Preparation of Dry Solid Lubricant for Drawing of Welding Steel Wires from Local Iraqi Materials

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ABSTRACT

Dry solid lubricant for steel wire drawing was prepared and improved from locally available raw materials for the benefit of Al-Hilal Welding Wire Factory/South of Baghdad. Due to the unavailability of international specifications for such lubricants, small proposed batches of 5.0 kilogram were tested each time in 5.0 mm steel wire drawing, and the observations on its performance were recorded. The reports of the performance of every designed batch were obtained and examined, then improved. After many trials in the actual production line of the factory by tuning the lubricant constituents, their proportions, and physical composition, the convenient performance was achieved. The convenient particle size distribution of the lubricant was studied, and monitored to get efficient application of the lubricant particulates around the wire surface, and found to be within certain limits (mesh size rang of 20-100) for the recommended wire specification. The product performance was compared to that of the imported lubricant, of German origin, and found to be identical; the above factory was supplied with its operational requirements of this lubricant. The work includes, as well a synthetic method useful for large scale production of calcium stearate, the essential component of the steel wire drawing lubricant, from industrial grade soap lump, calcium carbonate, and hydrochloric acid.

INTRODUCTION

In steel wire drawing operation, a wire rod is pulled through the die blocks reducing its size and extending its length, and the reduction in size is known as draft and is expressed in percentage of original rod size. This draft or reduction in size is usually 10 % to 45 % per drawing,
and fine wires require several drawings to reach the desired finish gauge. Various materials are utilized as lubricants to produce different finishes on the surface of the wire and to minimize die wear.

In dry drawing the coating frequently is an organic compound baked on the surface of cleaned wire and drawn through dry lubricants of various types in the die box. Stainless steel round wire is normally produced within a size range of 0.025 mm to 12.7 mm, inclusive [1]. The size of the wire to be drawn determines the diameter of the number of blocks to be employed. Coarse wire is drawn on large diameter blocks and fine wire on relatively smaller blocks, and the diameter of wire is specified in fractions of an inch or by decimal.

Lubrication is used mainly to reduce the resistance to sliding between the work piece (the wire) and the tool (the die). The reduction in resistance manifests itself in several ways, among which are the following [2-5]:

1. Reduced drawing force due to reduced values of the coefficient of friction.
2. Reduced wear on the die.
3. Reduced surface temperature on the die and on the wire.
4. Altered appearance of the wire surface.
5. Improved draw ability, deterred wire tearing, etc.

Each one of these factors can be measured and serve as a criterion for the evaluation of, and for the comparison among, lubricants. By any criterion there is no ideal lubricant or single lubricant that is superior to all others for all applications. For example, a lubricant that is best for the drawing of steel wire with a carbide die may be a poor choice for the drawing of copper wire, or even for steel wire with a diamond die. Furthermore, even for an identical set of work piece and tool, the lubricant performing best during wire drawing may not be the best, and may even prove very poor, for other processes such as rolling. Lubricants for large diameter wire differ from those recommended for fine wire, etc.

Lubricant performance evaluation must be performed under conditions that are as close to the actual production conditions as possible. There are good reasons for evaluating lubricants on production equipment, during production runs. The selection of the lubricant depends on other factors such as price, toxicity, safety and residual film advantages and shortcomings [6-9].

In this work, an attempt was made to produce steel wire lubricant as a substitute to a German product, which was used by an Iraqi plant (Al-Hillal Factory for Welding Wires, south of Baghdad).
MATERIALS AND METHODS

A. Chemicals and equipments:
Commercial soap lumps were obtained from the State Company of Vegetable Oil Industry (Baghdad, Iraq), calcium carbonate, calcium oxide, and hydrochloric acid were obtained from local industrial Iraqi origin, used without purification.

B. Calcium stearate preparation:
Soap lump (15.0 Kg) were dissolved in 60 liter hot tap water, in 100 liter aluminum vessel, and the mixture heated with aid of a propane flame to 90-95ºC with the aid of 0.5 horse power mechanical stirrer. A small portion quantity of 5.0 kg calcium carbonate was dissolved in 30 liter plastic container containing 10.0 liter of commercial hydrochloric acid. The pH of the resulting solution was adjusted by treating the solution with a small quantity of calcium carbonate (not more than 5 % of the required stoichimetric amount). The mixture was filtered through cloth to remove insoluble solid. The resulted solution was treated with the hot soap lump solution with efficient stirring, while keeping the temperature at 60-70ºC. White precipitate of calcium stearate was formed with time. After the completeness of the addition, the white solid was filtered drum centrifuge, washed with large amount of tepid water, and then left for longer time to remove wetting water. The product was spreaded on aluminum trays and dried at 80ºC for 24 hour, to yield 14-15 Kg of calcium stearate.

