Scientific Journal of Impact Factor(SJIF): 3.134
e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 4, April -2015

Reduction in heat generation due to friction in pneumatic pump shaft and sealing housing assembly

Meera B. Kokate [1], S. B. Jaju [2], M. K. Das [3]

[1] *Student M.Tech CAD/CAM, GHRCE, Nagpur- 440016, India*
[2]*Professor, department of mechanical engineering, G.H. Raisoni college of engineering Nagpur- 440016, India*
[3]*Sr. G.M.Design and Development, AMCL Machinery Ltd., Nagpur- 441122, India*

Abstract —*The pneumatic screw pump is a conveying unit. It conveys the material at required distance, required height with required pressure. Amount of the material is regulated using air amount mixed with material and pressure is regulated by controlling pressure of the air mixing with material.. The pump works on the high speed air flow pressure variation principle. Factors affecting performance of the pump are heat generated inside the pump, pressure in the pump, occurrence of negative pressure, leakages in the pump. The objective of this paper is to reduce the heat generated in the pump by doing chrome plating of the shaft and modifications in seal housing assembly, as this is the maximum heat generated area when checked experimentally. Surface finishing of the shaft also reduces the friction and thereby heat generation.*

Keywords- *seal housing assembly; grease spacer; chrome plating; pet coke; friction*

I. INTRODUCTION

The pumping system comprises of a stationary pump, a compressor, pipeline, and diverting valves. The Pneumatic screw pump is shown in figure.1. Pump pushes the material like cement, coal, pet coke etc. from atmospheric pressure range to the flow of conveying air of a pneumatic conveying airline which is at over pressure. The pump is designed according to high speed air flow pressure variation principle. When powder is delivered to Hopper and mixing chamber continuously and evenly, high pressure air flows out and then it is mixed with powder. Next the mixture enters into pipelines and pressure decreases gradually

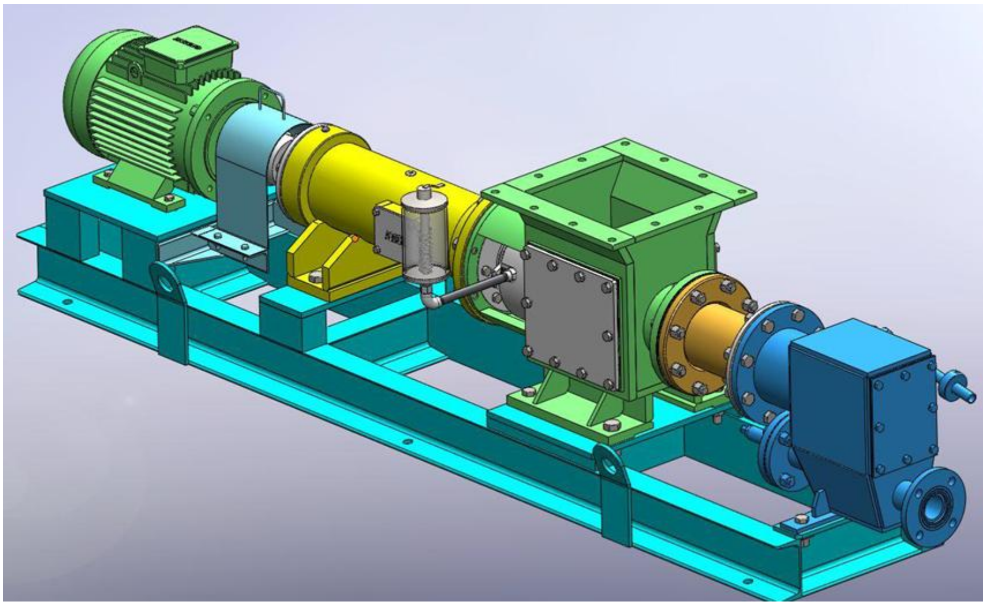


Figure 1. Pneumatic screw pump *(source: AMCL Machinery ltd, Nagpur)*

As maximum temperature occurred at seal housing assembly, that area is concluded as maximum heat generating area. And friction was considered as sole reason for heat generation as it contains seals, o rings, etc components.

