COMPARATIVE EVALUATION OF TECHNOLOGIC LUBRICANTS

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Abstract

Method for the assessment of technologic lubricants for cold rolled sheets with the criterion of efficiency is described. The evaluation of lubricants, currently used or tested once on the cold rolling mill 1700 in JSC “AMT” is described. It was revealed that there were no lubricants more efficient than the reference Quakerol 671 found. The less efficient lubricants are: Efrol-VP 5%, AKTO – 5%, Emulsol – 5%. The efficiency of various lubricants on technological parameters on the rolling mill 1700 of AMT JSC is considered.

Keywords: technologic lubricants, quality, cold rolling, qualimetry, technological parameters

INTRODUCTION

Specificity of technological lubricants application at modern strip cold rolling mills is characterized by high speeds of rolling and productivity, big consumption of lubrication and cooling liquids and capacities of systems for their supply. During cold rolling of sheets and strips most often applied lubricants are: Quakerol 671, mineral oil I-20, Emulsol T 5%, Mobirolling – 5%, GreenEngineer – 5%, Efrol 7/15 – 5%, Efrol VP 5%, AKTO 5% [1].

Researchers and technologists as well as developers of rolling lubricant coolant for cold rolling of sheets are facing the problem of the complex comparative assessment of technological lubricants already applied and newly developed.

So, authors of the work [2] have established criteria by which it is necessary to assess technological lubricants. They classified the following as the main assessed indicators: lubrication ability (ability of lubricant to reduce friction force, rolling strength, etc.); cooling ability (ability of rolling lubricant coolant to take away heat from rolls and the strip); ensuring of demanded strip surface quality (micro-geometry, contamination with settled lubricant and wear products).

Ability of technological lubricant to provide demanded surface quality for cold rolled strips is defined by such indicators, like quantity of settled lubricant and wear products on surfaces of strips after rolling, tendency to sooth formation at the subsequent heat treatment. Quality of finished products considerably decreases in the presence on such surface defects as spots, emulsion burn-in, sooth film.

1. METHOD OF EVALUATION THE QUALITY

According to the qualimetry principles the comparative assessment of technological lubricants can be made by means of the efficiency criterion which looks like [2]:

\[ K_{eff} = \sqrt{\frac{\sum_{i=1}^{n} \left(1 - \frac{x_{i,obs} - x_i}{x_{i,obs}} \right)^2}{k_{ucc}}}, \]  

(1)
Where $K_{\text{eff}}$ – complex criterion of technological lubricant; $n$ – number of parameters, by which technological lubricant is assessed; $x_{\text{ref}}$ – parameter, by which reference technological lubricant is assessed; $x_i$ – similar parameter for studied lubricant; $k_{\text{sec}}$ – weight coefficient.

Here the indicator of lubrication ability (i.e. ability of lubricant to reduce friction tension), as well as indicators defining the influence of technological lubricant on the surface quality of finished sheets are used as parameters allowing to assess the comparative efficiency of technological lubricant s.

The ability of lubricant to reduce tension of friction is assessed by the value of basic friction tension $\tau_{693}$. The indicator of strip surface contamination with settled lubricant and wear products after rolling, as well as tendency of technological lubricant to the sooth formation in the course of subsequent softening heat treatment are used as parameters defining the influence of lubricant on the quality of finished sheets surface.

By using of selected parameters for comparative assessment of technological lubricants the criterion of efficiency looks like [2]:

$$K_{\text{eff}} = \frac{\sqrt{\left(1 - \frac{\tau_{693}^m - \tau_{693}^{uc}}{\tau_{693}^m} \right)^2 k_\tau + \left(1 - \frac{C_{sm}^m - C_{sm}^{uc}}{C_{sm}^m} \right)^2 k_C + \left(1 - \frac{M_{sm}^m - M_{sm}^{uc}}{M_{sm}^m} \right)^2 k_M + \left(1 - \frac{\Gamma_{sm}^m - \Gamma_{sm}^{uc}}{\Gamma_{sm}^m} \right)^2 k_\Gamma}}{4},$$

where $\tau_{693}^m$ and $\tau_{693}^{uc}$ - values of basic friction strain of reference and studied lubricant, MPa;

