Stainless steel under impact test

A. Hadjoui[1], M. Benachour[1], F.Z. Seriari[2], N. Benachour[3]

Summary

The stainless steels remain not easily replaceable taking into consideration their high mechanical characteristic (capacity resistance, hardness and impact resistance) what their offer to be used in significant fields such as the nuclear power, the storage of the chemical products... This work presents an experimental study of the behavior of austenitic stainless steel 316L under the impact test. The various tests with the impact were led to various temperatures. The increase in the temperatures shows their effects on energy of fracture and tenacity. The Charpy test specimen are used where the influence of the angle and the depth of the notch were studied. The results thus presented show the effect of the temperature on the ductile behavior of this material.

Introduction

Stainless steels are primarily of steel, ie metal alloys Fe-C. The inoxydabilité comes from the addition of item (s) very oxidizable (s) having the effect of surface forming a thin layer of oxide (s), the film liabilities, which insulates the metal officers more or less aggressive the environment. Thus, the addition of chromium, the essential element to the corrosion of steel, led to the development of various grades of steel, then stainless qualified. For the phenomenon of passivity of a steel can establish and sustain, it is necessary that the alloy has a minimum chromium content in the range of 10-11%, chromium is in solution [1]. Beyond this concentration, steel form spontaneously in the surface layer and protective continues chromite Cr_2O_3. The film thickness of several nanometers is strongly solidarity with the substrate and, in case of damage locally, it has the property of being able to recover in many circles, owned by auto passivation.

Austenitic stainless steels at ordinary temperature retain CFC austenitic. These steels are the group most stainless steels used in practice. Outside of chromium which ensures the inoxydabilité, nickel is the largest of the alloying materials mainly because of its genre. Austenitic stainless steels are commonly called 18-8 or 18-10 of after their respective levels chromium and nickel [2]. Different parameters affect the formation of precipitates of stainless

[1] Automatic Laboratory, Dept. of Mechanical Engineering, Univ. of Tlemcen, Algeria
[2] Department of Mechanical Engineering, Univ. of Tlemcen, Algeria
[3] Department of Mechanical Engineering, Univ. of Tlemcen, Algeria

steel such as: temperature, chemical composition, time of precipitation [3, 4]. This precipitation affects the fracture behavior.

Much empirical evidence had been accumulated by the 1920/1930s which showed that high strain rates applied at temperatures close to or somewhat below room temperature in the presence of notches were more likely to result in brittle or sudden failure [5]. This issue was highlighted in a number of catastrophic failures in steel structures and whilst the science of fracture mechanics increasingly allows a rigorous approach to designing against brittle fracture in steel structures, the Charpy test remains as a well recognized method of specifying steel quality. After the mid 1950s, Charpy testing became an essential part of steel specification. Empirical correlations have been shown between Charpy value and service performance. Temperature is the one parameters effect used and presented in the. The temperature effect between 20 and 600°C was made for an austenitic stainless steel 316L under a specified environment [7].

The aim of this work is to shown the effect of temperature, dimension of notch of the stainless steel 316L under impact test (Charpy testing).

Material and impact tests

The Charpy test provides a measure of the energy required to break a material under impact loading. It was first standardized some 60 years ago to allow comparison between different types of steel made from a variety of manufacturing processes. The test consists essentially of a hammer with a given amount of energy striking a notched test piece of fixed dimensions and recording the energy required to fracture the test piece at a specific temperature and recording whether the fracture mode was ductile or brittle.

Test specimens of stainless steel 316L were obtained from 12 mm thickness plate, which were produced by rolling. Chemical composition of the studied material is shown in table 1 and mechanical properties are shown is table 2 obtained by tensile tests [6].

Table 1 Chemical composition of 316L in wt%

Fe	Cr	Ni	Mo	Mn	N	S	C	Si	P
62÷72	16÷18	10÷14	10÷14	2÷3	0÷1	0÷0.3	0÷0.3	0.75	0÷0.45

Table 2 Mechanical properties

σ_e (MPa)	$\sigma_{0.2}$ (MPa)	σ_r (MPa)	E (GPa)	A%	Z%
378	390.54	710	186.75	51.5	50

Impact test (Charpy testing) was performed on pendulum mouton "Charpy 300J" shown in figure 1. The machining of the Charpy specimens are obtained in two orientations L-T and T-L where the notch are U and V.

The variation of temperature test is obtained by using an electric furnace (figure 3). The Charpy specimens are heated to 500°C and maintained at one hour before the test. Temperatures are measured before each test once the specimen deposited at the sheep pendulum through an electronic thermometer.

Figure 1 Charpy pendulum

Figure 2 Dial reading of Charpy pendulum

Figure 3 Electrical furnace

Experimental results and discussions

Once the testing, the absorbed energy is determined on the dial reading (Figure 2). The absorbed energy is used to determine the toughness of the material by the relationship:

$$K = \frac{W}{S} \tag{1}$$

W is absorbed energy and S the section of the specimen.

L-T specimen orientation

Figure 4 shows the variation of the tenacity as a function of temperature U-notch specimen. The increase in temperature from 25°C to 200 °C permits to increase the tenacity of the material. Between 25 ° C and 80 ° C is the constant tenacity, this present the ductile stage. The tests on the V-notch specimen (V60°) (Figure 5) also show the ability to resistance shock by increasing the temperature up to 200 ° C. Between 100 ° C and 150 ° C, tenacity is almost constant which is reflected the same micro structural resistance.

