EXPERIMENTAL ANALYSIS OF SEPARATION DEVICE FOR MECHANICAL SEAL WITH TWO PHASE FLUID APPLICATION

Chandramuni.L.Honwadajkar[1], S.K.Bhor[2]

[1] *Design Engineer, Mechanical Engineering, Savitribai Phule Pune University, Maharastra, India*
[2] *Professor, Mechanical Engineering, Savitribai Phule Pune University, Maharastra, India*

ABSTRACT

The paper covers improvements of Mechanical Seal technology in Used in advanced fields such as in some refineries, pumping stations. Failure of the mechanical shaft seal is the most common cause of pump downtime. Slurry pumps to transport liquids and solids throughout the refining process. The failure of these pumps can significantly impact on a refineries ability to produce and consequently the reliability of the equipment is a major focus. Percentage of solid, concentration and particle size create a combination which will result in failure. This paper presents separation device working principle and experimental Design for high performance in order to avoid the mechanical seal Failure.

Keyword : - *Slurry pump, Mechanical seal, erosion of seal face.*

---

1. INTRODUCTION

Mechanical seal the design of mechanical seal an art which has been carried out since the development of the first mechanical seal in the early 1900's. Mechanical Seals is a device which is widely used in the industry to prevent the leakage of fluid into the surrounding. It's may also serve to prevent the entry of foreign bodies into the operating medium or loss of lubricant from transmission or bearings.[1] They are mostly used in industrial pumps, compressors, agitators, mixers, rotary unions, submersible motors and other applications to prevent leak between the component parts. Basically a leakage in observed in all mechanical seal but can be minimized. Stuffing boxes, labyrinths, bushings, lip seals, spiral-groove seals and mechanical seals made up of various materials, are the common systems used for sealing rotating shafts.[1]

The basic component of seal is a rotating part mounted on the shaft and a stationary mating part which is fixed into the housing. A mechanical seal is a dynamic design having a spring element mounted on stationary or rotating part of the sealing system. It can be a spring element mounted on stationary part of sealing system to compensate the misalignment of the seal and shaft

Mechanical seal consist of various components such as the spring giving contact force and the packing which eliminates intrusion of fluid from the outside. The seal faces are accurately flat face. Thus if it is worn, it wouldn't cause leakage of the Media as far as the wear is within the maximum allowable limit. Thus the life of such seal is long, maintenance free, effective and efficient in terms of reliability and economy.

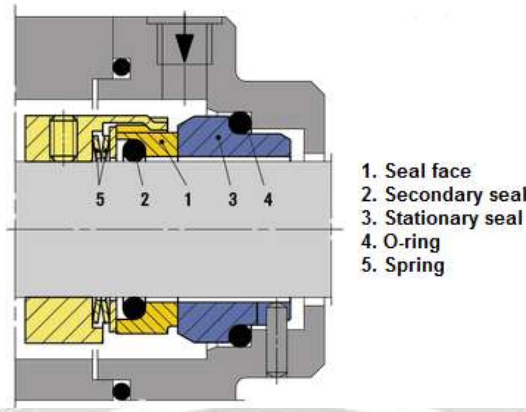


Fig - 1: Mechanical Seal Basic components

1.1 Introduction to Slurry Pumps [2]

With Slurry pumps are used to transport solids in a liquid medium. The solids may consist of bauxite, Silica and other minerals which can be up to10mm in diameter and are highly abrasive. This Aggressive application challenges traditional “clean fluid” pump technologies and has forced Pump manufacturers to incorporate numerous design changes into their components to perform the duty as per requirements. [2]

