PROTECTING BEARINGS FROM DUST AND WATER.

ABSTRACT

Protecting bearing from dust and water. Protection methods like labyrinth rings, rubber seals, felt seals and shaft mechanical seals are described. Choice of the appropriate shaft seal and seal configurations to protect against dust and water ingress is critical. Numerous shaft seal designs suited to contaminated conditions are reviewed.

Keywords: Particles, contamination, bearing, shaft, grease barrier, breather.

Dusty surroundings are one of the most difficult environments for bearings. In equipment handling powders or in processes generating dust the protection of bearings against contamination by fine particles requires special consideration.

BEARING HOUSINGS

Bearings are contained within a housing from which a shaft extends. The shaft entry into the housing offers opportunity for dust (and moisture) to enter the bearing. The shaft seal performs sealing of the gap between the housing and shaft. Choice of the appropriate shaft seal and seal configurations to protect against dust ingress is critical.

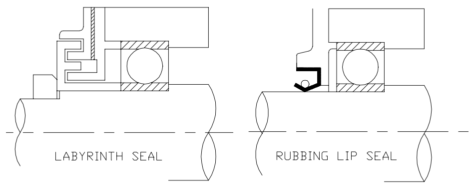


Figure No. 1. Shaft Bearing Housing Seals

Bearing housing seals for dusty environments may be either a labyrinth type or a rubbing seal type. The labyrinth type requires a straight shaft running true. Rubbing seals are the more common and allow for some flexing of the shaft. The sketches below are conceptual examples of each type of seal. When setting a lip seal into place to prevent dust ingress insure the sealing lip faces outward.

In situations of high dust contamination there may be a need to redesign the shaft seal arrangement for better dust protection than provided in standard housings. Some ideas which can reduce dust ingress into bearing housings are to :

i. provide two or more seals in parallel. Bearing housings can usually be purchased with combination seals as standard.
ii. retain the housing shaft seals but change from a greased bearing in the housing to one which is sealed and greased for life. If contamination were to get past the shaft seals, the bearing's internal seals would protect it.
iii. stand the bearing off the equipment to create a gap between the end of the equipment and the bearing housing while sealing the shaft at the equipment.
iv. put in a felt seal wipe between the housing and the wall of the equipment to rub the shaft clean. Install of a mechanical seal in very harsh environments.
v. install a grease barrier chamber sandwiched between two seals. This barrier is separate to the bearing housing and acts as the primary seal for the bearing. Grease pumped into the chamber will flush out past the seals.
vi. replace the grease barrier chamber instead with an air pressurised chamber.
vii. shield the bearing housing from dust with use of a specially fabricated rubber shroud encapsulating the housing and wiping the shaft or fit a rubber screen with a hole wiping the shaft over the opening emitting the dust.
viii. flush the bearing with grease by pumping excess grease into the housing and allowing the grease to be forced past the shaft seals or through a purposely drilled 15 mm hole in the housing. The hole must be on the opposite side of the bearing to the grease nipple, at the bottom of the bearing housing when in service and between the bearing and seal.
ix. Mechanical seals can be fitted to the shaft with the stationary seal sitting toward the machine and the rotating seal mounted back along the shaft. Combinations of other seals and wipers can also be used in conjunction with the mechanical seal. Mount the auxiliary seals so they see the dust/water first and keep the mechanical seal as the last line of protection.

ASSEMBLY

The process of assembling a bearing into the housing must be spotlessly clean. If contamination occurs at the time the housing is assembled no amount of external protection will stop the bearing from premature failure. When assembling bearings into housings make sure that:

i. your hands have been washed.
ii. the work bench is clear and wiped down clean.
iii. no one creates dust or grinds nearby during assembly.
iv. fresh, clean grease is used to pack the housing.
v. the components are clean and all old grease has been thoroughly removed.

