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THE APPLICABILITY OF THE METHOD AS-CFD INTO THE ANALYSIS OF DUCTILITY AND DISTRIBUTION OF STRESS OF AN ALUMINIUM ALLOY

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Abstract: The aluminium alloys become increasingly higher into the metallic materials category for transport, aerospace, electrochemical, electronics and microelectronics, chemical, industrial and civil construction industries and so on, mainly due to high ratio between mechanic strength and density, high corrosion resistance, thermal conductivity and electrical which were perfectly raised. The research of aluminium alloys can be done through direct physical and chemical laboratory methods, but also through indirect methods that highlights the research through simulation and physical or mathematical modelling. Autodesk Simulator is a programme for simulation which can help us determine physical characteristics, mechanical properties of certain processes, materials or complex installations so that we can give an overview and insight into the future in terms of the property of the element studied but also the economic benefits. The paper presents the authors' personal research over the significant qualitative characteristics of certain aluminium alloys through simulation and modelling using Autodesk Simulator CFD. For the analysis it was used an alloy bar Al-5Ti-B and has been studied its behaviour to a certain magnitude and strength oriented linear on coordinate Ox. The results have a major importance to establish the stress resistance and ductility of the alloy.
Keywords: Al-Ti-B, AS-CFD, ductility, Stress Distribution

INTRODUCTION

Worldwide, improving of aluminium alloys, especially the ones deformable are obtained through finishing grained, inoculating into the melt, before casing, an Al-Ti-B master alloy which contains TiB2 particles and TiAl3.

In this paper it has been chosen an Al-Ti-B alloy and has been studied, using AS-CFD, the stress distribution but also the influence it has on certain areas of material ductility.

AS-CFD programme is widely used in various simulations including in Metallurgy Industry (loading and distribution of raw materials into the furnace, oven, congestions, and the analysis of certain physical properties of ferrous and nonferrous elaboration). Into the Aluminium Industry we can highlight: the influence of chemical composition on the behavior of Al alloys in various processes, porosity analysis static stress etc. All these features can be combined and analysed also in Autodesk Simulation Mechanical (figure 1).

With the help of AS-CFD we can improve the ductility of alloys Al/Al-Ti-B using stress parameters (mechanical characteristics), in our case we have chosen only the unidirectional tests. A similar program has been used by others Japanese researchers [1-4].

Numerical modelling provides lots of information regarding the temperature conditions, stress, mechanical stress, electrostatic to optimize the development process of Al alloys, but also to approach a geometrical position corresponding to the mechanical request according to the product's destination.

MATHEMATICAL MODELLING AS-CFD/AS-M

The geometric model developed into Audesk Professional Inventor consists of a bar of Al-Ti-B of 70cm length (figure 2) and the chemical composition shown in Table 1.

Table 1. Chemical composition used in Al-Ti-B alloys bar

Alloy	Ti	B	Fe	Si	V	Al
Al-5Ti-1B	4.80	0.85	0.09	0.08	0.04	94.14

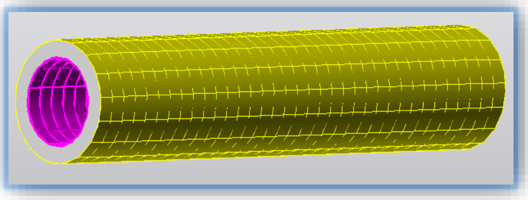

Figure1. AS-Mechanical-Aluminium Bar

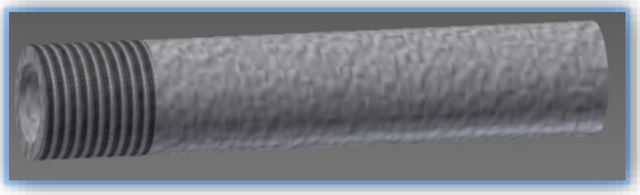

Figure 2. Model used into simulation

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The inner diameter of the hollow Al-Ti-C bar is 5 cm, and 2 cm thick. Kinetics simulation requires the analysis of two models: a process of infiltration, clash, between 2 materials, but also the interaction between particles after the mechanical strain (Figure 3).

