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COMPARATIVE ANALYSIS OF STRESS DISTRIBUTION BASED ON ALUMINUM ALLOYS

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Abstract: The research through numerical modeling provides lots of information about temperature, stress, strain and electrostatic condition to optimize the elaboration process of Al alloys, but also to approach a geometric position corresponding to mechanical requests according to the product's destination. The paper presents the author's personal research, using Autodesk Simulator CFD on two Al and Al-5Ti-1B alloy parts differently shaped to evaluate their behavior to a certain force linear oriented on coordinate Ox. The results have a major importance to establish the maximal strasses and strains in the parts made of aluminum alloys.
Keywords: Al, Al-Ti-B, AS-CFD, Stress Distribution

1. INTRODUCTION

The Autodesk CFD Simulator (AS-CFD) is a simulation program that can help us to determine physical, mechanical characteristics of certain processes, materials or complex installations so that we can give an overview and insight into the future in terms of the studied property of the element, but also the economic benefits.

In this paper we have chosen two models of Al materials and Al-Ti-B alloys and studied using AS-CFD the stress distribution but also the influence it has on certain parts of the material.

AS-CFD programme is widely used in different simulation, including also Metallurgy Industry (loading and distribution of raw materials in the furnace, oven, congestion, elaborate analysis of certain physical properties of ferrous and nonferrous materials. The aluminum industry can highlight: the influence the chemical composition on the behavior of Al alloys in various processes, porosity analysis, static stress etc. All these features can be combined and analyzed also in Autodesk Simulation Mechanical (Figure 1).

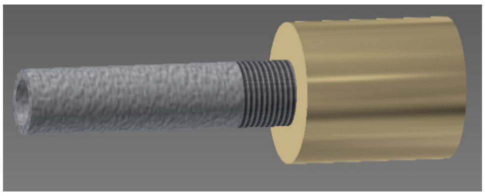

Figure 1. AS-CFD- Al/ Al-Ti-B Bar

With AS-CFD we can improve ductility of Al / Al-Ti-B alloys using stress parameters (mechanical), in our case we chose only unidirectional tests. A similar program was used by some Japanese researchers [1-4].

2. MATHEMATICAL MODELLING AS-CFD/AS-M

The geometric model developed in Audesk Inventor Professional consists in an Al bar of a 70cm length (Figure 1), and the chemical composition shown in Table 1. To highlight the variation of stress distribution we have compared different pattern to a bar of an of Al / Al-Ti-B alloy.

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

The empty inner diameter of the Al bar is 5cm and 2cm thick. The empty inside diameter of the Al-5Ti-1B Bar is 7cm to 8cm thickness bar.

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°
Create Curved Mesh Elements	No
Use part based measure for Assembly mesh	Yes

Kinetics simulation requires an analysis of two models: a process of clash infiltration, between two materials but also the interaction between particles after mechanical strain (Figure 2).According to the AS-AC the friction coefficient has been set to a value of 0.1. The calculated values were used Al alloy Al6061 with a density of 2.71g / cm^3 and Ti with the density of 4.51g / cm^3 (data outlined in the simulation conditions for materials - Table 2). The max magnitude was 310MPa and 344.5MPa.

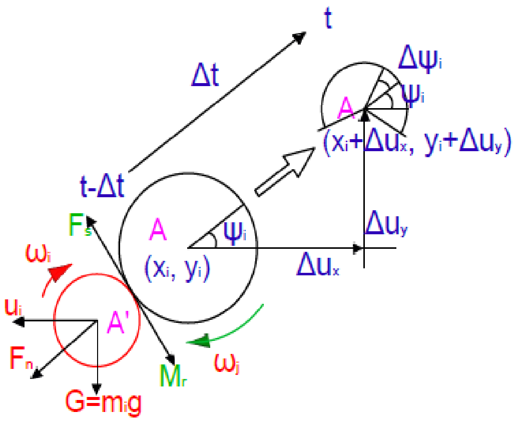

Figure 2. The forces who act between particles and schematic representation of Mathematic model used into simulation AS-CFD

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

Figure 3 shows the stress vectors analyzed according to AS-CFD for the 2 parts: in the first version the Al-Ti-B piece is placed halfway of Al Bar, in the second version two Al-Ti-B alloy parts barriers are placed at the end of Al bar. It can be highlighted areas with a minimum and maximum stress distribution depending on Al-Ti-B piece location: in a first phase in the mid of the assembly (maximum values of voltage tending to gain maximum values at the assembly extremities), in the second phase in the same conditions for applying tension and force to the ends of the assembly (maximum values tend to concentrate toward the end of Al-Ti-B - less subject to the influence of tension - without force-right end).

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, radian, Δu - decomposition of particles on a flat surface coordinates 0, X, Y.

3. RESULTS AND DISCUSSIONS

The simulation was performed with AS-M and AS-CFD for each material pursuing the stress variation of distribution in certain areas. The simulation was done in within 8 seconds per sample material to the dimensions given in the previous chapter.

