of high-strength aluminum alloy 1933 to corrosion resistance. **International Journal of Emerging Trends in Engineering Research**. 2020. T. 8. № 6. C. 2293-2295.
8. O.YU. Donetskova, (2019). Modernization of the modern education system in Russia. **Baltiyskiy gumanitarnyy zhurnal** *(Baltic Humanitarian Journal)*, 8, 2 (27), 37-39. (in Russ.).
9. O.O. Chertovskikh, (2019). Prospects for the use of digital resources in education. **Baltiyskiy gumanitarnyy zhurnal** *(Baltic Humanitarian Journal)*. 8, 4 (29), 184-187. (in Russ.).
10. G. T. Klinkov The specificity of manifestation of pedagogical communication as a special construct. *Scientific Vector of the Balkans*, 1, 51-52, 2018.
11. A. A. Sukhikh, T. M., Makhneva, V. B. Dement'ev **Austenite in nanostructured maraging steel,** *Inorganic Materials: Applied Research*, vol. 10, no. 4, pp. 966-973. , 2019.
12. I. F. Filchenkova**, Educational management of innovative activity of teachers as an object of pedagogical research.** *Vestnik Mininskogo universiteta* (*Vestnik of Minin University)*, 2019. 7 (4), 3. (in Russ.). 2019.
13. C. Santhosh, K. Hari Kishore, G. Pavani Lakshmi, G. Kushwanth, P. Rama Krishna Dharma, Teja, R. S. Ernest Ravindran, S. V. Cheerala, M. R. Kumar. Detection of Heavy Metal Ions using Star-Shaped Microfluidic Channel. **International Journal of Emerging Trends in Engineering Research**, 7, No. 12. 2019.
14. A. Zakaria, M. S. N. Ibrahi, **Experimental Evaluation of Multiple Savonius Turbines in Oblique and Cluster Configuration**, International Journal of Emerging Trends in Engineering Research, 7, No. 12. 2019.
15. A.V. Kirjukhin, O. O. Milman, A. V. Ptakhin, V. D. Kuprjashov, **Efficiency of Schemes of Active Broadband Damping of Vibration Forces Transmitted by Vibration Insulation to the Foundation**, International Journal of Emerging Trends in Engineering Research, 7, No. 12. 2019.