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A VANE ANALYSIS BY FINITE ELEMENT METHOD

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Abstract: *The paper propose a vane analysis by the finite element method, from mechanical conduct point of sight, as response to exterior forces action. The analysis will be made using a projection and assisted by calculator analysis program: Microstation Modeler – for 3D model generation and COSMOS/DesignSTAR – for analysis by the finite element method.*

Key words: vane, finite element, deformations, tension state.

1. INTRODUCTION

The vane has 1620 kg, disc diameter of 1470 mm and is made of T20Mn14N material, fig. 1, having the next characteristics: $R_{p0,2}$ = 295 N/mm^2, R_m = 600 N/mm^2, A_5 = 18 %, Z = 25 % respective $KCU_{300/2}$ = 49 J/cm^2.

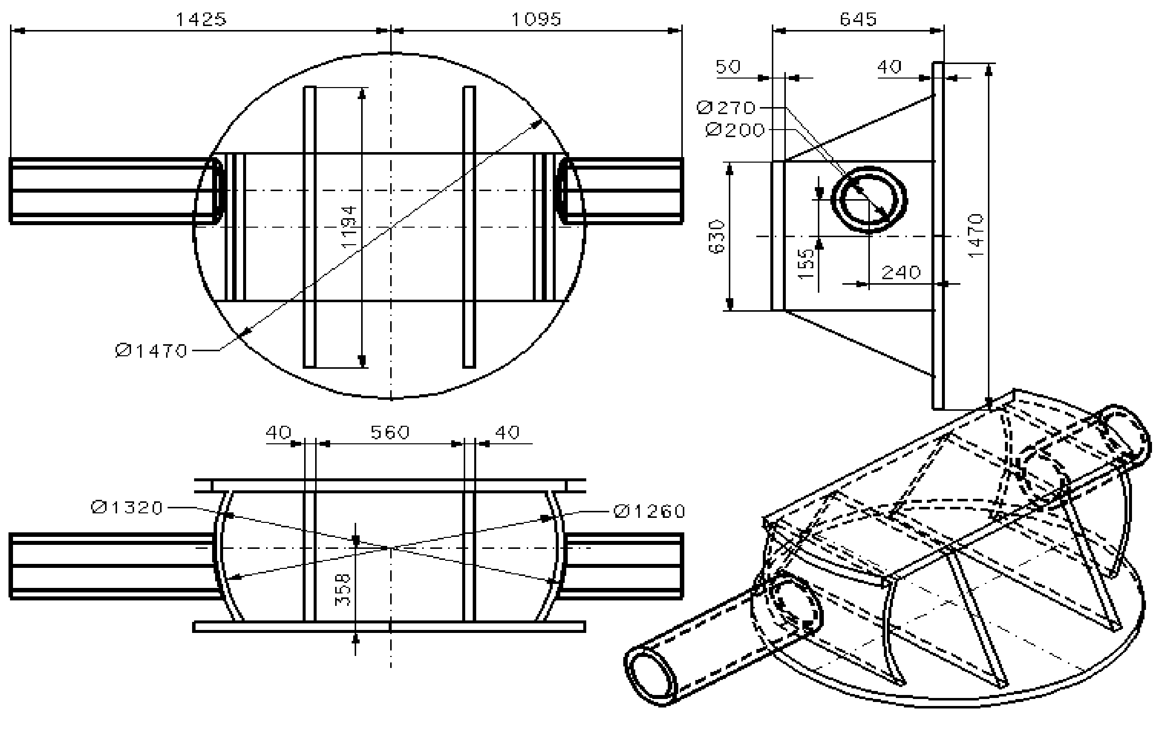


Fig.1. *The vane's structural description*

2. WORK METHODOLOGIE

The piece was modeled 3D by Microstation Modeler, fig. 1 and exported in Parasolid format to the finite element analysis program finit COSMOS/DesignSTAR, version 3.0/2001, fig. 2, having available the next analysis types:

- static linear and nonlinear analysis;
- modal: own frequencies and vibrating modes;
- buckling calculus;
- linear and nonlinear heat transfer in permanent and transitory regime;
- fluids flowing;
- electromagnetic analyze.

