GETTING THE FACTS ON OIL MIST LUBRICATION

By

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ABSTRACT

Oil mist lubrication is a proven and environmentally clean technology for the lubrication of rotating equipment in process industries. The use of oil mist lubrication has grown dramatically worldwide delivering increased reliability to many types of rotating equipment. Many advances have been made in both the technology of oil mist system design and methods for applying oil mist to rotating equipment. Key questions to be addressed include:

What is oil mist and how is it generated? How has oil mist evolved over the past forty years? Where oil mist is currently applied? What are the advantages of oil mist lubrication? How to justify oil mist lubrication?

Oil mist is considered a "best practice" by many companies in the process industries.

INTRODUCTION

This discussion is on oil mist lubrication and details what oil mist is, how the systems work, how it is applied to rotating equipment and user experiences after applying oil mist. The primary focus will be on retrofit of oil mist on existing pumps and motors, as they are the most prevalent applications in the HPI. However it is important to note that numerous other applications benefit from oil mist including gear boxes, blowers, turbines and pillow block bearings, to name a few.

Early in this discussion it is important to note that oil mist lubrication does not "cure" or prevent all lubrication related failures of rotating equipment. It is not unheard of to experience a bearing failure shortly after conversion to oil mist. This is not due to the lubrication by oil mist but rather due to pre-existing bearing conditions that led to an inevitable failure; oil mist will not "heal" a compromised bearing. However, oil mist greatly extends the life of bearings versus alternative lubrication methods. The reasons for this will be explored in more detail later, but can be summarized in that bearing temperatures run significantly cooler with oil mist, ambient contaminants cannot enter the bearing housing and the automated system ensures the right amount of lubricant all the time.

HISTORY OF OIL MIST

Oil mist has been applied to equipment in the HPI, CPI, Steel Mills, Pulp & Paper Mills, Textile Plants, Rock Quarries, Automotive Plants and others. A commonality of applying oil mist across all industries is the importance of not only the oil mist generator but also the piping distribution system. Historically, any unsatisfactory results or disappointment with oil mist lubrication were due to issues with the distribution system. The following discussion provides a brief history of oil mist and the evolution of design over the years.

Oil mist was developed in Europe in the early 1900's to replace grease and circulating oil systems on high speed spindle bearings. It was then introduced to the US industry in 1948 with the steel industry being the first to use it. Applying oil mist on rotating equipment in the refining industry dates back to the late 1960's where one of the first installations was in Amuay Venezuela and then moved into the US market shortly thereafter. A paper written by Mr. Charlie Miannay (3) in 1974, while at Exxon Aruba, is the first technical publication relating to oil mist in the HPI. Chevron, Exxon and Shell were the first to use oil mist on a wide scale in the US. Many articles have been written on oil mist lubrication that stress the simplicity of oil mist and equipment reliability improvements. More recent articles that discussed the application of pure oil mist and practical experience are "Large Scale Application of Pure Oil Mist in the Petrochemical Plant" (4) and "Practical Experience with Oil Mist Lubrication" (5).

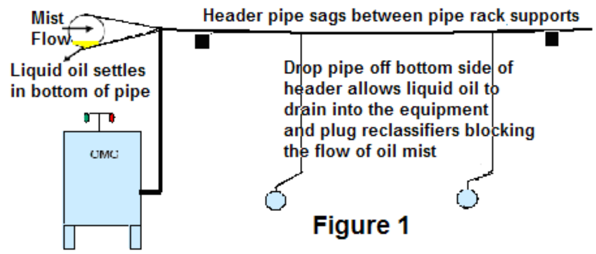


Figure 1

Early systems were installed by simply laying the piping header in the pipe rack and taking the shortest route possible between two points, the header and the application point, a straight line. With this type of installation the header would often sag between supports creating shallow pockets of oil in the line. Then the application drop, connected on the bottom of the header, would channel the liquid oil onto the reclassifier which was mounted in the bottom of the drop pipe or on top of the pump, figure1.

In these instances this caused plugging of the reclassifiers and prevented the oil mist from lubricating the bearings. As oil viscosity increases in cold weather the system plugging was more pronounced and caused some users to switch to lower viscosity oils in the colder months to try and alleviate the problem. Where these problems occurred the oil mist system was labeled as unreliable when the piping installation was the real issue.

Another hurdle encountered with early oil mist application to pumps was due to the method of delivering the mist into the bearing housing. Typically a single reclassifier mounted in the middle of the bearing housing was employed with venting taking place through the bearing housing seals. It was discovered, through extensive failure root cause analysis, that bearing windage could cause the mist to bypass the bearing via the oil drain back ports, leading to bearing failure. This was more prominent on double row thrust bearings.

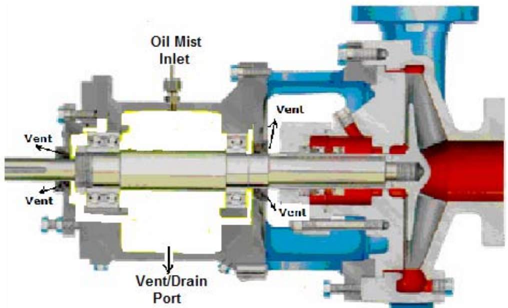


Figure 2

Additionally, early pure mist applications used a small hole drilled through the drain plug as a discharge, allowing excess mist and coalesced liquid oil to blow onto the base plate, figure 2. These issues led some early users of oil mist to believe the systems were not reliable and a housekeeping problem. These areas of early concern were addressed in subsequent system distribution and application designs, detailed in the following section.

