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TECHNOLOGICAL DESIGN OPTIMIZATION OF AN INDUSTRIAL CENTRIFUGAL FAN

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ABSTRACT

The paper aims to present a technological design optimization of an industrial centrifugal fan going through steps such as computer aided design CAD, simulation and analysis of elements of interest (CAE) and manufacturing optimization of CAM technology.

KEYWORDS**:** technological design optimization, centrifugal fan, CAD, CAE, CAM.

1. Introduction

The centrifugal fan is a mechanical device for moving masses of air or other gases, with a very low increase of pressure. They are usually cheaper than axial fans and simple to build than other types of fans. In the automotive industry, there are used for cooling internal combustion engines. The centrifugal fan was invented by Alexander Sablukov in 1832, and is spread worldwide.

2. Technological optimization of the fan assembly (CAD)

3D modeling of parts and their assembly were performed using the software SIEMENS NX 7.5.

Graphics with some parts of the centrifugal fan modeled "3D" are presented in figures 1 and 2.

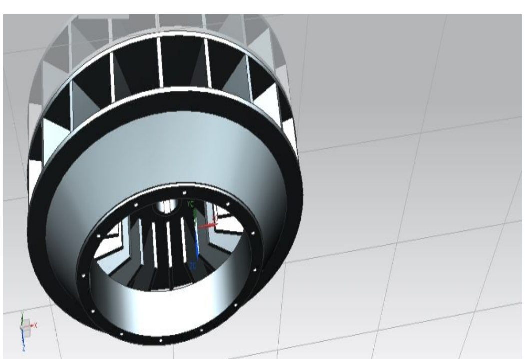

Fig. 1 Rotor with pallets

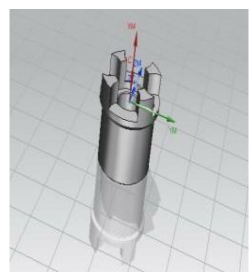

Fig. 2 Semi-coupling

Assembly was achieved only after the parts have been modeled. For a more accurate optimization of assembly, constraints were used as exemplified by the commands: Touch Align, Angle, Fixed, Parallel, Concentric, Distance.

In figures 3 and 4 are shown a sub-assembly and a general assembly of the centrifugal fan designed using NX 7.5 software.

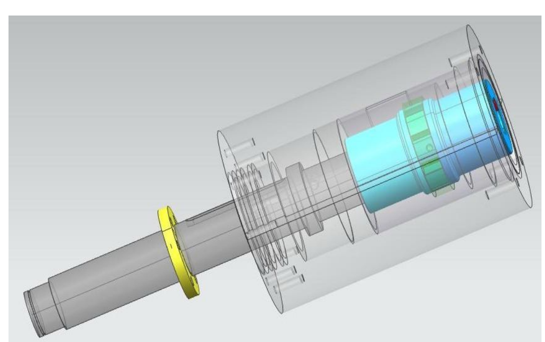

Fig. 3 Sub-set axle-pair-housing

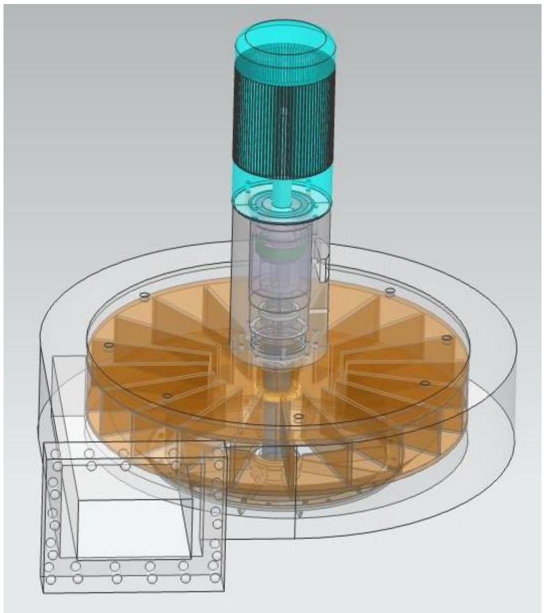

Fig. 4 General assembly, industrial centrifugal fan

3. Simulation and analysis of shaft coupling system (CAE)

Optimization phase type finite element analysis was performed with CAE software FEMAP Vs 10 from SIEMENS.

