A Review on Comparison of Lubricants and Development of Optimization Model of Rolling Mill

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Abstract: Lubricants play a critical role in nearly every type of machinery, and their performance is often critical to the speed, reliability, and life of the machines. As part of the product development process, lubricant manufacturers are continually faced with the need to evaluate the performance of candidate lubricants under many different conditions. Likewise, manufacturers of machinery frequently need to test the performance of alternative lubrications in order to determine the formulation that will enable their products to deliver the best performance and life. In the past, lubricant evaluation was typically based on intuition and experience. Today's requirements for products to run faster, longer, and more efficiently make it essential to use a scientific approach in lubricant development and application. This paper summarizes and reviews the major aspects of different types of lubricants commonly used in rolling mill as per different authors.

To achieve the best possible Quality rolled products it is Necessary to keep the rolling Process and all parameters as Constant as possible. Every Variable should be under Control as required by quality assurance. However, during hot rolling (flat products or sections) every parameter is changing. The rolled material varies in temperature and cross-section from pass to pass, therefore different type of problem occurred in the rolling process, thus this paper also looks for to optimising the rolling mill by developing the optimization model.

Key Words: Lubricants, Rolling Mill, optimization.

1. INTRODUCTION

In all types of machines, the surfaces of moving or sliding or rolling parts rub against each other. Due to the mutual rubbing of one part against another, a resistance is offered to their movement. This resistance is known as friction. It causes a lot of wear and tear of surfaces of moving parts. Any substance introduced between two moving/sliding surfaces with a view to reduce the friction (or frictional resistance) between them, is known as a lubricants. The main purpose of a lubricant is to keep the moving/sliding surfaces apart, so that friction and consequent destruction of material is minimized. The process of reducing friction between moving/sliding surfaces, by the introduction of lubricants in between them, is called lubrication.

1.1. FUNCTION OF LUBRICANTS:

(1) It reduces wear and tear of the surfaces by avoiding direct metal to metal contact between the rubbing surfaces, i.e. by introducing lubricants between the two surfaces.
(2) It reduces expansion of metal due to frictional heat and destruction of material
(3) It acts as coolant of metal due to heat transfer media
(4) It avoids unsmooth relative motion
(5) It reduces maintenance cost
(6) It also reduces power loss in internal combustion engines

1.2 THEORIES OF FRICTION

(1) **Welding theory :** All metal surfaces, regardless how much finely finished they are, appear as a series of peaks (or asperities) and valleys. So when two solid surfaces are pressed one over the other,

only the peaks of the two surfaces come in real contact. Under the action of a load, the local pressure at the peaks becomes sufficiently great to cause deformation of the peaks to create weld junctions between them.

(2) **Mechanical Interlocking** : When one surface moves over another, the peaks and valleys present on the surface undergo interlocking; restrict the movement of one surface over the other. This accounts for static friction.

(3) **Molecular Attraction :** Atoms of one material are plucked out of the attractive range of their counterparts on the mating surface, lead to the friction.

(4) **Electrostatic Attraction :** When stick-slip phenomenon takes place between rubbing metal surfaces, a net flow of electrons takes place producing clusters of charges of opposite polarity at the interface. These charges are responsible for holding the surfaces together by electrostatic attraction. surfaces, by the introduction of lubricants in between them, is called lubrication.

1.3 CLASSIFICATION OF LUBRICANTS

Lubricants are classified on the basis of their physical state, as follows;

(a) Liquid lubricants or Lubricating Oils
(b) Semi-solid lubricants or Greases and
(c) Solid lubricants**.**

(a) Liquid lubricants or Lubricating oils: Lubricating oils also known as liquid lubricants and further classified into three categories; (i) Animal and Vegetables oils, (ii) Mineral or Petroleum oils and (iii) blended oils.

(i) Animal and Vegetables oils: Animal oils are extracted from the crude fat and vegetables oils such as cotton seed oil and caster oils. These oils possess good oiliness and hence they can stick on metal surfaces effectively even under elevated temperatures and heavy loads. But they suffer from the disadvantages that they are costly, undergo easy oxidation to give gummy products and hydrolyze easily on contact with moist air or water. Hence they are only rarely used these days for lubrication. But they are still used as blending agents in petroleum based lubricants to get improved oiliness.

(ii) Mineral or Petroleum oils: These are basically lower molecular weight hydrocarbons with about 12 to 50 carbon atoms. As they are cheap, available in abundance and stable under service conditions, hence they are widely used. But the oiliness of mineral oils is less, so the addition of higher molecular weight compounds like oleic acid and stearic acid increases the oiliness of mineral oil.