WHAT IS OIL MIST LUBRICATION

Oil mist is a centralized lubrication system that continuously and efficiently atomizes oil into small particles and then conveys and delivers the correct amount of lubricant to bearings and metal surfaces which improves the lubrication process and extends machinery life. The oil mist particles when generated are nominally in the 1 to 3 micron range and are referred to as dry mist. Dry mist particles are too small for lubrication but are easily transported, via air flow, throughout the piping header system. The mist travels at a velocity of 7.3 meters per second (24 feet per second) in a continuous laminar flow at a pressure of 500 MM (20" water column or .74 PSI).

Oil mist can be referred to as the ultimate oil filter. The dry mist or small particles of oil, 1 to 3 micron, are physically too small to carry water or particulates throughout the piping system. The larger and or heavier particles that could possibly carry contaminates fall out of suspension either in the reservoir or in the piping system. Therefore only fresh clean oil is delivered to the bearings for lubrication. Contaminated oil is not re-circulated through the bearings as with a sump system (6).

The mist is generated by passing air through a vortex or venturi, figure 3, chamber where it picks up oil with a vacuum, siphoning effect, and introduces it into the high velocity air stream where the oil is atomized into the small particles, thus creation of the oil mist. A pressure drop occurs as the air passes through the vortex or venturi which creates the mist header pressure of 500MM (20" of water column).

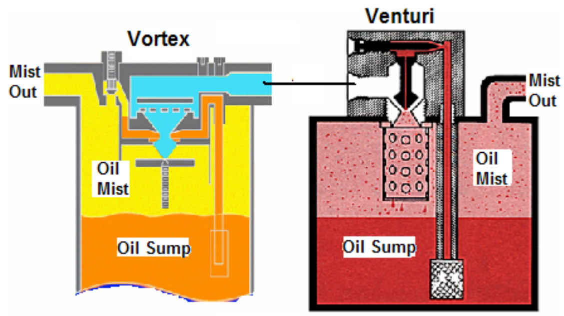


Figure 3

This air oil mixture is known as oil mist; it is not a VOC, Volatile Organic Compound or a vapor, it is an aerosol that consists of 1 part of oil to 200,000 equal parts of air. This mixture is well below the lean limits of flammability (7) and is non explosive. Regarding toxicity (8); the American Conference of Government Industrial Hygienists; gives a threshold limit value of 5mg/m3 for a normal 8 hour workday. Simply, this means that oil mist in concentrations found around oil mist lubricated machinery in typical open air HPI facilities is not a health hazard.

The particle size distribution of the oil mist is an important characteristic for successful lubrication. A large volume of very small mist particles (< 1.5 microns) can lead to inadequate lubrication, as particles of this size will not coalesce to allow wetting. Conversely, a large volume of large mist particles (> 3 microns) will fall out of suspension prior to reaching the application points. Careful selection of the correct oil coupled with the design advantages of the vortex mist head can assure the mist distribution necessary for the system.

Additionally, the velocity of oil mist travel through the distribution piping is important for proper lubrication. High mist velocity will cause the smaller particles to coalesce and wet out after impinging on the piping walls. Low mist velocity will not support the flow of oil mist particles in suspension.

Regardless of the control of particle size distribution and mist velocity, some level of oil will coalesce in the piping. The modern oil mist system installation, figure 4, is designed to accommodate this coalesced oil, returning it to the generator, unlike some of the problematic layouts of the past.

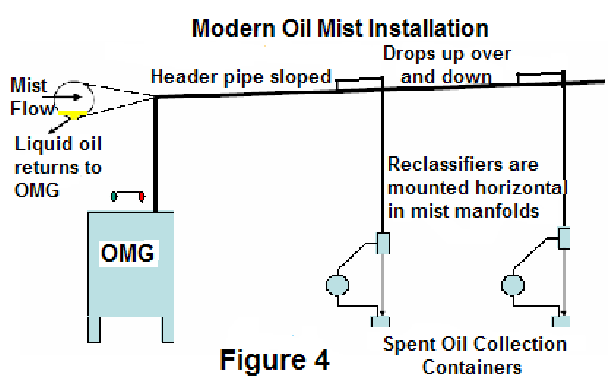


Figure 4

The header pipe, normally field routed, is supported, braced and sloped to facilitate the return of liquid oil to the oil mist generator (OMG) where it is recycled in the systems operation. The drop pipe is connected on the top side of the header and extends up over and down to the mist distribution manifold (MDM), figure 5, where the reclassifiers are located in a horizontal plane. This piping arrangement prevents liquid oil from draining down to the MDM's and plugging the reclassifiers.