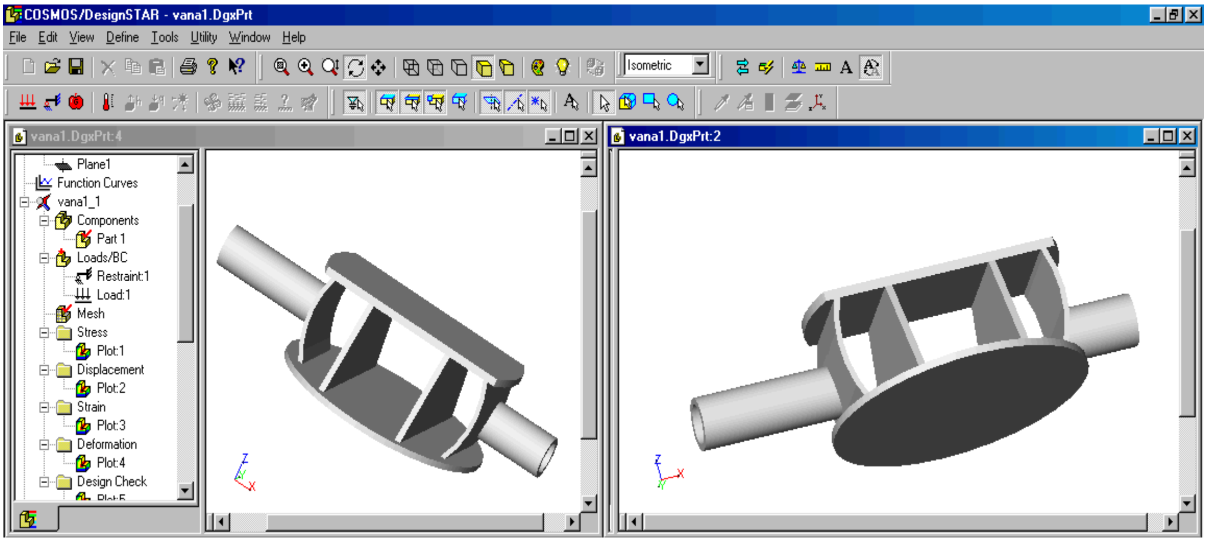


Fig.2. *The vane's geometrical model*

In the present paper it will be made a static linear analyze, having the followings periods:

- *3D model import* –3D generation vane was realized by Microstation Modeler, an assisted by calculator analysis program projection, what offers strog posibilities of geometric modulation.
- *Defining study of case* – part from which are defined analyze characteristics (the name, the type of the analyze: static linear and discretisation type, respective **Solid** (for moderated parts through solids) or **Shell** (for moderated parts trough surfaces); for vane model was chosen discretisation of type **Solid**;
- *defining material* – materials can be selected from the library of materials, provided with the program (fig. 3), which includes materials organized on categories: steel, iron, aluminum, copper, etc., each

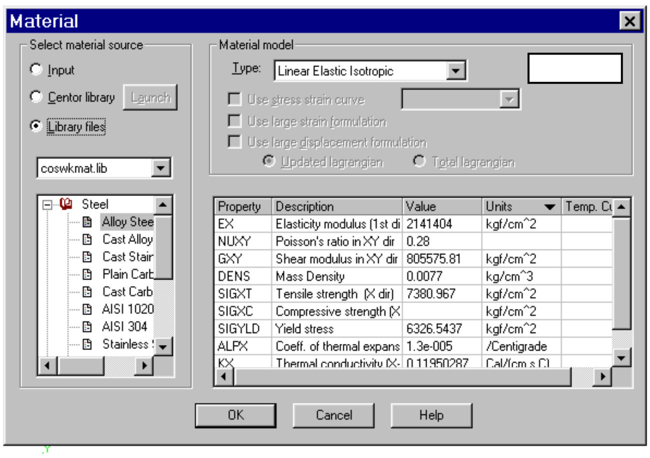


Fig.3. *The library of materials, provided with the program*

category containing a set of materials with predefined proprieties. Can be made usual operations: to create categories, to