BREATHERS

When protecting bearings from dust you want to always consider another important area. A breather is used to let hot air out of a confined space and then to let the air back in when it cools down. Enclosed bearings get hot when operating and cool down to ambient temperature when not in use. The air drawn back into the space needs to be clean of dust and moisture. A breather on a bearing housing or bearing housing enclosure allows ingress of moisture and dust into the bearings causing premature life failure.

OPEN TRICKLE CHUTES FOR WET AND STICKY PRODUCTS.

ABSTRACT
Open trickle chutes for wet and sticky products. For the effective flow of damp, cohesive (sticks to itself) products, a chute must be designed to maintain momentum. Sufficient inclination is critical. Keywords: gravity, wall friction, adhesion.

FLOW IN OPEN CHUTES

Flow in an open chute is the result of the interaction between gravitational and frictional forces. Open chutes block because frictional forces between the product-to-chute surface or product-to-product contact have overcome the momentum produced by gravity (unless a foreign body is stuck in the chute). This momentum is reduced through friction and adhesion.

Friction effects are reduced by fabricating from materials of low friction coefficient and minimising the surface area in contact with the flowing material while not causing bridging. Adhesion is reduced by using steep inclinations, introducing gradual direction changes in the chute and by providing a period of free fall into the chute to allow velocity to develop. By minimising friction and adhesion from product contact with the wall, the material is able to retain its velocity and momentum to continue its motion.

EXAMPLE OF A CHUTE

An example of applying some of the above ideas was in the redesign of an open inlet chute into a gas fired rotary drier. The products fed to the drier were damp and cohesive with a tendency to adhere to the chute walls. Product flow rates varied from 2 tonne per hour of wet fertiliser granules to 20 tonne per hour of moist ferrous sulphate.

The original 2.5m long chute was made of 3mm steel sheet with a 400mm wide base, 300mm deep sides and no top. The metal had rusted and had been bashed and hammered in attempts to clear blockages. It was inclined at 70 degrees with a bend half way down where the incline changed to 40 degrees so as to feed the product further into the drier.

Product built up in the chute at the bend and necessitated regular cleaning of the blockages.

The redesign involved a change to the material of construction and removal of the bend midway down to make the chute straight. It required installing helical fights in the drier to insure product, which now fell into the drier further back than previously, was fed forward and did not accumulate at the entrance of the drier.

The entire chute was made of 316 stainless steel with the intention that it would stay smoother because it would not rust. Plastic liners could not be used as heat from the drier escaped out the chute. The angle of the chute was retained at 70 degrees and the chute walls past the location of the old bend were increased to 400mm high in order to prevent the product leaving the chute until the exit. The other dimensions remained unchanged.

Following the changes the products did flow better through the chute. However in the case of the wet materials they first hit the chute bottom heavily and squashed firmly against it. Fortunately these materials heaped up in a fashion which created their own incline and once the incline was established the products rolled off themselves into the chute.

The use of a wide chute allowed the various materials to flow mainly along the chute bottom and not contact the side walls simultaneously. This limited the friction effect by minimising the area of product-to-surface contact and helped maintain the flow velocity.

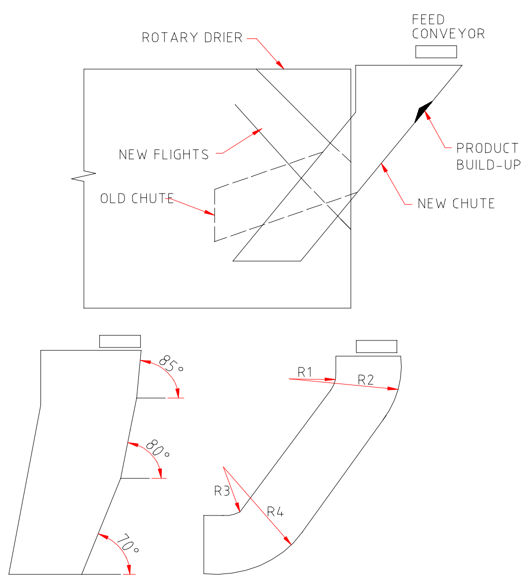


Figure No. 1 Alternate designs of a chute for wet and sticky product.