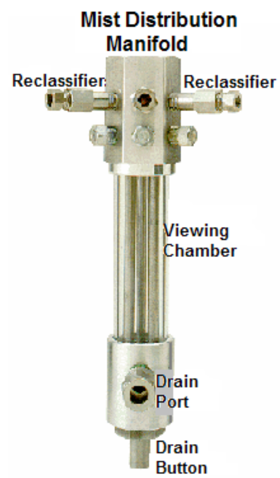


Figure 5

The MDM's are now equipped with a sight glass below the reclassifiers to allow a visual of liquid oil collecting with a push button drain valve that allows for the collected oil to be drained off, either to an oily water sewer cup or oil collection device. This arrangement allows only the oil mist to flow through the reclassifier and into the bearing to be lubricated. A fresh clean oil supply that continuously lubricates the bearings and pressurizes the bearing housing to eliminate the intrusion of air borne contaminates. Oil mist lubricates operating equipment and preserves/protects idled or standby equipment all from the same system.

LUBRICATION WITH OIL MIST

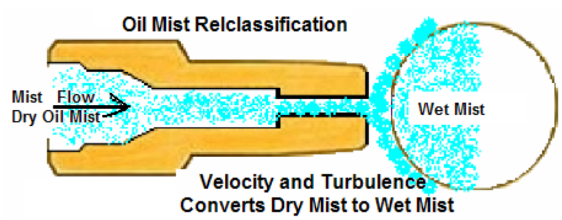


Figure 6

There are two types of oil mist, Figure 6. Dry oil mist is generated at the OMG and allows the mist to be conveyed throughout the piping header system. Wet oil mist is applied to the bearings for lubrication. As the dry oil mist travels down the drop pipe en route to the equipment it passes through a reclassifier (orifice fitting) creating a turbulent area where it picks up in velocity. The small particles coalesce, forming larger particles, and become wet mist; they are now large enough for lubrication. It is critical that the reclassifier be located within 2 meters (6.6 feet) of the application point to prevent the larger particles from falling out of suspension and not flowing onto the bearings.

The preferred method of application for any bearing is to pass the mist through the rolling elements from side to side or top to bottom for positive lubrication. Oil mist flow is critical to the system and lubrication of the bearings; no or low flow allows the particles to fall out of suspension and not travel into the bearings for lubrication.

After the oil mist flows through the bearing it travels towards the vent/drain, figure 7, whose port size is critical. Should the vent/drain port be too small and restrict the flow it will create a back pressure in the housing that will restrict the flow through the bearing. The decreased flow into and through the bearings will reduce the amount of oil being applied to the bearing. The vent/drain port diameter must be 3 to 4 times larger than the diameter of the reclassifier(s) orifice(s) to prevent a restriction of the flow. This must be closely monitored when more than two reclassifiers are feeding into a common bearing housing.

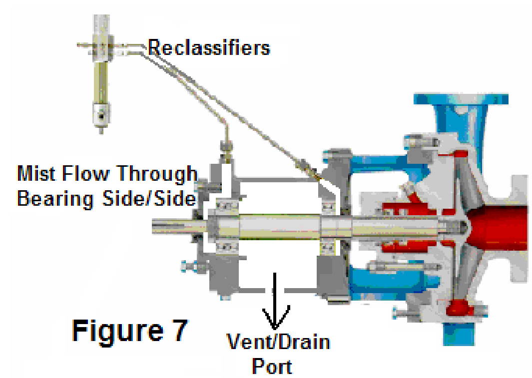


Figure 7

Current edition API pumps are designed for the oil mist to flow through the bearings, figure 8, prior to exiting the housing. The flow through characteristic is more critical on multiple row bearings; however, the flow through

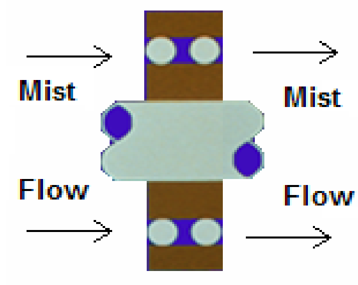


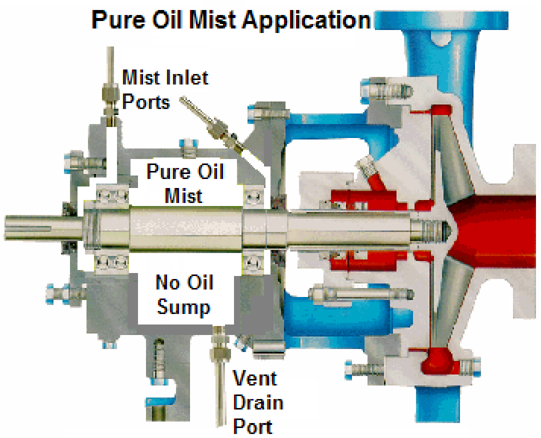
Figure 8

requirement is not always necessary with single row bearings in applications such as electric motors where the load is constant and thrust is not an issue.

APPLYING OIL MIST

There are two methods of applying oil mist: dry sump or pure mist and wet sump or purge mist. The dry sump and wet sump terms are not to be confused with dry mist or wet mist. Dry mist and wet mist is referencing oil particle sizes; dry sump and wet sump is referencing the application of oil mist to equipment being lubricated.