❑ introduce new materials, to modify the existing ones, to rename, to erase, etc.; from the library of materials was selected a steel having the modulus of elasticity E = 2141404 Kgf/cm^2 and the value of the Poisson's coefficient ν = 0,28;

❑ *defining loadings* – the applicable types of loadings are:

- "Force" – allows to apply a total force on one or many selected entities: vertex, edge or face;
- "Torque" – allows to apply a torsional moment on one or many selected faces;
- "Moment" – allows to apply a moment on one or many selected entities: vertex, edge or face;
- "Uniform pressure" – allows to apply a distributed pressure on the selected face.

The applying direction of the loading can be normal or directional, by the specification of the components value on the 3 axes, and for every type of loading can be selected the measure unit.

The piece is embed on cylindrical surfaces, and over the circular disc is applied a uniform distributed pressure, having the value of 1x10^6 N/m^2, fig. 4;

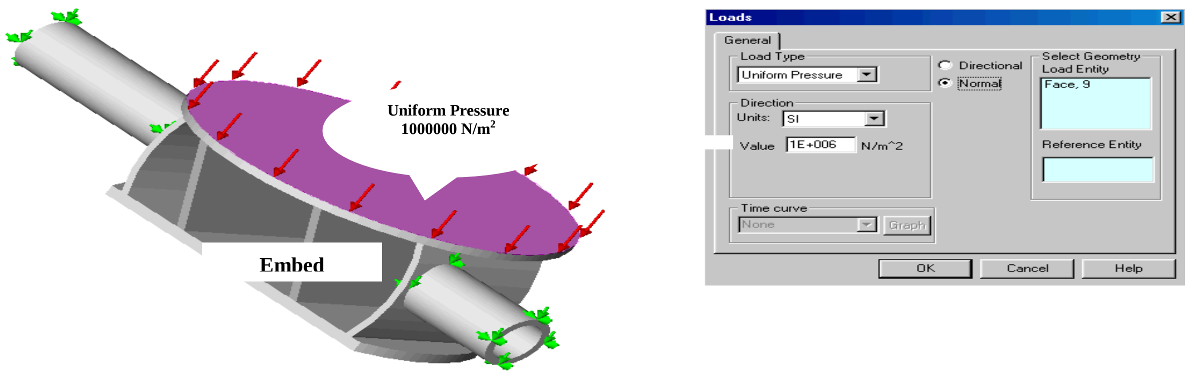


Fig.4. *The calculation model of the vane*

❑ *model discretisation* – COSMOS/DesignSTAR offers the possibility to automatic generation of the discretisation, initially proposing a global digital quantity of discretisation, calculated in function of model volume, its surface and information of geometrical type; the discretisation size (number of nods and elements) are depending of the model geometry and dimensions, of the selected quality: caddish - "*Draft*" or fine - "*High*" , tolerations, the imposed discretisation type and specifications referring to contact. Therewith, DesignSTAR permits local specification by the user of the element sizes, having different value from the global one, at the side of the vertexes, edges and faces, for a precise discretisation of the delicate zones from geometrical point of view "*User-defined Mesh Control*".

The discretisation with elements of "*solid*" type, offers two alternatives:

• "draft quality mesh" – by solid linear tetrahedral elements generation, defined by 4 nods connected by 6 linear edges;

• "high quality mesh" – by solid parabolic tetrahedral elements generation, defined by 4 nods, 6 median semi nods, respective 6 edges.

