IJITKM Special Issue (ICFTEM-2014) May 2014 pp. 245-250 (ISSN 0973-4414)

Improvement in Techno-Economic parameters by Roll Lubrication in Structural Steel Rolling

S K Jha[1], K Prakash[2], S Kumar[3], B Roy[4], D K Jain[5], , R Topno[6,] A.P Singh[7]
[1]RDCIS, SAIL, RANCHI
[7]Ganpati Group of Institutions ,Bilaspur, Yamunanager, Haryana
samirjha@sail-rdcis.com

ABSTRACT- Hot rolling of steel is an energy intensive process which is carried out at high temperature with lot of abrasion and friction involved. During structural steel rolling, stock above recrystalisation temperature is subjected to series of deformation between rotating steel rolls to produce final product such as angle, channel, beam, round, rail etc. Friction plays a major role in imparting deformation. On the other hand, presence of excessive frictional forces has a detrimental influence on operational parameters of mill and product quality.

For steel stock to enter into the roll pass gap and enforce subsequent deformation between two rotating rolls, presence of friction is an essential. Higher the coefficient of friction between roll and stock, higher degree of deformation is possible. However higher frictional forces increases deformation load on the equipment and rate of rolls wear increases. It leads to reduction in operational life of rolls and intermittent stoppage of rolling mills becomes essential. It is owing to deterioration of product surface quality and overshooting of dimensional tolerance of product as a result of using worn-out rolls. Shape of roll pass groove profiles vary with change in product profile. So wear prone part of the roll pass groove changes accordingly with different structural. It becomes pertinent to seek delay for changing rolls and subsequent maintenance. It hampers productivity of rolling mills. Hence it is imperative to address presence of excessive friction by pass groove lubrication in hot rolling mill with proper understanding of roll pass groove of different structural, roll material and stock rolling temperature. Wear vulnerable portion of pass groove needs attention. The present paper discusses methodology of roll lubrication application and benefit accrued while rolling different steel structural mills of SAIL plant. Roll lubrication assisted reducing cost of production by reduction in energy consumption, enhancing roll life, increasing productivity and improving product quality terms of dimension and surface quality.

Keywords: Hot rolling, roll pass lubricant, product quality, roll life

1. INTRODUCTION

Steel structural is produced by hot rolling in Structural Mills. Hot Rolling Mills consists of reheating furnace, rolling stands, hot and cold shear, cooling bed and bundling facility of finished bars. In hot rolling mills, heating and rolling are the most energy intensive operation. In which reheating furnace consumes the maximum energy followed by rolling. Rolling of structural consists of correct feeding of input into the roll pass groove, biting of input, plastic deformation into the desired shape and proper exist from the roll pass groove. During hot deformation, tribology plays a major role towards product quality, productivity and energy consumption in the mill.

Structural rolling process involves passing of red hot bloom through different sets of rolls and during the process high pressure water jet is being used for cooling the rolls. Absence of proper cooling of rolls leads to development of thermal cracks on rolls which results in poor roll life and lowers productivity. Due to excessive wear of rolls surface quality and dimensional tolerances of structural gets affected. These problems can be addressed to maximum extent by use of proper lubricant during the process with a suitable application system. Use of lubricant improves roll life and product quality substantially, which in turns improves mill utilization. Use of lubrication also reduces rolling loads which results in saving of energy.

2. ROLL PASS LUBRICATION

During rolling, roll is subjected to alternate heating by hot bar and cooling by water & air. It induces thermal stresses of compressive and tensile mode alternately in roll. When stresses level exceeds the elastic limit of the roll material with stress and strain hysteresis cycle on the roll surface layer causes roll surface to deform plastically. Plastic deformation is of compression mode when roll and bar are in contact. It changes to tension mode of plastic deformation on cooling. Rapid rise and fall of temperature leads to thermal fatigue. Severity of thermal fatigue depends upon duration of contact with hot stock and temperature of stock. It leads to fire crack generation [1]. It is more dominant in initial passes due to higher temperature of stock. In later passes, roll temperature rises due to contact of roll with relatively lower temperature stock and conversion of some of the energy generated during deformation into heat energy. Roll failure do takes place because of inefficient roll cooling and roll lubrication.