Dry sump or pure mist, figure 9, is commonly used on rolling element or anti friction bearings and the oil mist is the only source of lubrication for these bearings. The pure mist not only lubricates the bearing it also provides a slight positive pressure in the bearing housing that eliminates the intrusion of air borne contaminates, i.e. dust and moisture. Thus it lubricates operating equipment while protecting and preserving idled or standby equipment as it creates an ideal environment for the operating and idle bearings.



Oil Mist Flow is from Outboard to Inboard. Coalesced Oil and Oil Mist Vents/Drains out the Bottom Port

Figure 9

A thin film of fresh clean oil is continuously being applied to the bearings that allows the bearings to operate cooler and with less friction. Bearings being lubricated with pure oil mist typically operate 2°C to 4°C (25°F to 35°F) cooler than oil sump lubricated bearings. Bearings life is increased from the cooling effect; a 5.6°C (10°F) drop in bearing temperature increases bearing life by approximately 11% (9). Also, the mist flow through the bearing carries wear particles away and since there is no oil sump to allow recirculation of dirty or contaminated oil the bearings operate in a clean environment which also extends bearing life.

Pure oil mist also allows for the removal of cooling water to bearing housings. As equipment comes up to operating temperature it is expanding and the cooling water is trying to cool and contract which can preload bearings and cause failure. Removal of cooling water also reduces cost associated with the maintenance and upkeep of the cooling water system.

Wet sump or purge mist is commonly used on sleeve or plain bearings, figure 10, and on gear boxes such as the general purpose type or cooling tower fan gear boxes, figure 11. Oil mist in this application acts only as a purge to prevent the intrusion of air borne contaminates and is not sufficient to provide prolonged lubrication for the bearings or gearing should the oil level be lost. Although the benefits of purge mist do not match those of pure mist, and there are additional costs associated with necessary accessories, substantial cost savings are realized for these applications. The primary benefit of purge mist is extended oil change intervals achieved with the positive pressure preventing thermal cycling in the housing. Typical oil change intervals are extended from twice per year to one change every two to three years.

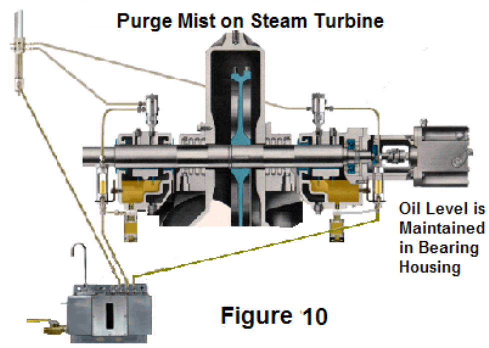


Figure 10

Oil sampling is recommended when oil change intervals are extended to insure that the oil quality is not compromised over the extended period of time. This is very cost effective on cooling tower fan gear boxes due to the location and man hours required for the task of changing oil and performing lubrication related maintenance activities.

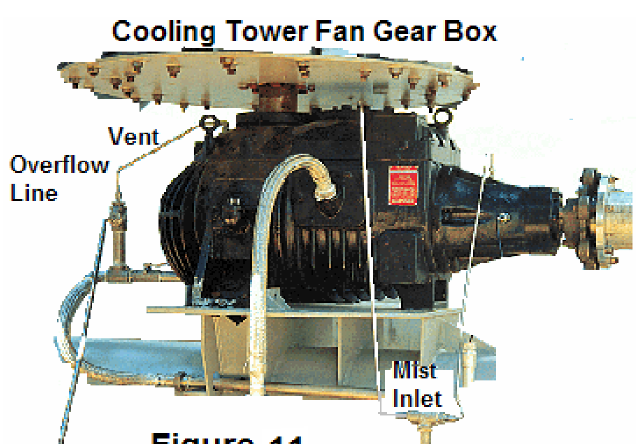


Figure 11

With purge mist the vent is just as critical as with pure mist. Excessive pressure in the bearing housing or gear box due to back pressure from the vent line can easily give a false, high, oil level indication in the oil level sight glass, figure 12. A high false oil level in the sight glass is in reality a low oil level in the housing which may result in bearing or gear failure.

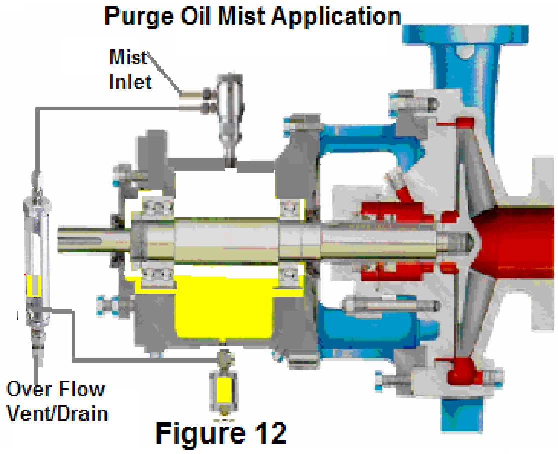


Figure 12

OIL MIST APPLICATIONS

Oil mist applications are bearings of all types and gears that are located in rotating equipment found in process industries. The most common applications for oil mist lubrication in the HPI are pumps and motors. Pillow block bearings, turbines and gear boxes are also common applications but not in the same quantities. With grass root or green field projects equipment, pumps and motors, are specified to be purchased for oil mist lubrication and manufacturing specifications are followed to insure proper lubrication.