$C_{sm}^m$ and $C_{sm}^{uc}$ - values of sooth formation at the strip surface after rolling and heat treatment with reference and studied lubricants, mm;

$M_{sm}^m$ and $M_{sm}^{uc}$ - amount of oil residue on the strip surface after rolling with reference and studied lubricants, mg/m$^2$;

$\Gamma_{sm}^m$ and $\Gamma_{sm}^{uc}$ - amount of contamination (wear products) on the surface of the strip after rolling with reference and studied lubricants, mg/m$^2$;

$k_\tau, k_C, k_M, k_\Gamma$ - weight coefficients for each quality parameter of technological lubricant s.

The most efficient lubricant is one for which the $K_{\text{eff}}$ value is the smallest.

Tasks of this work include the use of the considered method for assessment of technological lubricants used now or tested once at the sheets cold rolling mill 1700 of ArcelorMittal Temirtau JSC. There is also the analysis for the study of various technological lubricants influence on technological parameters during rolling at this mill provided.

2. RESULTS AND ITS DISCUSSION

Quality parameters of technological lubricants, currently applied or once tested at the mill, are given in the Table 1 [1-2,4].
Following was used as the basic data for calculation of power parameters: thickness of incoming strip $h_0=2.4\,\text{mm}$; width of incoming strip $b_0=840\,\text{mm}$; thickness of finished strip $h_1=0.5\,\text{mm}$; steel grade 08Yu; initial yield stress $= 250\,\text{MPa}$ [3]; diameter of backup rolls is $D_{BUR}=1500\,\text{mm}$; diameter of work rolls is $D_{WR}=600\,\text{mm}$; empirical coefficient for steel 08Yu $A=50$ [4]; the coefficient considering the scheme of loading $k_s=1.1$ [4]; temperature and speed coefficient $k_{tu}=1.1$ [4]; correction coefficient $c=1.375$ [4]; coefficient considering the nature of lubricant, $k_m=1$ [4]; height of roll roughness: for stands Nos.1÷4 - $R_z=1\,\mu\text{m}$; for stand 5 - $R_z=2.5\,\mu\text{m}$. Kinematic viscosity of lubricants $\nu = 50\,\text{mm}^2/\text{s}$ [4]; Mineral oil I-20 - 17 mm$^2$/s [1]; Emulsol T-5% - 31 mm$^2$/s [1]; Mobil Rolling-5% - 24 mm$^2$/s [1]; Green Engineer-5% - 19 mm$^2$/s [1]; Efirol 7/15-5% - 22 mm$^2$/s [1]; Efirol VP-5% - 40 mm$^2$/s [1]; AKTO-5% - 32 mm$^2$/s [1]. Rolling speed in the last stand $U_5=18\,\text{m/sec}$.

Quakerol 671 currently used at the mill was selected as the reference lubricant. The criterion of efficiency $K_{\text{eff}}$ for it will be equal to 1. It was also accepted that all parameters defining the quality of technological lubricant are equivalent, i.e. $k_\tau = k_C = k_M = k_f = 1$.

Results of efficiency criterion for considered lubricants are given in Table 2.

There was also the impact of technological lubricants on the force and capacity of rolling selected as the technological assessment of lubricants quality used at cold rolling of sheets. Calculation was carried out on the basis of methodology [5].

For the display convenience of received results at the rolling of strip 0.5×820mm from steel grade 08Yu they were presented in the form of histogram (fig. 1) and two graphs (fig. 2 and 3).

### Table 1 Quality parameters of technological lubricants [2]

<table>
<thead>
<tr>
<th>Lubricant</th>
<th>Quality parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\tau_0$, MPa</td>
</tr>
<tr>
<td>Quakerol 671</td>
<td>30.24</td>
</tr>
<tr>
<td>Mineral oil I-20</td>
<td>36.22</td>
</tr>
<tr>
<td>Emulsol T-5%</td>
<td>40.33</td>
</tr>
<tr>
<td>Mobil Rolling – 5%</td>
<td>34.20</td>
</tr>
<tr>
<td>Green Engineer – 5%</td>
<td>29.30</td>
</tr>
<tr>
<td>Efirol 7/15 – 5%</td>
<td>37.45</td>
</tr>
<tr>
<td>Efirol VP – 5%</td>
<td>32.70</td>
</tr>
<tr>
<td>AKTO – 5%</td>
<td>34.93</td>
</tr>
</tbody>
</table>