Femap is a preprocessing and postprocessor finite element analysis, meaning that this software is that assemble imported geometry was modeled with modeling software "3D" in preparation for finite element analysis environment:

1. Material declaration pieces with features: longitudinal elastic constant $E = 2.1 * 10^5$ N/mm^2, transverse elastic constant $G = 8.1 * 10^4$ N/mm^2, density ρ=7850kg/m^3, allowable tensile tension σ_t=150 N/mm^2, voltage allowable compressive σ_c=200 N/mm^2.
2. After declaring the material, the model is meshed in finite elements.
3. Request the necessary condition. If the fan was chosen for analysis it requested torque shaft. For this, the shaft was embedded at the end where it assembles pallets, and at the other end where are mounted couplers and forces are applied on coupling claws simulating so a couple of forces (fig. 5).

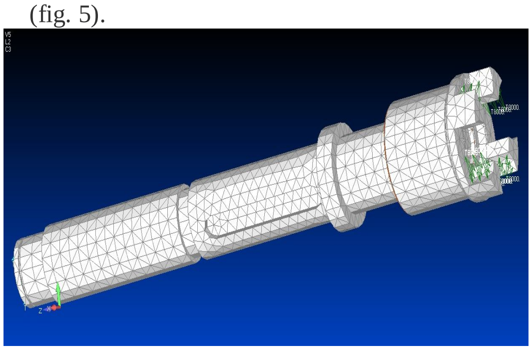

Fig. 5 Mesh axle

The Femap software can analyze the model in terms of static analysis of the processor element analysis finite NX NASTRAN. After the analysis made by NX NASTRAN, the results are reported back in Femap program to be read and interpreted.

The interpretation of results is shown in fig. 6 and fig. 7. In this model case the result is maximum, tangential stress is 10 N/mm^2 (fig. 6). The conclusion is that the axle resists in case of overloaded because the admissible tangential tension of the axle has values between 20÷60 N/mm^2.

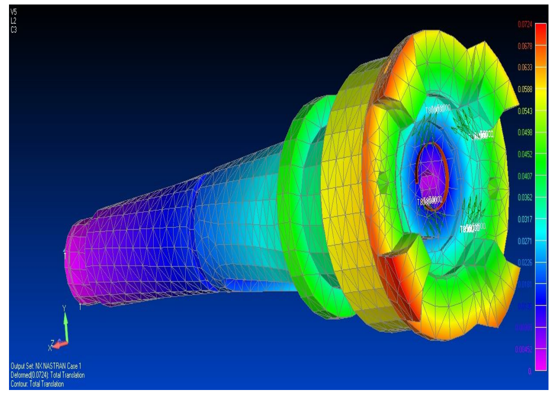

Fig. 6 Deformation Analysis

The maximum deformation is evidenced by the red color that indicates a deformation of 0.07 mm.

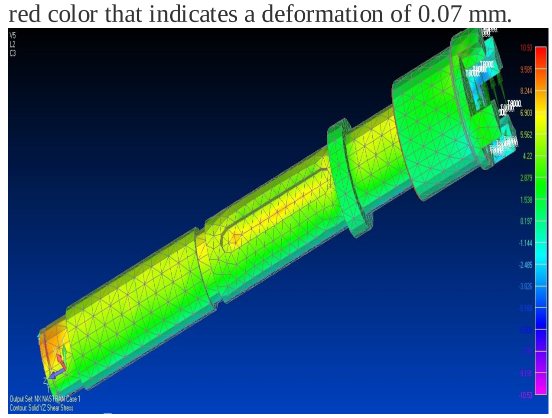

Fig. 7 Analysis of tangential stress

Maximum tangential stresses which occur in the flush are highlighted by orange color in the model with a value of 10 N/mm^2 (fig. 7)

4. Programming machine tools in NX Manufacturing (CAM)

We create a program with NX 7.5 with CAM mode for manufacturing a couple. Typical process includes several steps that must be performed in the right order:

1. Creating the setup of production - this step involves creating a set of manufacturing and adding other data on the manufacturing process. Manufacturing assembly includes the "3D" model of the work piece, in this case the

part of the coupling, but it may contain attachments, machine tool, etc.