• The discretisation control offers 3 possibilities:

• "Automatic Transition" – impose appliance of details, holes, geometrical sections of small dimension compared with the whole model discretisation; it is recommended to deactivate this option to large models discretisation, having a lot of small geometrical dimensions portions, to avoid the generation of a useless number of finite elements;

- "User Defined Controls" – when this option is activated, the program applies the discretisation specifications over all explicit by the user defined zones (vertex, edges, faces), others than the ones resulted from the global discretisation applied in the left-over of the model.
- "Smooth Surface" – activating this option, the program refines discretisation, in reallocating frontier nods, to improve the initial discretisation quality.

For the analyzed model was generated 10205 finite elements with 20366 nods,

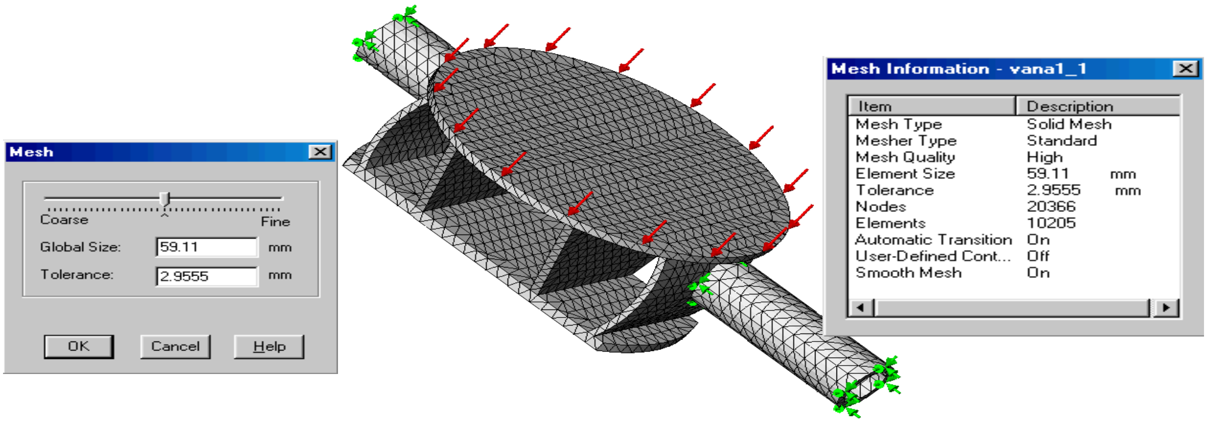


Fig.5. *The discretization for the analyzed model*

- *analyze calculus* – for the anterior defined conditions and on a calculator having an updated configuration, the calculus did not presented any problems from the consumed time point of view;
- *visualizing results* – COSMOS/Design Star offers strong instruments for the results visualization on graphical form (color maps and diagrams) respective numerical value: tensions and stresses, displacements, deformations, relative verification having imposed admissibility criterions

3. RESULTS

The color map corresponding to deformations is presented in fig. 6. The maximal resultant displacement is 3.441 mm, and the displacement zone is bigger than 2.7 mm, being presented in fig. 7, where we can observe the displacement asymmetry generated by the asymmetrical disposal of the cylinders.