Friction is one of the most important parameters in theory of rolling. The biting ability of rolls depends on frictional condition and it is a common practice to roughen the rolling by knurling/ragging in primary mills in order to increase its biting behaviour. But in finishing Mill, particularly last few passes govern the quality of the finished product and any deterioration in the roll surface directly reflects on product quality. Therefore it is important to enhance the life of rolls to increase production and productivity. There are many variables affecting the life of rolls, but friction in rolls plays important role in it. Reducing friction below certain level in finishing passes may result in slippage of the metal in rolls but generally in finishing passes friction is much more than the required value. This excess friction results in deterioration of the roll life. Frictional force in the rolls can be reduced by implementing roll pass lubrication which will enhance the roll life.

In section rolling, rolling in finishing stand needs to produce final product with desired surface quality and dimensional accuracy. Any deviation results in rejection of the material along with delays in adjusting the mill. Under these constraints the mills are run by precise mill setting. Once the section establishes the operator's objective is to get maximum tonnage through the pass. But in the rolling, pass/roll wear is inevitable. Moreover, during section rolling wear is seldom uniform due to varying roll pressure, reduction and sliding velocities at cross section. This means mill delays are required to change a pass or a roll, loosing available time. Therefore increasing life of rolls in finishing passes of section mill, needs serious attention.

Before adopting roll lubrication technology in section mill, various technical and operating conditions have to be taken into account and principal ones are nature of lubricant, application technology, steel rolling temperature, roll quality, roll cooling system, slippage, product mix, product quality and pollution.

The Principal forms of lubrication used by various mills in many years included

- Grease block fitted into a hardness suspended over the top roll protruding just enough to rush and gradually melt on the surface of the rotating rolls
- Used oil from the gear boxes of the mill were also applied by a hose,
- Heavy petroleum oil or tar were either dripped or pumped through the nozzle to the point of high wear usually engulfing the whole pass.

The primary purpose of a lubricant was to assist in producing quality product.. Development in the field of lubricants and their application techniques have generated interest in determining reduction in roll cost and elimination of air and water pollution caused by burning grease or any other type of lubricants.

The application techniques due to preferential wear of certain portions in the pass during section rolling, also plays an important role in making the roll lubrication technology a success. The nozzles their size, shape, spray pattern and location with respect to the pass are most critical aspect in deciding the application system. Section mill rolls various shapes, therefore, the nozzles and spray pattern should conform to the requirement of the section being rolled. It should be flexible in moving the new pass and rigid in fixing near the pass. The other required arrangements like emulsion preparation system, filtration, automatic spraying and stopping etc. are carefully designed to suit the industrial condition.

The product mix is a factor as it involves the required tonnage to be rolled for the particular section i.e. a particular rolling campaign. In contrast to the problems facing hot strip mills which roll almost identical products except for width, section mill roll comparatively limited tonnage, requiring frequent pass or roll changes whether for size change, pass or roll damage or wear. One of the main considerations is the percentage of pass or roll change delays due to wear only. In case the campaign size is so small that all the passes of a particular roll set could not be utilized, lubrication will be of little or no advantage. Similarly, during roll dressing also it will not reflect any gain as off take in any roll is decided by the off required to restore the worst affected pass in the roll. Therefore a principal consideration is the size of the campaign and it has to be large enough so that roll set needs change due to wear resulting in mill delays.

Roll pass lubrication is done in conjunction with effective roll cooling system. Primary aim of roll lubrication is to reduce friction during rolling, improve roll life and product quality. It is done in finishing passes of hot rolling mills where friction plays a key role. Roll pass lubrication is done on the entry side of rolls where as roll cooling is done on soon after exit of stock from pass groove [2, 3, 4,5]. There are two important elements of roll pass lubrication.