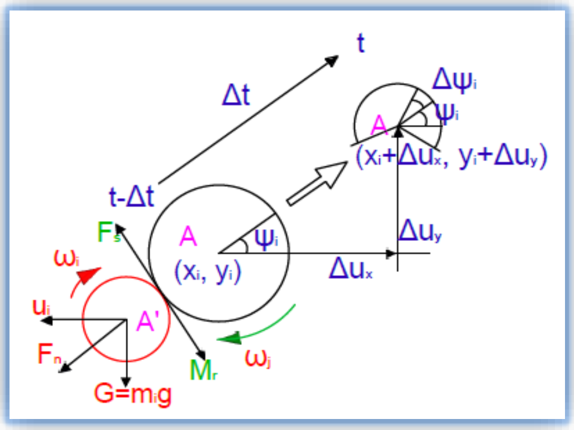

Figure 3. The forces who act between particles and schematic representation of Mathematic model used into simulation AS-CFD

where: M_r - Force moment, Nm, Δt - The time variation, s, F_n - normal force, N, ω -angular velocity, radian/s, G - Force of gravity, N, A, A' - A particle, B particle, ψ -acute angle between direction of mechanical stress and horizontal, rad, Δu- decomposition of particles on a flat surface coordinates 0, X, Y.

RESULTS AND DISCUSSIONS

The simulation was performed with AS-M and AS-CFD for each area tracking the distribution variation of stress onto certain areas. The simulation was carried out into a period of time of 8 seconds for each surface of the work piece to the previous size.

The basic data used are given in Table 2, for materials in Table 3. According with the experiment of this piece it has been acted with a magnitude of 20sqm, and a parallel force with the magnitude of 100N.

Table 2. Mesh settings

Avg. Element Size (fraction of model diameter)	0.08
Min. Element Size (fraction of avg. size)	0.2
Grading Factor	1.5
Max. Turn Angle	60 deg
Create Curved Mesh Elements	No
Use part based measure for Assembly mesh	Yes

Figure 4 shows stress vectors analysed according to AS-CFD on the 3 axis X, Y, Z, as well as the plot vector of interference stress length. The minimum values are found in the imaginary center of the piece, following that the values to grow symmetrically on the sides of the piece. Following the simulation we have obtained minimum and maximum values, according to Figure 5 there are 2 maximum vales, one of them more pronounced due to the use of F force in the direction of action of magnitude of Ox axis.

Table 3. Material(s)

Name	Aluminum 6061	
General	Mass Density	2.71 g/cm^3
	Yield Strength	275 MPa
	Ultimate Tensile Strength	310 MPa
Stress	Young's Modulus	68.9 GPa
	Poisson's Ratio	0.33 ul
	Shear Modulus	25.9023 GPa
Part Name(s)	Piesa1	
	Piesa1	

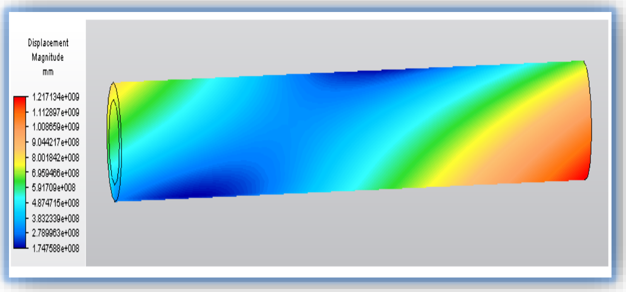

Figure 4. Stress distribution according to the analysed parameters.