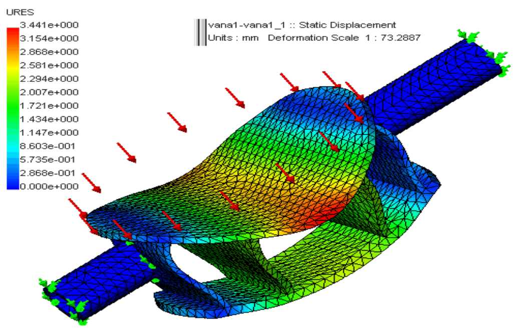


Fig.6. *Deformation of the vane*

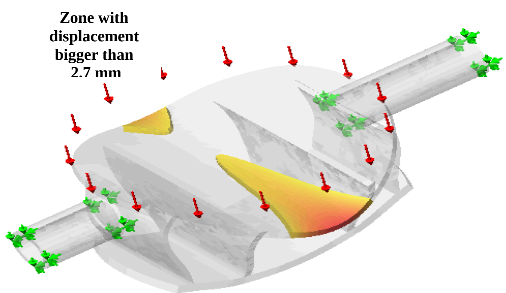
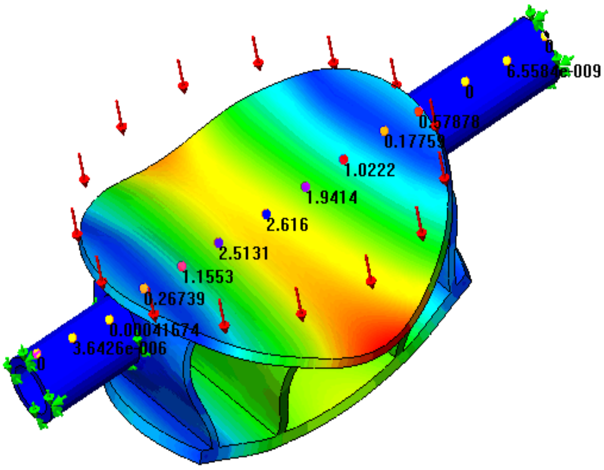


Fig.7*. Zone with displacement bigger than 2,7 mm*

The displacement variation in the long of the piece is numerical presented in fig. 8, and graphical in fig. 9. The maximal displacement zone is positioned on the central portion of the disc, opposed to the cylinders, fig. 10.



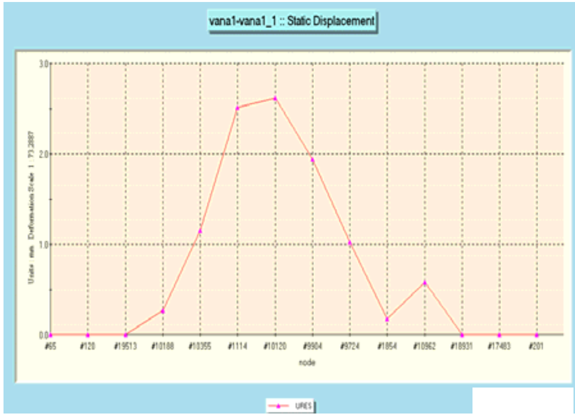


***Fig.8**. The displacement variation in long of the vane*

***Fig.9**. The graphical displacement the variation*

The corresponding color map to the Von Mises tension is presented in fig. 11; the tension variation in the long of the piece is presented numerical in fig. 11, and graphical in fig. 12. The maximal tension is 400 Mpa.

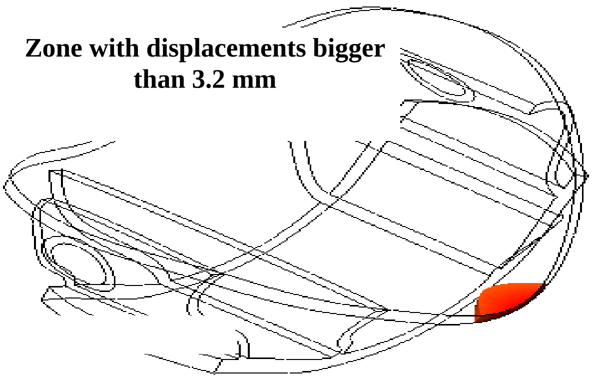
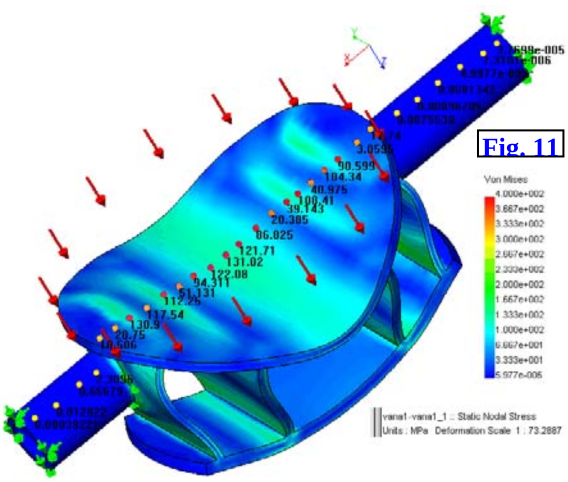


