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CONTRIBUTIONS REGARDING THE OPTIMIZATION OF THE TECHNOLOGICAL PROCESS PROCEDURE OF DRAUGHT BARS THROUGH THE DEVELOPMENT AND USAGE OF COMPUTATIONAL MATHEMATICAL MODELS THAT DEFINE THE MANUFACTURING SIMULATION

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Abstract This work is conceived in the context of pursuing the research contract between the "Politehnica" University of Timişoara and SC MEVA SA Drobeta-Turnu Severin, regarding the optimization of the processing of draught bars. According to STAS 3135-76 the draught bars designed to withstand a load of 300kN are manufactured with elastic elements made of rubber (dumper type). The utilization of the simulation concept was considered a progress factor in the manufacturing implementation of such parts (the technologically optimized drought bar presented in this paper).

1. INTRODUCTION; OBJECTIVES

The product that is referred to in the research contract belongs to [3] the impact, traction and coupling device category, having the role of coupling the vehicles, maintaining a certain distance between them, transmitting and dumping the traction and compression loads. These functions can be carried out by different devices, being named according to the role they fulfil.

As a progress factor in the manufacturing implementation of such parts (the technologically optimized drought bar presented in this paper), the utilization of the simulation concept was considered, for which one can relate the following facts:

- the use of simulations is generally accepted as a very important tool in checking out the hypothesis regarding the virtual system that will be executed, moving on from a design model.
- the use of computers allows a step by step elaboration of the complex model with acceptable costs for the market.
- the elaboration of such a mathematical model offers the possibility of using a simulation of the technological process without the restrictions regarding its accessibility or any risk in using it for the preparation of the manufacturing process of such a part and of course in taking the step towards a manufacturing with lower processing costs.

Starting from different classifications for the simulation process, for our case we considered the hybrid simulation category. For this case, we combine the speed and the adequate report machine tool-human operator, from analogical computers with the precision, logical capabilities and storage capacity of digital computers, so both continuum and discrete signals can be processed, in sequential mode as well as in parallel mode.

For this application of technological process optimization we can consider the following procedural objectives:

- 3D modelling of the given part with specialized software
- the import of the 3D model in a specialized CAM software
- the evaluation of the response of the processed part through numerical simulation models based on the finite element analysis method.

2. CONTRIBUTIONS REGARDING THE DEVELOPMENT OF THE DROUGHT BAR MANUFACTURING PROCESS OPTIMIZATION METHOD THROUGH SIMULATION METHODS

2.1. THE GENERAL STRUCTURE OF A FINITE ELEMENT PROGRAM USED IN THE OPTIMIZATION OF THE PROCESSING PROCEDURE BASED ON THE MANUFACTURING SIMULATION CONCEPT

When using the finite element analysis method, three major steps are considered:

- the definition of the part geometry, physical characteristics, mesh and the loads and boundary conditions
- running of the given analysis
- the post-processing, viewing and construing the results

According to STAS 3135-76 the draught bars are designed to withstand a load of 300kN and they are manufactured out of carbon steel having a tensile strength of 49-59 daN/mm^2 and a toughness of 144-175 HB after the normalization process.

The drought bar was modelled using the 3D software *SilidWorks*, moving on from a work sketch of the functioning part (fig. 1). This model was used for the upcoming simulation as well as for the development of technological itinerary using CAM software.

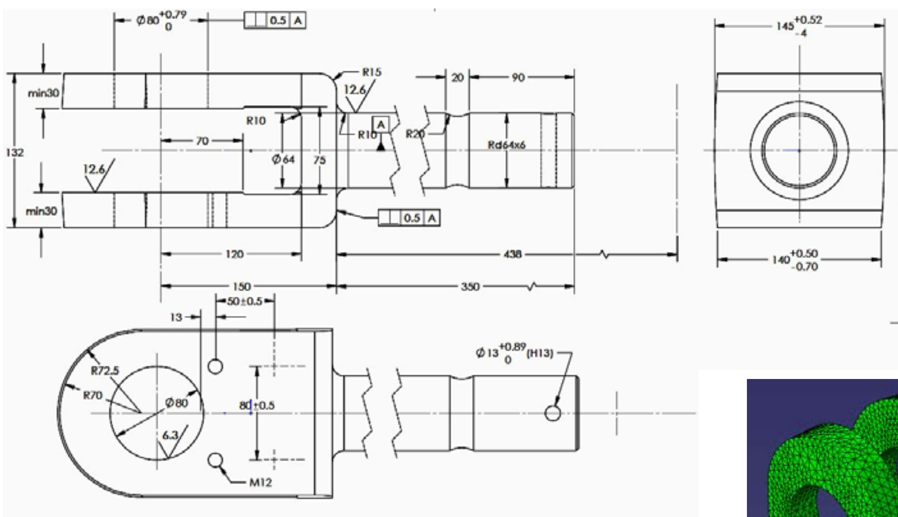

Fig.1. Drought bar work sketch

A simulation was performed using the software *ABAQUS/CAE* for the given work conditions.

