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Method for Automated Lubrication of Industrial Universal Cross Joint in Hot Rolling Mill

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Abstract:- The Quality of product made by Hot Rolling Mill mainly depends on the uniform functioning of the work rolls which are attached to the spindles. The proper rotation on these spindles depends on the proper working of the Industrial Universal Cross Joints. Efficient Lubrication has a huge impact on the functioning of these Industrial Universal Cross Joints. Inefficient lubrication may lead to unwanted stresses in the cross of the joint. Traditional Lubrication system involves halting the machinery and carrying out the lubrication of the Industrial Universal Joint which costs us both time and man power. To overcome this, an efficient Automated Lubrication Method has been discussed in this paper and its required redesigns of the parts and the system have been shown.

This new method suggests a need to redesign the Bush of the cross of the Universal Joint and the formation of an independent system which will inject the lubricant into the joint externally without having to halt the entire machine system.

Keywords: *universal joint, cross joint, lubrication, hot rolling mill, automated lubrication.*

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1. Introduction: Hot Rolling Mill

Rolling is the process of changing the cross section of the work piece by compressing it. The hot roll milling takes place at a temperature ranging from 800°C to 1000°C. The rolling mill here is used for making the long steel sheets of steel which are formed and its thickness is reduced from 20mm to 2mm using the Hot Rolling Mill.

The rolling mill is driven by various shafts and spindles which are run by the motors and couplings. One shaft is connected to the gearing arrangement of the motor while the other one is connected to the work rolls. Both of these are joined by an intermediate shaft which uses two industrial universal cross joint to couple the previous two shafts which serves the purpose of the angular rotational motion transfer.

2. The Need of Lubrication in this System

The Lubrication of these cross Joints is an important part of the maintenance of this whole process. Effective lubrication of these Cross Joints increases its working life and leads to a smooth vibration-free manufacturing of the product. Also the lubricant acts as a coolant at such elevated temperatures. Thus, effective lubrication adds a lot of advantages to the maintenance and the process of the manufacturing.

The joints need to be lubricated about every week as the lubricant wears out after its 24 hours working after approximately 6-8 days. This traditional lubrication process requires two men per universal joint for the lubrication and the process takes about at least an hour for its completion.

3. The New Proposed Method

The new method requires a few redesigns in the Bush and Bearing Cover Plate of the Universal Joint used in this Hot Rolling Mill. Also, it would require an independent "Lubricant Injector" which will be a whole new small system which will be placed alongside the axis of the rotation of the Universal Cross Joint. All these are being explained in details as follows:

3.1. Bush and Bearing Cover Plate Redesign

Traditionally, there's a bush over the internal roller bearing lining inside the bush. And then, the bush is again covered externally by Bearing Cover Plate which acts as a cover over the whole bush. But here, we plan to expose the upper part of the bush. Also, the Bearing Cover Plate will have a Circular Groove throughout which will be slanted internally. The slanted internal design is made to assist the flow of the lubricants into the bearings. A prototyped CAD design is being presented below. No major changes have been expected to be required for the material selection of this part. As mostly used, Chrome Steel Material (High Carbon Chromium) will be selected for the casting of this part.

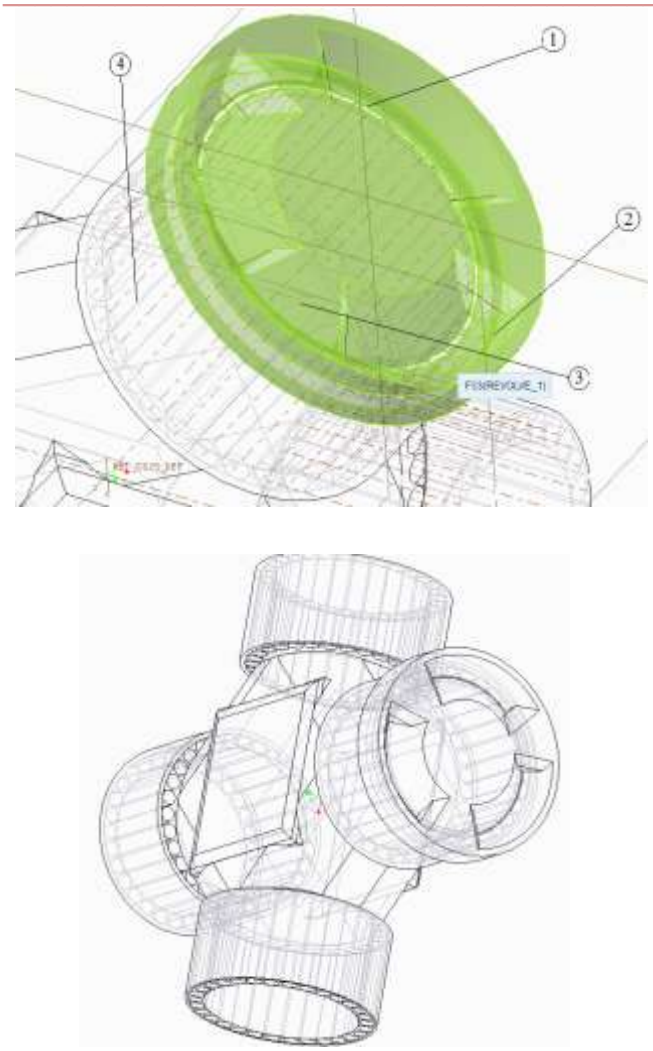

Fig. 1. Re-Designed Bearing Cover Plate
(1) Cavity (2) Groove (3) Rib (4) Roller Bearing