Table 3. Material(s)

Name	Titanium	
General	Mass Density	4.51 g/cm^3
	Yield Strength	275.6 MPa
	Ultimate Tensile Strength	344.5 MPa
Stress	Young's Modulus	102.81 GPa
	Poisson's Ratio	0.361
	Shear Modulus	37.77 GPa
Part Name(s)	Part1	
	Part1	
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
	Shear Modulus	25.9023 GPa
Part Name(s)	Part1	
	Part1	

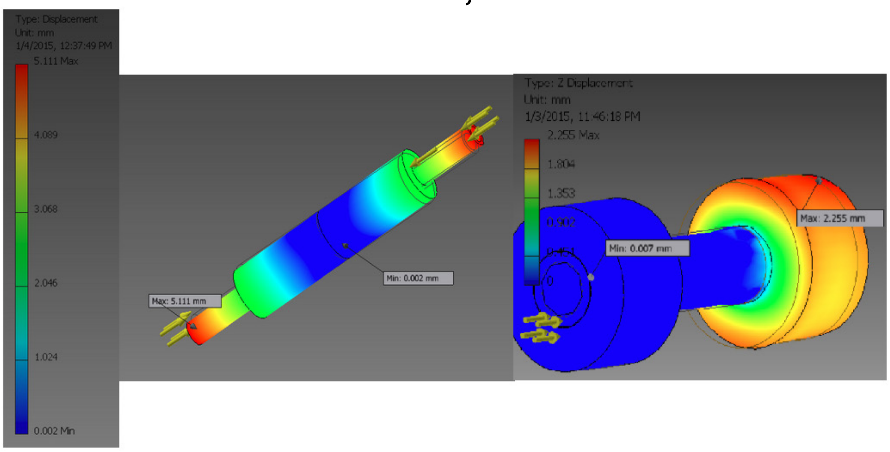

Table 4. Frequency variation to simulation

Frequency	Value
F1	83609.34 Hz
F2	101756.86 Hz
F3	105522.40 Hz
F4	106167.83 Hz
F5	107055.79 Hz
F6	133660.22 Hz
F7	140877.16 Hz
F8	145425.25 Hz

Figure 3. The stress distributions according to the analyzed parameters

Figure 4 shows the magnitude variation of the first piece (middle alloy-ends of aluminum) failed linearization attempt and its evolution till the end of simulation. Figure 4a shows the beginning of the experiment conditions, the action on the piece voltage and minimum and maximum values initially recorded. The same conditions are shown in Figure 4c, only in this case, a shift of the axis simulation causing tension and force them to action under an angle of about 15 ° to the horizontal plane of the simulation can be seen. Later we can see the stress distribution on the entire surface of the workpiece (Figure 4b and 4d) maximum points reaching on parallel areas to the tension and force action. In this case we can see inside the blue piece section remaining unchanged even at an angle of 15° action.

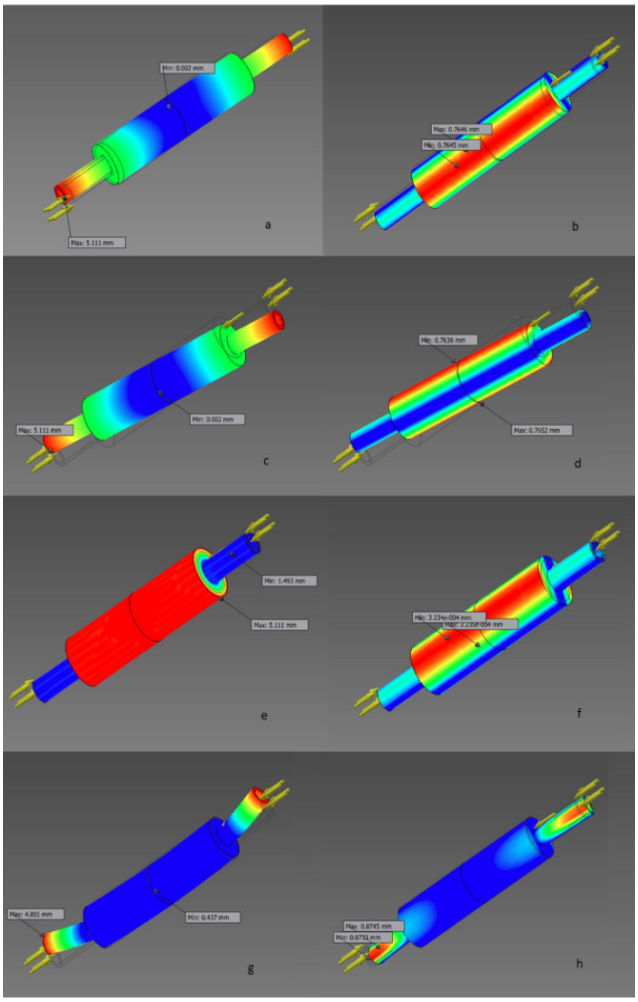

Figure 4. Variation of stress distribution for the first piece, maximum and minimum values recorded at the start of the simulation (a), and to the end of simulation (appearance of faults-weakening mechanical properties-h).