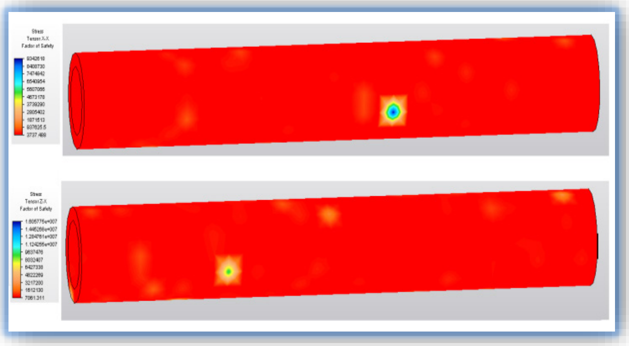

Figure 5. The tensor's stress variation on axis XX and ZX

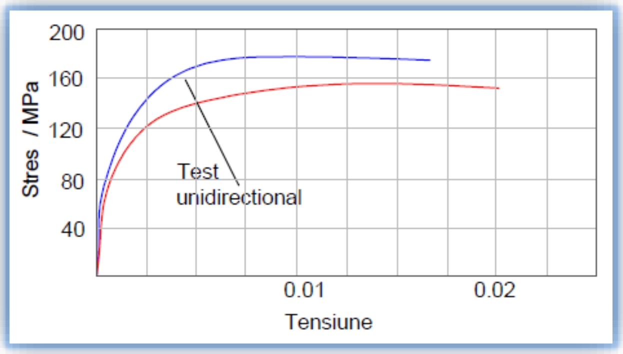

Figure 6. Curve of voltage-stress parameters of the experiment

From Figure 6 we can see that following the attempt to a magnitude of 20sqm, the unidirectional simulation test has raised to a closer value to alternative value given in the first place by the experiment (in our case highlighted with a red line). For a smaller diameter of the piece, the result was with 0.004 smaller than the results obtained to the alternative test (0.02). If it should be used only an Al material, the bar or wire would not *satisfy the conditions of ductility, but into this alloy Al-Ti-B the analysed material will satisfy both requirements: 160sqm magnitude and higher voltage than 0.015.*

According to AS-CFD the coefficient of friction has been set up to a value of 0.1. The calculated values were Al alloy used A16061 with a density of 2.71g/ cm³ and Ti with the density of 4. 51g/cm³ (dates highlighted in conditions of the simulation in Materials Table 3). The magnitude was 310MPa and 344.5MPa max.

Von Mises stress represents an equivalent stress which combines the values of 6 stress values on different individual axis. We can compare the value von Mises with the normal stress value highlighted on the piece to predict the materials breaks with major implications on the ductility of the piece. Under normal frequency, the optional stress and result tension is calculated to return relatives values of distribution stress and tension on the analysed model. Combined with the analysis of plot vector, we can highlight already in Figure 7 the surface in which the percentage of occurrence of a fracture grows, but also the area in which we register small values of ductility on unidirectional tests towards the alternatives.

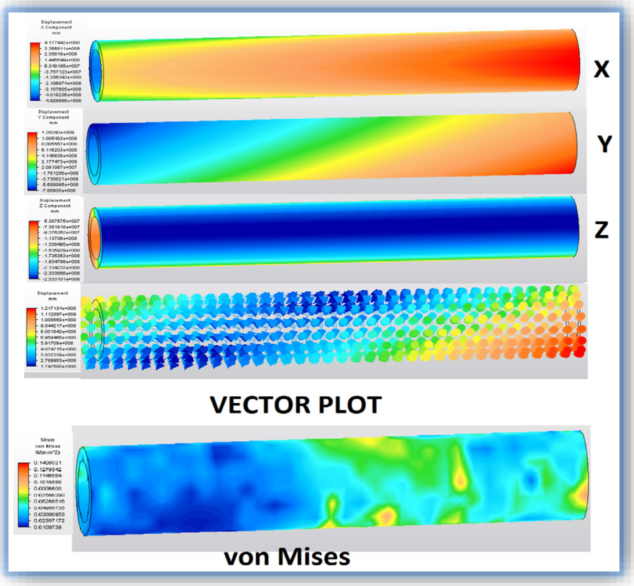

Figure 7. Magnitude distribution on the three axes X, Y, Z, and distribution vector / von Mises stress

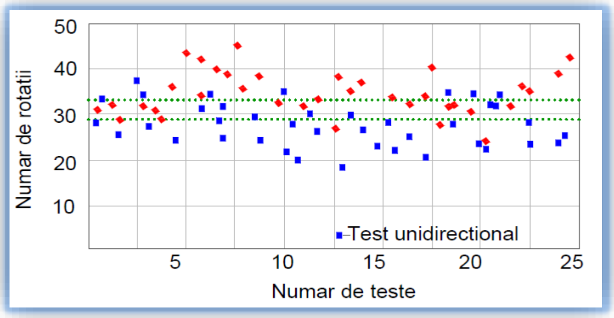

Figure 8. Variation characteristics for determining torsional ductility

Figure 8 shows the twisted values resulted after the simulation. By using the alloy Al-5Ti-B we can observe that the number of rotations per unidirectional test is very close to the same value of the alternative test result. For a given material or wire from Al, the value per rotations of the alternative test must of been almost double, establishing a value with 50% better ductility and stress resistance. Our bar used in the experiment performed talking values almost identical on both test models (29.5rot.-32rot.). These closed torsional values are shown also graphic in Figure 6 through the vector variation of surface von Mises. The figure shows a linearization of the tension distribution on bar/wire, an attempt to behave symmetrically towards both ends and to distribute evenly the tensions which appear, retaining the highest values towards the center of the material.