(iii) Blended oils: No single oil possesses all the properties required for a good lubricant and hence addition of proper additives is essential to make them perform well. Such additives added lubricating oils are called blended oils. Examples: The addition of higher molecular weight compounds like oleic acid, stearic acid, palmetic acid, etc. or vegetables oil like coconut oil, castor oil, etc. increases the oiliness of mineral oil.

(b) Semi-solid Lubricants or Grease: A semi-solid lubricant obtained by combining lubricating oil with thickening agents is termed as grease. Lubricating oil is the principal component and it can be either petroleum oil or a synthetic hydrocarbon of low to high viscosity. The thickeners consist primarily of special soaps of Li, Na, Ca, Ba, Al, etc. Non-soap thickeners include carbon black, silica gel, polyureas and other synthetic polymers, clays, etc. Grease can support much heavier load at lower speed. Internal resistance of grease is much higher than that of lubricating oils; therefore it is better to use oil instead of grease. Compared to lubricating oils, grease cannot effectively dissipate heat from the bearings, so work at relatively lower temp.

(c) Solid lubricants: They are preferred where (1) the operating conditions are such that a lubricating film cannot be secured by the use of lubricating oils or grease (2) contamination (by the entry of dust particles) of lubricating oils or grease is unacceptable (3) the operating temperature or load is too high, even for grease to remain in position and (4) combustible lubricants must be avoided. They are used either in the dry powder form or with binders to make them stick firmly to the metal surfaces while in use. They are available as dispersions in non-volatile carriers like soaps, fats, waxes, etc and as soft metal films. The most common solid lubricants are graphite, molybdenum disulphide, tungsten Disulphide and zinc oxide. They can withstand temperature upto 650° C and can be applied in continuously operating situations. They are also used as additives to mineral oils and greases in order to increase the load carrying capacity of the lubricant. Other solid lubricants in use are soapstone (talc) and mica.

2. BACKGROUND:

Lubrication oil is an important information source for early machine failure detection just like the role of the human blood sample testing in order to perform disease detection.

In modern industries, lubrication oil plays a critical part in condition maintenance of complicated machineries such as rolling mills. In recent years, health condition monitoring and prognostics of lubrication oil has become a significant topic among academia and industry. Significant effort has been put into oil diagnostic and prognostic system development and research. In comparison with vibration based machine health monitoring techniques, lubrication oil condition monitoring provides approximately 10 times earlier warnings for machine malfunction and failure (Poley,2012). The purpose of most research is, by means of monitoring the oil degradation process, to provide early warning of machine failure and most importantly extend the operational duration of lubrication oil in order to reduce the frequency of oil changes and therefore reduce maintenance costs. For the rolling industry, in order to reduce rolling energy costs, there is a pressing need to improve the rolling mill availability and reduce the operational and maintenance costs. The reliability and availability of a functioning rolling mill depends largely on the protective properties of the lubrication oil for its drive train subassemblies such as gearbox and means for lubrication oil condition monitoring and degradation detection. The rolling industry mostly uses offsite lubrication oil analysis. The lubrication oil in the rolling mill is normally sampled every 6 months and sent to oil analysis labs for feedback on the condition of the oil. However, the online health monitoring of functional failures of lubrication oil has been an issue that cannot be handled by such techniques and remains to be an unsolved problem. The purpose of lubrication oil condition monitoring and degradation detection is to determine whether the oil has deteriorated to such a degree that it no longer fulfils its protective function and to provide early warning of the possibility of total failure. As stated by Sharman and Gandhi (2008), and many other researchers, the primary function of lubrication oil is to provide a continuous layer of film between surfaces in relative motion to reduce friction and prevent wear, and thereby, prevent seizure of the mating parts. The secondary function is to cool the working parts, protect metal surfaces against corrosion, flush away or prevent ingress of contaminants and keep the mating component reasonably free of deposits. In a lubricated system, variation in physical, chemical, electrical (magnetic) and optical properties change the characteristics of the lubrication oil and lead to the degradation as its protective properties. The main causes of turbine lubricant deterioration are oxidation, particle contamination, and water contamination. These three are defined in this paper as lubrication oil basic degradation features. The parameters that describe the lubrication oil performance or level of degradation are called performance parameters. These parameters include viscosity, water content, total acid number (TAN), total base number (TBN), particle counting, pH value and so forth.

