

Design Validation Analysis and Optimization of a Pulley

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Abstract - The objective of the study is to perform the validation of the current baseline design and optimize a Single sheave Stringing Block for the required load conditions. The design requirement of the pulley is used for a cable stock bundles. The baseline design is evaluated for the required load capacity and optimized for the requirements. The main components of conveyor pulley are shaft, drum or shell, diaphragm plates, locking elements, hub, lagging and bearing assemblies. Create Single sheave(Pulley) wheel design using SOLID EDGE. Import to ABAQUS/CAE and mesh the pulley using Tetra elements. The base sheave design is analyzed using FEA and it was found that the design is oversized. There is substantial weight which can be optimized. The stress levels are found to be a small value of 5.5 Mpa. So the optimization was performed to study the scope of removing material in the base design. Through the optimization technique, it was found that up to about 40 % material can be removed. This is substantial and thereby reducing the cost to the same proportion.

Key Words: conveyor pulley, Sheave, design, ABAQUS, analysis, optimization, Hypermesh, FEA

1. INTRODUCTION

Pulley

A pulley-block may be a mechanical device that is helpful for lifting things. It reduces the hassle needed to lift a load. It consists of a wheel with a groove through that a string or rope runs. The rope includes a load on one finish and somebody or one thing propulsion at the opposite finish.



Fig 1.1: Pulley

The pulley-block is really a version of a wheel and axle that is joined with a rope, chain or elective wire to allow moving one thing all over or to and fro. The block are regularly joined with elective pulleys to downsize the amount of work important to convey massive measures of weight or to let them down. It might likewise make moving one thing like a banner up the shaft helpful to attempt to do from the base. It alters the course of the power important to attempt to take the necessary steps. I pull down on the rope, anyway the banner goes up.

Working Principle

The working principle of the pulley-block is:

When one end of the rope is force downwardly, the load on the opposite end of the rope is force upward. Therefore, the direction of force is modified from downwardly to upwards!

1.1 Anatomy of a Conveyor Pulley

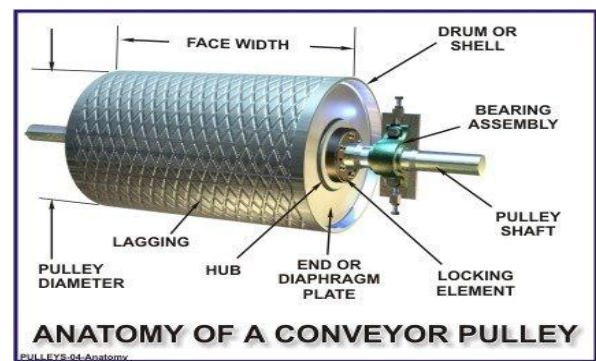


Fig 1.2: Components of a conveyor pulley

The parts of a pulley include the following:-

Drum or shell: The drum is that the bit of the pulley-block in direct contact with the belt. The shell is liked from either a moved sheet of steel or from empty steel conductor. The shell contains a particular 'face' measurement and distance across that is chosen by the element of the fabric and furthermore the sort and rating of the belt to be utilized on the transport.

Diaphragm plates: The diaphragm or finish plates of a block are roundabout circles that are unbelievable from thick plate which unit of measurement welded into the shell

at every end, to fortify the drum. The top plates are exhausted in their within to oblige the sq. shaft and what is more the middle points for the block protection components.

Shaft: The shaft is intended to oblige all the applied powers from the belt and/or the drive unit, with least diversion. The shaft is found and verified to the center points of the top plates by proposes that of a lockup part. The pole is upheld on every end by direction that territory unit housed in Plummer blocks, to help the shaft and pulley-block gathering on the transport structure. Shafts as a rule include totally various widths on their length on account of the twisting minutes and resultant diversion confinements. The distance across of the shaft at the arrivals for the direction could likewise be littler to fulfill the required bearing width that is less expensive (littler). Similarly inside the instance of a drive shaft, the drive connection could likewise be totally extraordinary to the contrary distances across on the pole what's more, thereupon pulley-square shafts zone unit normally ventured.