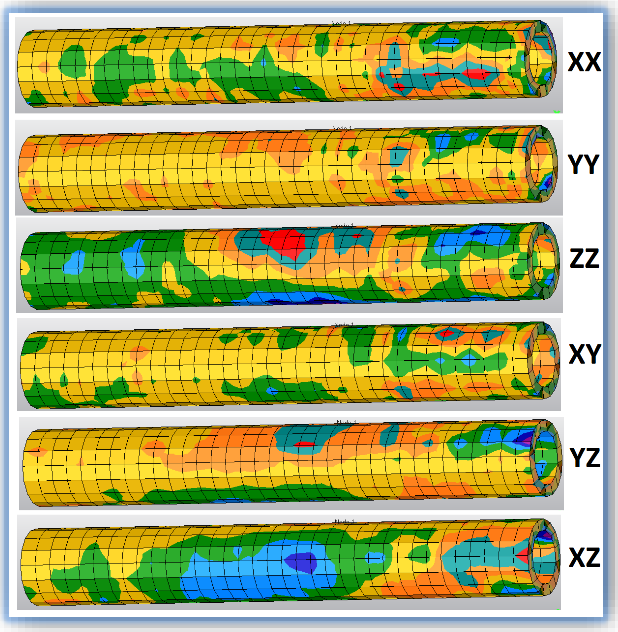

Figure 9. Stress linearization for each component part of barriers and test results.

Figure 9 and 10shows the phenomenon of linearization of stress distributions, the analysis was made with Autodesk Simulation Mechanical 2014 (AS-M) on all the axis of symmetry of the bar to be able to analyse the distribution of charged vector surfaces by a load of 20-160MPa and 100N. On 3 of the axis presented YY, ZY and YZ it can be best observed the phenomenon of linearization of vector distribution to resist to imposed request. Maximum points are shown on axis ZZ and partially on XX, and the minimum points are on XZ axis.

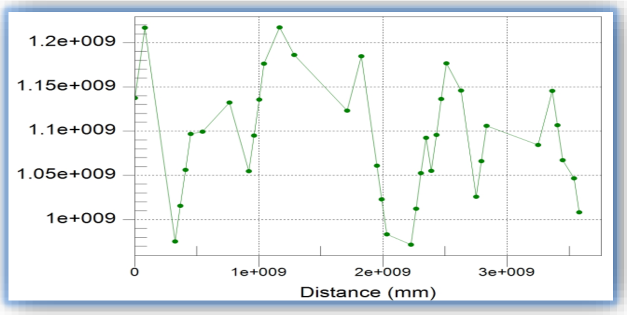

Figure 10. Symmetric variation of stress distribution over a certain distance

In the presented work was analysed according to AS-CFD stress distribution and the importance into the ductility analysis of Al-5Ti-B alloy emphasizing the following:

- *The alternative and unidirectional test values were very close; in our case the unidirectional test was smaller with 0.004 than the one alternative to a value of equalization decreasing value of the tension,*
- *The simulation on the Al alloy has passed the ductility test, resisting to a stress variation higher than 160MPa to a tension greater than 0.015. On this line, the torsional fatigue characteristics recorded improved values.*
- *The ductility values are close to both unidirectional and alternative tests, in the studied alloy produce a linearization on the piece length of stress distribution, which is highlighted by the vector values of surface into the Mises analysis.*

The test showed maximum variations of stress tensor in 2 points of maximum towards the bar center, the piece passing the ductility test: magnitude 160MPa and tension higher than 0.015.

In terms of vector orientation is observed a linearization of stress distribution to the whole surface of the piece, the alloy trying to resist to tension is higher than distributing them equable depending on the piece surface.

In conclusion, the test shows that using this alloy leads to obtaining a very close value for both tests: alternative and unidirectional, which is impossible in case of using only an Al material.

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