2. Analysis of geometry is an important step to establish the manufacturing plan, and to determine the tools that will be used in processing. Get how important this is, according to track characteristics we will choose proper processing methods and tools.
3. Creating or modifying the parent groups minimizes the selection process of objects in the operations when these are used repeatedly and establishes the concept of inheritance of the characteristics, so that the parameters can be passed to the component objects. Most operations allow to omit of this step, but this one is necessary. It can also be useful to define these groups for the operations which are using the same selection of information.
4. Creating operations - operations may inherit some information from parents, but other parameters must be specified in the window of the operation. These parameters define how the tool path is created.
5. Tool path generation and verification - after setting the parameters corresponding to the previous step, the operation is generated (the tool path is created). Check path minimizes errors.
6. Trajectory processing tool, in this stage, generates machine code (G code) depending on the particular combination machine tool and controller.

Creating technical documentation generates information that can be used by staff production workshops. Marker pair was performed on Mazak Integrex machining center 200-IV (Fig. 8).

Fig. 8 Marker pair was performed on Mazak Integrex machining center 200-IV

In fig. 9 is represented the couple in reality and in fig. 10 it is generated the virtual model.

Fig. 9 Couple

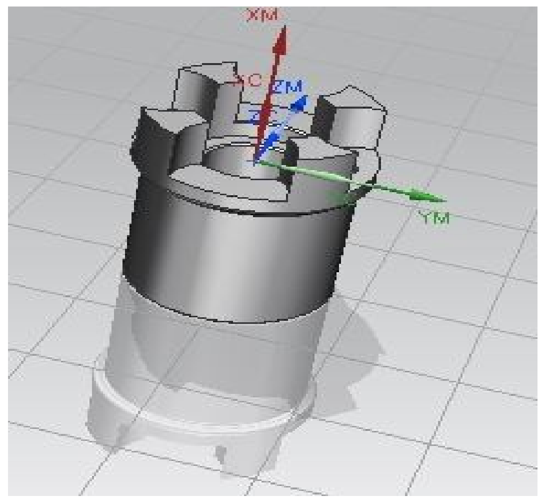

Fig. 10 Couple modeling using NX software (CAD)

In figures between 11 and 15 are shown the various technological aspects of processing phases:
- Front turning operation (fig. 11)

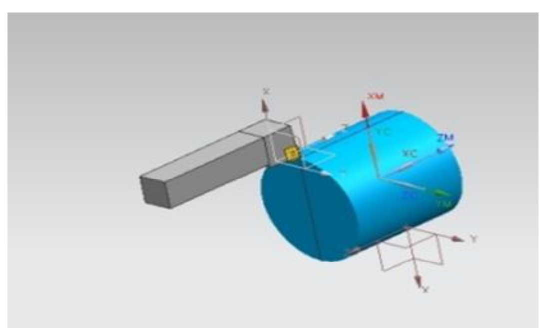

Fig. 11 Front turning

- Outside the rough turning operation

- Drilling operation of diameter Ø30 mm (fig. 12)