Locking Elements: These are high-accuracy production line made things that are fitted over the shaft and into the pulley-block center points. The lockup parts join the pulley-block immovably to the shaft by means of the top plates. Locking segments (see contiguous picture) take a shot at the grating grasp rule whereby the part is in a situation to be fixed to the shaft and center point simultaneously and concentrically, by change a progression of screws round the lockup part.

Hubs: The hubs are fictitious and machined housings that square measure welded into the tip plates. The hubs square measure sized per the dimensions of the pulley, the diameter of the shaft and therefore the size of the locking part that is needed for the precise duty.

Lagging: It is usually necessary or fascinating to reinforce the friction between the transporter and additionally the pulley-block therefore on enhance the force which can be transmitted through a drive pulley-block. Improved traction over simple machine in addition assists with the coaching of the belt. In such cases simple machine drum surfaces square measure 'lagged' or lined throughout a rubberized material. This cowl is typically eight millimeter to 12 millimeter thick and could be plain or have a grooved pattern. The rubber insolent is processed to the pulley-block shell to confirm that it remains connected below adverse operational conditions.

Bearing Assemblies: Bearings support the rod and also the pulley-block. The bearings are housed in 'Plummer blocks' that amendment the mass of the machine assembly and also the belt tension forces to be transmitted to the machine construction. Plummer block's unit usually secured to 'sole plates' that are welded to the structure. The sole plates incorporate

jacking screws to vary the pulley-block to be properly and relatively merely aligned.

2. OBJECTIVE

The objective of the study is to perform the validation of the current baseline design and optimize a Single sheave Stringing Block for the required load conditions. The design requirement of the pulley is used for a cable stock bundles. The baseline design is evaluated for the required load capacity and optimized for the requirements.

3. METHODOLOGY

First geometric model of one sheave design is made using solid edge tool. It's followed by meshing that is finished using HYPERMESH software package. When meshing is finished, FEM is ready with appropriate element for the actual product. This is often followed by restricting the model that is finished by applying boundary conditions for the model and by applying material properties. For static and dynamic analysis purpose the model is imported to ABAQUS. Wherever analysis is finished and final results are obtained supported the constraints. ABAQUS is that the code used for performing static and dynamic analysis. By following these steps in written record order the results are obtained and additional examination is finished by studying these results.

3.1 Static Stress Analysis

Direct static pressure examination of a sheave is done utilizing ABAQUS programming. At first the segment is fit in Hyper Mesh and is imported to ABAQUS. Hyper work is a pre-processor and post-processor, ABAQUS is the solver. Static stress examination is performed to decide the greatest burdens actuated in the sheave structure to recognize most extreme worry in the structure. Sheaves with greatest pliable burdens are viewed as further investigation.

3.2 Optimization Analysis

The objective in the optimization is attempting to limit the greatest strain vitality determined from every one of the components in the sheave, as a result boosting the auxiliary solidness of the sheave. The limitation is constraining the streamlining to lessen the volume by 40% from the underlying worth. During the improvement the thickness and the firmness of the components in the focal point of the sheave are diminished with the goal that the components are, as a result, "expelled" from the examination. Be that as it may, the components are as yet present, and they could assume a job in the investigation if their thickness and solidness increment as the streamlining proceeds. A geometry confinement powers the improvement to make a model that could be thrown and expelled from a form.

3.3 Material Properties

Most common important aspect is to check whether the sheave withstand the load by applying material properties at pre-processing step. Here the material properties were applied while meshing. The material used in sheave design is Aluminium 1050; the properties have been specified below (Table 1).gives the material properties applied to the model. The material properties required for the current analysis are density, modulus of elasticity, Poisson’s ratio and tensile yield strength.

