Design, Modeling and Analysis of Rotary Air-Lock Valve

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ABSTRACT

The Rotary Air-locks provide reliable service in high pressure, high temperature and other severe service conditions. The valves can be used in various industries such as food, plastics, chemical, asphalt, mining, baking, cement and paint. The main function of a Rotary Air- lock Valve is to regulate the flow of material from one chamber to another while maintaining a good airlock condition. The material or product being handled is usually dry free flowing powder, dust or granules.

Rotary Air-lock Valves are used at the bottom of Bins, Cyclones, Dust Collectors or Feed Hoppers to discharge materials at a controlled rate or act as an Airlock. They are also used to introduce materials into positive or negative conveying systems. A Rotary Feeder / Airlock Valve consists of a rotor which turns at a given RPM in close clearance to its casing thus maintaining a uniform rate of material flow and provides a seal.

In operation, a motor and drive chain turn the rotor shaft, spinning the rotor inside the housing and head plates. As the blades rotates a fixed volume of material passes through the material inlet to the spaces between adjacent blades (called rotor pockets) and is carried in the pockets toward the material outlet.

As per Bevcon provide drawings of Rotary airlock valve are designed and drafted in year 1995`1996 manually on a drawing board. 3D modeling of Rotary airlock valve is done in Pro-e. Theoretical calculations are performed for selecting bearing diameter and deflection of shaft as per beam analysis find out by using Ansys.

The analysis of shaft and rotor assembly done in Ansys to find the deflection values from these values Factor of safety of selected diameter is calculated. In brief 3D models developed in pro-e & analyzed reports have been submitted to Bevcon for their consideration in their designs.

Keywords: *Air locks, Ansys, Bevcon, Pro-E, Rotary feeder.*

I. INTRODUCTION

The main function of a Rotary Air- lock Valve is to regulate the flow of material from one chamber to another while maintaining a good airlock condition. The material or product being handled is usually dry free flowing powder, dust or granules. In operation, a motor and drive chain turn the rotor shaft, spinning the rotor inside the housing and head plates. As the blades rotates a fixed volume of material passes through the material inlet to the spaces between adjacent blades (called rotor pockets) and is carried in the pockets toward the material outlet.

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Rotary Air- Locks are usually used to accomplish 3 basic tasks:
a) to feed material from bins or hoppers.
b) To deliver fines from the collector while sealing against air loss.
c) And to feed material to pneumatic conveying line against pressure.

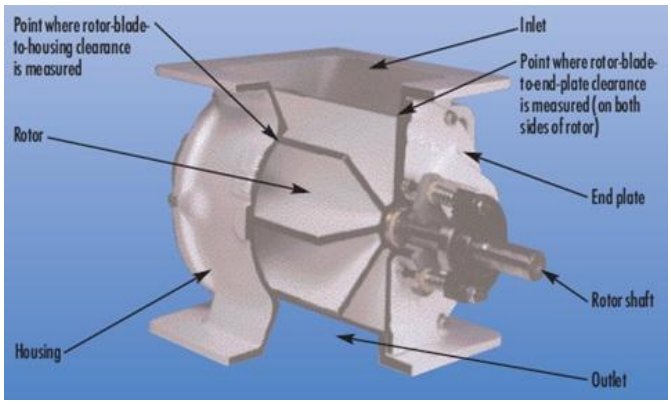


Fig.1 Rotary Air-lock valve cut way view

II. ROTARY

Refer to this figure and locate the vanes and pockets. The word 'rotary' refers to the fact that during operation of a rotary airlock, the vanes turn or rotate. As they turn, the pockets, which are formed between the vanes, become rotating pockets. The material being handled enters the pockets at the top, through the Inlet port, travels around in a rotating motion, and exits at the bottom, or through the Outlet port. As the vanes and pockets continue to turn, material continues to be moved from top to bottom, or from Inlet port to Outlet port, in a rotating motion.