Heat generation will affect:

- Failure of screw shaft because of deflection
- Shorten the life of any Rubber part, seals
- Change the viscosity of the bearing oil and eventually cause bearing failure

To reduce heat generated, friction between shaft and seal housing assembly need to be reduced. Friction and thereby heat generated can be reduced by surface finishing of the shaft, by using proper lubrication and cooling techniques, by using sensors or alarms so that the maximum temperature value should not be exceeded.

Chrome plating of the shaft can improve smoothness of the shaft. Hence friction will be less between shaft and seal housing assembly. During grinding of the shaft, depth of 75 microns can be given to the shaft. Through this depth plating will be done. Because of plating of the shaft, chances of replacing shaft is reduced, since if the shaft surface is damaged, chrome plating can be done again and again. There is no need of chrome plating of the whole shaft as maximum friction occurs at of seal housing assembly. Hence only the shaft portion under seal housing assembly need to be chrome plated. Properties of the chromium are high hardness, Corrosion resistance, Wear resistant, Chrome plating can be used over a wide temperature range. Chrome plating area of the shaft is shown in figure 2.

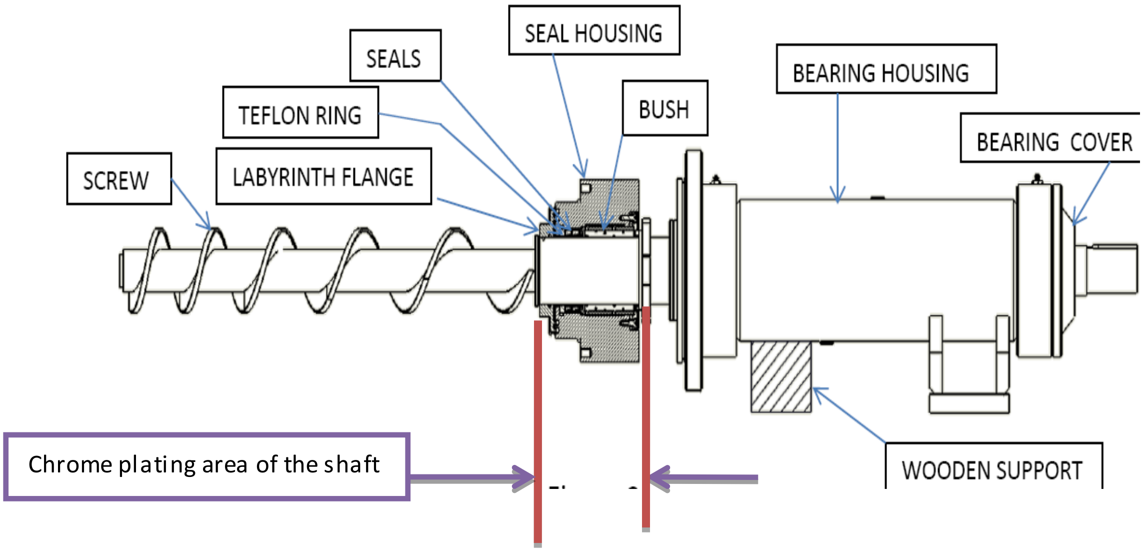
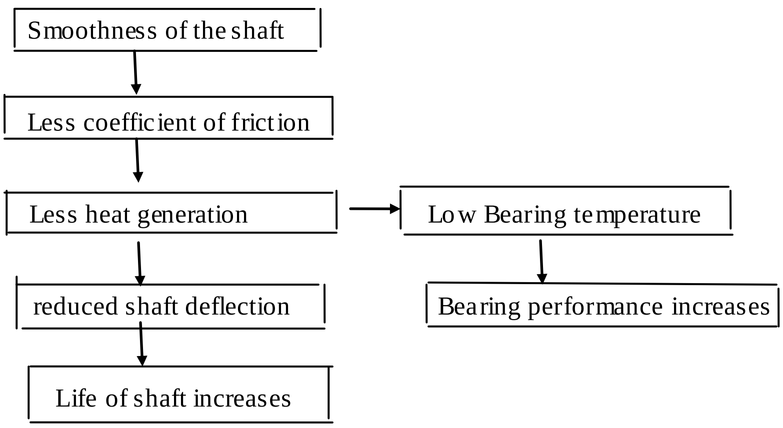