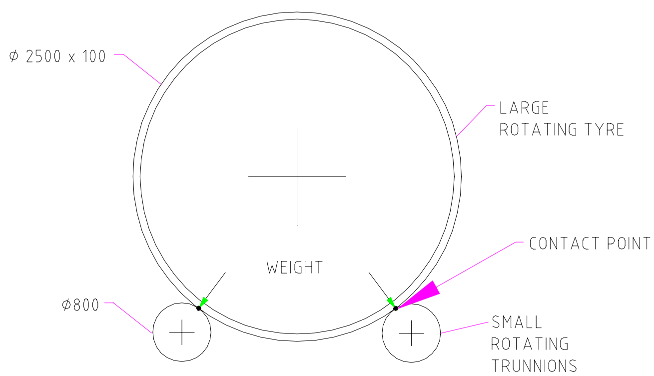
Rotating tyre and trunnion wear

ABSTRACT
Rotating tyre and trunnion wear. Roll mills, drum dryers, kilns, ball mills and rotating reactors usually turn on metal tyres and trunnion rollers. Eventually the tyres and rollers wear thin or fatigue and require repair or replacement. Keywords: surface hardness, steel, contact stress, metallurgy, bisalloy, casting.

Usually the equipment manufacturers keep material specifications as proprietary information and one is forced to buy the parts from them. In situations where supply from the original manufacturer is impractical you will be forced to find alternate materials and suppliers. They will require a materials specification from you to fabricate or cast a replacement.

WEAR MECHANISM

When properly aligned the rollers carry the weight of the drum and product on a very narrow contact line formed between the tyre and roller (FEED FORWARD FLYER Volume 1 No 5). The sketch below shows the location of the thin contact line formed between tyre and roller.



The stress created on the contact line fluctuates as the drum rotates and the contents move. This high, fluctuating stress causes work hardening of the roller and tyre surfaces.

EXAMPLES

Tyres on a twin tyre, 2 meter diameter, rotating drum dryer of three tonne operating weight had to be replaced after several years of service revolving at 6 RPM. The rollers were 150mm wide and 500mm diameter turning at about 24 RPM. The tyres were repaired in-situ as they could not be removed. They were re-skinned by welding two rolled half rings of boilerplate to the remnants of the old tyre. (Make the mating ends at 45 degrees to the axis so the hard weld rolls over each roller in point contact and do not cause an abrupt impact as would occur if the weld was made axially.)

Some months after repair it was noticed that the tyres were wearing faster than expected. Upon investigation it was found that the trunnion rollers were made of 4140 steel and had a surface hardness of 320HB while the fabricated boiler plate tyres had a surface hardness of less than 250HB.

Contrast this to a 3 meter diameter rotary reactor of 35 tonne operating weight rotating at one third revolution per minute mounted on trunnion rollers of 800mm diameter. The 200mm wide rollers turned at 2 RPM. The tyres were made of Bisalloy 80 with a rolling surface hardness 310HB while the 4140 steel rollers were 360HB. However in this case, after two years in operation, there was no evident wear.

On review it seemed the wear rate for rotating metal tyres and trunnions was influenced by the surface hardness, the disparity between surface hardness and surface velocity.

SPECIFYING STEELS FOR ROLLING SURFACES

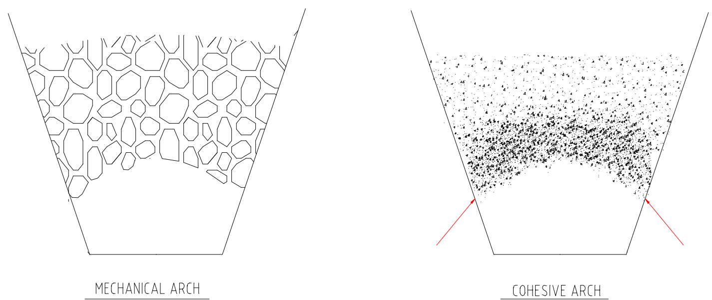
Fortunately the choice of steels to use in making tyres and rollers is very similar to the steels used to make railway lines and locomotive tyres. These are made from carbon steels with a carbon content about the 0.5% to 0.8% and initial surface hardness of about 280HB to 320HB. The surface hardness increases with usage.