Oil mist installation is relatively straightforward in these cases, when trained technicians are performing or supervising the project. Brown field, or retrofit, projects have greater installation complexity due to industry practices used at the time of equipment manufacture. Some of this equipment could easily be 30 to 40 years old and oil mist was not considered when the equipment was manufactured. As there are specifications / designs to follow when new equipment is purchased for green field projects, the following section will focus on retrofitting oil mist to existing pumps and motors.

RETROFITTING PUMPS TO OIL MIST

Over hung and between bearing pumps are fairly easy to retrofit to pure oil mist in the field, without equipment shutdown, since the bearing housings are designed to house only the bearings and the lubricant. Draining the oil and applying oil mist is performed by removing plugs and attaching the oil mist inlet and vent/drain lines either with pure or purge mist, figure 13. When purge mist is used, additional components are required to maintain the oil level and to contain the oil mist.

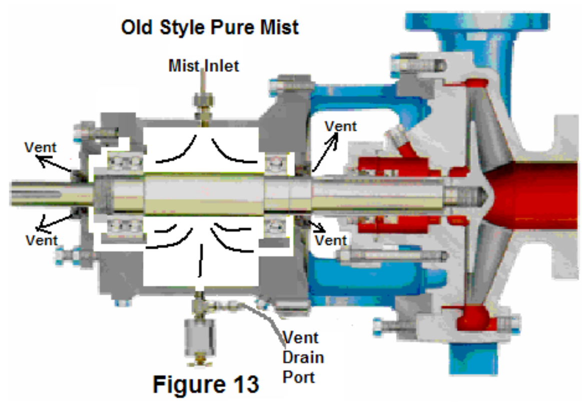


Figure 13

When lubricating rotating equipment with pure mist there are several items to be aware of; driver HP, RPM, bearing housing internal configuration and the seals. When the driver is 150Kw (200 HP) and above with an RPM of 3000 or higher the reclassifiers should be sized for a heavy service factor; when below 150Kw (200 HP) and 3000 RPM or less the reclassifiers may be sized for a moderate service factor.

Older bearing housing internal configurations may require plugging of drain back ports where they exist. This ensures that oil mist will pass through the bearings removing the remote possibility of circumvention. Situations where this is required will be addressed shortly. Additionally, labyrinth or lip seals should be used as bearing isolators may block the mist flow and jeopardize a multiple row bearing.

Older pumps typically have a single inlet port located on top of the housing where oil mist can be applied with a single reclassifier sized to accommodate both the thrust and radial bearings. With this application the oil mist creates a pressure in the central housing and forces the mist through the bearings and the housing seals to insure lubrication for the outboard rolling element of the multiple row bearing as well as the single row radial bearing. The low point vent/drain requires a defined restriction to insure that the oil mist passes through the bearings before exiting through the housing seals.

Slinger rings have been a somewhat controversial topic, specifically whether they should remain or be removed when applying oil mist. LSC's experience demonstrates that they pose no threat to the communication of pure oil mist and the additional labor to remove them is unnecessary. It should be noted that, although not problematic, additional noise in vibration readings are likely from running the rings dry after converting to pure mist.

Converting from oil sump to pure mist in the field one must take bearing temperature and vibration readings before, during and after draining the oil. Taking the bearing temperature and vibration readings prior to draining the oil provides a base line to work from. Readings should be taken immediately after the oil is drained and then again every 5 minutes for at least 20 minutes. Typically the bearing temperature will drop 10° F to 20° F in the first 10 minutes. This indicates that the bearings are in good condition and one should not expect any issues to arise. Should the temperature hold steady or increase the oil needs to be replaced and the pump scheduled for a bearing replacement. It is not uncommon to expect and experience some bearing failures when converting to pure oil mist. This indicates the bearing life was already jeopardized or possibly the pump is operating too far from its BEP.

Should this be the case or if the pump is operating at 3000 RPM and the driver is 150Kw (200 HP) or greater the pump may require two lubrication points to provide sufficient lubrication to the thrust bearing (10). This modification may be performed in the field, figure 14, without taking the pump out for rework. A small 1/8" NPT port can be tapped into the bearing end cap to allow for another reclassifier to provide lubrication directly onto the thrust bearing. This

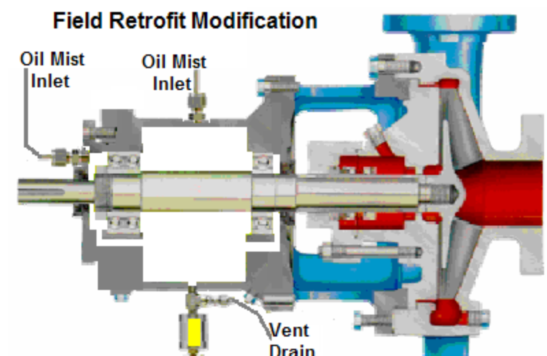


Figure 14

arrangement should resolve any lubrication issues and should bearing failure persist there is the probability that other pump related issues should be investigated. As the pump goes into the repair facility for rework it would be wise to remove the slinger rings, plug the drain back ports, tap both end caps for inlet ports and insure that the bearing housing seals are containing the oil mist and allowing it to vent only at the bottom port.

