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# Hot Rolling Oil for Steel Plants – A Case Study

**TRACK OR CATEGORY**
Metalworking Fluids

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## INTRODUCTION

Hot rolling [1] is a metalworking process that occurs above the recrystallization temperature of the material. The starting material is usually thick slabs of metal, like semi-finished casting products. Hot rolling is used mainly to produce sheet metal or structure. Rolling, a forming process needs metal stock to pass through a pair of rolls in steel plants to reduce the thickness of the steel sheet or slab or formation of new structure. The rolling lubricant [2,3] plays an important part in the production of high quality metal products; these lubricants have to be adapted and tailor-made to the individual Mills. Hence, there is always demand for rolling oil with new technology due to the changing market requirements, increased competitiveness, improved quality standards, improved operational parameters of plant and cost reduction. All these factors put pressure on the process of rolling steel and the fluids / techniques utilized to achieve the desired finished product quality. The hot rolling oil is required to fulfill two key properties i.e., lubrication and cooling. For these reasons, dispersion of oil in water are preferred for the use of hot rolling operations as cooling properties is derived through water while oil separated from dispersion during use provide necessary lubrication requirement. Other plant parameters like wear of rolls, energy consumption, easy of difficult to roll material etc are also improved during this process.

This paper deals with the development of a tailor made hot rolling oil with excellent dispersion and lubricity properties in author's laboratory for sheet rolling followed by industrial trial in reputed Indian Steel Plants. The effect of physicochemical properties of the developed hot rolling oil like saponification value and kinematic viscosity and high lubrication than the optimum one during industrial trial were discussed and correlation established. This study has revealed that suitable laboratory experiments and data provided good direction for selecting right candidate oil for conducting the field tests in industrial steel plants. The oil is successfully commercialised in hot strip mills in India after successful field trial.

## EXPERIMENTAL

### Background of the Development

Generally water was traditionally used during hot rolling at different parts of India. Due to increased awareness, better lubrication, roll protection and low power consumption, the use of hot rolling oil is ever increasing in hot strip, structural and rail mills at least partially at few stands of the mill.

The requirement and application of different plants were quite different. Hence, one oil may not be suitable for different hot strip mills available with different customer. Specific oil has to be developed and established to the target plant. Accordingly a tailor made new hot rolling oil, "Oil A" with high lubrication and excellent dispersion property in water was developed for flat rolling of mild steel and field evaluation was conducted.

### Ingredients & Methods

The critical ingredients of a hot rolling oil are mineral oils, synthetic and/vegetable ester/s, extreme pressure, antiwear and free fatty acid. Depending upon the applications, emulsifiers present in the formulation.
In order to develop a superior product, several candidate blends were prepared with an aim to have good balancing of the following properties in the final rolling oil:

a) High lubrication characteristic like Falex Jaw load, Wear Scar Diameter and Friction
b) High dispersion characteristics

The candidate oils (CO) shown in Table 1 have been blended with carefully selected additives and evaluated in screening tests – a) Kinematic Viscosity b) Saponification No c) Dispersion property and d) Falex Jaw load Wear Scar Diameter and Friction. The best candidate oil was22 found to be Oil A which was selected for field trial.

| S. No. | Additive | CO-1 | CO-2 | CO-3 | CO-4 | Oil A |
|---|---|---|---|---|---|---|
| 1 | Base Oil | A | AA | A | AA | A |
| 2 | Synthetic and vegetable ester/s | B | BBB | BB | B | BB |
| 3 | Free Fatty Acid | C | CC | C | C | C |
| 4 | Antiwear Additive | X | X | XX | XXX | XX |
| 5 | Extremme pressure additive | Y | Y | YY | YY | YY |

**Table 1: Blending of oil samples with different additives**

The critical properties of the blends were tested as per the following methods:
Saponification (SAP) Number OF Neat Oil: ASTM D 94. Kinematic Viscosity: ASTM 445
Dispersion Characteristics of oil in water: In house method.
Falex Film Strength Test of oil in water: ASTM- D 3233. Friction Coefficient (Neat Oil): ASTM D-6425 .W.S.D (Neat Oil): ASTM D 4172

## RESULTS AND DISCUSSION

**Screening Tests in Laboratory**:

All the candidate oil samples were evaluated in screening tests as explained earlier and test results are compiled in Table 2.