***Fig.10.** Zone with displacements bigger than 3.2 mm*



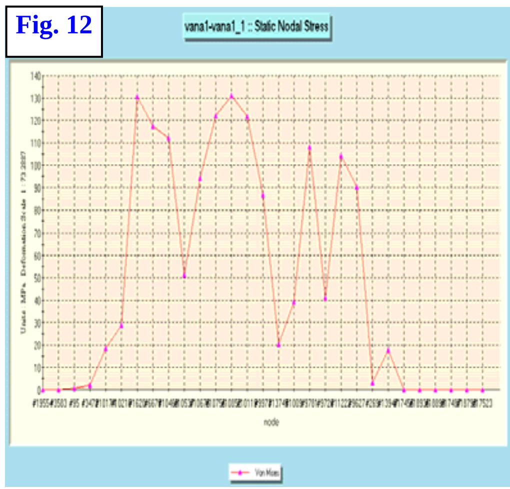
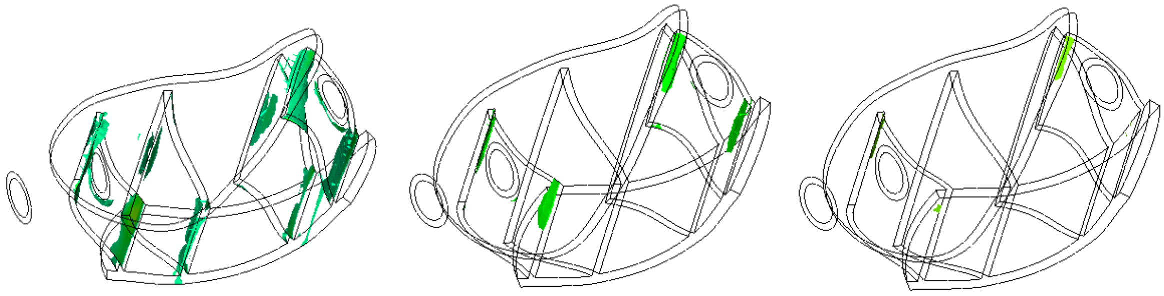


***Fig.11**. The tension variation in long of the vane*

***Fig 12.** The graphical tension variation*

Fig. 13, a,b,c presents tension zone having a bigger value than 135 MPa, 200 MPa respective 250 MPa, resulting the substantial reduce of the zone with tension increment and their localization to the superior part of the lateral ribs. The maximal value for the tension of 400 MPa generated by the program can be considered as a local value, applied on a very reduced zone, similar to the effect of a local concentrator.

The calculus was relapsed for the same piece, on which was modified the thickness of the two central vertical ribs, from 40 mm to 50 mm. In these conditions, the maximal displacement was reduced to 2.882 mm, and the Von Mises tension to 354 MPa.



a b c

Fig.13*. The maximal value for the tension:*
a) Zone with tensions bigger than 135 MPa; b) Zone with tensions bigger than 200 MPa; c)Zone with tensions bigger than 250 MPa

4. CONCLUSIONS

The paper exemplifies the obtained results by the method of finite element over a vane, using both programs Microstation Modeler and COSMOS/Design Star. The analyze results are presented graphical and numerical, with the prominence of the sensitive zone, from deformations and tension point of view. Also analyze a variant of the vane, generated by the increasing the thickness of the two central ribs.

The modeling of piece behavior by the method of finite element offers digital and qualitatively results, which allow the knowledge of mechanical behavior of the piece and the analyze of the possible variants, offering in this way to the engineer a projecting instrument especially efficient.

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