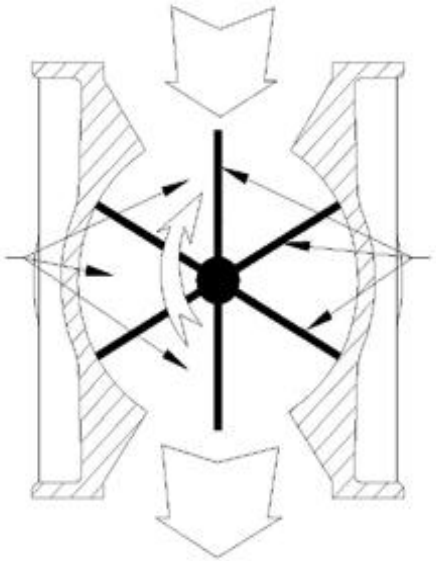


Fig.2 Rotary

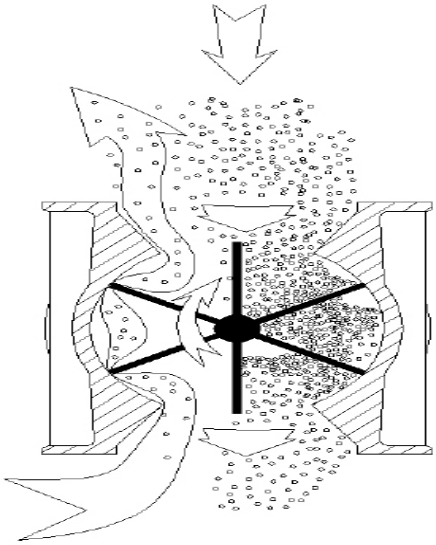


Fig.3 Airlock

III. AIRLOCK

Refer to above figure, the word 'airlock' means that this device is to act as a seal, or lock to the air, between the Inlet and Outlet ports, while moving material in a continuous rotating motion through its pockets. Material travels downward from Inlet port to Outlet port, but airflow is restricted. To provide a reference in discussing airflow through the rotary airlock, we have notated a 10 PSI air pressure on the Outlet port side. The air pressure, in this example, is trying to push airflow up through the rotary airlock

IV. OPERATING PRINCIPLE

The material is fed into rotor pockets (A gap between two vanes) from hopper or bin. Due to rotation of shaft vanes also rotates. Due to rotation of vanes the, material in the rotor pockets will be transferred from inlet of airlock valve to its outlet. From outlet it will go to the pneumatic conveying system.

1. Types of Rotary Air-lock valves:

- Drop Thru Rotary Airlock
- Side Entry Rotary Airlock
- Blow Thru Rotary Airlock
- Easy Clean Rotary Airlock
- The Removable Gland Follower

2. Features of Rotary Airlock valve

- Outboard bearings
- Replaceable packing rings
- Round or square flange available
- Larger shaft diameters than competition
- Cast iron, 304SS, 316SS, 316SS Ni-Hard

3. Benefits of Rotary Airlock Valve:

- No product contamination higher operating temperatures
- Easy packing change without rotor removal
- Select from multiple sizes to fit the application
- Reduces deflection
- Assures maximum torque delivery

4. Design of shaft

Data for calculations

- Weight of Air lock valve = 600kg
- Arm Length = 240mm
- Speed = 27 rpm
- Shear Force = 650 kg/cm2
- Bending Force = 800 kg/cm2
- Combined shock & fatigue factors for bending (k_m) = 2
- Combined shock & fatigue factors for torsion (K_t) = 2
- Power = 2 H.P
- Bearing Length = 140cm

Summary for Theoretical Calculations

The deflection obtained theoretically is 0.0135mm. This deflection will compared with deflection obtained in Ansys. We can ensure a safety by seeing Factor of safety. For Rotary Airlock valves the factor of safety should be in range of 1 to 2. For us the factor of safety obtained is 1.45. So these values are safe for designing airlock valve.

v. ASSEMBLY MODEL OF ROTARY AIRLOCK VALVE

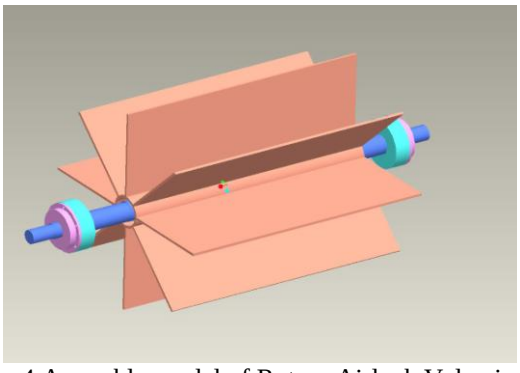
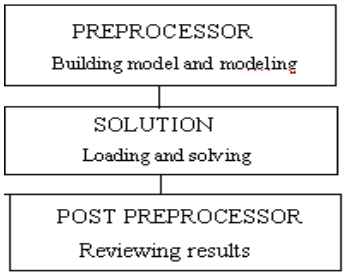


Fig.4 Assembly model of Rotary Airlock Valve in Pro-E

VI. ANALYSIS OF ROTARY AIRLOCK VALVE IN ANSYS

Basic steps in ansys (Finite Element Software):