Each performance parameter can be measured by certain sensing techniques. The relationship among the basic degradation features, performance parameters, is shown in Fig. 1. Also, For example, for water content, it measures the water contamination percentage of the lubrication oil. This performance parameter is necessary and crucial to gearbox, hydraulic system, engine, compressor and turbine applications. Water content can be measured by a capacitance sensor, viscosity sensor, and water in oil sensor. To find a feasible solution for online lubrication oil health condition monitoring and remaining useful life (RUL) prediction, it is necessary to conduct a comprehensive review of the current oil health monitoring techniques. Over the years, scientists and experts have developed sensors and systems to monitor one or more of the lubrication oil performance parameters in order to monitor the oil condition effectively. (magnetic), physical, chemical, and optical techniques. For example, the most effective electrical technique for oil health monitoring is detecting the dielectric constant change of the lubrication oil.

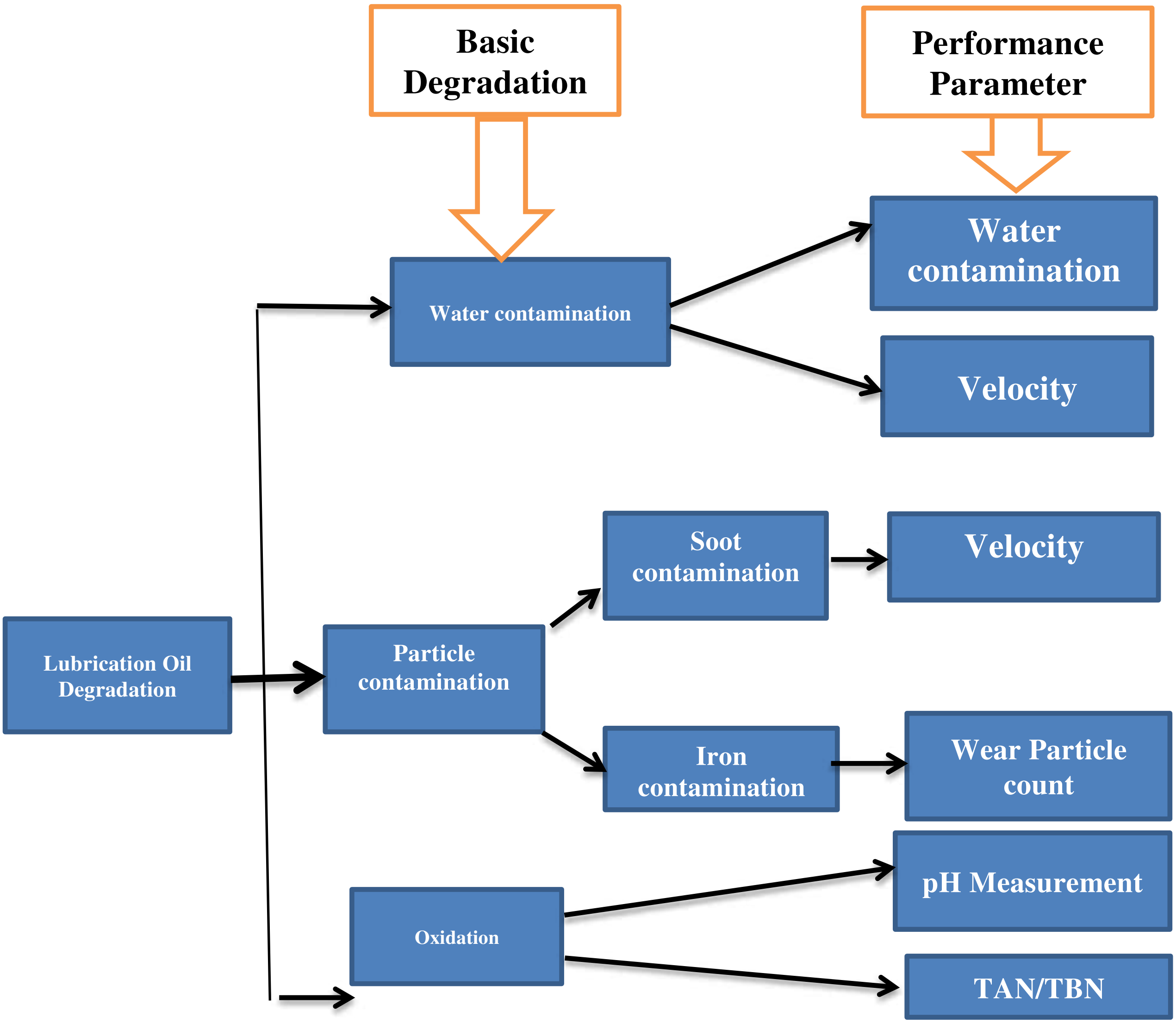

Figure 1. The relationship among the basic degradation features and performance parameters

