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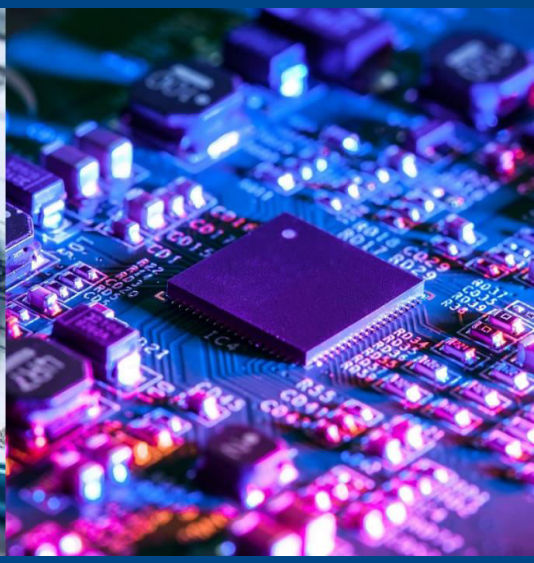

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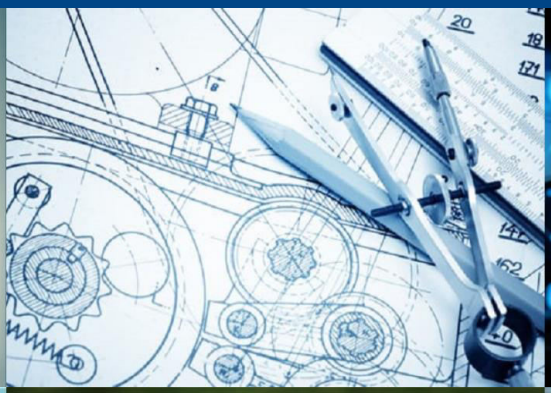

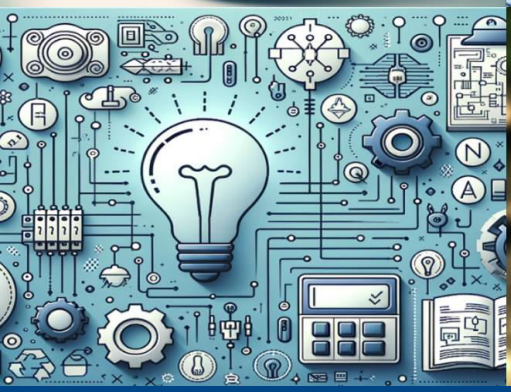

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Modeling and Finite Element Analysis of Sprocket in Carousel Systems

Amit Kumar Gupta[1]

Associate Professor, Department of Mechanical Engineering, Institute of Engineering & Technology – DAVV, Indore, India[1]

ABSTRACT: Sprockets are extremely important part of the transmission of energy and movement in most of the industrial and manufacturing sector. They exist in different dimensions and materials. Here the sprocket is used in vertical carousel storage system which is mostly used as a space optimization technique in various industries. To efficient power transmission chain sprocket should be designed as per the requirement and loading conditions. This paper reviews the design of sprocket, analysis using FEA and using the results to select the material for the sprocket. The material used for the sprocket arenamely 16MnCr5- Steel and Grey Cast Iron. The analysis was done using Finite Element Analysis in Ansys R16.2 software. Comparison of stress and total deformation was done and on the basis of comparison optimum material for the sprocket was selected.

KEYWORDS: Carousel System; Optimum Space Utilization; Sprocket; Ansys (R16.2).

I. INTRODUCTION

Stationary shelf storage system consists of shelves that goes from floor to a designated height. These are the most commonly used storage system because of their simplicity and the low-cost relative to its competition. But these systems come with some major difficulties. Items stored near to the top and bottom shelves are often hard to reach in order to unload the items. Anothermajor disadvantage is that heavy items cannot be stored in the top shelves because while unloading accident is prone to take place. Therefore, a solution to these problems is constructing a rotating shelves system, so that we can load the items wherever we want. A vertical carousel storage system occupies less floor space and instead utilizes more vertical space. The shelves or racks are rotated with the help of chain and sprocket drive and a suitable motor is used for supplying the power to the mechanism. The whole system is mounted on a solid frame structure. Roller chain drive is recognized to be one of the most effective forms of power transmission in mechanical systems. It has a basic feature with a constant ratio becauseof no slip-page or creep. Roller chain drive is generally suitable for the transmission under a slower speed due to its polygonal action and meshing impact.[1] Also, chain drives provide a high transmission efficiency of up to 98%. Chain sprocket is one of the important components of chain drive for transmitting power from one shaft to another. To ensure efficient power transmission chain sprocket should be properly designed and manufactured. There is a possibility of weight reduction in chain drive sprocket.[2] A sprocket is a profiled wheel with teeth, or machine gear-pieces, that work with a chain, track or other punctured or indented material. The name 'sprocket' applies for the most part to any wheel whereupon outspread projections connect with a chain disregarding it. Sprockets are generally used to transmit power with the help of a chain drive. The sprocket is an extremely imperative part in the transmissionof energy and movement. They exist in different measurements, teeth number and are made ofvarious materials. By and large sprockets are made of mellow steel.[3] Here, in this paper, wehave analysed the sprocket for 2 materials, 16MnCr5-Steel and Gray cast iron.