1.2. Failure of slurry pump sealing system

The Slurry pumps to transport liquids and solids throughout the refining process. The failure of these pumps can significantly impact on a refineries ability to produce and consequently the reliability of the equipment is a major focus. Slurry pumps of tenutilise tradition stuffing box style glands to seal the wet end of the pump from the atmospheric. Pump glands often are usually the first part of a pump to fail and often are merely symptom of bigger issue within the pump or the process of which the pump is subjected Slurry pumps are used to transport solids in a liquid medium. The solids may consist of bauxite, Silica and other minerals which can be up to10mm in diameter and are highly abrasive. This Aggressive application challenges traditional “clean fluid” pump technologies and has forced Pump manufacturers to incorporate numerous design changes into their components to perform the duty as per requirements. Slurry is best defined as a liquid suspension of solids that does not change its characteristics when affected by either temperature and/or pressure. Slurries are often described in terms of percentage solids and fall into categories: they maybe fibrous, non-fibrous and abrasive or non-abrasive. Liquids carrying abrasive particles represent the most common type of slurry applications found in industry. Percentage solids, concentration and particle size create a combination which will result in failure if not properly managed. Single seal applications can suffer from product build up on the atmospheric side of the seal, deterioration of the seal faces, internal mechanical damage and dry running, subject to the mechanical seal environment. The use of double mechanical seals can offer protection to the mechanical seal faces, but does not overcome the environmental problems.

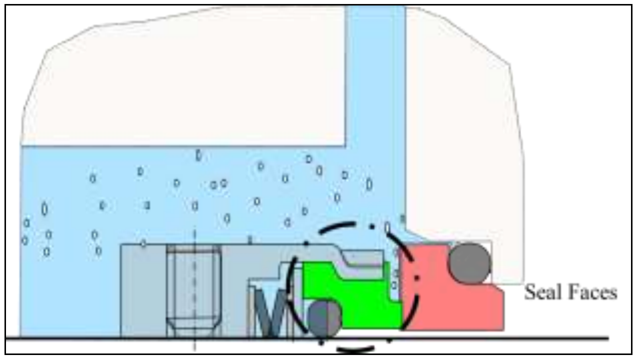


Fig.2. Detailed view of Seal face Area

With the ever increasing levels of sand in the exploration operations, traditional seal technologies are unsuitable as both the seal springs and drive mechanisms are clogged with sand causing the seal faces to hang up. Furthermore, the tight radial clearances between the seal faces and the rotating equipment shaft / shaft sleeve is yet a further area which is prone to clogging, and will ultimately lead to seal face hang up and leakage**.**

2. SEPARATION DEVICE

Separation device is a combined restriction neck bush and lantern ring for gland packed pumps which incorporates a number of long-standing design concepts such as the patented "pumping screw" and the conical taper of a CYCLONE Separator. It serves several purposes

It serves several purposes:

1. Optimizes the distribution of flush water between the gland packing and the pump
2. Separates residual solids from the flush water
3. Prevents solids in the pumped liquid from entering the sensitive gland area
4. Reduces the amount of flush water required
5. Reduces the number of packing rings required

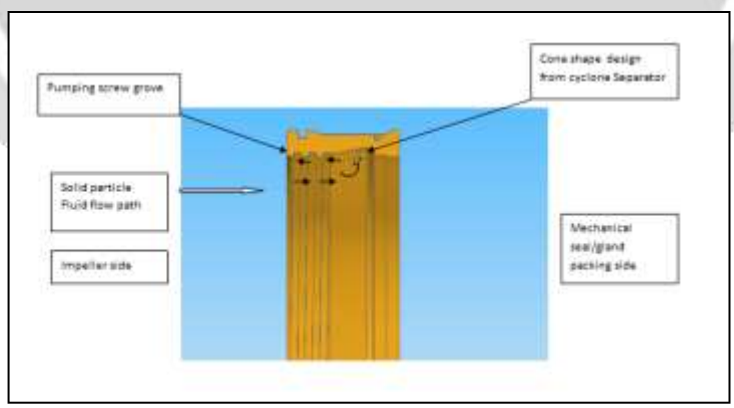


Fig .3. Separation Device

2.1. Experimental Test with HRS Mechanical Seal

HRS seals especially for application in solids containing media without external flush or internal product circulation. Solids content 40 % (single seal) and 60 % (double seal)Operation under vacuum without seat locking possible Pumping screw for increased circulation available Springs are protected from product and leakage. No damage of the shaft by dynamically loaded O-Ring and Insensitive to shaft deflections due to stationary design.