Table 1: Material properties

| Sl no | Properties | Magnitude |
|-------|---------------------------------------|-----------|
| 1 | Density (kg/m ³) | 2700 |
| 2 | Young’s modulus (GPa) | 69 |
| 3 | Poisson’s ratio | 0.33 |
| 4 | Tensile yield strength (MPa) | 103 |
| 5 | Ultimate tensile yield strength (Mpa) | 110 |

3.4 Geometric Modeling

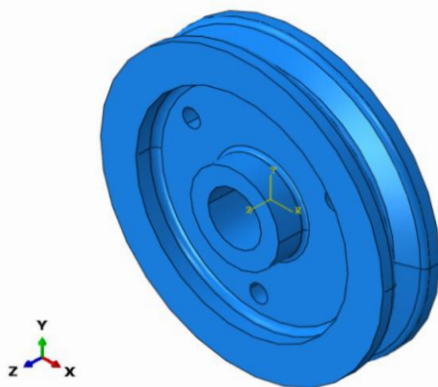


Fig 3.1: Finite element model of sheave.

Solid works might be a modeler that uses a highlighted basically based consistent way to deal with get model geometry and get together components. The Constraints are alluded as parameters that used to confirm the type of the model geometry or get together part esteems. Parameters will be geometric or numeric, numerical is additionally circle distance across or very surprising lengths of line and geometric segments, such is likewise parallel, concentric, digression etc. Model is built in solid edge by 2d sketch. Then to outline the dimensions and placement, dimensions are superimposed to the sketch. Attributes ar outlined by the relations like perpendicularity, tangency and correspondence. Latter drawings are created from components. Supported this drawing views ar generated mechanically and to the present tolerance and dimensions are superimposed.

3.5 Meshing

The meshing of a sheave is done by using the quadratic tetrahedral elements are shown in the below

The figure shows the ordinary bearing for the sheave component. The side surface of the sheave component has positive typical heading and is alluded as positive face for characterizing the contacts. The contrary surface is negative ordinary bearing along the typical. Both negative and positive surface inside the component counterbalances alluded to sheave mid-surface. The FE displaying is quadratic tetrahedral components of type C3D10 as appeared in above. Every component has 4 nodes for quadratic and three nodes for triangular components. These components give precise outcomes when the structure is under consistent bowing and film strain approximations. A reasonable better component size is utilized to catch the twisting and static redirection in the structure. Various components, can supplant to triangles. Nonetheless, C3D10 component become stiffer than quadratic, consequently C3D10 components are utilized. Free cross section procedures are basic lattice system in ABAQUS and use hexa shell component to acquire the exact and DOF.

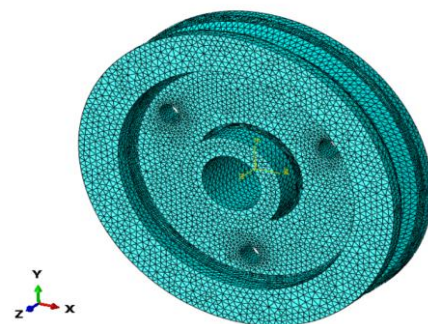


Fig 3.2: Meshing of a sheave component

4. RESULTS

4.1 Loads and Boundary Conditions

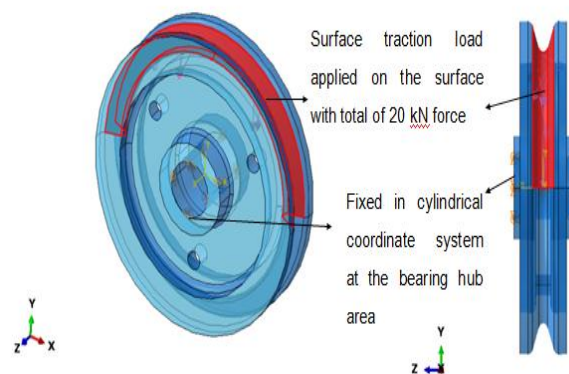


Fig 4.1: FEM of sheave and boundary condition applied to it

Traction load is applied on the one half of the sheave as it will be pulled by the rope/cable. Loading conditions or loads are forces, acceleration or deformation applied to a structure or its parts. Loads cause deformations, displacements and stresses in structures. Mechanical structures such as satellites, aircrafts, space stations and rockets have their own structural loads and actions according to the standards of contracts or published regulations. Thorough understanding of the boundary conditions is required to get good results. The load and boundary conditions are assigned in this section.

