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Compressive strength of Aluminum-copper alloys at different temperatures

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Abstract

An Al-Cu alloy developed for applications requiring an alloy of moderate strength, weldability and good resistance to sea water, it is an excellent, versatile alloy ideal for many applications. The results obtained show that the level of spring back is strongly related to the imposed boundary conditions. If he is conceivable to overcome this problem by a "practical" tool for single curvature panels, it seems more delicate for double tooling curvature. In conclusion, if the prospects offered by this type of process seem attractive, a vast campaign of digital investigations must be considered in order to define more precisely the limiting radii of curvature that can be achieved without causing problems with spillage or buckling of the stiffeners, especially for double curvature applications. The boundary conditions considered should be able to be reproduced experimentally during shaping.
For high strain rate testing, the only usable method to obtain information about the distribution of strains in the specimen is the use of high-speed photography. This method is used to visualize the location of deformations and fracture and also to measure the deformations of the specimen. The use of ultra-fast photography for large-scale tests strain rates can be performed in order to qualitatively study the behavior of materials. The proposed new geometry for the specimen will be modified by the use of high-speed photography.

Keywords: *Aluminum copper alloys, Compressive strength, Strain rate, Plastic deformation, Aerospace material*

1. Introduction

The materials of aerospace differ with the precise component under condition. The aerospace materials design depends upon the design necessities such as geometric limits, loading type, maintainability, ability of manufacture and environmental features.
High purity aluminum has high ductility associated with low mechanical characteristics. Its hardness can be significantly increased by additions of metallurgical elements which cause the formation of aluminum alloy. In general, the behavior of aluminum alloys is quite similar to that of pure aluminum, but differences may occur depending on the composition (purity and alloy family) and metallurgical states.
Plastic deformations of materials with high strain rate are often described by a constitutive law expressing the constraint as a function of the strain rate, strain and sometimes temperatures. The objective main of current work is characterizing the thermomechanical performance of aluminum copper alloys at different strain rates and temperatures. An objective secondary is to apply the results of the characterization to hot forming quasi-static. The behavior aluminum alloys are dependent on the thermo-mechanical process due to the formation of precipitates. the mechanical properties under compressive loading were examined in the temperature range from (20 - 400) °C. The dealings between dislocations and precipitates are found to vary with the strain rate.
Aluminum – Copper alloys are mostly alloyed are treatable by heat to strength them comparable to high strength materials such as steel. Copper dissolved in the Aluminum to forms (Al_2Cu) compound. The precipitation of copper results in higher strength. Weight reduction and an improvement of aircraft engine have been the driving forces in development of engine materials. The materials of engine are required good mechanical properties in a high temperature, destructive environment and low densities to weight reduction. Aircraft turbine engines consist of hot sections combustion turbine, chamber and cold sections casing, compressor, fan which require high specific strength and corrosion resistant materials. The hot and cold sections of engines work are working at different temperatures. Cold section components. The aerospace materials are restricted by the mechanical properties such as strength, which is not satisfy the increasing demand.

Strain hardening increase in strength and hardness caused by plastic deformation at below recrystallization temperatures. Strain hardening is limited ability of material to harden with increasing level of strain and is an important property enhancing the formability of metals. The strengthening is a result of dislocation-dislocation interactions and dislocation multiplication. The hardening depends on the energy of plastic deformation expended in a deformation process. It is incontestable that the reliable proposed flow stress model is more caring a wide range of strain rates and elevated temperatures for design.

2- Experimental procedure

In this study the behavior of the (Al-Cu) alloys (table 1) at elevated temperatures were examined to simplify characterization of materials at high temperature and high strain rate, this procedure the limitations and principles of the samples and equipment for work on the raised up temperature (20, 100, 200, 300 and 400) °C.

