Design and Development of Automatic Belt Tensioning Mechanism

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ABSTRACT

Drive System is the one of critical system in air compressor operating systems. The main function of drive system is to transmit desired power to the Air end. Compressor drive system consists of prime mover (motor), air end, structure and gear or belt. The drive system design either belt or gear is critical for efficient working of compressor.

KEY WORDS: Design, belt, inputs.

1. INTRODUCTION

The main objective of the work is to design automatic belt tensioning mechanism to eliminate the need for periodic tensioning of belt in conventional method. As the belt tension is the important factor for the slip threshold value, which determines the efficiency of power transmission.

Problem Definition: Maintaining proper tension in belt driven compressors for power transmission is essential throughout the life of the belt.

In conventional method, belt tensioning is maintained by periodic adjustment. In case of tension reduction in-between the two adjustments, the performance of the compressor gets degraded. Factors that get affected due to less tension is power, cost and life of belt.

Objective: To design and develop belt tensioning mechanism to maintain the initial set tension automatically.

2. METHODOLOGY

a) Frame design inputs, b) Selection of components for drive system, c) Concept generation for automatic belt tension mechanism, d) Concept selection, e) Simulation of drive assembly, f) Validate the system.

Concept: Concept is with the horizontal arrangement, Air end is fixed on the rigid frame,

a) Air end is placed on the sliding frame, b) Sliding frame is mounted on the two rods, rod and sliding frame will have the sliding contact, c) Spring is placed in-between the sliding frame and rigid frame, d) Lock-nuts are used to adjust the center distance between the pulleys, e) Belt tension can be achieved thereby adjusting the center distance, f) Spring will act against the belt tension with-respect to the pivot point to maintain the initial set tension, g) As the belt gets elongated over a period of time, spring will help in retaining the set tension, h) Working range for the belt is determined by the available sliding distance in the rod.

Drive System Design: Based on the selected concept Drive system has to be designed. Parts to design in such a way that the Final should be optimum i.e. lower the cost and Higher the performance. Detailed design has to be done for the following parts in the following sequence, a) Pulley, b) Belt, c) Spring, d) Structure, e) Anti-Vibration Mount.

Table.1. Design inputs

Parameter	Data
Power	15 KW
Duty Cycle	Continuous
Type of Duty	Medium Duty
Service factor based on type of Duty	1.3
Design Power	19.5 KW
Operating Ambient maximum	45°C
Operating Hours	24 hrs
Air Circulation	Forced
Operating Condition	Dusty/Humid
Efficiency of Belt Drive	98.6%
Motor RPM	2960 rpm
Air end Speed	7496 rpm

Spring Design: Purpose of spring is to retain the spring tension throughout the life of the belt. Input for spring is Belt and pulley design.

Input Data: Free Body diagram for Spring Design.

3. RESULTS

Table.2. Free Body diagram for Spring Design

Parameter	Data
Spring Available Length	70mm
Spring Cross Section	Circular
Spring ID (d)	16 Min
Motor Weight	160kG
Mean Coil Diameter (D)	21 mm
Manufacturing method	Cold Formed
End Coil Design	Closed and Grounded

Table.3. Spring Material Data

Parameter	DATA
Spring Material	Stainless Spring Steel
Shear Modulus G	81500 N / mm2
Youngs Modulus	206000 N / mm2
Density	7.85 kg/dm3
Condition	Shot Peened

Structure Design: Structure is one holds all the components of the drive system, entire load of motor, air end and dynamic loads transmitted to the structure.

Input Data: Free Body diagram for Structure Design:

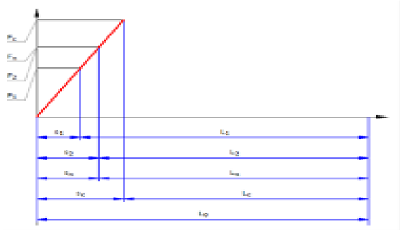

Figure.1. Design output

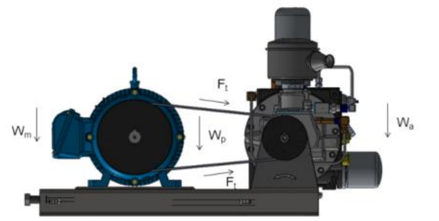

Figure.2. Free Body diagram for Structure Design

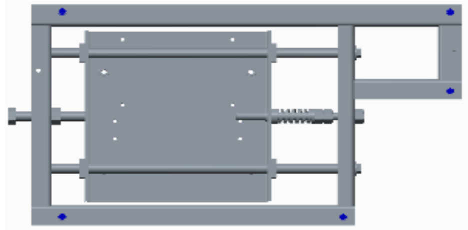

Figure.3.Boundary Condition

The structure is fixed in the above encircled region, where Anti-vibration mounts are fixed.