The model specifications are:

- Model:
  - Imported *.igs model of the drought bar form *SolidWorks*
- Mesh (fig.2):
  - Element type: C3D4H
  - 4 point tetrahedron elements
  - Hybrid formulation
  - Linear pressure
  - 21271 nodes
  - 102137 elements
- Boundary conditions (fig.3):
  - Encastré on the thread region

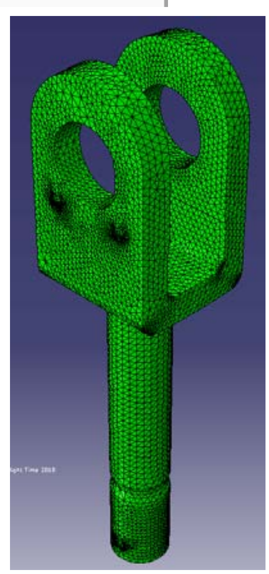

Fig.2. Meshed drought bar

- Loads (fig.3):
  - 300kN force
  - Uniform distribution
  - Ramp amplitude

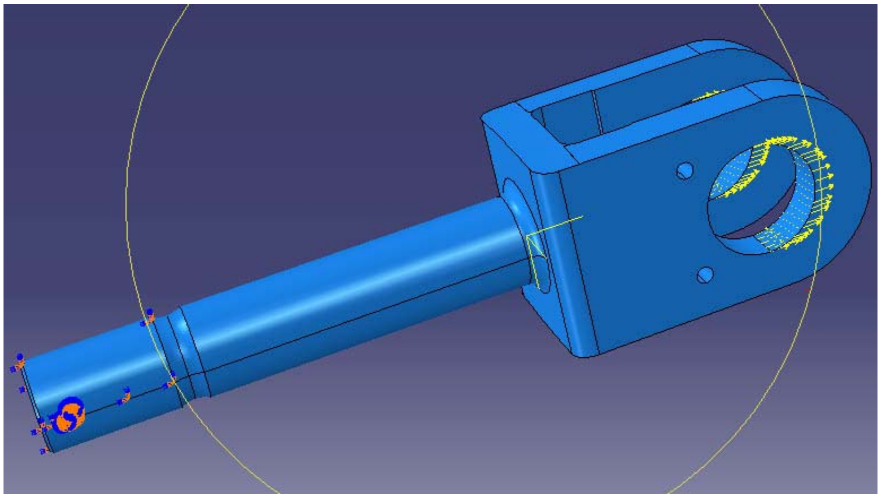

Fig.3. Boundary conditions and loads

The stress distribution and the deformed part are showed in figure 4.

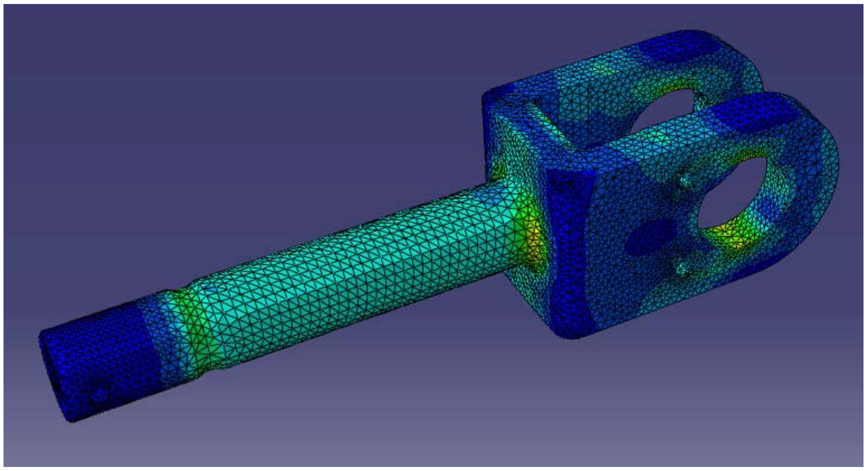

Fig.4. Stress distribution for the 300kN load

Next we will evaluate the stress distribution along the area subjected to tensile stress and along the area subjected to crush stress.
For the area subjected to tensile stress (fig. 5) the variation of the von Misses stress along the true distance is showed in figure 6.
For the area subjected to crush stress (fig. 7) the variation of the von Misses stress along the true distance is showed in figure 8.