Figure 2. Chrome plating area of the shaft *(source: AMCL Machinery ltd, Nagpur)*

II. BENEFITS OF CHROME PLATING



III. CALCULATIONS FOR HEAT GENERATED DUE TO FRICTION BETWEEN SEAL HOUSING ASSEMBLY AND SHAFT

Heat generation due to friction

$$Q = \mathbf{F_f} * V$$

Where, $\mathbf{F_f}$ - friction force

V- sliding velocity of the cylinder

since, shaft seals are rotational, heat generation is expressed in terms of rotational velocity ω

$$Q = \mathbf{F_f} *\omega*\pi*(r_{outer}+ r_{inner})$$

$$\mathbf{F_f = \mu* F_n}$$

μ is the coefficient of friction

$\mathbf{F_n}$ is the normal force or weight

$$Q = \mu* \mathbf{F_n} *\omega*\pi*(r_{outer}+ r_{inner})$$

Total heat generated at seal housing assembly (for steel shaft):

$$Q = (2*Q_S) + Q_O + Q_{fp}$$

Q_S is the heat generated due to friction between shaft and seals

Q_O is the heat generated due to friction between shaft and o' ring

Q_{fp} is the heat generated due to friction between shaft and felt packing

Input data:

Data required for calculations	value	units
ω	1450	RPM
μ for steel and rubber	0.4	-
μ for steel and o ring	0.4	-
μ for steel and felt packing	0.28	-
μ for chromium and rubber	0.25	-
μ for chromium and o ring	0.25	-
μ for chromium and felt packing	0.15	-
r_{outer} for seals	46	m
r_{inner} for seals	40	m
r_{outer} for o ring	42	m
r_{inner} for o ring	40	m
r_{outer} for felt packing	43.5	m
r_{inner} for felt packing	40	m

Table 1. Input Data

Calculated values:

Calculated data	values	units
Q_S before chrome plating	0.76	W
Q_O before chrome plating	0.195	W
Q_{fp} before chrome plating	0.695	W
Q_{Total}	2.41	W
Q_S after chrome plating	0.48	W
Q_O after chrome plating	0.122	W
Q_{fp} after chrome plating	0.372	W
Q'_{Total}	1.45	W

Table 2. Calculated values

From table 2., it is shown that after chrome plating, heat generation value reduces by 40% than the heat generation before chrome plating.

Heat can also be reduced by a little amount by addition of a grease spacer in between two seals. Through this spacer, grease is supplied. This grease will provide lubrication and will pass away the heat generated between shaft and seals continuously. Addition of grease spacer is shown in figure 3.