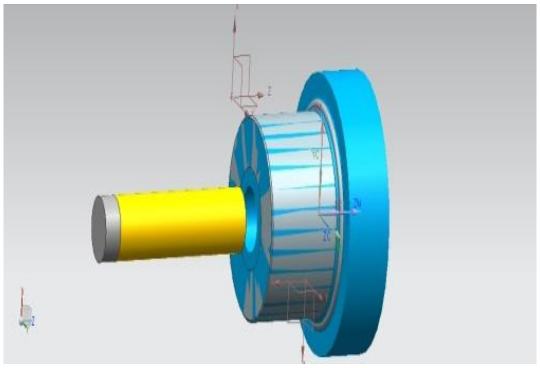

Fig. 12 Drilling Ø30 mm

- Operation of milling cutter grip with diameter Ø20mm (fig. 13)

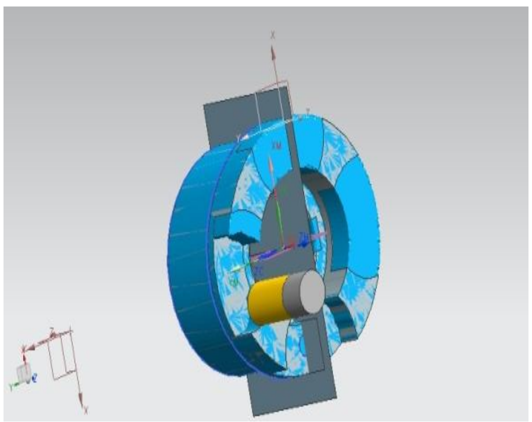

Fig. 13 Milling grip

- Turning cylinder-front surface (fig. 14)

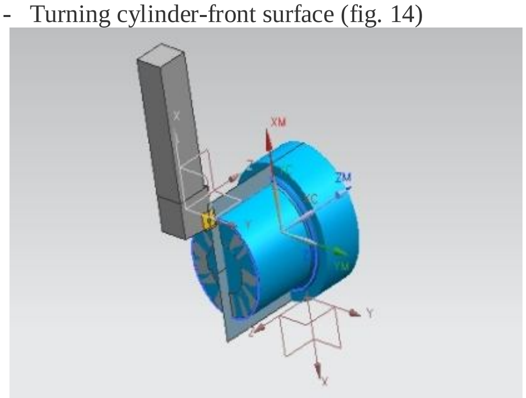

Fig. 14 Turning out cylinder-front

In fig. 15 is shown the image of the finished piece. The addition of processing remaining after machining is presented in color grid.

Releasing the command "Show thickness by color" is seen as a color code (legend on the right of the graphic window) the addition of processing, as this is bigger or smaller, it tends more towards blue or green.

The areas with red color represent the regions where the material defects appeared during the manufacturing process.

In this case there are very small values, due to working tolerances.

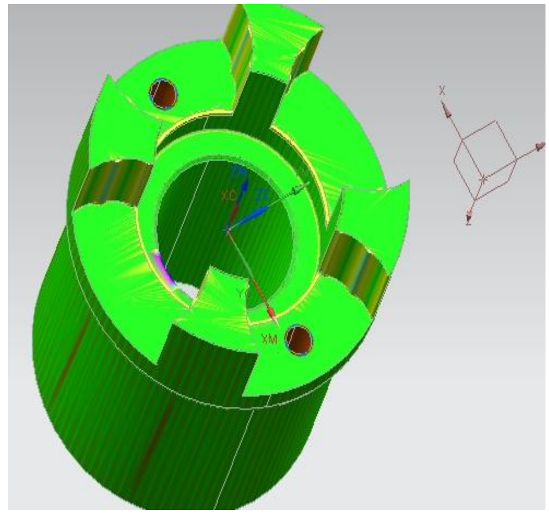

Fig. 15 Semi-coupling in the final stage of processing

5. Conclusions

1 It was developed the methodology of designing in 3D of a centrifugal fan. This allows a CAD, CAE, CAM analysis in order to reduce the time of realizing for production.

2. This paper presents the optimization of the technological process for a certain type of piece manufactured on CNC machines.

3. The NX 7.5 software allows to use the virtual analysis beginning with designing and ending with manufacturing without requiring physical manufacturing of the pieces. We can visualize the potential deficiencies of the future pieces without manufacturing it.

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