According to recent studies, the capacitance or permittivity change can be used to monitor the oxidation, water contamination, and wear particle concentration. On the other hand, for physical techniques, viscosity is commonly discussed. The lubrication oil oxidation, water contamination, particle concentration, and

some other property changes all have an influence on oil viscosity. Therefore, viscosity is considered an objective mean of oil degradation detection. The final goal of all above mentioned systems is to achieve lubrication oil online health monitoring and remaining useful life prediction in industrial machineries. In this way, the actual condition of the lubrication oil cannot be determined online because of the sampling and analysis delay. With the deployment of online oil condition monitoring techniques, one can optimize the maintenance schedule and reduce the maintenance costs.

3. PRE-EXISTING STATE AND MANAGEMENT OF THE ROLLING LUBRICANTS:

At that time, the rolling lubricant being used was a marginally adequate lubricant. The existing management of the lubricant was with minimal proactive management. The only existing on-site, real time testing of the lubricant was testing for the percentage of total oil. This is an important measure for lubricant management but additional measurements provide a mill with more critical and useful decision making information. Lubricant tests such as irons in solution, tramp oils and pH are important indicators of the condition of the lubricant which positively or negatively affect mill performance. These tests were being performed by the previous rolling oil supplier but results were not real time because the testing was performed at an off-site facility. The lag time between taking the lubricant sample, testing and reporting results was a minimum of 24 hours and the frequency was, at most, one sample per week. By performing these tests on-site, with real time results, permits the ability to maintain the lubricant at an optimum condition. , Productivity and quality gains can be maximized.

4. IMPLEMENTATION PLAN:

The first step in implementing the change became the transformation process to achieve new levels of performance at the Bagdad Operation ---develop a new approach to formulating rolling oil. The standard methodology that is used to begin development of rolling oil that is designed to provide the required performance for an individual cold rolling mill is to do an extensive survey of the mill equipment and systems. This survey process captures a significant amount of information about the mill systems, product mix, production performance and practices, and quality objectives. The major information categories provided on a typical survey include:

A. Mill Equipment Information
B. Products Produced
C. Pickle Line Information
D. Rolling Oil Solution System Information
E. Last Stand System Information (If the last stand is configured with an individual system)
F. Neat Rolling Oil Storage
G. Water Supply
H. Annealing Processes
I. Quality and Performance Data
J. Schematic Diagram of the Roll and Spray Configuration
K. Solution System Diagram

5. CONVENTIONAL COLD ROLLING AND ITS PROBLEMS:

Cold rolling is a process that simultaneously deforms and strengthens metal. It is used as the final stage in the manufacture of metal strip, after hot rolling. In the manufacture of strip stock, hot rolling is typically followed by cold rolling.

