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A Review: Onrolling lubricant optimization

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Thus in the field of rolling mill technology the surface quality of rolled product and stability of rolling oils are precarious in the selection of lubricants. Additionally, production cost and environmental impact are also critical in the selection of lubricants. The performance of bio-composite based rolling oils was investigated and optimize. Deep end-cavity rollers are one of the advanced concept used to eliminate the sharp edge-stresses at the apexes of the roller. The main objective of this work is to enlighten the engineers to make use of deep end cavity rollers to increase load carrying capacity and improvement of fatigue life. These are based upon the various factors and summarize the effect of parameters liable for the deformation concluded by the various researchers in the past history of cold rolling mill.

1. Introduction

With time, another characteristic was added to steel industry cold rolling oils. It required that the cold rolling oil took to be recoverable after use. This brought about the requirement that the cold rolling oil should be oxidative unwavering with regard to high temperature and water. The oil was not only used to protect the steel from friction and corrosion, it was also castoff to measure the steel cleanliness. The steel cleanliness was measured with a Tape test. This test is merely done after the steel has been put through the mill. Any detrimental condition of the oil was perceived after the process. This caused a very high cost for the industry because the steel cleanliness could merely be measured after the process and no modification can be made to the oil. Therefore, it is considered important by the steel production to have a parameter of predicting the steel cleanliness with regard to the neat oil.

The main drive to investigate the poor steel cleanliness phenomenon was initiated by the cold rolling mills supplying coating lines and the automotive industry. Therefore, the initial steel cleanliness problem concerns the rolling oil composition. The most used quality analysis of the rolling oils during the early 1980's was by measuring the pH, acid value, saponification value, oil content, etc. These indicative methods only give the total change in the amounts of acids and esters contained in the oil. This type of system specific research, limits the use and implementation of the results obtained. Due to the unique demands from each cold rolling mill product, oils are formulated and manufactured according to the type of mill and method of application, resulting in a large range of different products with

compositions unknown to the steel industry.
The use of cold rolling oils on rolling mills, the expectations and specifications set for this usage and the problems faced, initiated research over a wide front in materials research and included a number of particular areas. Numerous publications exist, dealing with: the rolling oil itself, application procedures, different test techniques, different composition of rolling oils, oxidation mechanism of the oils etc.
Products, which originated from different cold rolling suppliers for the cold rolling process, were tested. The synthetic based cold rolling oil gave good oxidation constancy, while the vegetable based oil gave poor oxidation stability. These circumstances necessitated the testing of the major modules of the vegetable based oil. The site related conditions in producing the steel strip and the detailed oil used, required the investigation of the total problem to determine the mechanism(s) responsible for poor oxidation stability of the oil.
There are numerous methods for identifying thin surface layers (Auger, ESCA, SIMS etc.) but, in the case of lubrication where one is interested in both the oil film and its interaction with the metal, these methods are not suitable. According to de Werbier and his co-workers, [11] two other techniques for characterizing surface, namely, Fourier-transform infrared spectroscopy (FTIR) and a combination of Mass Spectrometry and Thermo desorption might be used. The progress made by use of Fourier-transform spectroscopy in respect of sensitivity and rapidity was quite remarkable. Using this technique, it was possible to study the composition of the surface oil film.

2. Literature review

Hypothesizing that the flattened work roll may not remain circular in the arc of contact, and to improve the accuracy of rolling force models for thinner gauges, more recent attempts to solve the plane strain problem were made, for example, by Fleck and Johnson who studied foil rolling [14]. To overcome some of the simplifying assumptions of previous investigators, Wilkund employed the plane-strain slab method and Gratacos used the elastic-plastic finite element method [15-16] to determine required rolling force and torque. The second general area of focused rolling research has been to study the problem of the non-uniform deflection of the rolling stand and components (housing, rolls, and strip). This involves the phenomenon that leads to non-uniformities in the strip thickness reduction (with respect to the direction transverse to rolling) and is thus the cause of the strip thickness profile and flatness characteristics introduced previously.
Singh, Mondal [1] have published the importance of Non Destructive testing and they stated that it is almost unbearable to detect and remove the cracks that are generated on the surface and sub- surface regions of the rolls. By the use of eddy current analysis our ultrasonic testing the cracks can be detected and removed by machining if they are small in size and shape. In ultrasonic testing machine a pulsar/receiver type electronic device which produces high voltage pulses, the high energy ultrasonic drive produces by transducer, this energy takes the form of wave by means of sound energy. When there is any incoherence in the path of the wave it reflected back, this signal transformed into the electric signal and displayed on the screen.
Soszyński & Studnicka [2] ensure in their research paper about the performance and mechanism of defect formation, Defects that are due to cold plastic distortion can be estimated by the deviation from their original geometric outline of the flat sheet. These deviations are dependent of the numerous factors, these factors are affecting the final shape and tolerances of the sheet metal the factors are: 1. available rolling