Older model between bearing pumps commonly have the oil inlet and drain ports in the same plane, figure 15, which does not support the flow of oil mist through the rolling elements. When this is the case a

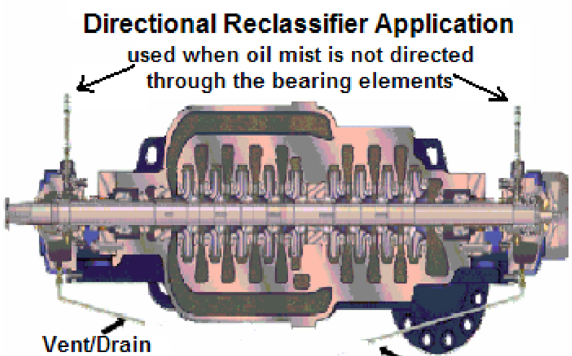


Figure 15

Figure 16

directional reclassifier must be used. The directional reclassifier extends down into the bearing housing and the orifice port is directed at the mid level point of the top rolling element so that the mist is directed onto the bearing. This is more critical on double or multiple row bearings than it is on a single row bearing.

At times the bearing housing may require modifications to accept the directional reclassifiers, figure 16. When this is encountered the pump will have to be retrofitted to purge oil mist until it is taken out of service and modifications can be made to the housing. It is possible that a reclassifier can be mounted on a horizontal plane that would direct the mist into the rolling elements.

When applying pure oil mist there are certain application conditions that must be considered prior to conversion. The first condition is where a pump is operating far from its BEP. In this case, the pump should be converted to purge mist (remain on purge if already mist lubricated) until it can be taken out of service and re-rated for its current application. At that time the pump can be converted to pure mist. The second condition to consider is a tapered roller bearing application. Due to the high frictional condition typically placed on the end of the rollers, additional measures are necessary to ensure proper oil mist application. Care must be exercised to ensure oil mist is directed precisely on the shoulders of the bearing element in an abundant quantity to provide adequate lubrication.

RETROFITTING MOTORS TO OIL MIST

Electric motor construction is not governed by detailed industries standards such as API. As a result, oil mist conversion for motors – although not complicated – requires more effort than for their pump counterparts. However, motor manufacturers are making significant strides in meeting user demands and requirements for oil mist application. In fact, some manufacturers have motors designed specifically to accommodate oil mist with little to no extra effort.

TEFC motors that are grease lubricated are excellent candidates for pure oil mist, figure 17. Typically, 15Kw (20 HP) and greater show significant payback values for oil mist conversion. For motors not manufactured specifically to accommodate oil mist, several factors must be considered during the conversion.

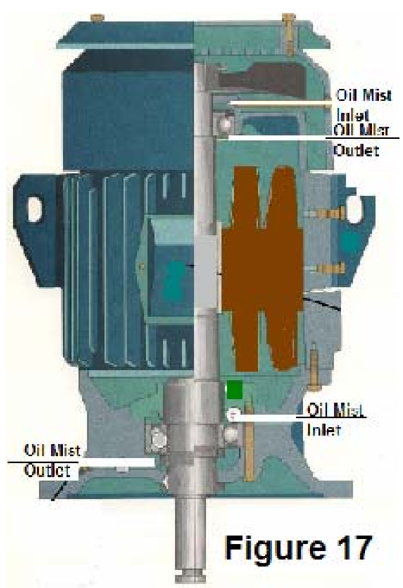


Figure 17

First, all grease must be removed from the bearing cavity and the inlet / outlet lines prior to applying oil mist. The low pressure oil mist is not capable of displacing the grease from these areas. Next, winding epoxy and lead wire insulation must be confirmed as compatible with the oil. Many epoxies and insulation materials have no compatibility issues, yet this should be reviewed. Also, the internal porting to the junction box (where the lead wires enter) must be thoroughly sealed to prevent oil mist from entering the box. Additionally, as the oil mist will enter the housing around the rotor and the operation of the motor will cause the mist to wet out and settle in the lower housing of the motor, a case drain, figure 18, must be installed in the condensate drain plug port on the coupling end of the motor. Finally, the fan end condensate drain plug must be removed and replaced with a standard plug to prevent leakage and venting at the fan end.

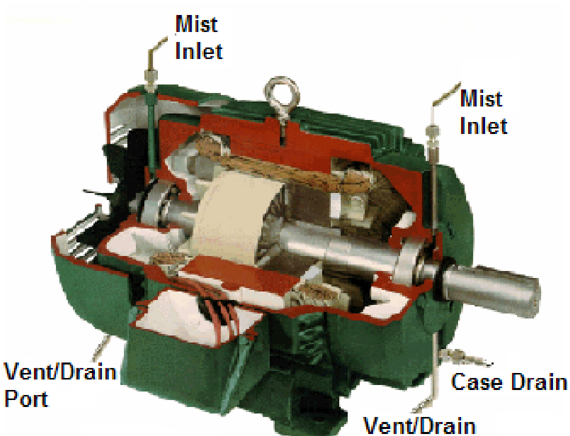


Figure 18

JUSTIFICATION OF OIL MIST

Many grass roots projects are justified based on previous user experience with oil mist and the resultant benefits of reduced maintenance costs and increased uptime and product throughput. However, this experience factor does not always translate to automatic inclusion in a project and the need to justify the investment in oil mist is a common requirement.