C. Preparation of the lubricant formula:
Different weights of each of calcium stearate, sodium stearate, and calcium oxide (both dried at 80ºC) were mixed together as different six batches, as shown in Table-3. Each batch was milled with the help of seed miller with three different sizes (0.5, 3, and 4) according to the stated mesh size. An amount of 5.0 kg of each batch was tested in the production line used to produce 5 mm size stainless steel wire drawing of five blocks. The result of the test was reported by the factory, compared to the German lubricant.

RESULTS AND DISCUSSION:
Al-Hillal factory used the wire lubricant under the trade name TRACTOL 2963 from (Carl Bechem, GmbH, Germany) for seven years [10], is especially used for electrode core wire for pre drawn wire, clean wire surfaces. It was considered by this factory as a reference steel wire lubricant for their routine requirements. During the embargo on Iraq 1990-2004, there was big need for welding wires, and it was difficult to import this product. There was a need for local substitute,
and sample of this lubricant was supplied to our laboratory to find the possibility to prepare such substitute.

A set of preliminary tests were performed to identify the major chemical composition of this solid lubricant. It was found to be water insoluble, and on treatment with hot dilute acid solutions release an oily product, which solidify at 55-60°C. A sample of 0.50 g weight in 50 ml 1:1 HCl solution gave the analysis for metal ions presented in Table-1. The sample consist of 23.56 % of calcium salt, sodium metal come next to it with 6.70 %, while other metals such as lithium and magnesium exist with very small percentage. From this result, it is very obvious that the major constituent of the sample is calcium salt. The qualitative analysis of other anions, such as sulfate, chlorides, phosphates, etc were negative.

Other chemical and physical analyses were performed, among them the is the loss on drying and the loss on ignition, and the results were presented in Table-2, respectively. On exposing the sample to a temperature of 100°C for 3h, it gave 15.0 % loss on drying. When ignited at 1000°C for 5h, it loss 41.0 % of its weight. It is worth mentioning that the following analyses were performed on sample of the prepared calcium stearate: the loss on drying and the loss on ignition. The result obtained was 5.0 %, and 55.0 % respectively.

Table-1: The metal ion analysis of the German sample of the steel wire lubricant TRACTOL 2963 (Carl Bechem, Gmbh) by flame emission photometry.

<table>
<thead>
<tr>
<th>No.</th>
<th>Metal ion</th>
<th>Conc. (ppm)</th>
<th>Metal%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Calcium</td>
<td>2244</td>
<td>23.56</td>
</tr>
<tr>
<td>2</td>
<td>Sodium</td>
<td>553</td>
<td>6.70</td>
</tr>
<tr>
<td>3</td>
<td>Magnesium</td>
<td>18.5</td>
<td>1.56</td>
</tr>
<tr>
<td>4</td>
<td>Lithium</td>
<td>15</td>
<td>1.48</td>
</tr>
</tbody>
</table>

Evaluation of lubricant mechanical performance should be conducted under conditions that are as close as possible to that of the actual production process. Due to the lack of the international specifications for dry solid wire drawing lubricant, the practical try and error methodology was followed to prepare its formula. Samples of varying constituents and proportions of calcium stearate, calcium oxide were prepared as presented in Table-3 and tested in the steel wire drawing machines of five blocks in the production line. A quantity of 5.0 kg of each batch was equally divided into five die compartments of the drawing machine in Al-Hilal factory. The machine were turned on by the factory staff and the observations of its performance were recorded by the workers. The lubricant performance was compared with that of the imported lubricant viz Tractol 2963 as the reference material.
The following were considered the most important parameter for this comparison:

1. The temperature of the die should not exceed the melting point of the lubricant.
2. The lubricant should not stick to the wire as scales.
3. The sample particle size distribution should enable agitation of the lubricant particle around itself, and hence to expose fresh lubricant to the wire continuously.
4. The surface of the produced wire should be clean and free from rust and lubricant scales.