utensils solutions, 2. the way of technical process realization, 3. applied tool (roll) solutions. The most important element involved in the manufacturing procedure and having an influence on the obtained dimensional tolerances is the roll. Unrelated of the rolling mill tools used and the scale of its complexity, the roll has a substantial impact on the quality of the product. Its quality, design and features allow continuing high dimensional tolerances. Roll and its features is a conglomerate of influences which give the greatest possibilities in the field of narrowing obtained dimensional deviations, and thus improve the quality of cold rolled products. It seems that control the roll deflection is the simplest and most effective way to improve the quality of cold rolled products

Jeng and Chiou [3] observed the surface pits, cracks and spilling marks on First Intermediate roll, the main causes of deformation are fatigue, contact stresses, metallurgical microstructure and chemical & physical characteristics of contact surface.

Shen et al [4] have shown the importance of rolling lubrication and coolant used in the process of Cold rolling. They have conducted their study on laboratory simulation and actual temper rolling process. The use of new rolling lubricant as rolling chemical RL1B and RL1C were shown enhanced results of rolling lubricity and cold rolled surface cleanliness by 20- 40%.

Saboonchi & Aghili [7] have discussed about the role of temperature in rolling mill and on rolls. The temperature is one of the important parameter which is being constituted by various researchers for analyzing the performance of the roll. The study conducted on the headers having series of nozzles, which are responsible for the cooling and expansion of the work rolls.

Anand S. Nilewar, et al [8] have discussed in their review article about the study of lubrication and its effect on steel in cold rolling mill .Lubrication plays an integral role in the production and it is considered one of the important parameter by various researchers for analyzing the performance of the roll. They initiate by discussing the effect of cold rolling oil properties. They further emphasize on the improvement of rolled sheet quality due to lubrication. In this section they review around 11 articles and put in their analysis. They further suggest improvements in rolling productivity due to lubrication. They also showcase their concern for environment by highlighting the effect of rolling oils on the environment.

Katsumi et al [10] this paper described rolling mills for aluminum and copper, among other non-ferrous metal materials. The development of society and the diversification of industry are driving the continued increase in the demand for nonferrous metal materials such as aluminum and copper. Quality requirements for the products are also rising. IHIMT has developed an automatic strip shape control system and automatic set-up system in our push to increase the value added to rolling equipment for non-ferrous metal materials. Our company intends to continue its contribution to the development of the non-ferrous metal rolling industries by mobilizing its advanced technology and rich experience.

Atkins [11] this paper summarizes the effects of roll flattening and to the inlet zone of pressure build up in the determination of lubricant film thickness in cold rolling. It shows that under present day practical conditions, the thickness of the lubricant films relative to surface roughness are insufficient to maintain full fluid film lubrication. Although the mathematical model predicts a “speed effect” for rolling, the speeds involved are much faster than present commercial rates. Thus speed effects in the literature must have been caused by a change over from boundary to mixed lubrication and lubricant puddle entrapment in surface micro crevices. The non-dimensional form of the solutions shows that laboratory experiments rarely approach full-scale mill conditions, thus reflecting the notoriously difficult problem of evaluating commercial metal-working lubricants.