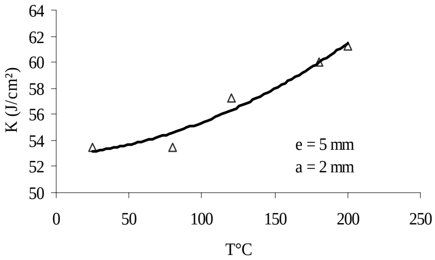

Figure 4 Tenacity in U-notches specimen in L-T orientation

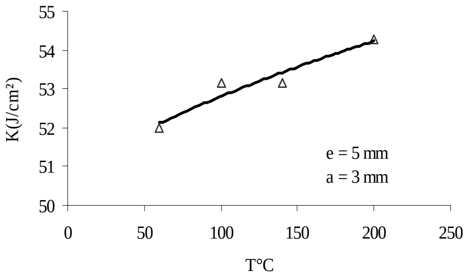

Figure 5 Tenacity in V-notches specimen (V60°) in L-T orientation

T-L specimen orientation

The impact test performed on specimens machined in T-L orientation (Figures 6-8) shows the same variation of change of tenacity. A slight augmentation of the tenacity is noticed between tests at room temperature and tests at temperatures above nearby. This increase is due to micro structural changes. The resilience has been increased and the material is more ductile.

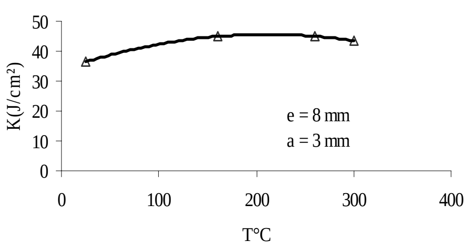

Figure 6 Tenacity in U-notches in T-L orientation

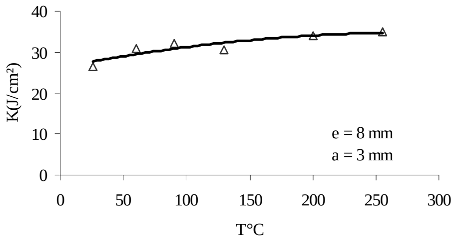

Figure 7 Tenacity in V-notches specimen (V45°) in T-L orientation

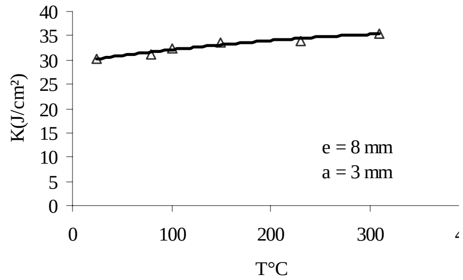

Figure 8 Tenacity in V-notches specimen (V60°) in T-L orientation

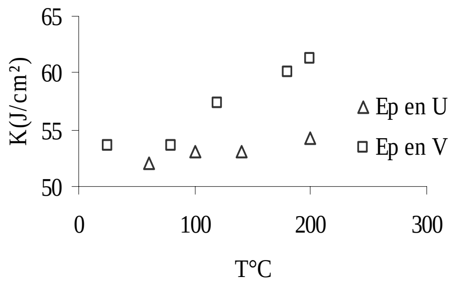

Figure 9 Notch effect (Thickness 5 mm)

Notch effect

Experimental results show the variation in the shape of the notch impact on the capacity of resistance to shock. Figure 9 shows a lighter variation of the tenacity for U-notch and V-notch specimen (V60°C) with 5 mm of thickness. At high temperatures, a difference on the tenacity is important. The increase in the thickness affects the variation of tenacity (figure 10). The variation of the depth of the notch showed the lower variation of the tenacity (figure 11).

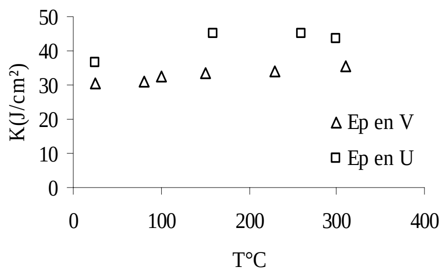

Figure 10 Notch effect (Thickness e = 8 mm)

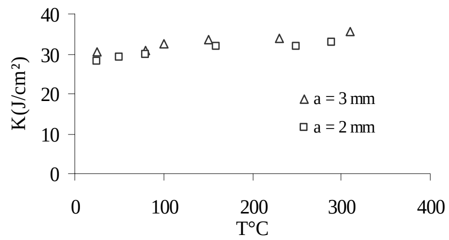

Figure 11 Depth notch effect (V-notch)

Conclusion

The influence of temperature on impact resistance of stainless steel 316L was investigated by performing Charpy tests experiments in the temperature range 20–300°C. The increase in the latter makes the material 316L ductile. The influence of different geometric parameters were highlighted namely the shape of the notch (U or V), the angle notches. For the same temperature and thickness, the U-notch specimen presents greater resistance comparatively to the V-notch specimen. For the same V-notch specimen, the increase of the angle provides superior toughness (tenacity).

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