CONTACT A METALLURGIST

Bridging in Silos and Hoppers

ABSTRACT
Bridging in silos and hoppers. Bridging is the name given to the self-created arch that develops just above the outlet of a bulk material silo or hopper as it empties. A bridge forms when wall friction holds up the ends of the arch. To overcome bridging the wall friction must be reduced or prevented from occurring. Keywords: live bottom, cohesive, powder, hopper design, angle of repose.

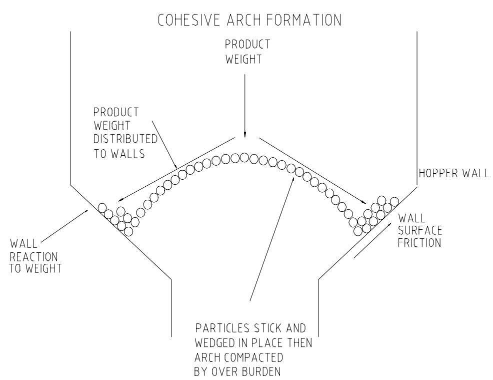
There are two types of arch. One is mechanically formed by relatively large particles (above 3mm) interlocking, while the second is formed when powders bind together under compression (cohesive arch). The resulting arch can support the weight of the material above it and prevent flow. The sketch below shows the two types of arch.



It is easy to tell if a silo has a material flow problem by looking for 'hammer rash' on the wall. If the product is not moving freely through the silo and outlet the operator will strike the side walls to rattle the material free.

WHAT CAUSES BRIDGING?

Bridging starts when friction stops the product at the wall and a neighboring particle wedges in behind or sticks to it. The product binds to itself until an arch is formed. Product from above compacts it into place and makes the arch so strong that it supports the overburden. The sketch below shows a simplified view of the arch building process.



Whether bridging occurs depends on a number of factors.

a) The angle of the discharge section wall.
b) The material of which the silo or hopper walls is made.
c) The stickiness (cohesiveness) of the bulk material.
d) The amount of attraction between the particles of the bulk material.
e) The extent of settling (consolidation) within the bulk material.
f) The natural strength of the material forming the arch.
g) The amount of moisture in the bulk material.
h) The ease with which the bulk material slides over itself.

This list can be divided into two categories – effects that depend on the **bulk material properties** and effects that depend on the **silo and hopper design**.

OVERCOMING BRIDGING IN HOPPERS

Solutions to stop hopper bridging focus on reducing the stresses created in the bulk material at the bottom of the hopper. If wall friction can be reduced or removed then the arch cannot get a foothold against the wall. If the cohesiveness if the bulk material can be reduced, then the arch cannot span the gap before it collapses under the weight of the overburden. If the weight from the overburden can be directed away from the arch it will prevent compaction.

CHANGING OUT DUST BAGS IN REVERSE PULSE DUST COLLECTORS

ABSTRACT
Changing out dust bags in reverse pulse dust collectors. The dust bags in pulse jet dust collectors require replacement if damaged and leaking or if blinded by the product. This work procedure indicates the process and methods to use to change-out and replace dust bags and cages in a dust collector. Keywords: tube plate, bag collar, air manifold, air plenum.