II. VERTICAL CAROUSEL STORAGE SYSTEM

A 3D model of the vertical carousel storage system was built in Solidworks software as shown in fig. The dimensions are as follows height of 3000 mm and base of 1500 mm*1000 mm. the storage system have in total 12 trays connected to the chain. The chain is mounted on the shaft which is driven by the induction motor. The material used for the frame and trays is AISI 1010 Steel, hot rolled. These systems can hold up to 30kg on one shelf, can reach over 10m tall, automation controlled, and fully enclosed. The weight of each tray, frame and hole assembly was calculated to be 12.267 kg, 96.281 kg and 265.27 kg respectively.

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Fig.1. Vertical Carousel Storage System

III. ANALYSIS OF SPROCKET

A 3D model of sprocket was built in CATIA software as shown in fig 1. The dimension of 3D model had pitch circle diameter 76.35 mm, top diameter 86.033 mm, roller seating radius 5.16mm, root diameter 66.03mm, tooth side radius 15.875mm, tooth side relief 2.38 mm, sprocket thickness 9.625 mm and overall thickness of body 40 mm. The outer and inner diameter of spline shaft hole were 25 mm and 22 mm respectively.

The geometry was saved in (.igs) format and exported to ANSYS software for finite element analysis. In the inputs we applied forces normal to the face of teeth which would be in contact with chain. Here we have 5 teeth in contact with chain and each tooth has force of 706.32 N acting on it. We have also applied angular velocity of 23.25 RPM.

A fixed support is applied at centre of sprocket. After the geometry optimization, two different materials were assigned to 3D model in ANSYS. The two materials considered for analysis were 16MnCr5-Steel and Gray Cast Iron.

Table 1. Properties of Material

Properties	16MnCr5-Steel	Gray Cast Iron
Density(kg/m^3)	7700	7200
Young`s Modulus (GPa)	200	110
Poisson`s Ratio	0.3	0.28
Bulk Modulus (GPa)	166	83
Analyse Shear Modulus(GPa)	76.92	42.97
Ultimate Tensile Strength(MPa)	880	240
Ultimate Shear Strength (MPa)	1160	610

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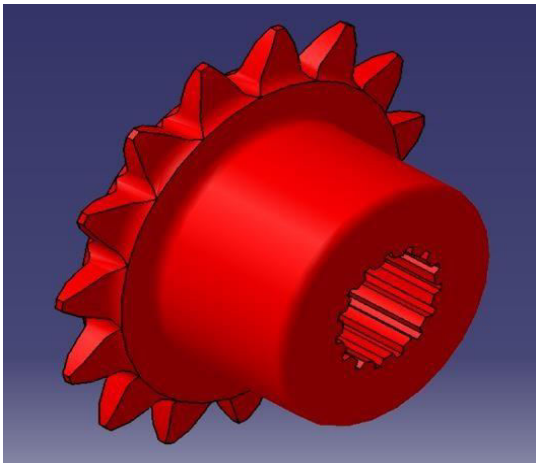