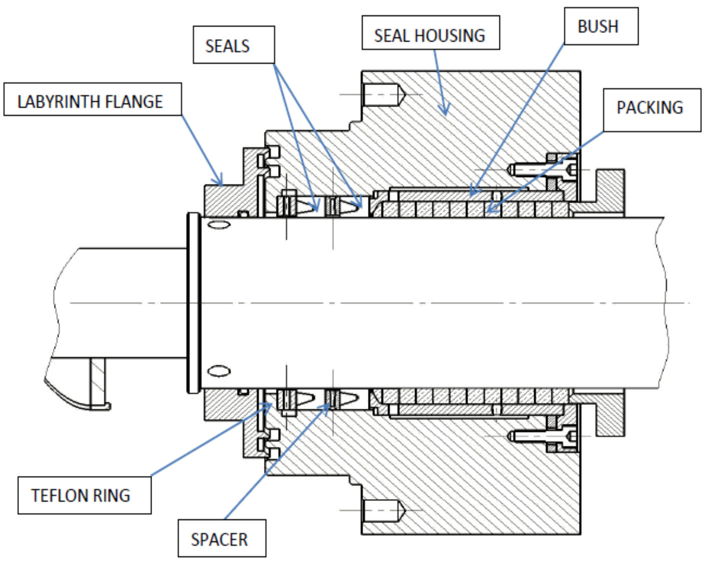


Figure 3 – Addition of grease spacer between two seals *(source: AMCL Machinery ltd, Nagpur)*

IV. LITERATURE SURVEY

As bearing failure occurs due to more heat generation, in one of the paper [6] hot box detectors are used. The finite element (FE) model was used to simulate different heating scenarios with the purpose of obtaining the temperatures of internal components of the bearing assembly, as well as the heat generation rates and the bearing cup surface temperature. The results showed that, even though some rollers can reach unsafe operating temperatures but the bearing cup surface temperature does not exhibit levels that would trigger HBD (hot box detector) alarms.[6]

The pumping system incorporates only one component in the pipeline, allowing the pipeline to be back-pressurized from the silo to the blockage with air at a slightly higher pressure than the conveying pressure. The back-pressure then is released in a controlled manner such that the blockage is drawn through the conveying line. These systems have been incorporated successfully in the control circuits of plants handling difficult-to-convey materials and also have been used on conveying pipelines up to 1.5km in length [8].

Pneumatic screw pump have many application for handling different materials with high pressure. Because of high pressure, and friction between mating surfaces, heat generation is more. For that cooling lubricants are used. Contamination of the cooling lubricants which cannot be avoided completely often leads to premature wear, resulting in loss of production and high maintenance costs.
The specially developed pump case is manufactured from silicon carbide, the screw rods are made of specially treated high-performance steel. This combination of materials prevents wear almost completely, resulting in a maintenance-free pump and an extraordinarily high efficiency. Depending on the design, this pump can be operated inside or outside of the pumping medium and reaches delivery pressures of up to 150 bar [9].

It is recognized commonly that

$$\text{Erosion} \ \alpha \ \text{velocity}^n \qquad (1)$$

Where, the power index, n, is 2 for ductile materials and 6 for brittle materials [8]. Hence, one direct way of reducing pipeline wear (e.g., pipe, bends). is to limit the ‘‘natural’ increase in velocity in the direction of flow _i.e., due to the expansion of the carrier gas.. This can be achieved by increasing the bore of the conveying pipeline in the direction of flow.

Other advantages of stepped-diameter pipelines include the minimization of pressure loss, air flow and hence, power consumption, which are particularly important when considering long-distance and/or large-throughput applications. By selecting accurate stepping pipe criteria and models to predict pressure drop [8], it is possible to optimize the design of these pipelines and obtain more efficient transportation over longer conveying distances e.g., up to L=3 or 4 km. Some examples of long-distance stepped-diameter pipeline systems include 100 t/hr of fly ash over 1.5 km [8] and 24 t/h of pulverized coal over 1.8 km [8]

Following numerous blockages on the test facilities at the University of Wollongong [8] attempted to determine the minimum conveying velocity of various materials over long distances, a pipeline unblocking system was developed and installed at the end of the pipeline. Refer to Figure 4. for a typical arrangement.

