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THE DIMENSIONAL OPTIMIZATION OF A CARDANIC CROSS ACCORDING TO THE ANALYSIS BASED ON FINITE ELEMENTS

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ABSTRACT:
The project of a cardanic transmission should correspond to all requirements of designing the technological processes. Only in case of reasonable designing of such machine body parts and of production technology we are able to ensure the increase of reliability and a reduced consumption of the raw material. Due to this paper work and with the help of the software of finite elements CATIA V5R6, we have been able to produce a design for the cardanic transmission within a machine. We have been also able to make the analysis of the tensions and deformations. Thus, we have determined the most dangerous area of the item subject to our analysis. Based on such elements, we have been able to come up with the best shape and dimensions of the cardanic cross. The analysis for the optimization of the shape and dimensions has been possible after a theoretical check up in order to confirm the information in the present paper work.
KEYWORDS:
optimization, cross, tension, deformation

1. INTRODUCTION

Cardanic transmissions of machines, cars, and different industrial machines belong to the cinematic rotation transmission chain from an engine to the wheels. A cardanic transmission refers to an ensemble of machine body parts (joints, shafts, bearing necks etc.) who is used for transmitting mechanical energy through a rotation movement, without amplifying the twisting point amongst the aggregates; its position varies within the space or not. The main domains where the cardanic transmission is used are: transporting vehicles (terrestrial, sea going or air going), agricultural machines, machine tools, lifting and transport vehicles, textile machines, polygraphic machines, drilling machines, stands, pumps, etc.

Designing any cadranic transmission must submit the requirements of the design of techonological manufacturing processes, so that there would not be any problem concerning the manufacturing of the body parts of a cadranic transmission. The reasonable design of all body parts and manufacture technology is ensuring an increasing reliability when using the machine and reducing material consumption. Due to the diversity of typo-sizing of all cardianic transmission we have been able to design, during the designing stage, the standardization of different components for a certain use (agriculture machines, lifting and transport machines etc.). Considering all these aspects, we must come up with the best sizing, divided into categories of typo-sizes, which should be performed during the designing stage.

In order to do that, during the designing stage we should analyze all the elements in order to know the critical area where there are any tension and deformation in order to improve the sizing. This paper work is meant for finding out the best size of a cardanic cross, belonging to the cardanic transmission of a vehicle whose engine reaches the highest value - 135 N m, with the help of the designing software CATIA version V5R6.

2. CALCULATIONS ELEMENTS

The most important thing about a cardanic transmission is the cardanic joint which is made up by the two forking, the cardanic cross, and the connection and the safety elements. The intermediary element in between the two forking is looking like a cross whose arms are perpendicular, and it is called the cardanic cross. The cardanic cross should be made up by one or two segments, according to the type of transmission you need and to the value of the twisting point which should be transmitted. These are made up of alloyed steel through cementing, and the main alloying element is the crome. Cementation is performed at only 0,7-1,5 mm in depth, while its dourness varies between 56 and 65 HRC.

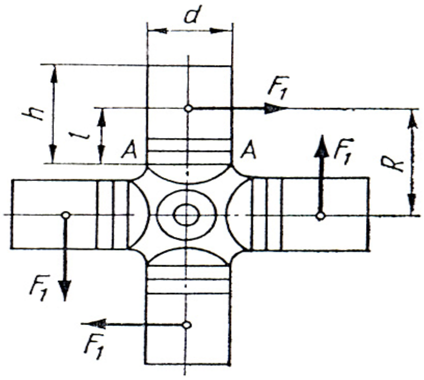

FIGURE 1. Calculating the cardanic cross

The cardanic cross is bent, cut and crushed by a force called F_1 , who is the result of two forces, one performed by the forking of the conducting shaft and the other by the forking of the transmission shaft. The cardanic cross is calculated as such, in fig. 1.

All tables contain the main dimensions of the cardanic crosses, according to the highest point they reach. The calculation could be made according to the scheme in Fig. 1: l = 16,5 mm; d = 36 mm; R = 55,5 mm; h = 33 mm; $\gamma = 16^0 30`$.

3. SHAPING UP THE CARDANIC CROSS-ELEMENT ACCORDING TO THE ANALYSIS OF THE METHOD OF THE FINITE ELEMENT

The cardanic cross of the cardanic transmission has been made up at real size, and the working are equal to the practical lines (the highest point when the torsion could be performed in case of such sizes of the cardanic cross - 135 Nm).

Fig. 2 refers to using the forces onto the arms of the cardanic cross, as well as onto the force, corresponding to the stressing of the item within the ensemble of the cardanic transmission.