Here, the part denoted by the green colour is the newly redesigned cover plate. The Cavity (1) facilitates the input of lubricant into the roller bearings for the lubrication purposes. The Slant Groove (2) helps the slippage of the lubricant if the lubricant happens to fall on the spot apart from the destined spot. The Rib (3) provides the strength that is required for the symmetry and stability of the Cover Plate. The Roller Bearings (4) are behind the cover plate which are to be lubricated.

3.2. Lubricant Injector

This can be considered as the most important segment of this method. It is designed such that the whole system is independent of the Hot Rolling Mill Power Supply. It primarily consists of a nozzle, a metering pump, an image sensor and a PLC. A schematic of the whole assembly is shown below.

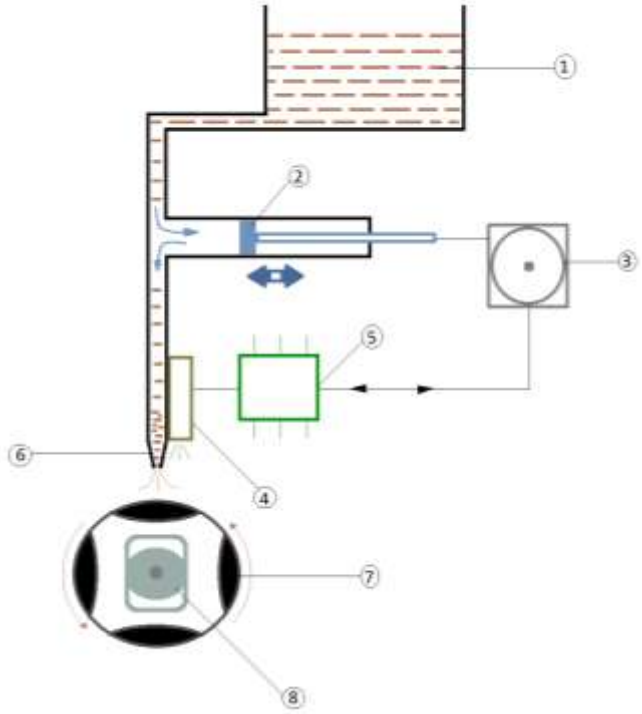

Fig. 2. Lubricant Injector
(1) Lubricant Reservoir
(2) Piston
(3) Metering Pump Kit
(4) Image Sensor
(5) PLC
(6) Nozzle
(7) Bearing Cover Plate
(8) Axis of Rotation of Universal Joint

The above assembly will be placed behind the Universal Joint and the nozzle, as shown above, will be right above the cover plate location. The supply and other accessories are kept independent of the spindle supply such that in case of failure of Lubricant Injector, no harm should happen in the working of the Spindle, and thus, the Hot Rolling Mill. Some brief description about a few important components is given below:

a. *Lubricant Reservoir*: It is preferred to be placed at the top of the whole assembly so that no extra pump is required for bringing it to the required spot. Moreover, the top position acts as an additional advantage of the gravitational force pulling the lubricant downwards for quicker operation.
b. *Metering Pump Kit*: After looking for various options available, it came up to be the most compact and cheap method for the suction and injection of lubricant. With the suction stroke, it

will suck a controlled amount of lubricant from the reservoir and in the next half cycle and compression, it will inject the lubricant into the required spot.

c. *Image Sensor*: Image processing will be required for the detection of the position of bearing cover plate. Hence, the image detection package with colour and/or pattern recognition will be programmed and installed.

d. *PLC*: Programmable Logical Circuit (PLC) are required to receive feedback from the Image Sensor and perform control functions of the Metering Pump accordingly as programmed. PLC is preferred over a Microcontroller as the working temperatures are pretty high at HRM and chances are that a microcontroller might breakdown while in operation which is highly undesirable.

e. *Nozzle*: Here, for now, a single point nozzle has been considered for the injection purpose but however, a multipoint lubricant distributer might also be used for higher lubrication discharge and larger surface cover.

