Overview and Future Trends of Manufacturing Lubrication and Conditioning Monitoring Technologies

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ABSTRACT
The longevity of component and fluid life can be greatly extended by controlling, within acceptable limits, root-cause aberrations. In fluid lubricated systems, the stability of a basic lubrication program and a vehicle for prediction of potential root-causes of failure must be considered and incorporated in the equipment design process. Condition monitoring and proactive maintenance are critical tools for achieving significant improvement in tribological performance of mechanical components and extended lubricant life.

INTRODUCTION
This invited paper will provide an overview of current knowledge-based manufacturing lubrication practices. We will describe how oil management, lubricant specifications, and proactive maintenance program can enhance plant manufacturing efficiency and reduce manufacturing cost. Knowledge-based maintenance for the manufacturing lubrication system has proven to be the most cost effective method of plant management ever developed. Advanced and emerging developments in machinery and lubricant condition monitoring equipment continue to surface. Recently, there are several novel condition monitoring tools to reduce manufacturing costs through machinery reliability and efficiency. In this paper, the current conditioning monitoring technologies and future development trends will be reviewed and discussed in detail. In addition, it is anticipated that future advances and technological breakthroughs using advanced condition monitoring or tribological systems will be beneficial for improving our manufacturing efficiency and controlling lubricant degradation.

MANUFACTURING MAINTENANCE LUBRICATION
The design parameters of machinery for the manufacturing sector rely heavily upon the use of “Wet” sumps and fluid lubrication to this day. Conventional petroleum hydrocarbon based products are the predominant lubricants. In cases where operating conditions / parameters that exceed the performance characteristics of the petroleum based lubricants are taken into consideration, Synthetic based lubricants are accepted as viable alternatives.

One trend in manufacturing machine design is leaning in the direction of “Self Lubricating” and “Lubed-for-Life” machining components. Accordingly, engineering grade plastics have identified their way into the design criteria of some industrial machinery. The utilization of engineering plastics in many cases is little more than an inexpensive replacement for a metallic component. In many instances, the PV limits of the plastics are exceeded and the surface finish of the interacting metallic surface is too rough. The consequences of premature failure of the component are soon realized. However, when properly utilized engineering grade plastics are a step in the right direction to “Self Lubricating” and “Lubed-for-life” components.

The aerospace sector has been the driving force behind the research and advancements in hard coating (surface alteration / engineering) of components utilized in tribological Interfaces.
In their severe operating environment, the use of fluid lubrication mediums is impractical or otherwise fails to function. The manufacturing sector could surely benefit from a shift in paradigms in machinery design and embrace the proven benefits of surface alteration / engineering as a means to reducing the utilization of petroleum based lubricants in manufacturing machinery.

PROACTIVE MAINTENANCE

Proactive maintenance programs have proven to be the most cost effective method(s) of asset management ever developed. The heart of the proactive maintenance program is the utilization of the machine and lubricant condition monitoring technologies. Proactive maintenance utilizes lubricant and machine service history and data accumulated through the utilization of the condition monitoring technologies to schedule repair, overhaul or replacement prior to machinery failure.

LUBRICANT AND COMPONENT CONDITION MONITORING

1. LUBRICANT CONDITION MONITORING

One of the first steps in this direction is to establish and mandate compliance, of stringent lubricant Specifications. The lubrication specification will ensure that machinery delivered and placed in service will be maintainable from a lubrication perspective. The lubricant specification must qualify lubricants that meet specific performance characteristics to ensure long life in service. Lubricant condition monitoring and maintenance procedures / goals must be established which embrace “Cradle to Grave” ownership and service life of the lubricants and machinery assets. From the condition monitoring perspective, lubricant analysis continues to provide the earliest warnings of pending lubricant / machine anomalies. Any wear or distress in the machine will be evident using the wear particles monitoring technique. Wear particle size, quantity, and surface morphology have been utilized in manufacturing machine condition monitoring to diagnose and predict the rooted cause of machine failure. In addition, many modern condition monitoring devices have been developed to set up in-situ monitoring system to determine wear changes during the operation. The lubricant sample must be representative of the lubricant mass in order to better evaluate lubricant and machine condition. Continuing improvements in machinery design and lubricant extraction equipment / accessories are geared towards providing manufacturing with more efficient and consistent methods of obtaining lubricant samples. Typical lubricant monitoring technologies include: oil analysis, viscosity measurement, spectra-analysis, quantitative ferrography, analytical ferrography, Fourier Transform Infrared (FTIR). These monitoring techniques are very effective in detecting lubricant degradation and the onset of machine failures.

2. COMPONENT CONDITION MONITORING

Besides the traditional technology of condition monitoring for determining lubricant degradation during the manufacturing process described above, recently a lot of novel condition monitoring techniques have been developed to detect the component wear life in-situ and potential problems in manufacturing process before the component failure occurs. These modern techniques include electrical AC impedance, vibrational analysis, optical fiber detection, ultrasonic analysis, and high speed video monitoring device. These in-situ monitoring devices have made significant contribution to determine the failure modes and feasible prevention of failure in advance. In addition, these novel techniques using the electrical AC impedance measurements, as well as methods and instrumentation suitable for real-time monitoring of the viscosity and the electrical properties of lubricants in a plant environment. The correlation between these fluid properties and the degradation mechanisms of fluids in a manufacturing environment can be made through these novel technologies.

ROOT CAUSE FAILURE ANALYSIS (RCFA)

Redundant equipment failures are not a “Way of Life”. Root cause of these failures must be ascertained and corrective actions taken to eliminate them. The RCFA process when properly employed is an invaluable tool to establishing true cause of an equipment failure. Through process of elimination, you completely rule out any and all conditions that can be determined to be effects rather that the cause. You will systematically eliminate any component, Physical intervention and management issues that cannot be directly attributed as the root of the failure. Always bear in mind that theory behind RCFA is to ascertain and correct “Root Cause” and not an exercise to find fault or lay blame.

SUMMARY

(1) Knowledge-based maintenance for the manufacturing lubrication system has proven to be the most cost effective method of plant management ever developed.
(2) Advanced and emerging developments in machinery and lubricant condition monitoring equipment continue to be an emerging technology.
(3) These novel condition-monitoring tools have been proved to reduce manufacturing costs through machinery reliability and efficiency.
(4) The capabilities of these monitoring methods in-situ will be illustrated with real manufacturing data on lubricants of automotive interest. We will also provide with several case studies in U.S. and China manufacturing plants to demonstrate the effectiveness of knowledge-based maintenance and usefulness of these condition-monitoring devices in our plants.

CONCLUSION

In this paper, the current conditioning monitoring technologies and future development trends have been reviewed and discussed in detail. In addition, it is anticipated that future advances and technological breakthroughs using advanced condition monitoring in tribological systems will be beneficial for improving our manufacturing efficiency and controlling lubricant degradation.