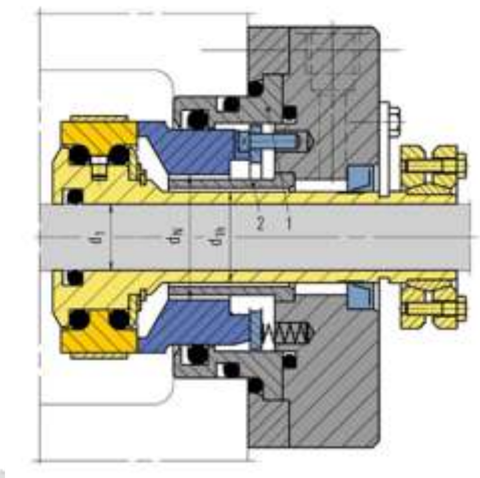
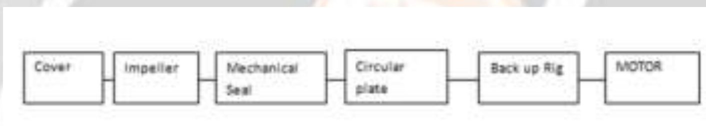


Fig .4. HRS Mechanical seal

Arrangement of Test rig SR140 is as follows.

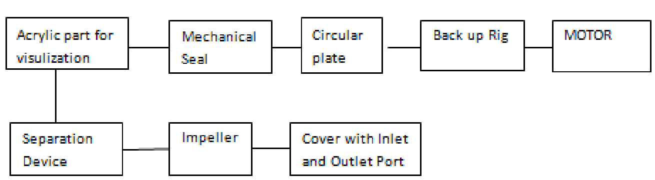


2.2. Working Of STR140 Test rig Design

Slurry media can come through the inlet port and its pump by the impeller and sealing of this media done by the mechanical seals.in this test Rig Motor has capacity to rotate at a 1400 rpm. Its specification of shaft is around diameter of 140 mm and for the bigger diameter of slurry mechanical seals can be tested .for that there is shaft sleeve is used to increase the shaft diameter as impeller rotates by the motor its start to pump the slurry media some slurry Particle goes in the area of mechanical seal.

3. NEW TESTRIG DESIGN FOR SEPARATION DEVICE

As Discussed above there is need to redesign the STR140 design because in Exiting design test is carry out for Mechanical Seal only to see performance in working Hours. For separation device arrangement of new test rig design should are as mention below.in new test rig design include the 3 flange, one acrylic part which is used for visualization for the inpection.in component flange 1 contain venting as well as Drainage hole. Acrylic part is fixed between flange 1 and flange2.layout of new are as follows.



Adapter has function to hold the separation device. Adapter is created in such way that if different type of separation device can be used or if any modification needed can be used for future.

3.1 Testing procedure

When sand and mixture fluid is entered through the inlet port LI. and shaft is rotating at 800 rpm.LO connection provided for liquid outlet. When mixture media pass through Separation device which has function to revert back the sand particle and keep the mechanical seal area clean.

Flushing is provided through FI port to flush out the sand particles through the separation device.Drainge port has function to collect media which is present near the seal face area and this can be used as sample fluid for calculation purpose. When test rig its static condition it is necessary to remove the air trap in mechanical seal area. So this purpose venting is provided in flange 1 to remove the air from seal face area at initial condition.