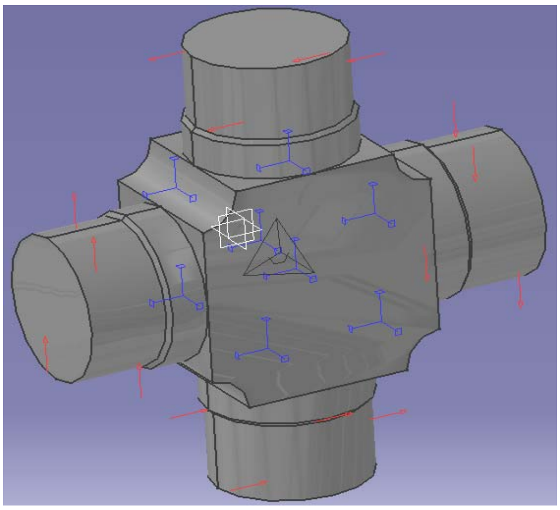

FIGURE 2. Using forces onto the arms of the cardanic cross

In order to make a correct analysis of this item, we need to make a serie of forces as a result of the stress. So, we consider the central segment of the cardanic cross is fixed, because it is blocked with the help of the Clamp force; the force has been applyied to the arms of the cross, according to fig. 2. Therefore, fig. 3 represents the highest tensions within an item – we could see which are the most stressed areas. Fig. 4 represents a section of the most stressed area and we can observe the tension onto the material of the item, according to the colour written in the left side of the figure.

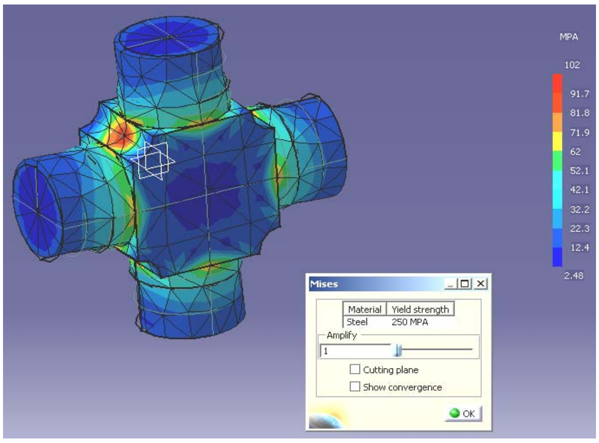

FIGURE 3. The most exposed areas of the cardanic cross segment

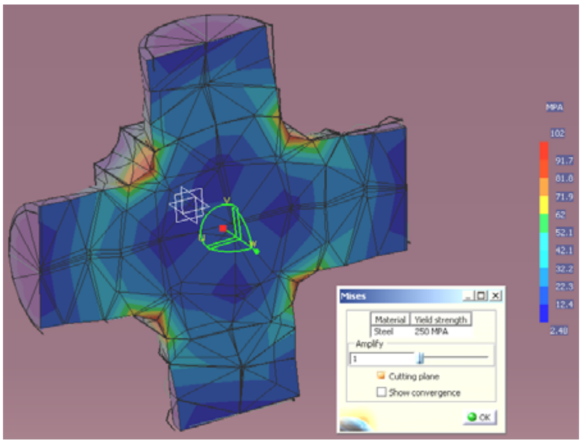

FIGURE 4. Section through the most stressed area

The result of the analysis is represented like some surfaces that are coloured differently, according to the value of the stress. The value scale is written down in the right side of the screen and it starts from the blue (the least stressed area) up to red (the most stressed areas). As we can see in fig. 3, the highest value of the Von Misses tension is 132 MPa, and it is registered in the areas where to the arms of the cross connect with the body. Thus, there are some areas that focus all the tension, which we call critical areas, and where the breaking of the element is more possible, in case the highest value of the tension is exceeded. Fig. 5 represents the cardanic cross after the analysis and it has a broken arm, caused by a force of 200 MPa.

FIGURE 5. Cardanic cross made up by one element

Fig. 6 presents the highest misplace of the item caused by forces that stress the arms of the cardanic cross.

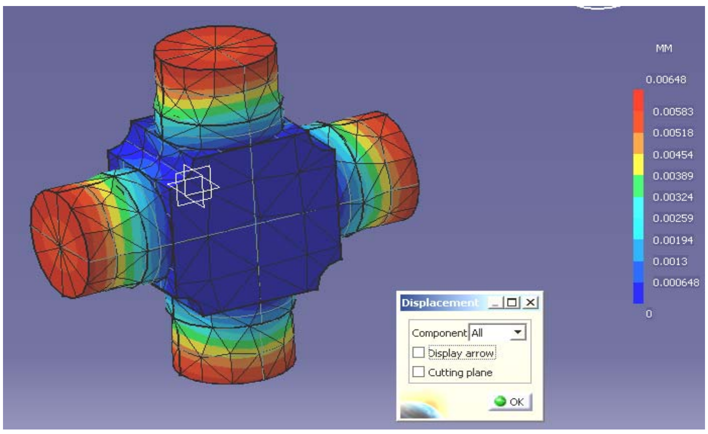

FIGURE 6. Most stressed areas of an item

If we know the most stressed areas – tension and highest misplace – and their values, we are able to perform the improving of the sizing.