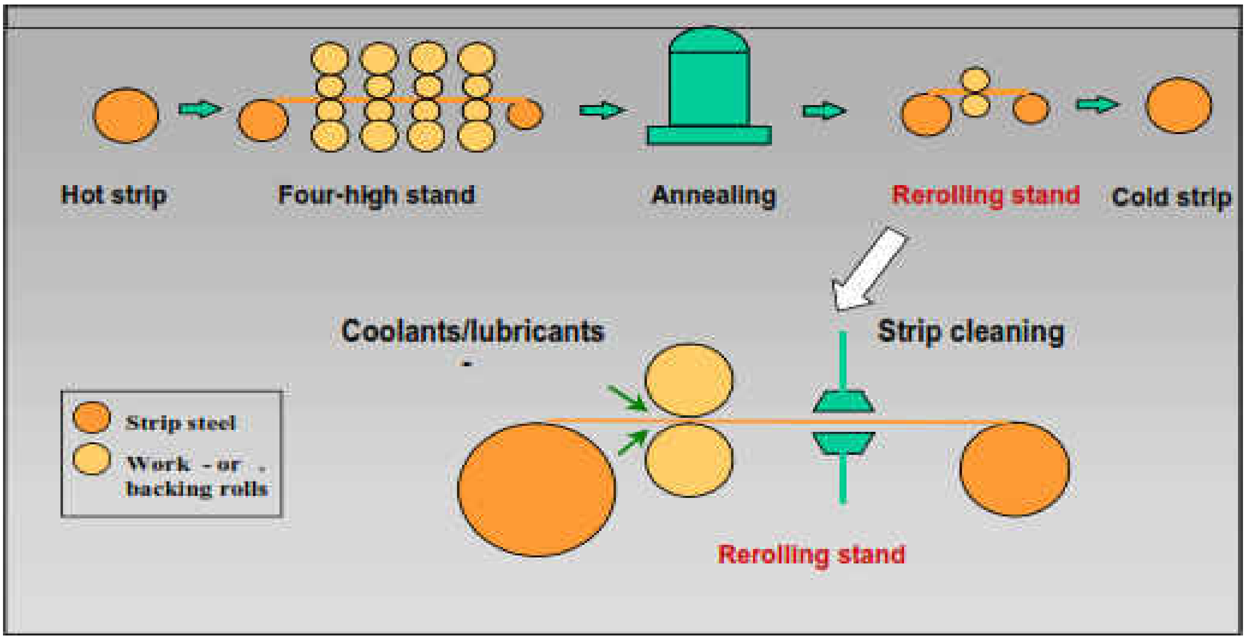

Figure 2. Process of Rolling mill

Hot rolling can achieve large dimensional changes in a single step, but gives poor dimensional control and surface finish. Because it is carried out at temperatures above the re-crystallization temperature of the metal, hot rolling does not increase the strength of the metal. Cold rolling, on the other hand, takes place without re-crystallization, so the material undergoes work hardening. As a result, cold rolling can be used to fine-tune the mechanical properties of the strip, as well as yield a product with a high-quality surface finish. Cold-rolled steel strip is typically used for motor vehicle bodies and domestic appliances.

During the survey process a great deal of information is provided which assists in deciding the formulation approach that will be required in order to achieve the performance that the customer wishes through a change in lubricants. Also, the survey helps establish an understanding of the current state of operational practices for managing the rolling lubricants system. Various researchers, includes following articles

Year	Title/Author	Finding	variable	Country
2003	Some aspects on lubrication and roll wear in rolling mills Mohammed tahir	lubricants and roll wear in strip rolling	synthetic lubricants is compared with currently used mineral oils and emulsions	KTH, Switzerland
2012	Monitoring Lubricant Performance in Field Application S. Peric et al	Monitoring Maintenance of Oil analysis	increased temperatures, Different kinds of pollution are also a frequent cause of lubricant degradation. Gaseous combustion products, air, water, glycol, fuel, various process media, wear products, and other pollutants, may be the cause of a serious impairment of the condition of the lubricant	
2013	Lubrication Oil Condition Monitoring and Remaining Useful Life Prediction with Particle Filtering Junda Zhu et al	Useful Life Prediction	Different performance parameter of lubricants	Chicago, USA
2013	Study of the Effect of Minimum Quantity Lubrication on the Surface Roughness of Incoloy 800 during Turning Operation Md. Imran Ansari et al	The effect of Minimum Quantity Lubrication(MQL) on the surface roughness produced during Turning Incoloy 800	Regression Analysis was Carried out for different cutting conditions using Minitab software and Mathematical models were generated which established relation among Cutting parameters and surface roughness	Warangal, India
2012	Tribological Approach for Improvement in Productivity and Quality of Flat Rolled Steel Products: A Review	Improvement in Productivity and Quality of Flat Rolled Steel Products	the different issues related to Tribology in steel rolling viz requirements of rolling lubricants, development of methodology for evaluation of properties of cold rolling oil, tribological measures for improvement in product quality and enhancing mill productivity, environmental issues etc.	Rachi, India
2013	Friction in cold rolling of a low carbon steel with lubricants	The coefficients of friction are determined	two mathematical models. While both models show that the coefficients decrease with Increasing speeds and reductions, their magnitudes are strongly dependent on the models.	Waterloo, Canada

2015	Review on cold rolling mill roll deformation Dr. Ravi Goyal et al	To highlight those reasons which are responsible for the breakage of rolling mill	Thermal breakages: Thermal gradient Strength Residual stress	Jaipur (Rajasthan) India
2015	Roll cooling and lubrication Peipers	To find The best possible Quality rolled products	The rolled material Varies in temperature and cross-section from pass to pass heat is transferred to the rolls which gain thermal crown	Siegen, Germany

6. CONCLUTION:

The study of above article it was realized that there is a change of physical-chemical characteristics of oil for lubrication in the engines vehicle. These changes are in direct dependence on the state of all elements tribomechanical engines system, and depending on their functional characteristics. The interpretation of used oils analysis is very complex, because the individual analyses are interdependent. That is the reason why it is necessary to know the entire oil analysis, and not bring conclusions based on individual analysis results. Analyses from used oil sample should always be Compared with previous samples and final conclusions should be based on "trend analysis".

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