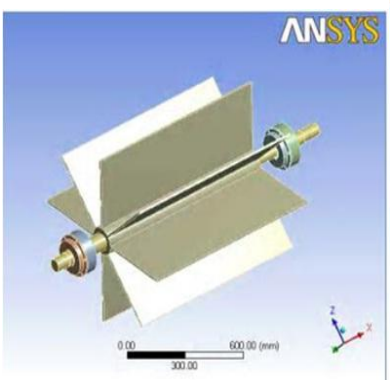


Fig.5 Imported model

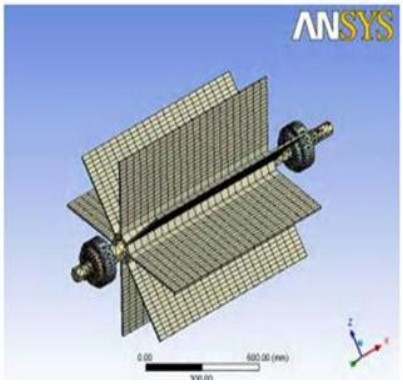


Fig.6 Meshed model

VII. RESULTS & DISCUSSSION

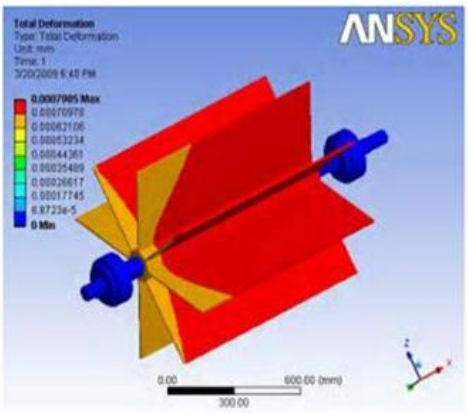


Fig.7 Total deformation

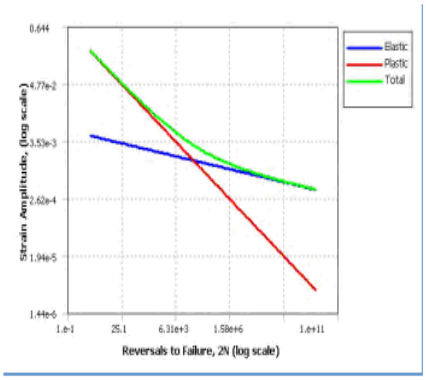


Fig.8 Results summary

Let us see the results in 2D and 3D. We have taken beam as element type and analysis is performed on it. We got maximum deflection of 0.04194mm which is very less compared to safe limit. The following figure shows the nodal solution.

Now we can see the stresses in shaft. Maximum stress developed in shaft is 22.9 N/mm^2 which is far less than the yield strength of the material, which is 45 N/mm^2. So that shaft will not fail under these conditions.

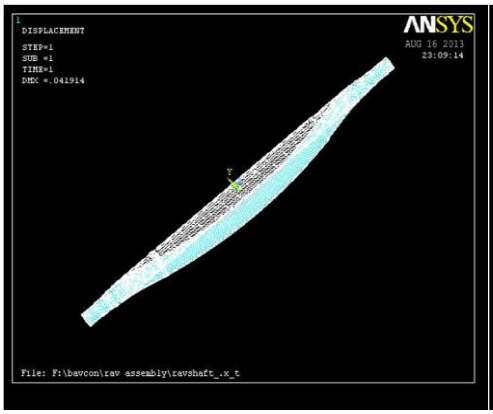


Fig.9 Maximum stress

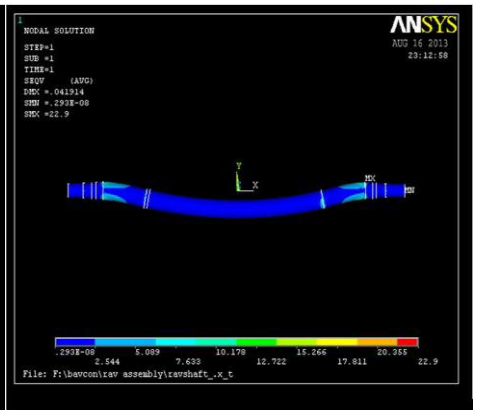


Fig.10 yield strength

VIII. CONCLUSION

As per Bevcon provide drawings of Rotary airlock valve are designed and drafted in year 1995`1996 manually on a drawing board. 3D modeling of Rotary airlock valve is done in Pro-e. Theoretical calculations are performed for selecting bearing diameter

- As per calculations selected diameter is 60 mm
- Bearing selected for Rotary airlock valve is deep groove ball bearing.
- As per drawings shaft diameter is 90mm. Based on calculations the diameter obtained is 60mm
- Deflection of shaft as per beam analysis 0.0134 mm
- As per analysis of shaft and rotor assembly done in Ansys, deflection values of shaft and rotor assembly are 0.041 and 0.0007 mm respectively.
- Factor of safety of selected diameter is 1.45
- 3D models developed in pro-e & analyzed reports have been submitted to Bevcon for their consideration in their designs

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