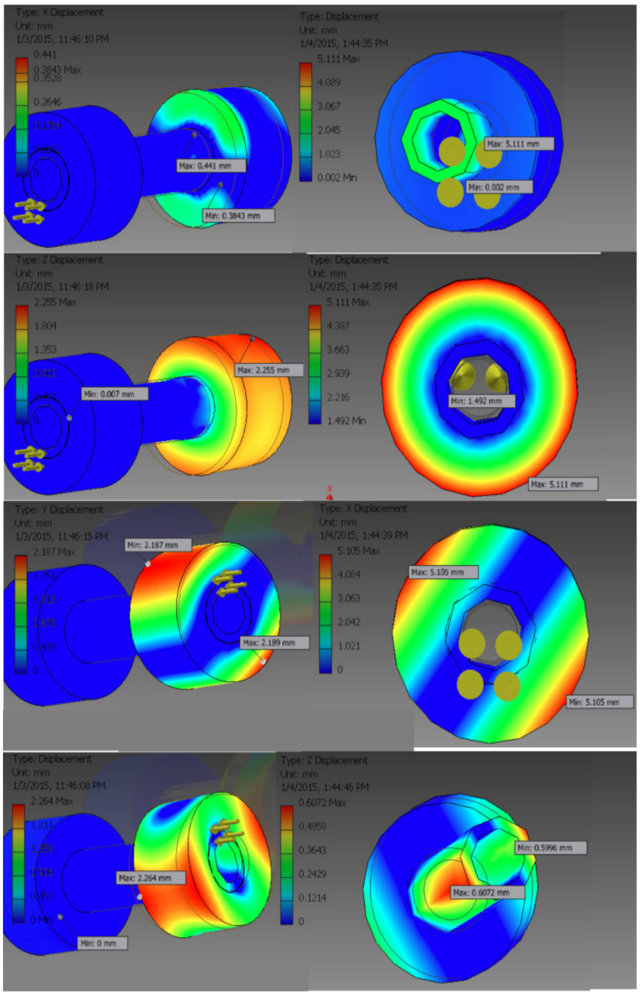

Figure 5. Variation of stress distribution for the second piece, maximum and minimum values recorded at the start of the simulation, and the end of it.

At the end of the simulation we can notice the tendency of plastic deformation but also the damage of the mechanical resistance properties of Al Bar (end piece). Deformation is symmetrically performed at both ends in the same direction and at the same angle. The Al structure retained all tension exerted on the retained piece, deforming in plastic at the end of the simulation, by losing their mechanical resistance strength.

The parallel evolution to the piece form Model 2 is shown in Figure 5, the presentation being made on OX axis (standard plan) and OY (vertical view). Since the first stage of the test we can notice the voltage variation on the right piece surface. Intensity tends to increase, taking over the entire circumference of the piece, and in response to the magnitude of the alloy it is applied the dispersion of the tension- in the 4th stage on the sideways of the piece, and in the 5th the alloys tries to standardize the tension and force applied, work that ultimately fails, deforming the plastic piece. Following this analysis we observe a tendency to accumulate tension only on one of the 3 bodies of the piece (2 sideway heads - Al-5Ti-1B alloy and fix central bar - Al), on the right side end, the result of which was applied besides that magnitude and a force of 100N. In a first phase the tension builds up on the outside of the piece, the Al center remaining untouched. At the end of the simulation, after the plastic deformation of the right body of the piece, stress distribution if uniform, it is affected also the Al core, but the smoothing could not prevent the plastic deformation

4. CONCLUSIONS

In the work presented was analyzed according to AS-CFD the stress distribution built on two different pieces: first with an Al-Al-1B alloy center and extremities of Al, 2nd the other way around: alloy extremities and the connection of Al. The simulation was performed according to data from Tables 1,2,3,4 thus obtaining the following results:

- When modeling the first piece in the central part - the Al-5Ti-1B body remains relatively unchanged, the unidirectional values coincide with those alternatives, and uniformity occurs successfully. The ends of the Al piece of Al- do not register the same alternative values with a double preventing the uniform distribution of tension in the piece so these are plastically deformed.

- For the second part the uniformity occurs on the central body -of Al- and the left extremity component, instead on the right aggregate (where it has been acted with F force in plus) a plastic deformation occurs, the piece loses its mechanical strength properties.
- In case of Al-5Ti-1B components the uniformity occurs faster, providing a higher resistance to stress, and by default to the mechanical stress. The Al components tend to deform rapidly, weakening the mechanical characteristics of the entire piece.

Tests showed maximum variations of tensor stress in the two extremities of the first pieces, involving plastic deformation of Al components. For the second piece the deformation occurs only at one end of Al-5Ti-1B, where it acts with an additional force F.

Of the two simulations we can observe that the uniformity process of stress distribution is successful done only in case of Al-5Ti-1B components, and even in our case only to one component of this type of alloy the deformation occurred, it has been achieved in a much smaller angle as in the first piece.

These tests are highly important to determine and use exact components,of a specific chemical composition in different equipment, machinery, etc. so that this meets the standards of mechanical stress, in accordance with each destination.

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