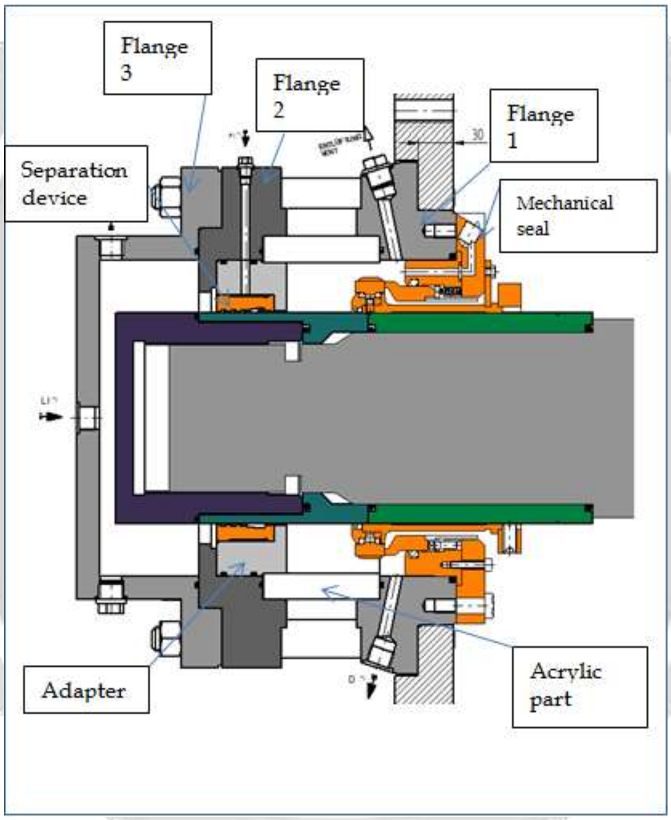


Fig .5. New test Rig Design

When sand and mixture fluid is entered through the inlet port LI. and shaft is rotating at 800 rpm.LO connection provided for liquid outlet. When mixture media pass through Separation device which has function to revert back the sand particles and keep the mechanical seal area clean.

3.2 Working conditions

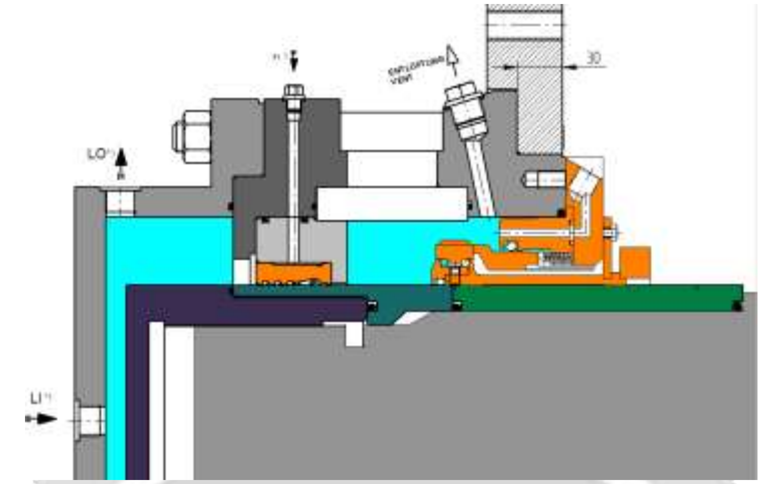


Fig .6. Detail view of all ports

Initial Testing conditions are as follows.
Mixture Fluid pressure: 10 bar
Temp of media: 40C°
Rotation of shaft: 800 Rpm
Density of Slurry: 1154 kg/m3(30% Ratio with water)

4. MODELLING OF TEST RIG IN SOLID EDGE TOOL

Test set rig are to be developed in 3D environment so solid edge is tool Solid Edge is a 3D CAD, parametric feature (history based) and synchronous technology solid modeling software. It runs on Microsoft Windows and provides solid modeling, assembly modeling and 2D orthographic view functionality for mechanical designers. Through third party applications it has links to many other Product Lifecycle Management technologies.