- Selection of lubricant
- Application technology

2.1 SELECTION OF LUBRICANT:

In recent years base lubricant used in roll pass lubrication can be classified as

- Mineral based oil
- Natural esters

- Synthetic extents etc

Lubricant with their formulation needs to have

- Ease of spreading
- Wetting roll surface
- Anti wear characteristics
- Minimum likelihood of nozzle blockade
- Ability to cling to the roll surface.
- Withstand the impact and flow of roll cooling water.

2.2 LUBRICATION APPLICATION TECHNOLOGY

In structural rolling, deformation in pass groove varies with depth. There is a large variation in roll pass design in structural mill depending upon the type of structural rolled. It requires suitable system with flexibility in terms of set up and control system for roll pass lubrication. Application methodology has to take care of critical area in the pass groove [2, 3, 6]. There are three method of application

- Neat lubricant spray system
- Lubricant and water emulsion spray system.
- Lubricant application under air pressure for atomization

3. EXPERIMENTAL

In structural mills of SAIL steel plants roll lubrication trial was carried out. Roll pass lubrication operates in automatic mode by using hot metal detector as energizing signal. Two methods of application is being used in SAIL plants.

3.1 Lubricant and water emulsion spray system: Oil and water emulsion spray is enabled after biting to provide necessary friction and flow is stopped before tail out to burn off residue present in roll pass groove surface. This enables effective friction to remain in roll for next biting. Pass lubrication operates only when stock is in the roll gap. Several trials with different percentage of lubricant and different lubricant were done in SAIL plants. Lubricant performance was assessed on the basis of reduction in roll wear, product quality, operating parameters and cost-benefit index. It has been stabilized with one lubricant with 1.5% concentration in water and spray pressure 2.0-3.0 kg/cm^2.

Basic raw materials for roll pass lubricant formulation were selected from renewable resources and other performance additives were selected from commercial suppliers of repute. Field trial was conducted at different long product mills of SAIL. Trial parameters were set against reference data which were over the times are being accumulated by the plant personnel during the use of roll pass lubricants supplied by different reputed manufacturers. Application has following steps:

- Emulsion making
- Application of lubricant

- **Emulsion making**

In mixing tankwater was filled upto about 80%. After that water was added in the tank to make emulsion of varying percentage. Thus increases bulk flow rate. It reduces the productivity of nozzle blockage. Using agitator oil-water emulsion was prepared. Prepared emulsion was used for roll lubrication.

- **Application of Lubricant**

Theoil water emulsion was used using hot metal sensor to sense incoming stock. Emulsion is then fed applied for roll lubrication using headers as shown in fig.1. Emulsion is fed to the pass groove at desired pressure and flow rate using spray nozzles. When emulsion strikes the roll surface it breaks and lubricant spreads over the roll surface beneath water and firmly bonds itself to the roll surface. Roll pass spray should cover the all critical area of high deformation and frictional force.