4. IMPROVING ELEMENTS

If we consider the value of the twisting moment and the highest stressed area (fig. 3 and fig. 4, the area of the connection radius of the arm and the body of the cross), we propose to determine the best radius through a certain method – according to the highest values of the tension inside the item – with the help of the designing software CATIA V5R6 (fig.7). In order to perform the best analysis of the item, we need to perform some forces and getting some results: we consider the central segment of the item is fixed and blocked out by the Clamp force; the force that stresses the arms of the cross, according to fig. 3.

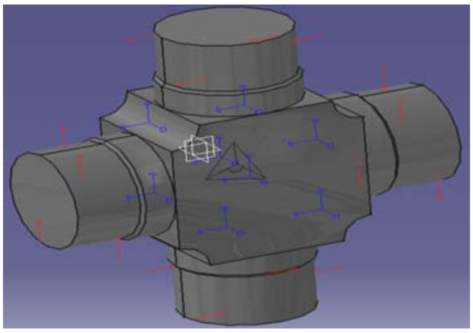

FIGURE 7. Shaping up in order to establish the best connection radius for a cardanic cross

We should analyze the influence of the connection onto the tension and deformation of an item. In order to do that, we consider different values of the radius, we determine the equivalent tensions and the misplacing. Table 1 contains all the results obtained with the help of the calculating software based on finite elements, for different values of the connection radius r.

TABLE 1. The values obtained after the analysis of the finite elements for different values of the connection radius of the cardanic cross

No.	Connection radius r [mm]	Equivalent tension von Misses σ_e [MPa]	Displacement maximum u [μm]
1.	0.5	102	0.006
2.	1	97.5	0.00601
3.	1.5	83.9	0.00593
4.	2	84.3	0.00596
5.	2.5	91.2	0.00597
6.	3	78.3	0.00592
7.	3.5	90.6	0.0061
8.	4	96.7	0.00647
9.	4.5	108	0.00696
10.	5	122	0.00737

We see that once we increase the connection radius „r", the tension inside the item varies according to some principle; the same is true in case of misplacing within an item. We see that the lowest value of the Von Misses equivalent tension has been obtained for position 6 in Table 1, and the misplacing is low for a connection value of 3 mm.

If we choose the connection radius of 3 mm (position 6 in table 1), we get some good results, reported to the size of the cardanic cross. If we consider this value is the most appropriate, we are going to try and determine different size for the tension, and the deformation should be the lowest.

Fig. 8.a. presents the space design of the results, meanwhile fig. 8b, the space section for the best interpretation of the results.

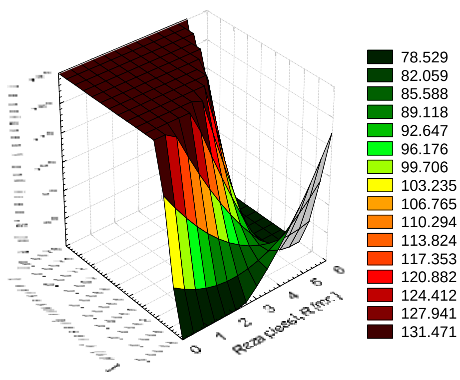

FIGURE 8.a. Space representation of the results of the best connection radius

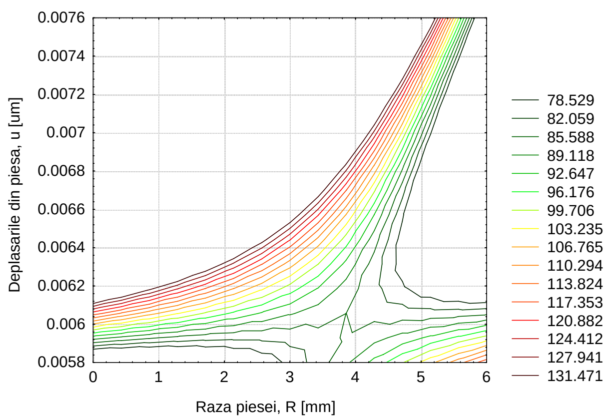

FIGURE 8.b. Space section of the results of the best connection radius

With the help of the space section, we are able to choose the best values very easily, according to the parameters or the requirements for the most fitted functioning of the cardanic transmission equipment.

5. CONCLUSIONS

This paper work refers to the analysis we have been able to make with the help of the finite elements software CATIA, referring to the most dangerous areas of a cardanic cross; this element is a compound of the cardanic transmission of a car. In order to do that, we have established the von Mises equivalent tensions and the highest values of deformation of such areas. Based on these results, we have been able to come to the best shape and size of an item. We can see that once the speed of the connection radius is increased, the highest values of the tension and of the misplacing increase, too.

Depending on the connection radius (and on the shape of the item), we shall change the technological process when manufacturing the cardanic transmission component – the cardanic cross.

It is very important to find the most fitted size during the designing stage, because it allows the producers to come up with a product in short time, the production prices are very low, and the reliability is also high. The best solution should be kept in a data base so as it could be easily sent by e-mail to the technological, production or control departments. Thus, we eliminate the designing efforts.

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