### Table 2 Results of efficiency criterion calculation

<table>
<thead>
<tr>
<th>Lubricant</th>
<th>Efficiency criterion $K_{\text{eff}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quakerol 671</td>
<td>1</td>
</tr>
<tr>
<td>Mineral oil I-20</td>
<td>6.85</td>
</tr>
<tr>
<td>Emulsol T-5%</td>
<td>1.71</td>
</tr>
<tr>
<td>Mobil Rolling – 5%</td>
<td>1.87</td>
</tr>
<tr>
<td>Green Engineer – 5%</td>
<td>2.87</td>
</tr>
<tr>
<td>Efirol 7/15 – 5%</td>
<td>2.46</td>
</tr>
<tr>
<td>Efirol VP – 5%</td>
<td>1.34</td>
</tr>
<tr>
<td>AKTO – 5%</td>
<td>1.64</td>
</tr>
</tbody>
</table>
Considering that Quakerol-671 in comparison with other technological lubricants, as per conditions of the methodology will be the best – reference lubricant, following shall be received (Table 2).

Lubricants that are more effective, than the reference, value of $K_{\text{eff}}$ have to be less than 1 – there are no such lubricants in the assessment, less effective ones – more than 1. It is possible to classify lubricants Efirol VP-5%, AKTO – 5% and Emulsol-T 5% to them. Their criteria of efficiency are 1,34; 1,64 and 1,71 correspondingly. This is explained by the fact that considered lubricants have rather low values of basic friction tension that promotes good lubrication ability.

It is possible to classify, according to assessment, lubricant Mineral oil I-20 as the worst lubricant, its complex efficiency criterion is 6,85 times more than at the reference lubricant Quakerol 671.

At the calculation of power parameters of rolling it was revealed that at application of Quakerol 671 lubricant values of forces and capacities of rolling have the minimum values in all passes. That is explained by higher viscosity of this lubricant (55 mm²/S) in comparison with other lubricants, and, therefore, the smallest friction coefficient (from 0,26 to 0,28 at Quakerol 671, and from 0,27 to 0,32 at other lubricants) (fig. 2, 3).
Fig. 2 Graph of forces distribution pass by pass with different technological lubricants application

Fig. 3 Graph of power distribution pass by pass with different technological lubricants application
It was also revealed that rolling with application of lubricant Mineral oil I-20 and Green Engineer-5% is impossible at selected reduction since forces in the last pass exceed the maximum admissible force by 6.86 and 2.02 kN respectively, or by 27.44 and 8.08%, and admissible excess of force is around 4-6%.

The closest lubricant on properties and quality to lubricant Quakerol 671 is technological lubricant Efirol VP-5%. It is proved also by similar results of assessment on forces and rolling capacities. Therefore, technological lubricant Efirol VP-5% can be well used as substitute of Quakerol 671 lubricant.

CONCLUSION

1. The methodology of technological lubricants for cold rolling of sheets by means of complex efficiency criterion is described.

2. The assessment of technological lubricants, used now or once tested at the strip cold rolling mill 1700 in the conditions of ArcelorMittal Temirtau JSC is carried out.

3. It was revealed that there are no lubricants observed being more effective than the reference – Quakerol 671. It is possible to classify following lubricants to the less effective lubricants: Efirol VP-5%, AKTO – 5% and Emulsol-T 5%. Criteria of efficiency for these lubricans are 1,34; 1,64 and 1,71 respectively.

4. It is possible to classify lubricant Mineral oil I-20 as the worst one, complex criterion of efficiency for which is 6,85 times more than at the reference lubricant Quakerol 671.

5. The influence of various technological lubricants on technological parameters at rolling at the mill 1700 of ArcelorMittal Temirtau JSC is investigated.

6. The closest lubricant on properties and quality to lubricant Quakerol 671 is technological lubricant Efirol VP-5%. It is proved by similar results of assessment on forces and rolling capacities.

REFERENCES