The obvious improvement of reduced pump repairs may in many cases be sufficient to justify investing in oil mist, figure 19.

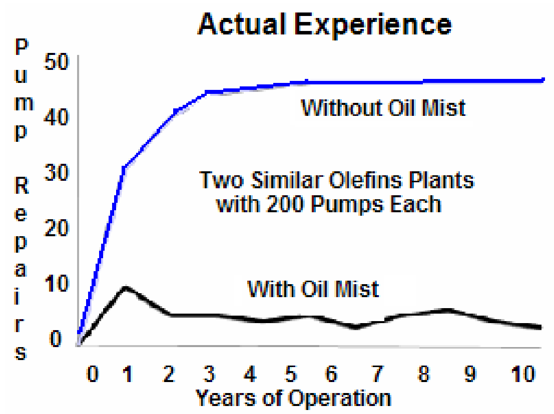


Figure 19

However, when viewing the example from US refineries, where the average MTBR for pumps is reported between 60 and 70 months, figure 20, further savings and benefits may be required, not relying on pump bearing failures alone (11).

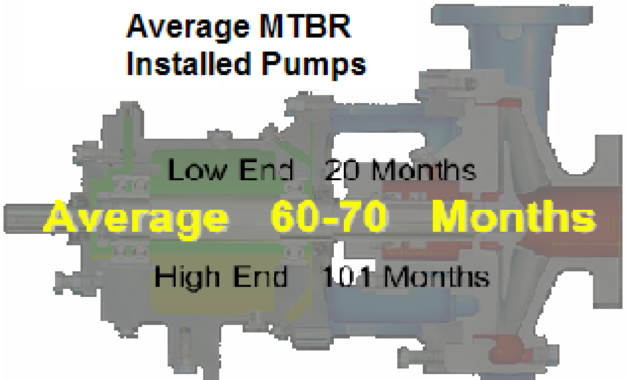


Figure 20

With hundreds and often thousands of pumps and motors in a process facility, it takes little imagination to understand the massive man hours required to maintain oil quality and levels as well as re-greasing requirements to achieve respectable reliability. For a facility with 600 pumps and 600 motors, the time required for routine lubrication is approximately 3,000 man hours per year. This time can be redirected from routine lubrication to proactive failure avoidance and reliability improvement tasks. The fully burdened savings for redirected man hours can easily reach $100,000 or more per year.

Often bearing failures are under represented in facility MTBR calculations. This is because mechanical seal failures are deemed as the root cause, and during seal change out the bearings are replaced simultaneously. With careful root cause analysis, however, it is often discovered that a bearing issue led to the premature failure of the seal.

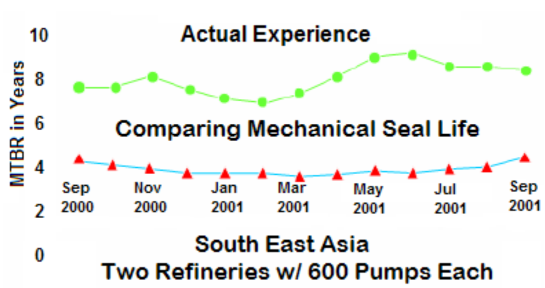


Figure 21

Irrespective of the time taken to determine true root cause of failures, data has been collected that demonstrates oil mist reduces mechanical seal failure, figure 21. These reductions range between 35% and 50% and when applied to the example of 600 pumps equates to an annual savings of approximately $410,000.

Another savings is a reduction in cooling water usage. When a bearing housing is converted from sump lubrication to pure oil mist, cooling water is not required (12). Elimination of the cooling water in the bearing housing reduces the water treatment and maintenance related issues associated with the water. By removing the water from the pumps it is estimated that 3 pump failures are eliminated in a typical medium sized industrial facility. This equates to an estimated annual savings of $156,000.

Periodic pump switching from Pump A to Pump B, which is a recommended practice for pump reliability (13), also provides justification for oil mist. When switching from pump A to pump B it is not uncommon for a failure to occur which results in the possibility of lost production. A reduction of these failures equates to an additional .33 days per year for production which equates to a savings of approximately $330,000 dollars.

Double pumping is a common occurrence during peak production seasons. This does not create a total loss of production but it reduces the product output and there is a loss of production in the peak season. Using oil mist helps to eliminate failures when double pumping and the estimated savings is $450,000 dollars.