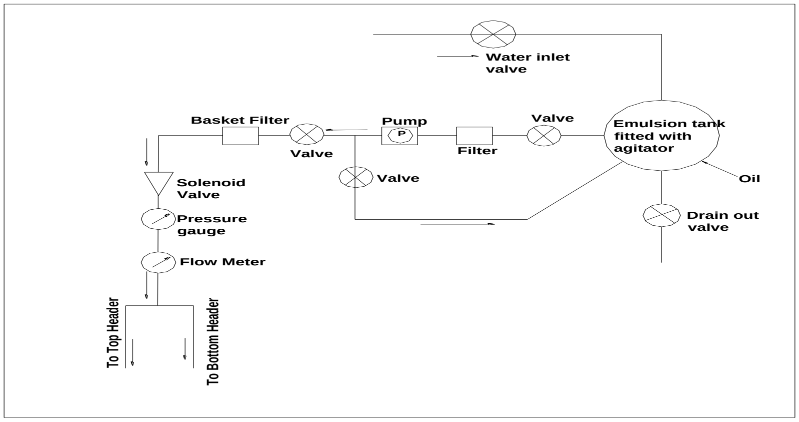

Fig.1: Schematic diagram of Emulsion Application system

3.2 LUBRICANT APPLICATION UNDER AIR PRESSURE FOR ATOMIZATION:

Fig.2 shows the roll lubrication header installation, used for applying lubricant under air pressure, at the entry side of roll pass groove. In such system, lubricant is fed directly near the pass groove where in the mixing nozzle lubricant is atomized by air pressure of 2-3 bar and atomized lubricant is sprayed on roll pass groove. Fig.3 shows the roll lubrication header position while rolling channel section.

Fig.2: Roll lubrication header with lubricant atomization in rail rolling

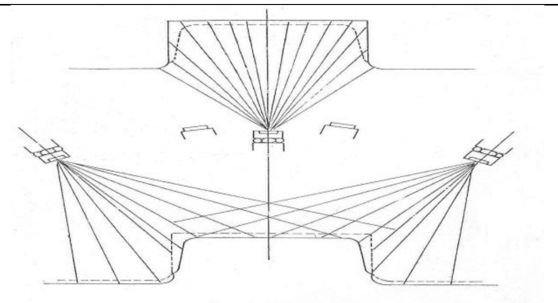

Fig.3 : Roll lubrication header position for channel rolling

3.3 MONITORING OF PERFORMANCE

Roll wear pattern, mill loadsetc were monitored during running of mill with lubrication and without it. Various templates were used for measurement of wear of rolls. During the field trial following data were recorded:

- Tonnage rolled
- Evaluation of roll wear
- Evaluation of roll during roll dressing/grinding
- Evaluation of rolling loads by measuring motor current

4. RESULTS

4.1 REDUCTION IN ENERGY

Roll pass lubrication reduces the power consumption used during rolling process. Table 1 shows the recording of mill motor current during rolling Channel-200x75, Beam 150x75, channel 150x75 and angle 110x110. Recording of mill motor current and speed were done for two consecutive bars having same temperature condition and mill setting for entire cycle time of rolling. Table-I shows the reduction in mill motor current by 13.4-14.7% for Channel 200x75, 12.76-15.78% for Beam 150x75, 10.34-16.07% for Channel 150x75 and 11.53-17.3% for angle 110x110.

Table.1: Motor Current with and without lubrication

Section	Motor current at middle (Amps)		% Reduction
	Without	With	
Channel 200 x 75	670	580	13.4
	710	595	14.7
Beam 150 x 75	475	400	15.7
	470	410	12.7
Channel 150 x 75	580	520	10.3
	560	470	16.1
Angle 110 x 110	480	430	11.5
	520	430	17.3

Variation in current, in different set, is due to variation in condition of input stock and operational condition of mill. Rolling load reduces with increase in lubricant flow rate. But there is limit beyond which increase in lubricant floe rate has no influence on load [4,5]

4.2 INCREASE IN ROLLING SPEED

Recording of rolling speed shows that roll pass lubrication increases the rolling speed in comparison with without lubrication rolling speed. It is due to the reduction in friction resistance between roll and stock. Fig.3 shows increase in rolling speed during rolling