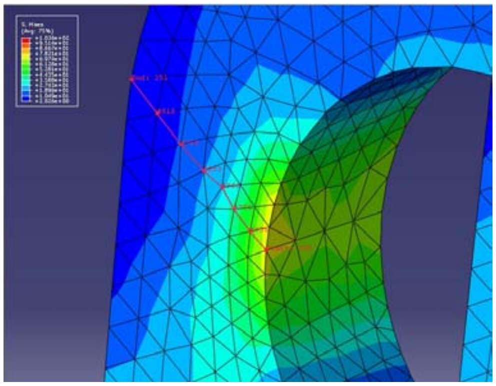

Fig.5. Path chosen for the stress distribution

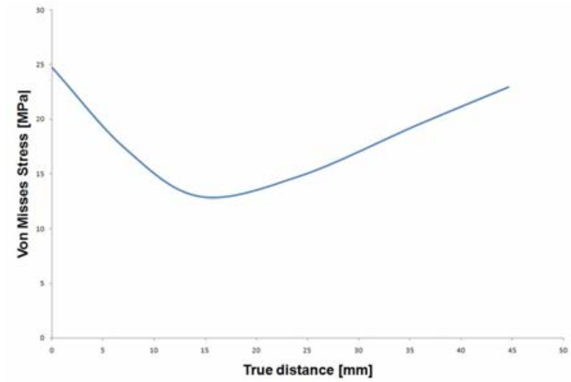

Fig.6. Von Misses stress variation along the path

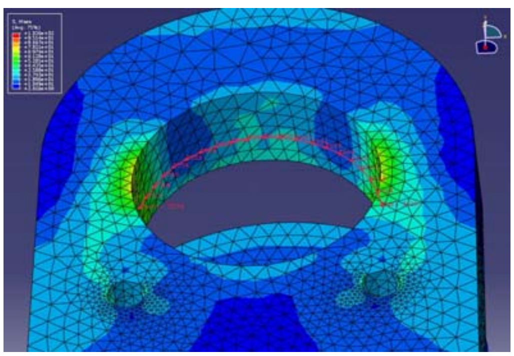

Fig.7. Path chosen for the stress distribution

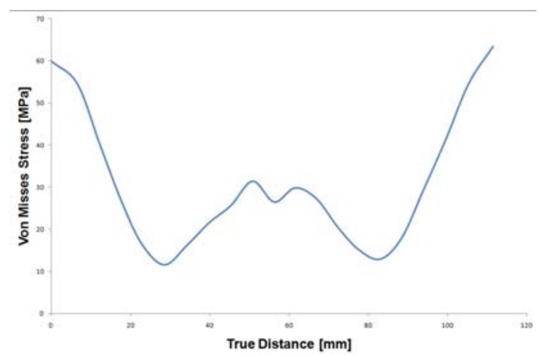

Fig.8. Von Misses stress variation along the path

2.2. CONTRIBUTIONS REGARDING THE DEVELOPMENT OF THE BASIC SIMULATION PROCESS FOR THE DROUGHT BAR

In order to design the manufacturing simulation process for the drought bar, the following steps will be followed:

- the first step in conceiving the simulation is that of importing the 3D model (that can be designed in various specialized CAD software) in the CAM software, along with its design history (conception tree). Through the import of the design history, the elaboration time of the technological itinerary will be shortened.
- the next step in conceiving the simulation is the implementation on the virtual CNC machine in the CAM software, on which the simulation will take place (this virtual CNC machine is used because of the construction limits of the CNC's (that belong to the Manufacturing Department's laboratory HTECH-Timişoara - HAAS Technical Education Centre) in report to the size of the part). In this case, the CNC machine that will be used for the simulation will be MORI SEIKI NL 1500 SMC with the following characteristics:
  - SMC - subspindel + Milling + C axis control
  - Revolver head with 12 tool stations, having a spindle speed of 6000 rot/min
  - two spindles construction
  - main spindle speed of 6000 rot/min
  - secondary spindle speed of 6000 rot/min
  - movement along the X/Y/Z axis: 260/150/590

The operations form the technological itinerary will be conceived using both clamping systems from the two spindles.