Schindler et al [12] the impact of various cold deformation size in combination with several modes of heat treatment on mechanical properties of the QStE 420 steel strips was ascertained. The new experimental equipment of the Institute of modeling and Control of Forming Processes at VŠB – Technical University of Ostrava in the sphere of cold rolling was exploited, i.e. laboratory rolling mill Q110 as well as vacuum annealing furnace CLASIC 1812 VAK . By the described combinations of cold deformation and recrystallization annealing it is possible to homogenize microstructure of the hot rolled strip and gain a major share of ferritic grains, but an average size of resulting grains is not smaller in comparison with that one after hot rolling. It was confirmed that by a suitable set of size of previous cold reduction and parameters of the following heat treatment it is possible to influence a complex of mechanical properties of individual strips. Trends of the particular obtained curves in all graphs reflect the well-known relation between strength and plastic properties. Formability of the studied HSLA steel rises and vice versa strength properties fall with an increasing temperature of recrystallization annealing. Demands of the client on resulting mechanical properties of the HSLA steel strip can vary a lot. With regard to this fact it is of course not possible to establish a general-purpose optimal annealing mode. The experimentally obtained particular trends of strength and plastic properties may be utilized for optimization of conditions of heat treatment of the investigated HLSA steel QStE 420 in a cold rolling mill, reflecting the specific requirements for a relation between strength and plastic properties of the given steel strips. The experiment should be supplemented by additional TEM analyses explaining the behavior and role of precipitates during recrystallization annealing.

Limei Jing [13] has reviewed some previously published experimental and theoretical studies of hot rolling. A thorough understanding of the available roll design methods; and conditions of their application is extremely important in order to achieve the objective of producing high quality rolled products. Successful hot roll design is dominated by the calculations of some important parameters, which describe two-dimensional (2D) or three-dimensional (3D) deformation in the work piece. These parameters, such as roll separation force, torque, elongation, spread and draft, are discussed in detail. The method or formula for the calculation of each parameter is different for each set of different application conditions. A thorough study of these methods in different application cases will lead to the optimized design of hot rolled products .Finite Element (FE) is an important method which has been employed in the study of hot rolling. Design theory, commercial software and application cases have been described. 2-D and 3-D Finite Element Methods (FEM) for hot rolling simulation have also been discussed within the work. The current techniques and the problems of using the Finite Element system in hot roll design have been presented briefly. Possible solutions to these problems have also been discussed and there need to be considered in order to successfully apply Finite Element theory in hot roll design. An important alternative approach for hot roll design has been introduced in this thesis. A Matrix-based roll design system has been developed. It includes a Matrix-based system for flat and section roll designs. The realization of the Matrix based system is discussed. All the methods and formulae considered previously can be integrated in the proposed roll design system. The approach emphasizes the need for teamwork. The design procedure allows both less experienced designers and senior designers to benefit from participation. It is suggested that high quality rolled products could be achieved from optimized designs produced using this systematized the approach compared to the ad-hoc use of existing techniques, formulae and methods.

Jiang [14] in his paper has developed successfully a new model for rolling mechanics of thin strip in cold rolling when the work rolls edge contacts. A strip plastic deformation-based model of the rolling force was employed in the calculation, and a modified semi-infinite body model was introduced to calculate the flattening between the work roll and backup roll, and the flattening between the work roll and strip, as well as a Foppl model was employed to calculate the edge contact between the upper and down work rolls. Based on the theory of the slit beam, the special rolling and strip deformation was simulated using a modified influence function method. The calculated results show that the specific forces such as the rolling force, intermediate force and the shape and profile of the strip for this special rolling process are significantly different from the forces in the traditional cold rolling process, and those form a new theory of metal plasticity in metal rolling. The edge contact of the work rolls can improve the strip shape when no work roll bending force is applied. With an increase of reduction, the rolling force, intermediate force and edge contact force increase significantly, however the strip shape becomes poor. Strip width has a significant influence on the edge contact force and edge contact length of the work rolls, which can result in an unstable work roll edge wear. When the friction coefficient increases, the edge contact force between the two work rolls increases, this can improve the strip profile. The transverse friction has a significant effect on the rolling force, edge contact force and the length of edge contact. It affects the strip shape and profile significantly, which is helpful in improving the strip shape and profile by modifying transverse friction. The calculated rolling force increases when the strip width increases and the rolling speed decreases, and it is in good agreement with the measured value. At lower rolling speeds, the work roll edge contact force becomes higher as a percentage of the total rolling force.