Boundary conditions are the constraints necessary for the answer of a boundary value drawback. A boundary value drawback may be an equation to be resolved in an exceedingly domain on whose boundary a group of conditions is understood. The condition is one more vital issue that governs the output of FEA. The load and boundary conditions are assigned during this section. Within the case of static express analysis, the amplitude should be predefined in assigning displacement boundary conditions in an analysis step, amplitude ramps the load and prevents impact loading.

4.2 Static Stress Analysis

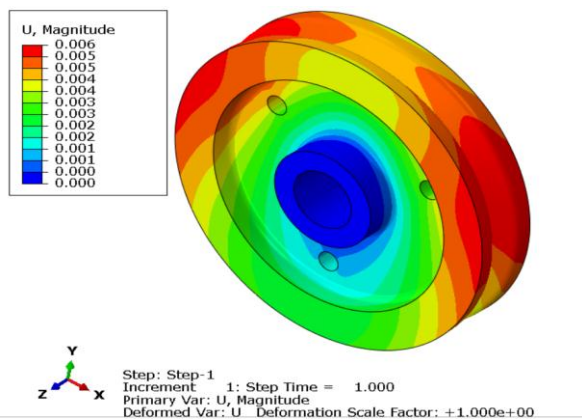


Fig 4.2: Displacement plot of the complete component

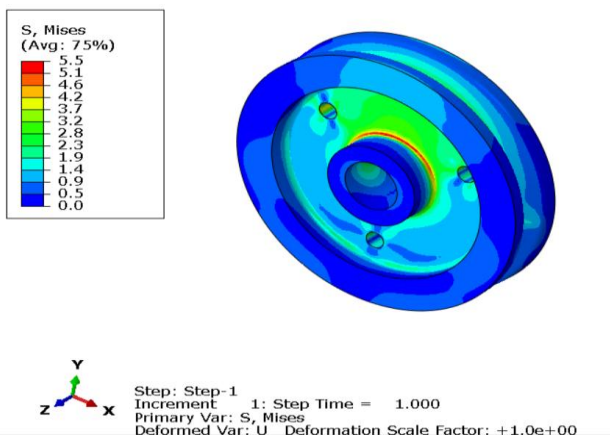


Fig 4.3: Static stress analysis of sheave component

The above figure [3.1] gives the representation of the displacement plot of complete sector model. Displacement is the change in the situation of the hubs in the material around the radii as for the first position of that hub in that material. This displacement plot is based on the boundary conditions and application of load or rotational body force on the material. It is clear from the figure that maximum displacement on the structure is 6 micron and tip growth remains as nearly same as maximum displacement, which is within acceptable limits and the minimum displacement on the structure is 0mm

The isometric model of a sheave where the von misses stress plot can be seen in the above the load is applied on the model deformation takes place and applied load is transverse through entire body. Once a body is subjected to load the sheave deformation takes place and the external force is develop the internal forces and reaction to render the body into a state of equilibrium.

4.3 Design Optimization

Optimization is maximizing or minimizing some capacity comparative with some set, frequently speaking to a scope of decisions accessible in a specific circumstance. The capacity permits correlation of the various decisions for figuring out which may be "ideal". Also, the fundamental goal of enhancement is limiting the expense; acquire more benefit, negligible mistake and ideal plan, optimal management.