Table 1: Composition of Al-Cu alloys

Element	Cu	Zn	Mn	Mg	Al
%	4.6	0.35	0.8	1.2	rest

The thermal behavior of the sample makes it conceivable to bring the cold bars in contact with the heated sample automatically and without using bulky mechanisms, increasing the possibility that the experimentations will be successfully carried out at the chosen temperatures.
In a widespread range of engineering, it is required to guess progression of the (Al – Cu) alloys response through a compressive load under variable temperature and strain rate. However, it is mostly assumed that the mechanical behavior of materials variations under changed values of the temperatures and strain rate. Strain rate (0.05-1) S^{-1} is a main parameter in determining the strength of the material.
The cylindrical specimen (figure 1) is in interaction with the pressure bars and heating it makes temperature changes in the bars, which due to changes in their mechanical properties.

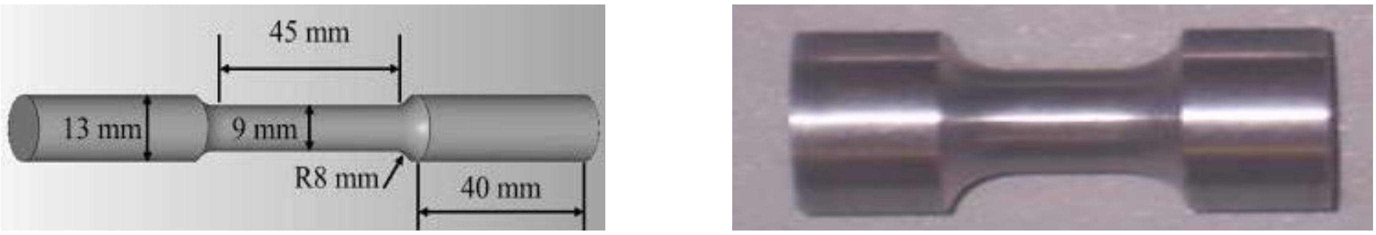

Fig. 1: Dimensions of compressive sample

3- Results and Discussion

Figure 2 shows the specimen before and after deformation. Note that the central part of the specimen is domed. This tumbling phenomenon calls into question the assumption that the deformation occurs uniformly in the sample.

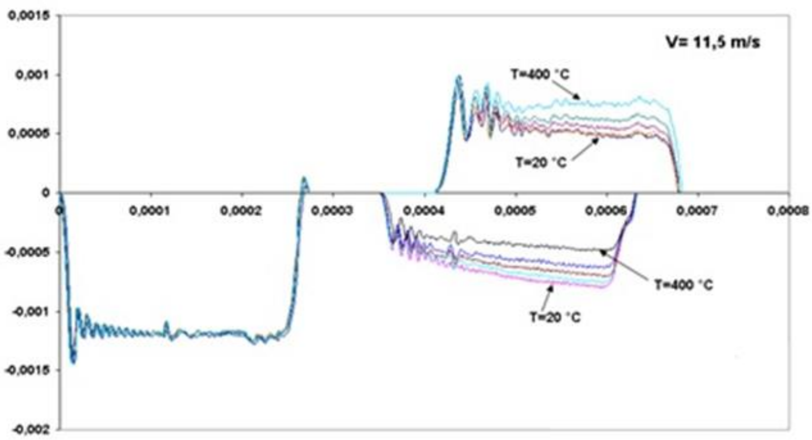

Fig. 2: Experimental signals of the elastic deformation in the bar incident at various temperatures at the impact velocity of 11.5 m/s

At the interfaces, the sum of the forces at the boundary nodes is recovered to compare it to the measurement during the test. An optimization of the force is made by comparing the experimental forces calculated and applied by the incident bars (figure 3).

These figures show that the level of stress decreases with temperature and, therefore, it can be noted that the increasing in temperature causes a reduction in flow stress for a constant strain rate. For a constant temperature, yield stress normally increases with strain rate led to an increasing in dislocation multiplication rate and dislocation density.