- Tag out and make the equipment safe for access.
- Clean out product in the plenum.
- Mark-up a tube plate map showing the location of all blocked-off bags or leaking bags and hand-in with the work order on completion.
- Lift cages out square to tube plate without damaging the cage collar. Use tee-handle hook tool that fits down the bag and hooks onto the cage wire ring two down from the top.
- Remove the bags if they don't come out with the cage.
- Clean top AND underside of tube plate back to clean metal.
- Starting at the edge of the bag house, and doing one complete row at a time, slip bags into each hole and insure the cuff seals fully around 360 degrees of tube sheet. Line up the bag seams in the same direction.
- Inspect the cages for weld dags, galvanising dags or paint dags and for welding wire poking out. Any sharp or rough edges on the cage will rip the bag. Do not use broken or damaged cages.
- Lower the cages into the bags feeding them in gently and being careful not to drop them into place.
- Install venturis if they are separate to the cages. Replace gaskets with new ones if they are required. If separate venturis are to be installed insure the bag seam is opposite the slot in the cage collar.
- Do not step on newly fitted bags as it may ruin the seal with the tube plate. Instead plank-out across the top of the installed bags, cages and venturi and share the load across all tops.
- Insure blow tube holes are clean and pointing directly into the centre of the bag.
- Check manometer or magnehelic tapping points are clear and hoses seal and do not leak.
- Remove any planks and tools from the plenum and close up the covers.
- Check the air solenoid manifold is free of water. If water is present an automatic drain should be installed.
- Test-run the dust collector and check pressure differential across bags is below operating pressure.
- Check outlet of dust collector for sign of discharge. If discharge is present stop and isolate the dust collector and open up plenum for inspection. Look for product deposits in and around the bags indicating location of leaks.
- Sign-off the works order when job is complete and hand back the equipment to the operators.

Mike Sondalini – Maintenance Engineer

Hazardous areas for dusts and flammables.

ABSTRACT

Hazardous areas for dusts and flammables. Many explosions in the processing, manufacturing and bulk materials handling industries involve flammable gases or vapours and explosive dusts or fibres. Such chemicals are known as hazardous materials. The article provides a basic overview of the design requirements and maintenance practices for electrical equipment in hazardous areas. Keywords: explosive range, hazard assessment, zone classification, explosion protection, surface temperature, pressure wave, explosive range.

WHAT IS A HAZARDOUS AREA?

One definition of a hazardous area is "an area in which an explosive atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of potential ignition sources." Flammables and combustible dusts are dangerous if present at explosive concentrations; in an atmosphere that will support combustion; when exposed to a sufficiently energetic ignition source. An explosion is impossible unless all three requirements are present together.

EXPLOSIVE RANGE

As with the engine of a motor car not firing if the fuel mixture is too lean or too rich, so must the concentration of a flammable gas or vapour be within a certain range for it to explode. For flammable materials like gasoline, methane or hydrogen to be in explosive concentrations, the atmosphere must be laced, or loaded, with appropriate quantities of the material to support combustion. The bottom of the flammability range is called the lower explosive limit (LEL) and the top of the range the upper explosive limit (UEL).

For explosive dusts the criteria for an explosive condition is the amount of dust suspended in the atmosphere. Combustible dust clouds will only explode once a minimum threshold concentration in air is passed and a minimum amount of ignition energy is available. Should an ignition occur when sufficient the dust is suspended then an explosion would result. A combustible dustlayer siting on equipment will ignite if the layer ignition temperature is reached for a sufficient length of time.

ASSESSING THE HAZARDS

It is the responsibility of the User to assess the nature of the hazards present. The persons involved in assessing hazardous areas need to have a strong background in the industry concerned as well as a good appreciation of the nature of the hazards caused by the chemicals present.

The chemical properties and explosive nature of a flammable gas or vapour are major factors that influence the extent of the hazard. Other properties for consideration include the flash point temperature, vapour pressure, boiling point, extent of the explosive range, density of the gas or vapour and the ignition temperature to set of an explosion.

If the hazardous area involves dusts and fibers a good appreciation of the physical, chemical and bulk material properties is required. The critical factors are the dust layer temperature at which a heated surface can ignite a layer of the dust. And the dust cloud ignition temperature at which a cloud of the dust ignites. Additional factors like fineness of particle size, dilution by inert materials and moisture content also affect the extent of the hazard.