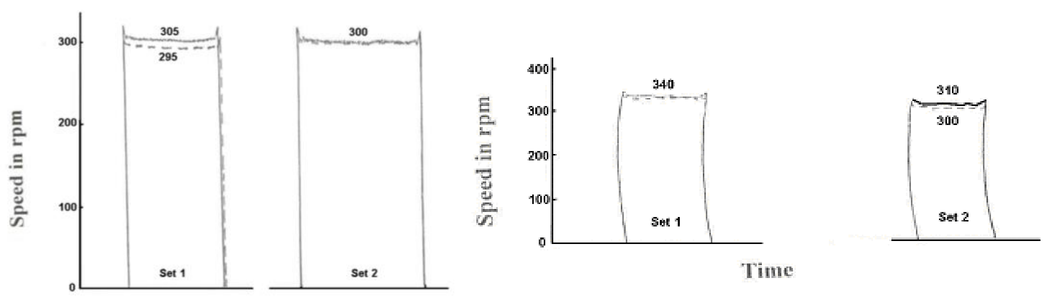

Fig. 3 Increase in rolling speed while rolling with roll lubrication
(--- speed without lubrication)

Channel 200 x75 mm **Beam 150 x75 mm**

4.3.1 DECREASE IN ROLLING TEMPERATURE

Reduction in mill motor loading and rolling load enables to roll at lower temperature in finishing pass. Because additional mill reserve is created by roll lubrication. Subsequently, temperature in soaking part of the reheating furnace can be reduced accordingly. It can reduce energy load slightly on reheating furnace.

4.4 IMPROVEMENT IN ROLL LIFE

By reducing friction between mating surfaces of roll and stock, roll wear reduces. It enhances roll pass life and roll life. This leads to lowering of mill down time due to reduction in roll pass changes and roll changes. Hence it reduces specific roll consumption and mill roll inventory. While rolling channel 125x65mm &150x75mm and angle 150x150mm, keeping similar condition of rolling, trial was conducted with lubrication supported by efficient roll cooling of pass groove and without lubrication for adjacent passes of same roll. It showed, Table-II, 80% and 96% improvement in pass life during rolling of channel and angle. More tonnage rolled with Roll lubrication and efficient roll cooling.

Table-II

Section rolled	Roll No.	Tonnage/pass without roll lubrication	Tonnage/pass with roll lubrication + efficient roll cooling
Channel 125x65mm	19/31	160	315
Angle 110x110mm	98/01	381	694
Channel 150x75mm	16/39	155	405

During redressing of rolls, off-take was measured. Tonnage rolled per unit off take has increased roll lubrication. Average tonnages rolled per millimeter of off take have increased from 21.8t to 27.2 t and 22.3 t to 24.9 t during rolling of Joist 150x75mm and Channel150x75mm respectively.

Section rolled	Tonnage/mm off-take in rolls while rolling without roll lubrication	Tonnage/mm off-take in rolls while rolling with roll lubrication + efficient roll cooling
Joist 150x75	21.8	315
Channel 150x75mm	22.3	24.9

4.5 IMPROVEMENT IN PRODUCT QUALITY

Roll pass lubrication probability of erratic roll pass wear of certain part of the pass groove. It keeps the surface of roll smooth, which results in improved dimensional accuracy of structural with better surface finish.ere

5. CONCLUSIONS

- Roll Pass lubrication resulted in improvement of Roll life by 15-20%
- Application of roll pass lubrication also resulted in improvement in surface quality of the product
- Improvement in roll life resulted in improvement in Mill availability by 10%.
- Roll pass lubrication has reduced mill motors current by 10.3 -17.3% during rolling of steel structural. Accordingly it has reduced mill energy consumption.

6. REFERENCES

[1] Stevenson PG, IvensKP;Journal of Iron and Steel Institute ; Jan. 1971; 1-11
[2] Skelton CR; Darkali bre un Hoft;, April, 1985; 37-42
[3] Munther Per A, Lenard John G; Scandinavian Journal of Metallurgy; Vol-; 1997; 231-241
[4] Peretic Michael J, SzedelJuergen, KraemarAtephen; Iron and Steel Technology,: may 2004, 27-36
[5] ShirizlyA,Lenard JG; 40th MWSP Conf. Proceeding, Pittsberg; ISS; 1998; 489-495
[6] Mort RJ; Iron and Steel International; Apr. 1975; 121-122