Review & Design 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 systems design either belt or gear is critical for efficient working of compressor. The main objective of this paper is to design automatic belt tensioning mechanism to eliminate the need for periodic retensioning 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.

KEY WORDS: Drive system, springs, Belt tensioning.

1. INTRODUCTION

Compressor is a device that converts input power from (Electrical motor or engines) to pressure energy. Drive system is the one that transmit power from prime mover to the Air-end (Screw) which in-turn converts that into pressure energy.

The drive system should be designed in such a way that the power loss has to be minimum. As the designed drive system is tend to be less efficient the energy loss is more. Hence the efficient design of drive is extremely important in the aspect of energy saving.

The drive system consists of; a) Air end, b) Motor, c) Transmission Device, d) Structure, e) Anti vibration Mount.

The automatic belt tensioning is the important criteria for belt life and performance. Factors like heat generation, friction, span vibration influence the performance of the belt drive system.

Drive System Design:

Drive System: Drive system design involves selection of components based on the design inputs and optimized design. As a system it has to be components to design, so that the interactions between the components will be smooth. It also involves the design of automatic tensioning mechanism which effectively maintains the belt tension throughout the life of the belt.

Drive System Function: The drive system has two functions; Power Transmission and Compression.

Motor is the prime mover for the drive system, power from the prime mover is transmitted to the air end by belt. Air end converts that into pressure energy.

Component Design Inputs: Drive system design starts with the lay-outing of the component based on the size limitations of the compressor package. Before that, the components have to be selected, following are the basic design guidelines and inputs for the drive system components design.

Air end: Basic screw is selected based on the two main design input power and flow. Capacity of the air end is determined by the L/D ratio of the screw. It determines the volume of getting trapped in-between the two screws.

Motor: Motor selection is based on the power it needs to deliver and speed of the motor. The power that the motor delivers is utilized for compressing the air.

Speed of the motor is one of the key phenomenons in selection of pulley diameter. A speed requirement determines the no of poles of the motor. Efficiency of the motor is also one of the key factors in motor selection .Higher the efficiency of the motor more will be the energy savings.

Pulley: Pulley selection is based on the motor speed and air end speed. It determines whether it has to speed up or speed down. It is done by the basic formula.

$$\frac{N1}{N2} = \text{Eff} \times \frac{D2}{D1}$$

Belt: Input parameters for belt design are; a) Pulley diameters, b) Centre distance, c) Surrounding temperature.

Anti-Vibration Mount: Type of AVM and number of AVM is based on; a) Weight, b) Center of gravity, c) Isolation requirements, d) Transmissibility.

Concept Generation:

Concept Design: Concept generation starts with the lay-outing of the components of the drive system. The two type of chosen for arrangement of components of drive system are; Vertical Arrangement and Horizontal Arrangement.

Concept 1: Concept one is with vertical arrangement.

a) Motor is fixed on the rigid plate given in the bottom
b) Air end is placed on the swing plate.
c) Swing plate is pivoted in the vertical bar.
d) Other side of the swing plate is rested over the screw stud
e) Lock-nuts are used to adjust the center distance between the pulleys.

f) Belt tension can be achieved thereby adjusting the center distance
g) Spring will act against the belt tension with-respect to the pivot point to maintain the initial set tension.
h) As the belt gets elongated over a period of time, spring will help in retaining the set tension.

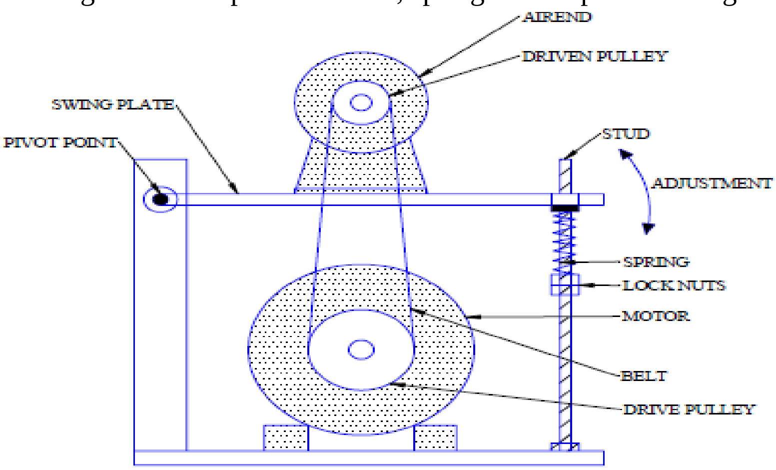

Figure.1. A Vertical Arrangement

Concept 2: Concept one is with horizontal arrangement.