| S. No | Properties | CO-1 | CO-2 | CO-3 | CO-4 | Oil -A |
|---|---|---|---|---|---|---|
| 1. | Kinematic viscosity @ 40 $^0$C, cSt | 48 | 69 | 62 | 54 | 50-60 |
| 2. | Saponification value, mg KOH/g | 78 | 102 | 82 | 105 | 90-100 |
| 3 | Coefficient of Friction for Neat Oil (300N,50 Hz.,1mm,50-150 0C, 1 Hr) | seizure | 0.10 | 0.11 | 0.08 | 0.09 |
| 4 | Wear Scar Dia (15Kgs, 1200 rpm,75 $^0$C ,1 Hr),mm | 0.70 | 0.60 | 0.50 | 0.40 | 0.45 |
| 5 | Falex Jaw load, lbs (5 % oil in water dispersion) | 1350 | 1600 | 1400 | 1750 | 1800 |

**Table 2: Screening test results with different oil samples**

**Field Trial in Industrial Plant:**

200 KL hot rolling oil “A” along with its application system on build-own-operate (BOO) basis was supplied to all six finishing stands (F1- F2) of the Hot strip mill and the performance was evaluated for six months. Performance of the RBL was evaluated in terms of its effect on the following parameters:

(a) Rolling parameters such as roll force and power,
(b) Mill wear & grinding-off take of work rolls,
(c) Specific consumption of work rolls,
(d) Specific oil consumption.

**Roll Force**: On an average, reduction in total roll force of all the stands was 5.9-13.3 % (average 9.7%).

| Sl. No. | Date, No. of Coils, Grade, Size | Av. Roll Force (MN) | | | | Average reduction, % | | |
|---|---|---|---|---|---|---|---|---|
| | | Without Oil A | | With Oil A | | | | |
| | | F1 | F2-F6 | F1 | F2-F6 | F1 | F2-F6 | Total |
| 1 | 8/12/16, 9 coils Gr I (Galv) 2.3 mm x 935 mm | 21.7 | 8.5 | 20.4 | 8.0 | 6.0 | 5.9 | 5.9 |
| 2 | 9/12/16, 7coils 2062E 250 BR 8.0 mm x 1250 mm | 17.0 | 9.9* | 15.9 | 9.0* | 6.5 | 9.1* | 8.7 |
| 3 | 9/12/16, 8 coils 2062E 250 BR 10 mm x 1250 mm | # | 10.5 | # | 9.1 | # | 13.3 | 13.3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | 10/12/2016, 10 coils Chequered rolling, C255 Gr-III 6.0 mm x 1250 mm | 16.8 | 9.5 | 15.7 | 8.4 | 6.5 | 11.6 | 10.7 |
| | Average | * F6 Dummy, # F1 Dummy | | | | | | 9.7 |

**Table 3: Effect of RBL on Roll Force**

**Power Consumption**

There was difficulty in getting direct energy data due to change in the energy meter. Data was collected only for one set of data for 8 coils each with and without lubrication. It indicated a reduction in energy / power consumption by around 5.9%.

**Work Roll Wear**

Average mill-wear along with average roll dressing (reduction in diameter during grinding) with and without lubrication was collected. There was reduction in average mill wear for all the six stands (F1-F6) by around 42% from 0.210 to 0.121 mm/campaign/roll. In order to include the effect of campaign size of rolling on the mill wear and roll dressing, the specific off-take of work rolls was calculated in terms of mm per ton of campaign size for all the rolls of F1-F6 stands. It was found that the average specific off-take of work rolls was reduced with RBL by over 24.0%.

**Oil Consumption**

A total of 71.6 KL hot rolling oil was used for rolling 9.3 lakh ton of steel during the evaluation period of 8 months. The specific oil consumption for this period was 77.10 ml/t.

## CONCLUSIONS

- ✓ A hot rolling oil was successfully developed in authors laboratory which was successfully commercialized in Indian Steel Plant.
- ✓ Hot Rolling Oil A is useful in improving productivity of the mill and life of rolls. Regular use of Hot Rolling Oil A at the six finishing stand of Hot Strip Mill has demonstrated achievement of following benefits:
  - (a) Reduction in roll force and power by around **6-10%,** helping in rolling of steels in critical sizes.
  - (b) Reduction in average specific off-take of work rolls by **24.0%.**
  - (c) Reduction in specific consumption of work rolls by average **14.0%.**
- ✓ The above benefits have been achieved at specific oil consumption level of **77.10 ml/ton** of production.
- ✓ Good correlation observed between laboratory results and plant rolling parameters.


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## KEYWORDS

Hot Rolling Oil, Properties, Laboratory Studies