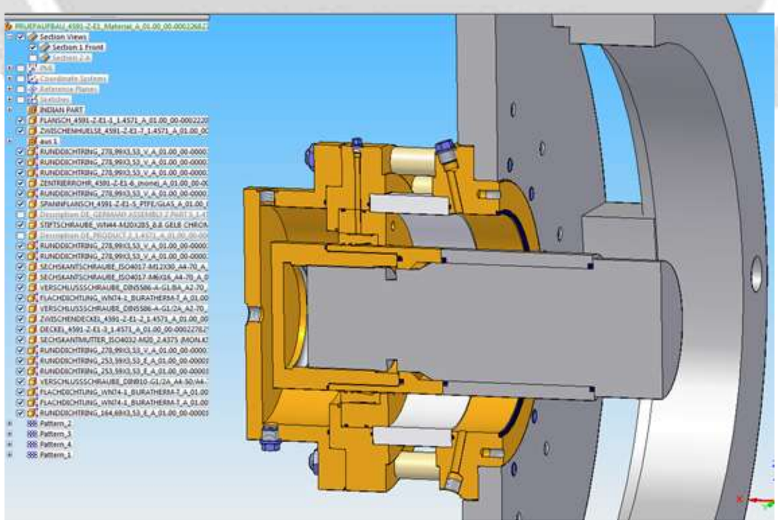


Fig .7. Solid edge model

5. TEST RIG SCREW CALCULATION

Test set rig are mainly joints by bolt and screws.so calculation need to consider on 3 main screws which shown in below fig.Bolt no.1 is mainly joint the flang1,2,3 respectively. The pres-sure acting on bolts as media pressure and considering sealing diameters

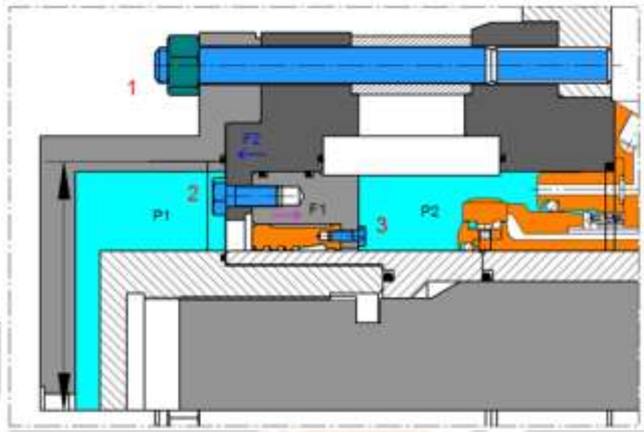
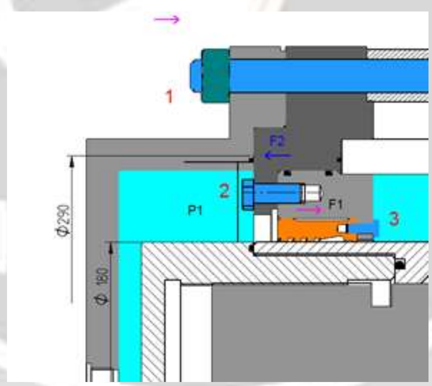


Fig .8. force distribution on screws

Calculation For position 1



P1= 10 bar(1 N/mm^2)

D1=290 mm

DB=180 mm

$$F_{screw} = \frac{P1 \times (D_1^2 - DB^2) \times 3.14}{4}$$

$$= \frac{1 \times (290^2 - 180^2) \times 3.14}{4}$$

$$= \frac{51700 \times 31.14}{4}$$

$$= 40.584 \text{ kN}$$

Considering suppilimentary load According to DIN2505

= 20.30 KN

Now,

Total load= Fscrew + Supplementary load

= 40.584 +20.30

= 60.88 kN

From Existing Design available thread is M20

So for M20 ,maximum allowable load is 35.418 KN

By considering no .of bolts 4= 35.418 x 4

= 141.67 kN

This allowable load is greater than total load so design Is safe

Table. I

Bolt Loads	Calculation
Pressure load [N]	40605,085
Gasket load [N]	0,000
Load by leverage of support [N]	20302,543
Supplementary load [N]	0,000
Supplementary pipe load acc. to DINV 2505 [N]	0,000
Total load [N]	60907,628
Max. allowable bolt load [N]	141673,526
- Construction allowance c5m [mm]	3,000
Required root diameter [mm]	12,136
- Construction allowance c5e [mm]	3,000