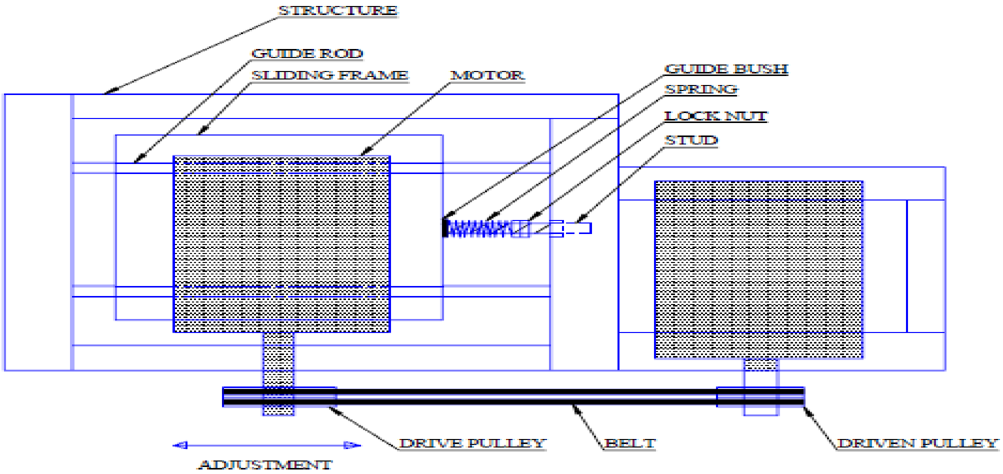

Figure.2. A horizontal Arrangement

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

Concept Selection: Concept selection is done using Pugh matrix by selecting the important requirements parameters.

Table.1. Pugh Matrix Selection

Criteria	Importance Rating	Concept 1	Concept 2
Performance	5	3	4
Life	4	3	4
Cost	3	4	3
Manufacturability	2	3	3
Assembly	2	3	3
Servicability	2	2	3
Total		18	20

Based on the above concept two looks better in many parameters, hence concept 2 was selected for detailed design.

Detailed Design:

Table no.2 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	45^0C
Operating hours	24 hrs
Air Circulation	Forced
Operating Condition	Dusty/Humid
Efficiency of Belt Drive	98.60%
Motor RPM	2960 rpm
Airend speed	7496 rpm

Table.3. Design Output

	Parameter	Result	Unit
Motor			
	Power	15	kW
	No. of Poles	2	-
	Service factor	1.1	-
	Motor RPM	2960	rpm
	Frame size	132	-
Pulley			
	Drive Pulley Diameter-D1	200	mm
	Driven Pulley Diameter-D2	80	mm
Belt			
	Belt speed – v	31.4	m/s
	Modified Power rating – Pm	10.12	Kw
	No. of Belts	2	-
	Center Distance	393	mm
	Belt Pitch length - Le	1230	mm
	Span Length	387.9	mm
	Axial Load - Fv	-268.88	N
	Static Tension - Ts	386	N
Spring			
	Free length	44	mm
	Coil diameter	5.5	mm
	Solid Height	27.5	mm
	Coil inner diameter	16	mm
	Spring rate	75	N/mm
Anti-vibration mount			
	Load	1500	N
	Deflection	5	mm
	Deflection Ratio	79	-
	Transmissibly	98	%

Detailed 3D Model: Detailed 3D model has been done based on the selected components.

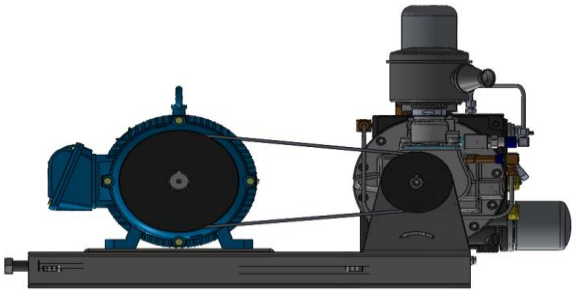

Figure.3. A 3D Model Arrangement

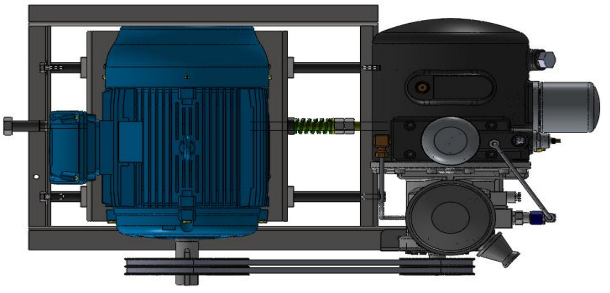

Figure.4. A Side View Arrangement

2. CONCLUSION

Drive system design has to be analyzed for structural strength and drawings will be released for procurement. Once procurement is done, drive system has to be assembled and tested, same will sent to field for validation. This estimated design will give better efficiency process.

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