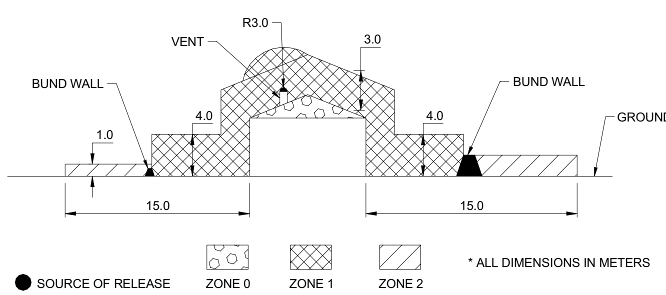
The size of the hazardous zone may increase during maintenance and cleaning if dust is lifted off equipment.

WHAT IF AN EXPLOSION OCCURS?

An important factor to consider is what occurs if a flammable or combustible material is ignited and explodes? Explosions generate a pressure front or shock wave that travel ahead of the flame front. Properties of the shock wave, maximum generated pressure, the speed of pressure rise and the amount of energy liberated by the explosion need to be considered when addressing the hazards.

DOCUMENTATION IS CRITICAL

The result of a hazard assessment is the classification of an area of plant and equipment into hazard zones. The area classification documents, zone indication drawings and justifications must be compiled in a verification dossier and made available to all persons who work on the plant.



ABOVE GROUND FIXED ROOF VENTED STORAGE TANKS,
ADEQUATELY VENTILATED

Figure No. 1 Zone classification for a flammables tank.

CONFIGURATION OF A CYCLONE IN USE

A cyclone requires a high velocity, moving stream of gas to be consistently fed to it. A fan is used to push or suck the gas through the cyclone. The flow needs to be steady and not fluctuate otherwise the counter-moving vortexes within the cyclone cannot develop and be sustained.

The bottom outlet is required to be air tight so no air bleeds into the low-pressure central vortex. If air does leak through the bottom outlet the particles on the inside wall of the cyclone are re-entrained in the air steam and are sucked up the inside vortex and out the gas outlet nozzle. A rotary valve or an automated twin butterfly valve air-lock arrangement can be used on the bottom outlet. If a dustbin is installed on the bottom of the cyclone empty the bin regularly so the dust does not fill up and enter into the cyclone.

Cyclones can be run in series or in parallel. When in series they are often configured so that the first one takes out the big particles while the next takes out smaller particles. Series operation produces high-pressure drops and requires more powerful fans to force the stream through the system.

High particle velocities within the cyclone will wear away the walls. For aggressive materials the internal walls will require lining or use of a harder material than the particles. If rubber is selected check that the particle hardness and shape do not rip into the soft rubber. At times harder urethane plastics and even ceramic linings maybe required.

Mike Sondalini – Equipment Longevity Engineer

References: Muhammad E. Fayed & Lambert Otten, Handbook of Powder Science and Technology Chapter 15, 1997
Perry Robert H, Perry's Chemical Engineer's Handbook 1984,
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(Nylon)							
Polyaramid (Nomex)	2	3	3	3	3	3	2
Acrylic – homopolymer	3	3	3	3	3	3	3
Polyphenylene Sulphide (Ryton)	3	3	2	2	3	1	2
PTFE (Teflon)	4	4	4	4	4	4	4

Note: 1 Poor, 2 Fair, 3 Good, 4 Very Good.

Table No. Fibre Resistance to Chemicals

Fibre (Trade name)	Specific Density	Tenacity (Tensile Strength)	Cont. Operating Temp °C	Max Short Duration Temp °C	Price Ratio
Polyester	1.38	60	150	170	1
Polypropylene	0.91	50	90	100	1.4
Polyamide (Nylon)	1.14	60	110	120	1.2
Polyaramid (Nomex)	1.38	33	220	250	5
Acrylic – homopolymer	1.15	35	135	150	1.5
Polyphenylene Sulphide (Ryton)	1.37	35	190	200	5
PTFE (Teflon)	2.3	18	250	260	20

Table No 2. Fibre General Properties

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