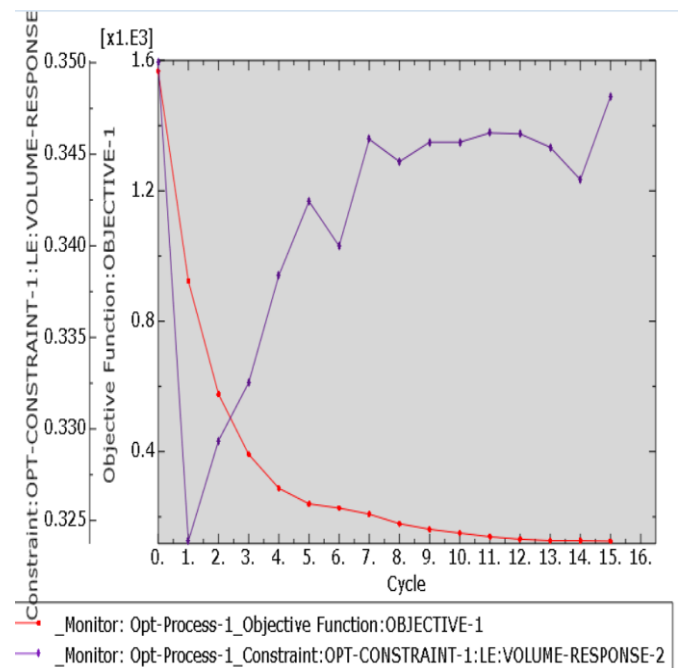


Fig 4.4: Optimization cycles of a sheave component

Design optimization chart shows the 12th case is stable and converged solution. The above graph represents the steps containing results of optimization design cycles for analysis. The design optimization chart shows that the 12th case is

stable and has the converged solution and hence the material can be removed from the base design upto 40% and reduce the cost of the sheave for same work efficiency.

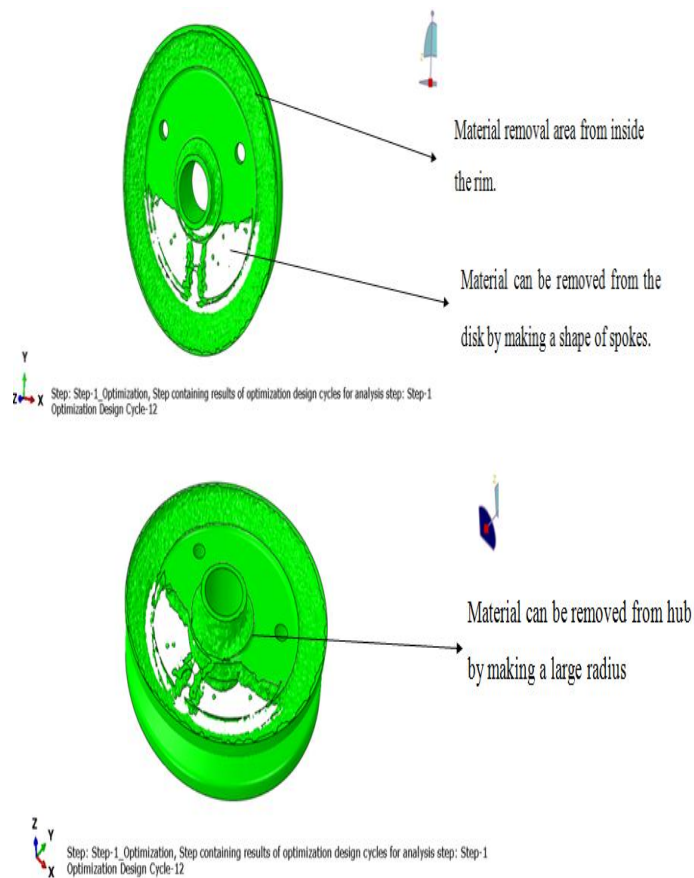


Fig 4.5: Optimized design of a sheave component

The above figures represents where the extra materials can be removed from the baseline design to reduce the size of the sheave without affecting its efficiency. Material can be removed from the disk by making a shape of spokes, inside the rim and from hub by making large radius. Thus the cost of the sheave can be reduced without changing its performance.

5. CONCLUSION

The base sheave design is analyzed using FEA and it was found that the design is oversized. There is substantial weight which can be optimized. The stress levels are found to be a small value of 5.5Mpa. So the optimization was performed to study the scope of removing material in the base design. Through the optimization technique, it was found that up to about 40 % material can be removed. This is substantial and thereby reducing the cost to the same proportion. At last the enhancement is done so as to change the measure and shape yet not the qualities.

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