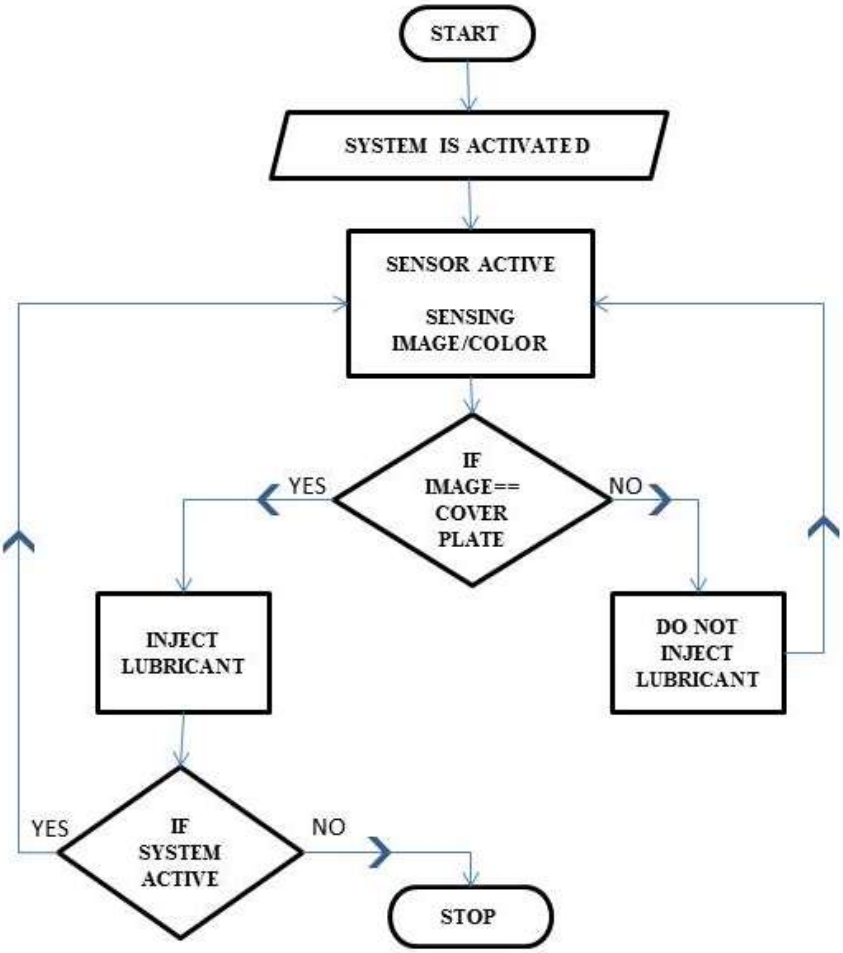

Fig. 3. PLC working Flowchart

The functioning of the whole system together will take place in the following order:

i. First of all, the Lubricant Injection System is activated when the lubrication of the universal joint will be needed. The metering pump, image sensor and the PLC will become active and the process will be good to go.

ii. As the universal joint is rotating, the image sensor will start to look for the prefixed image or colour of the Bearing Cover Plate which is previously programmed into PLC.

iii. As soon as the image sensor detects the predefined image/colour/pattern, the metering pump will be actuated, as programmed into the PLC, and the nozzle will inject the lubricant into the

cavity present in the groove as shown in Fig. (1) and Fig. (2) The working of the PLC will take place as shown in the flowchart Fig. (3) During all this, we are considering ideal conditions and zero delay. However, for practical purposes, we'll need to predefine some standard delays according to which the system will function efficiently.

iv. As the lubrication of this first cross took place, the lubricant will be injected into the following three crosses one after another. The process will continue to take place for each rotation such that all four crosses are lubricated in a single rotation of universal joint.

v. Once, enough lubrications are done as per required quantity, the Lubricant Injector (system) will be disabled until further required or scheduled maintenance.

4. Advantages

i. The workers will no longer have to manually fill up the lubricant in the universal joint.

ii. The time required for the lubrication will drastically reduce as no special time will have to be allotted for the same.

iii. Also, systems like true-lube drive shaft can be replaced with this method as those systems increase the weight of the spindle and drive shaft which can be considered as undesirable.

iv. Lubrication can now be done at any point of time simply by switching on the Lubricant Injection System without having to wait for the scheduled maintenance.

v. Installing this system can just be considered as an accessory as this whole system is independent of the traditional HRM and hence, no changes will have to be done to the traditional HRM section.

vi. Also, the breakdown of this system won't halt the HRM process as the lubrication of the U-Cross Joint can still be done manually till the system is restored.

vii. No skilled labour is required for the process as the worker only has to switch on the system whenever needed.

viii. The frequent lubrication will help minimise the stresses on the roller bearings in a small amount.

5. Disadvantages

i. High initial cost as compared to the traditional method.

ii. Need to change the design of bush and bearing cover plate which is not easily welcomed by the industries as it takes time, money and human knowledge to accomplish the same.

iii. The speed of the spindle will have to be reduced to adjust to the image/colour/pattern sensing capacity of the Sensor which might slow down the production for a while.

iv. Skilled labour will be required for the maintenance of the Lubrication Injector in case of its breakdown.

v. In case of improper calibration and functioning of the Lubricant Injector, the nozzle might inject the lubricant at an inappropriate spot which might lead to a little wastage of lubricant.

6. Conclusion

In this way, the Hot Rolling Mill Section can replace its traditional method of lubrication of Industrial Cross Joint with this Lubricant Injection System because of its efficiency and feasibility of lubrication without directly hampering the traditional Hot Rolling Mill layout.

7. Acknowledgements

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