- in the main spindle the cutting operations will be performed using a 80^{o} tool as well as a drilling operation with a 12mm drill (fig. 9)
- the milling operations will be performed in the second spindle, and the order of the operations will be performed with the adequate tools that are available in the laboratory facilities (bearing in mind the given process restrictions and capability of the tool to access the processing areas) (fig.10)
- the control and verification operations will be performed outside the CNC machine on adequate equipments

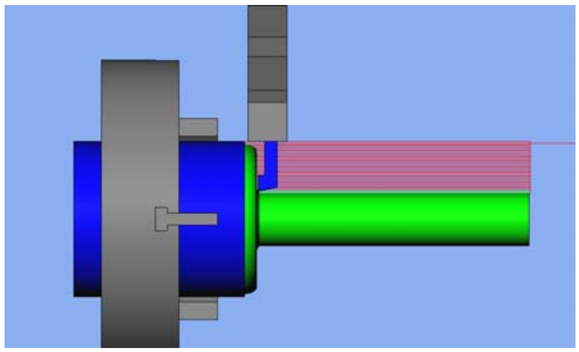

Fig.9. Cutting simulation on the piece mounted on the main spindle.

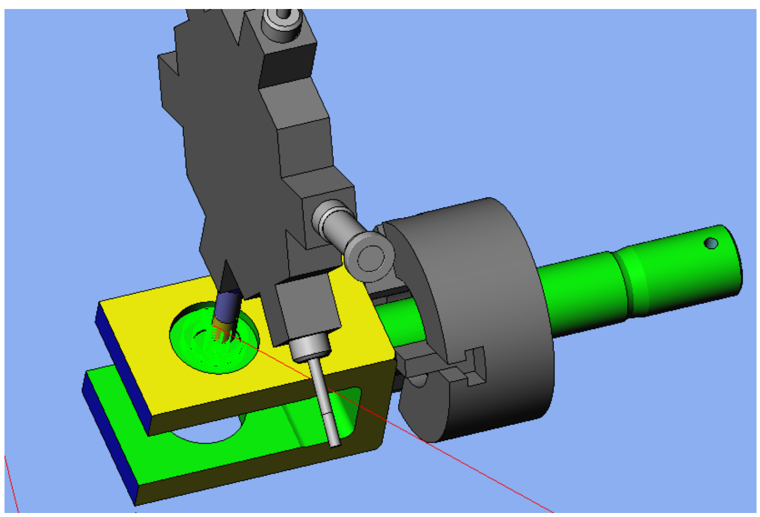

Fig.10. Milling simulation on the piece mounted on the

After the technological itinerary will be complete, a simulation will be run in order to observe different errors and to perform several analyses, as:

- programming error analysis
- tool path optimization
- the analysis of the removed volume of material
- time cycle analysis

After the NC code has been developed for the drought bar, it will be sent to the numerical equipment of the MORI SEIKI NL 1500 SMC tool machine, on which one can run a simulation or modify certain operations from the technological itinerary, because it uses the same manufacturing software used for developing the NC code.

The CNC laboratory of the Manufacturing Department of the "Politehnica" University of Timişoara, in which the technological itinerary was conceived, is equipped with HAAS CNC machines, whose dimensions do not allow the manufacturing of these pats. Apart from these machines, the laboratory is equipped with HAAS NC simulation panels and different CAM software.
The conception and simulation of the technological itinerary was performed using the CAM software Esprit.

3. CONCLUSIONS

This paper succeeds in satisfying the objectives stated in its content, especially regarding the interactive design and phase simulation.
The finite element analysis method precedes the process simulation method in order to check if the designed part is able to satisfy the behaviour requirements in accordance with the rolling stock standards.
Taking into account the basic principles of mathematical modelling in developing an application of manufacturing simulation, the behaviour requirements of the drought bar are rigorously satisfied, no matter what conditions it is subjected to during use. The simulation process also shows that there are no programming errors or over timed cycles in the CAM program and the tools describe corresponding paths during processing. After the program is ready, the CAM software can export the NC code in order to be implemented in the numerical equipment of the MORI SEIKI NL 1500 SMC machine tool, where the technological itinerary can be modified and the simulation can be run once again.
One can observe the multitude of advantages resulted from the elaboration of the structures presented in this paper as being according to a manufacturing of today's standards.
There are also a number of advantages for the company for which the research has been performed, regarding the use and implementation of such results in developing new products and investing in manufacturing equipments of such performance and efficiency.

4. ACKNOWLEDGMENTS

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