Similarly position 2 and 3 can be in same way

Table .II

Bolt Loads	Calculation
Pressure load [N]	31808,626
Gasket load [N]	0,000
Load by leverage of support [N]	15904,313
Supplementary load [N]	0,000
Supplementary pipe load acc. to DINV 2505 [N]	0,000
Total load [N]	47712,938
Max. allowable bolt load [N]	51410,538
- Construction allowance c5m [mm]	3,000
Required root diameter [mm]	9,602
- Construction allowance c5e [mm]	3,000

For position 3

Table.III

Bolt Loads	Calculation
Pressure load [N]	2756,748
Gasket load [N]	0,000
Load by leverage of support [N]	1378,374
Supplementary load [N]	0,000
Supplementary pipe load acc. to DINV 2505 [N]	0,000
Total load [N]	4135,121
Max. allowable bolt load [N]	4777,140
- Construction allowance c5m [mm]	2,215
Required root diameter [mm]	4,441
- Construction allowance c5e [mm]	2,060

6. CONCLUSION

In this paper explained Test Rig design used for experi-mental analysis of separation device. This design is made in such way that it can be replaced by other design of separation device. Test Rig design are Handled Pressure up to 10 bar. For this pressure Screws and bolts are select by using screw calculation.

7. ACKNOWLEDGEMENT

The authors would like to thank EagleBurgmann Hadapsar, Pune for providing opportunity to work on the design improvements of STR 140 Test Rig Design for Separation device. The author would also like to thank Mr. Peter Droescher, Head of Engineering Department Mechanical Seals (Pumps & Special Rotating Equipment, EagleBurgmann Germany), and Mr. Akshay Kunkolienkar (EagleBurgmann India).

8. REFERENCES

[1] E. Mayor, Mechanical Seal, (Book, London – Boston: Butterworth Scientific, vol1 1982 Reprint

[2] Pump- Shaft Sealing Systems for Centrifugal and Rotary Pumps, (Book, Washington, D.C: ANSI/API Standard 682 Third Edition, September 2004)
[3] Xylem inc, "Mechanical seal Guide",Vol 1 pp. 1-14 June 2015
[4] Damon Thomas Bishop, "Pump Gland Improvement project" pp.37-50Nov-2010
[5] Magazine " Pump&System" pp40-422007
[6] FSA "Sealing Sense" pp31-33 Dec 2009

[7] Aberdeen Conference "A Guide to Sealing Slurries". pp. 1-28 July 2002
[8] Bob Flitney " Mechanical Seal Housing Design" pp1-6 2004

[9] Mehdi Azmian &Hans –jorg Bart "experimental analysis of erosion in slurry tank test rig" pp-1-8 2013
[10] Pump- Shaft Sealing Systems for Centrifugal and Rotary

[11] Cokorda Prapti Mahandari and Ariyanto,
Performance of centrifugal pump mechanical face seal, Gunadarma University, Jakarta-Indonesia

[12] Bob Flitney, 'Mechanical seal housing design – are there real benefits, and do we want them?'Sealing Technology,September 2004, pp. 10–14.
[13] American Petroleum Institute, Washington, D.C., API Standard 682,"Shaft Sealing Systems for Centrifugal and Rotary Pumps,"(Fourth Edition, 2014)
[14] American Petroleum Institute, Washington, D.C., API Standard 682,"Shaft Sealing Systems for Centrifugal and Rotary Pumps,"(Fourth Edition, 2004)

[15] American Petroleum Institute, Washington, D.C., API Standard 682,"Shaft Sealing Systems for Centrifugal and Rotary Pumps,"(Second Edition, 2001)

[16] American Petroleum Institute, Washington, D.C., API Standard 682,"Shaft Sealing Systems for Centrifugal and Rotary Pumps,"(First Edition, 1994)

BIOGRAPHIES

	**C.L.Honwadajkar** is Student of Master's in Engineering Design from Department of Mechanical Engineering from Savitribai Phule University, Pune, India.. He obtained his Bachelor's degree in Mechanical Engineering in Amravati University, India.
	**Prof.S.K.Bhor** is Professor & HOD at Department of Mechanical Engineering, D.Y.Patil Institute of Technology,Ambi Pune. He completed his M.E. in Heat Power.