Table.4. Structure Design Input Data

Parameter	Data
Weight Of the Motor	160kg
Weight of the Air end	75kg
Gravity Load	10g
Belt Tension	386 N

Table.5. Material Specification (For Formed Channels)

Description	Machined Push plate
Material Specification	Fe 410 IS 2062-1992
Young's Modulus	$2.1x10^{5}$ N/mm2
Poisson's Ratio	0.3
Density	7.85 x 109 N.Sec2/mm4
Ultimate tensile strength	410 N/mm2
Yield Strength	255N/mm2
Fatigue Strength	210 N/mm2

Table.6. Material Specification

Description	Machined Push plate
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Poisson's Ratio	0.3
Density	7.85 x 109 N.Sec2/mm4
Ultimate tensile strength	410 N/mm2
Yield Strength	255N/mm2
Fatigue Strength	210 N/mm2

Gravity Load: Gravity load of 10g i.e. (10*9.81*1000=98100mm/sec^2) is applied with respect to world co-ordinate system.

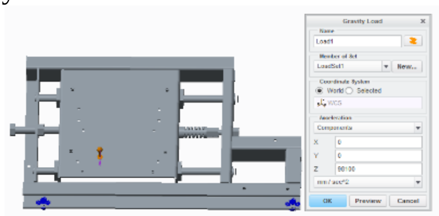

Figure.4. Gravity Load

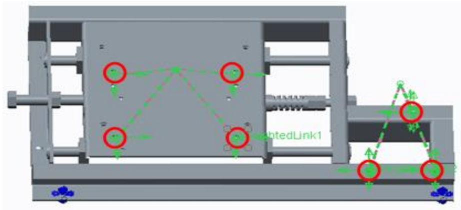

Figure.5. Weighted Link

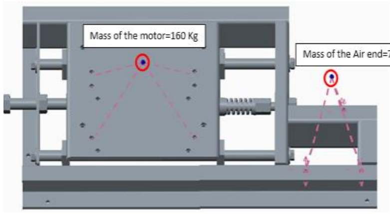

Figure.6. Mass Addition

Weighted link: A new co-ordinate system is created where the C.G of the motor and the air end acts. Weighted link is created in the encircled regions linked to the newly created Co-ordinate system for both the motor and air end.

Mass: The mass of motor and the air end are measured and the masses were added to the point were the C.G of the motor and air end lies.

Pre Processing: P-Type meshing is created for the model and it is preferred over H type meshing.

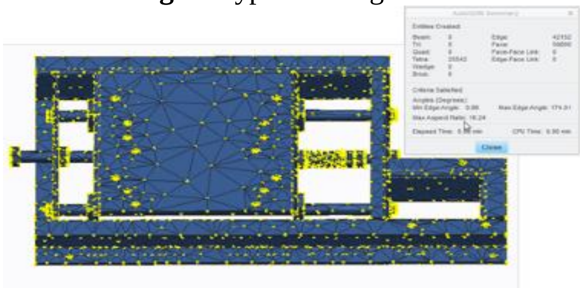

Figure.7. Meshing

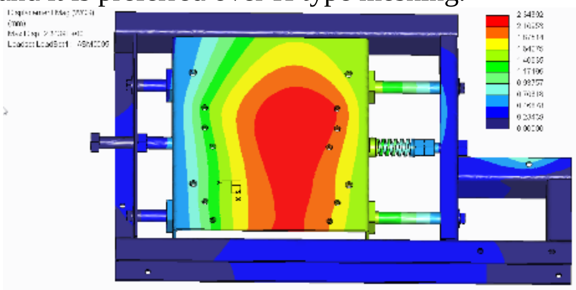

Figure.8. Deformation Plot

Post Processing: Static structural Analysis: For the given Boundary condition static structural analysis is done and the following results were obtained.

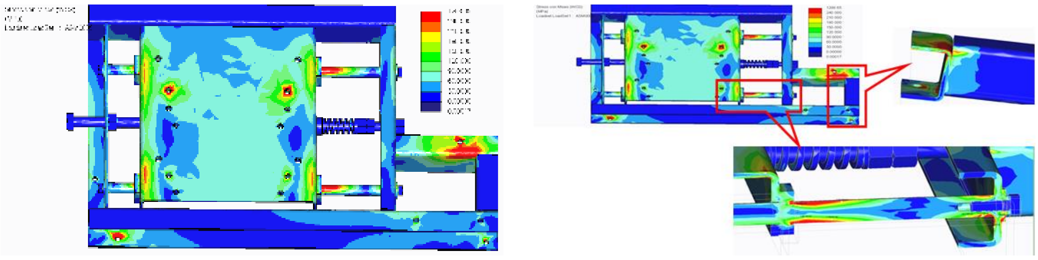

Figure.9. Von Misses Stress Plot

Table.7.Structure Design Output

	Maximum Deformation (mm)	Von misses stress (MPa)	Allowable stress (MPa)	Factor of Safety	Remark
Loading at 10g	2.34	198	240	1.21	Safe

The result summary table shows that the structure is safe for the given loading condition.

CONCLUSION

Maximum deformation from the deformation plot is 2.34 mm which is acceptable as it will be taken by the Anti – vibration mount.

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