Fig. 2. 3D model in CATIA

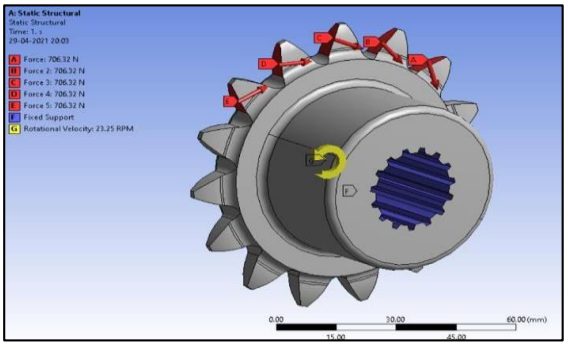

Fig. 3. Forces Applied on teeth and angular velocity

After the geometry optimization, two different materials were assigned to 3D model in ANSYS. The two materials considered for analysis were 16MnCr5-Steel and Gray Cast Iron.necessary to convert it into finite elements. The more are number of elements more is the accuracy. The meshing part was carried out and number of nodes formed were 575095 as shown in fig 2. The meshing was carried out in hex dominant manner, so most of the elements were quadrilaterals and few were triangles.[6]

IV. RESULT

On the basis of analysis of sprocket, it was observed that sprocket made out of two different materials is safe as total maximum stress is within the limit of one materials which is 16MnCr5- Steel which are shown in fig. 5.a, 5.b.

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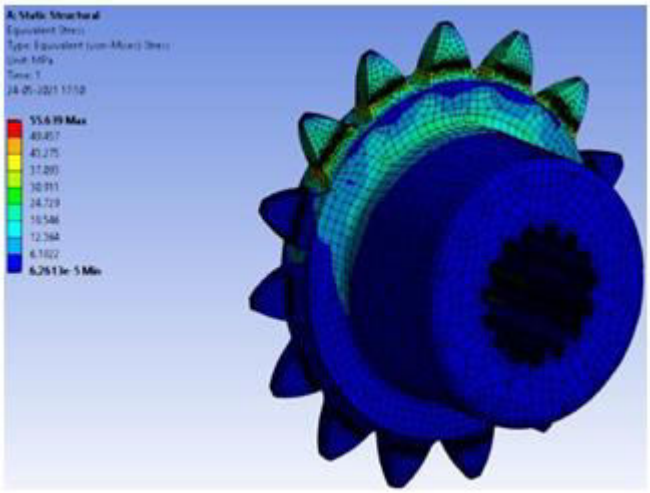

Fig. 4.a. Equivalent Stress for 16MnCr5- Steel Maximum value is observed deformation was as 56.037 MPa

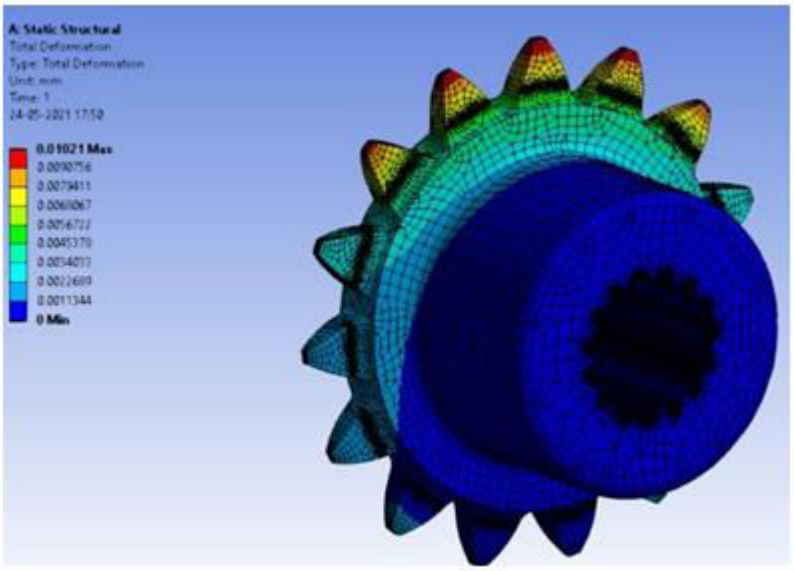

Fig. 4.b. Total Deformation for 16MnCr5- Steel Maximum deformation was observed as 0.0056711 mm

V. CONCLUSION

The sprocket was simulated and analysed by using finite element analysis software ANSYS. Grey Cast Iron and 16MnCr5-Steel were the materials selected for analysing the sprocket. Total deformation and Equivalent stress were obtained for both the materials. It can be observed from the results that the minimum deformation occurred in the case of 16MnCr5- Steel and minimum stress occurred in the case of Grey cast iron. It can also be noted from the results that the maximum value of stress and total deformation is almost equivalent and hence any one of the materials can be used for manufacturing the sprocket for vertical carousel storage system. For future works, simulation of the sprocket of same or different dimensions as compared to the model used in this paper can be carried out with different materials and the analysis of its performance at various conditions is possible.

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