Sample prepared according to formula No. 1, presented in Table-2 was found to give bad performance. It consist of lower melting points <150ºC will stick to the wire after leaving the die area of each step. The temperature of the die was high as compared with German lubricant, it melt the lubricant in contact (Figure-1). The consequence of that is the bad quality of drawn wire, and the lubricant stick to the wire as scales. It is possible to feel this scale on the wire when it leave the die. Scales of the drawing lubricant has to be removed, since it form layer that prevent the fresh part of the lubricant to come in contact with the wire. It require additional step to clean. The temperature of the dies was reported to be higher, according to the workers. Excess heat is not recommended by the worker, since it ends with the some mechanical defects in the wires.

Some calcium oxide was added to the formula as shown in formula No. 2 to improve the performance. Formulae having melting point >190ºC gave better performance, regarding the formation of scales. No sticking behavior was observed, and much better wire mechanical quality was obtained. However the excess heat liberation was still observed, but only in the last block. Generally the performance was inferior to the recommended one.
Sodium stearate was added to the formula up to 25%, to improve its performance, as shown in formula No. 3. Much better performance, except that that the sample in the die lubricant compartments requires to be remixed by hand from time to time to expose the wire to fresh lubricant. The physical constitution has to be improved to achieve the required mechanical behavior.

The sample particle size distribution is of great importance, because it help to agitate to sample around itself, and hence to expose fresh lubricant continuously. The particle size distribution of the German solid lubricant was examined by taking 150.0 g, and divided by using set of different size sieves. The weight of the particle that went through each mesh size was weighed. Generally, it is possible to recognize four ranges of particle size, as shown in Table-2, less than 18, 20-40, 40-80, and more than 80 mesh size. The presence of large grain in the lubricant is important to achieve good sample agitation, and hence fresh lubricant to contact with wire when it pass through die compartment. The performance of formula No. 7 was approved by the Al-Hilal factory, and they consider it as good as the German lubricant Tractol 2963. All the disadvantages of the other formulae were excluded from it.

Table-2: The constituents and proportions of many formulae of the batches tested in Al-Hillal factory for welding wire.

<table>
<thead>
<tr>
<th>No.</th>
<th>Calcium stearate %</th>
<th>Sodium stearate %</th>
<th>Calcium oxide %</th>
<th>Mesh size</th>
<th>M.p (ºC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>&gt;100</td>
<td>145</td>
</tr>
<tr>
<td>2</td>
<td>95</td>
<td>-</td>
<td>5</td>
<td>&gt;100</td>
<td>150</td>
</tr>
<tr>
<td>3</td>
<td>75</td>
<td>25</td>
<td>-</td>
<td>&gt;100</td>
<td>180</td>
</tr>
<tr>
<td>4</td>
<td>75</td>
<td>20</td>
<td>5</td>
<td>&gt;100</td>
<td>190-195</td>
</tr>
<tr>
<td>5</td>
<td>70</td>
<td>25</td>
<td>5</td>
<td>&gt;100</td>
<td>195-200</td>
</tr>
<tr>
<td>6</td>
<td>50</td>
<td>45</td>
<td>5</td>
<td>&gt;100</td>
<td>200-210</td>
</tr>
<tr>
<td>7</td>
<td>50</td>
<td>45</td>
<td>5</td>
<td>18-100*</td>
<td>210-235</td>
</tr>
</tbody>
</table>

Table-3: The Particle size (Mesh) distribution analysis of the reference steel wire drawing lubricant TRACTOL 2963 (Carl Bechem, GmbH) and its equivalent prepared according this study (Formula No. 7).

<table>
<thead>
<tr>
<th>No.</th>
<th>Particle size (Mesh)</th>
<th>Percentage %</th>
<th>TRACTOL 2963</th>
<th>Formula No. 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18&lt;</td>
<td>17.68</td>
<td>27.68</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>40-20</td>
<td>25.29</td>
<td>33.50</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>80-40</td>
<td>35.59</td>
<td>31.10</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>80&gt;</td>
<td>20.53</td>
<td>7.70</td>
<td></td>
</tr>
</tbody>
</table>
REFERENCES