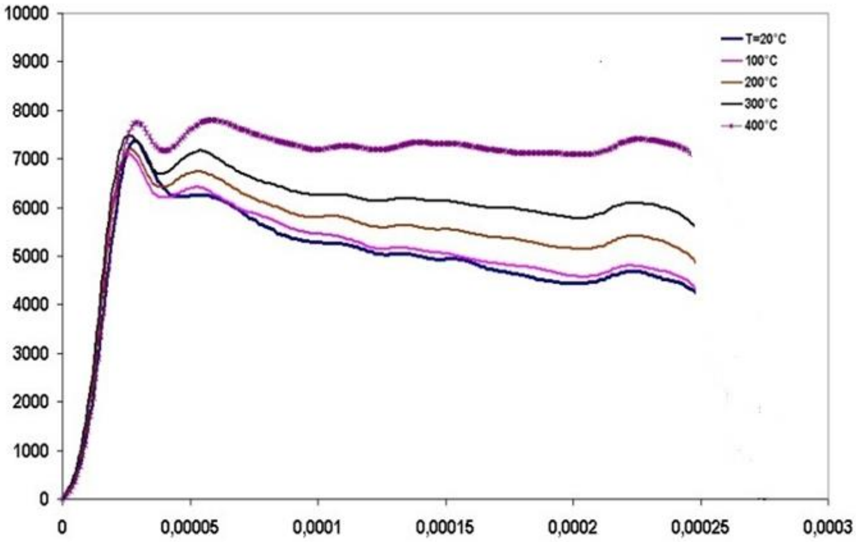

Fig. 3: Experimental speeds applied to the interface of the simplified model for various temperatures at impact velocity 11.5 m/s of aluminum copper alloys

The cracked samples and the gotten flow stress-strain data are showed in (figure 4) Afterward, the elastic area was removed from the flow stress-strain curve so as to get the accurate plastic flow stress-strain data for the persistence of estimation of the constitutive model parameters. We observe a very weak influence of in the direction of rolling compared to the direction of tension, on the values of the modulus of elasticity. These figures illustrate the influence of the speed of deformation for three characteristic temperatures encountered in different strain rate.

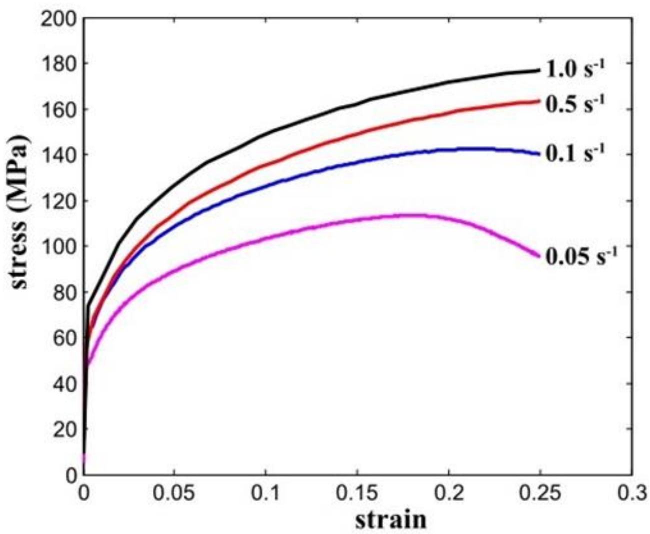

Fig. 4: stress-strain curves of aluminum copper alloys

4. Conclusion

The objective of this research work was to study the behavior of metallic materials in high strain rate at high temperature. A bibliographic study made it possible to direct our work towards tests on Hopkinson compression bars. To carry out the hot tests, it was necessary to set up means of investigation at high temperature.

Heat generated by plastic deformation in the specimen during testing at high strain rates does not have time to dissipate during loading. It is for this reason that such tests can be considered adiabatic. It is therefore particularly important to know the temperature if one wishes to study the dynamic behavior.
A temperature measurement of the specimen can be made using an infrared camera or infrared radiometry device to track the estimated temperature rise in the specimen.
A temperature characterization of the elastoplastic behavior of the aluminum copper alloy was carried out from tensile and relaxation tests. Another phenomenon, very penalizing, in the range of manufacture envisaged in these hot forming processes is the observed spilling of the stiffeners. This spill is all the more important as the stiffeners modeled here have an asymmetric section. However, the importance of the problem raised here should be weighed in the sense that the radius of curvature of the tooling modeled in the present study is low (2 m).

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