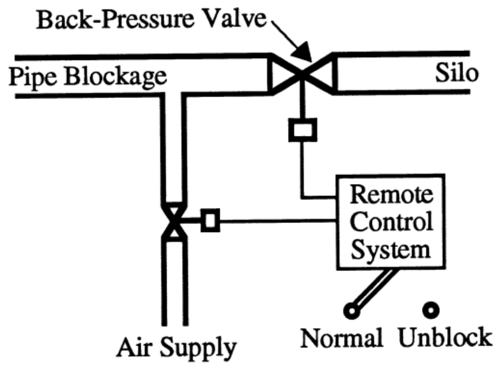


***Figure 4. Pipe unblocking system** [8]*

More demanding service requirements impose challenges on screw pump manufactures to provide higher pressure or flow capability, better wear resistance, improved corrosion resistance and lower leakage emissions. Better materials and more precise machining techniques as well as engineering innovation have led to improvements in all these areas. Single screw pumps, also known as progressive cavity pumps use an elastomeric stator and a flexible joint eccentric rotation metallic screw. They are most commonly used for high solids content, viscous flows such as sewage, cement and other difficult slurries

Three screw pumps are the largest class of multiple screw pumps in service today. They are commonly used for machinery lubrication, hydraulic elevators, fuel oil transport and burner service, powering hydraulic machinery etc. Three screw pumps are renowned for their low noise levels, high reliability and long life.[7]

In twin screw the stationary bores in which the screws rotate can be provided with a thick industrial hard chrome coating which further reduces the likelihood of galling as well as providing a very hard, durable surface for wear resistance. [7]

IV. CONCLUSION

. Heat is generated because of friction between seal housing assembly and shaft. Hence if friction is reduced to some extent, heat generation will also get reduced. Friction can reduced either by surface finishing of shaft or electroplating of the shaft with hard and smooth material like chromium or nickel. As chromium can sustain more temperature as compare to other electro plating materials, it can used in high temperature applications. Heat generation is reduced by 40% after chrome plating of the shaft.

By adding grease spacer in between two seals, heat generated can be reduced. Grease passing through the spacer will carried out some of the heat and lubrication will also be provided

REFERENCES

[1] Francis E. Kennedy Dartmouth College "MODERN TRIBOLOGY HANDBOOK" Volume 2 chapter 6 Frictional Heating and Contact Temperatures. Bharat Bhushan – 2000 - Technology & Engineering

[2] D. Dowson, M. Priest, G. Dalmaz, A. A. Lubrecht "Tribological research and design for engineering system", Tribology series -41, pg no. 125

[3] Ju Chen1; Ben Young, M.ASCE2; and Brian Uy, M.ASCE3 Behavior of High Strength Structural Steel at Elevated Temperatures

[4] Eric Svenson "DuraChrome Hard Chromium Plating" Plating Resources, Inc. Cocoa, Florida, USA 1980, 2006

[5] James Carvill "Mechanical engineer's data handbook", pg no 96-97

[6] Constantine M. Tarawneh1 Arturo A. Fuentes Javier A. Kypuros Lariza A. Navarro Andrei G. Vaipan et al.,"Thermal Modelling of a Railroad Tapered-Roller Bearing Using Finite Element Analysis", , SEP. 2012

[7] Peter W. Wypych "Pneumatic conveying of powders over long distances and at large capacities" Department of Mechanical Engineering, Unifersity of Wollongong, Wollongong, NSW 2522, Australia , Powder Technology 104 _1999. 278–286

[8] P.W. Wypych, A.R. Reed, Powder Handl. Process. 2 (1990) pg no-217.

[9] P.W. Wypych, O.C. Kennedy, P.C. Arnold, Bulk Solids Handl. 10(1990)421

[10] R.D. Marcus, L.S. Leung, G.E. Klinzing, F. Rizk, Pneumatic Conveying of Solids, Chapman & Hall, London,(1990).

[11] P.W. Wypych, Mech. Eng. Trans. IE Aust ME20 (1995) 293.

[12] L. Rozeanu, F.E. Kennedy "Surface and Near-Surface Interactions Affecting Friction and Wear" tribology series, Volume 36, 1999, Pages 665–672 14 September 2007

[13] F.T. Barwell "Advances in friction and wear mechanisms" Tribology International Volume 17, Issue 6, December 1984, Pages 299–307 13 February 2003