Hanoglu[15] has in his paper described the mathematical and physical modeling of flat rolling process. Here he gives us a detailed account of Flat rolling process 1.Plasticity of material during rolling and compression 2. Roll deformation 3. Roll separating force, roll pressure, shear stress, and friction 4. Friction factor and coefficient of friction 5.Schey’s model, sim’s model, Orowan model and refinements to Orowan model 6.Temperature gain and loss during rolling 7.Static, dynamic and meta dynamic recrystallization 8.Roll torque and power calculations 9. Influence of physical quantities on rolling 10.Temper, accumulative roll bonding, and flexible rolling 11.Comparison of some calculations 12.Base of computational simulation to be done

Malvezzi et al [16] has in his article proposed procedure that includes a mathematical model for lubricant flow based on Reynolds equation and a mathematical model for plastic deformation process based on Orowan approach. In this way was determined a free boundary problem with a choice of boundary conditions proposed by authors in a precedent paper .The improvement in this paper consists the authors have studied the introduction of the plastic deformation more advanced than slab analysis. The results gave better approximations. Other improvements can be obtained by introducing the deformation of the rolls or the pressure and thermal effect on the lubricant.

Durovsky et al [17] the mathematical relation between frictions force on single stand rolling mill derived by using genetic algorithm. The Bland ford method used for tandem rolling mill. The main objective of the research paper is to use the results obtained by the model to superimpose the thickness, flatness, speed and tension with the value of flatness for different hardness materials.

Jian et al [18] has given finite element analysis for strip rolling mill. The main findings of the research paper related to the spalling (metal loss in rolls) of Back up roll in the rolling mill. As the hot rolling mill process works above the recrystallization temperature and the cold rolling mill process is below the recrystallization temperature. The temperature plays a vital role in the rolling process. The Finite element analysis used 3D ANSYS software for full analysis of Back up roll. Stress distribution on the contact of work roll and back up roll could be estimated by strip width, rolling force and thermal stresses can be analyzed. The results shows that when the strip width and rolling force per width changing the peak of the surface contact between work roll and back up roll is dissymmetry then the changing stresses will be maximum and above certain level it tends to the roll deformation.

Wendt et al [19] have discussed about the sticking problem after annealing process in cold rolled steel. The coil of cold rolled steel when uncoiled after annealing face sticking. The sticking is termed as welding and the cause may be diffusion or sintering or other adhesion mechanism. Basically in sticking the role of roll and their attributes are having no significance but as the heat increases due to hard material and high speed rolling mills. The types of stickers are Ridge Stickers – Due to strip profile which can cause high radial pressure inside the coil. Spot Stickers – These are localized spots caused by the high pressure and undesired foreign particles. Edge Stickers – These are on the edge of the coil, due to damage of the coil at the edges these stickers are formed, the sheet thickness is important because more thinner sheet will be having more edge stickers if the coil is damaged by external means. General Stickers – These are the irregular lines at the centre of the strip. Due to the crowning in the roll the roll pressure is centralized on the strip and due to this high pressure the general sticker marks occurs on the centre. Before annealing the factors which are affecting the sticking are Steel grade, hot strip profile, Coiling tension, Strip roughness, Strip Cleanliness, Strip dimensions, Coil dimensions. The factors affecting the sticking during annealing are Cooling rate, heating up gradient, Coil position. The factors affecting the sticking after annealing are Uncoiling speed, Uncoiling tension and Uncoiling geometry.

David [20] has given the analysis of thermogravimetry used to evaluate the burn off residue and decomposition of rolling oil system. A Dupont 9900 thermal analysis system used to conduct the experiment at a heating rate of 20^{o}C /min from ambient to 780oC under a N2 atmosphere at a pure rate of 70 cm3/min. The oil sample is mixed with carbonyl iron powder by 1 percent to interact with the oil. The TG technique used to find out the residual stresses in the rolling after annealing.

3. CONCLUSION

The literature survey stated that formulation of rolling oils is in the hands of long established suppliers, where they formulate and manufacture the oils according to the type of mill and method of application. The large number of lubricant combinations possible, the number of possible environments and the absence of standardized neat oil evaluation tests for steel surface cleanliness predictions, all add to the uncertainties regarding the use of lubricants on steel surfaces. The conclusion of this work was to determine the cause or causes of poor steel surface cleanliness with respect to cold rolling oils oxidative stability from a specific production line. In broad terms, the literature study revealed the following:

(a) That the poor steel surface cleanliness was as a results of carbonaceous matter left on the steel surface after rolling [10];

(b) That the oil/surface interaction species were the determining factor in interpreting the steel surface cleanliness [11];

(c) That the components in the rolling oil determine rolling oil properties [5].

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