Motors are excellent applications for oil mist (14) since the grease lubricated bearings account for about 90% of all motor failures, figure 22. Reducing the motor bearing failures with oil mist contributes to the justification and by reducing motor failures there is also a reduction of additional pump failures that are caused by motor failures. With a population of 600 motors the savings

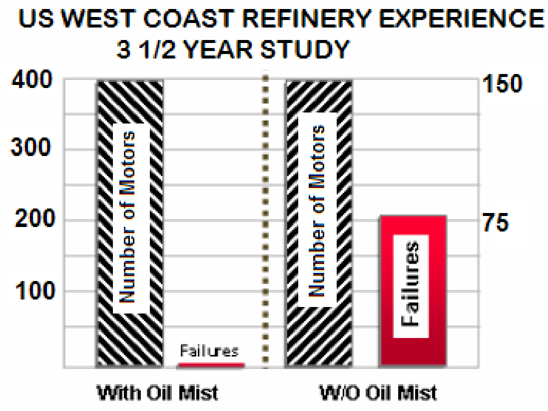


Figure 22

from converting to oil mist equates to approximately $368,000 dollars.
Oil is another item that is often overlooked in the justification process. It has been documented that converting to oil mist reduces the amount of oil normally used in sump lubrication. Converting 600 pumps from the traditional oil sump to oil mist provides annual savings of approximately $36,000 dollars.

Over an extended amount of time, pump failures have proven to be a root cause of major fires that result in substantial repair cost and lost production, often totaling several million dollars per occurrence, not including potential health and safety liability and environmental impact. With an estimated fire every 10 years, the reduction of pump-failure related fires through the use of oil mist equates to approximately $2,390,000 per year.

With the noted savings totaling over $4 million, the justification for investing in oil mist is very real, with payback periods well under 2 years, often calculated in only months.

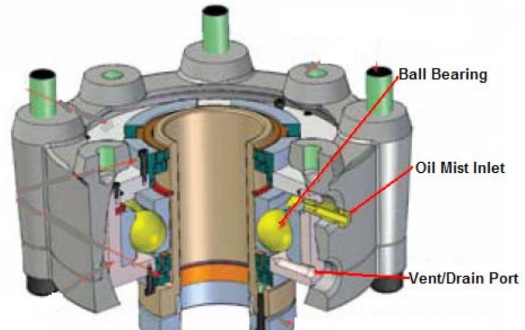
NEW HPI OIL MIST APPLICATION

As noted earlier, pumps and motors are the most common applications for oil mist due to the quantity present as compared to other mist applications such as gear boxes, blowers, turbines, and pillow block bearings on FD / ID fans. All benefit from oil mist because of the constant supply of fresh, clean oil and the slight positive pressure that is created internally.

A fan application that has not seen the benefits of oil mist, even with considerable lubrication related reliability issues, is that of the air cooled heat exchanger (ACHE) bearings. Traditionally these bearings and their motor drivers have been lubricated with grease – either manually or automated. Both methods require system maintenance and, given the location of the fans, do not always receive the proper attention necessary. Even with fastidious maintenance, grease lubrication has inherent deficiencies – timing and amount of grease application, cross-contamination concerns, solidifying and liquefying in lines (automated systems) and mechanical failures of the delivery systems themselves.

However, applying mist has historically been avoided because of the legitimate concern of stray mist escaping the bearing housing and adhering to the tube bundles of the ACHE. This would consequently create the ideal surface for adhering all dust, dirt and other ambient particulates drawn through to the tube bundle by the fan, rapidly reducing its heat transfer properties.
In 2007, a bearing was designed specifically for ACHE applications that contains oil mist and allows it to be removed from the fan area for reuse, figure 23. Additionally, the bearing design allows for shaft misalignment and thermal growth – common culprits to bearing failure.

Accelerated wear testing was performed that demonstrated significant improvement in performance versus premium grease bearing alternatives; no bearing failures or visible bearing wear could be produced with loadings far exceeding field conditions. In early 2010, three trial systems were installed at major North American refineries and all are performing up to expectations as of this writing. In addition to the bearings, a major



Oil Mist Lubricated ACHES Bearing

Figure 23

motor manufacturer partnered to develop a vertically mounted motor designed to contain oil mist. These motors are currently on trial and have performed flawlessly. ACHE bearings and motors are another excellent application for oil mist (15).

CURRENT MIDDLE EAST INSTALLATIONS

Owner	No. Sys.	Yrs.	Location
Sadaf	10	20	Saudi Arabia
Kemya	8	10	Saudi Arabia
Saudi Chevron	18	10	Saudi Arabia
Ras Tanuar Ref	5	8	Saudi Arabia
Aramco Juaymah	2	10	Saudi Arabia
Samref	2	4	Saudi Arabia
Aramco GOSP1	2	5	Saudi Arabia
Sabic	8	8	Saudi Arabia
Saudi Yambu	1	10	Saudi Arabia
Sharq	21	2	Saudi Arabia
Yansab	15	2	Saudi Arabia
Bapco	13	20	Bahrain
Qchem	11	9	Qatar
Ras Laffan Olefin	5	2	Qatar
Enoc Processing	10	12	Dubai
Gasco	2	10	Abu Dhabi

CONCLUSION

Oil mist lubrication is a proven technology when systems are properly installed and applied to rotating equipment. Systems have been performing in the HPI for 40 years and providing cost justified results. The closed loop oil mist system is the Best Available Technology (16) for lubrication of process equipment.

The oil mist systems low maintenance and operating expenses with improved rotating equipment reliability have resulted in maintenance credits as much as 95% over conventional lubrication in some major HPI facilities (4).

Their versatility for working in all climates, no temperature limits, preventing the intrusion of air borne contaminates, and providing lubrication of operating equipment while protecting/preserving standby equipment make these systems valuable to plant reliability.

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