Technical Bulletin

Borates in wire drawing

1. Introduction

Ferrous rod can be drawn successfully by reducing the friction between the rod and the die. This can be done through the use of suitable lubricants such as drawing soaps or greases. However, these lubricants do not adhere sufficiently to the rod, and a lubricant carrier is necessary which will form a tenacious coating and porous base on the rod to which the lubricant will readily adhere. Borax decahydrate or *Neobor*® borax pentahydrate is an effective lubricant carrier and provides the additional advantages of neutralizing residual acid and preventing corrosion during storage periods.

The worldwide production of steel wire rod has grown significantly in recent years. The causes of this growth are many but can be summarized as follows:

- Wide range of wire uses
- Development of inventions requiring great quantities of wire
- Improvements in the methods of producing steel and steel wire

2. Process

Steel wire is drawn from slender bars of metal called rods (wire rod). As the rod comes from the rolling mill, it is wound into coils to be used in wire mills and can be considered as the first step in the making of wire. For practical purposes, 7/32 inch (0.56 cm) round rod may be considered as the standard as this size rod is the smallest round produced on a rolling mill. For large wires the rod will of course, be larger.

Mill scale forms on hot rolled rods as a hard black iron oxide or the slow forming red rust and must be entirely removed before drawing. If these oxides remain on the surface of the rod, they result in very rapid wear on the wire drawing dies and also cause scratched and off-gage wire production. Proper cleaning and coating is largely responsible for success in the wire drawing operation and it is in this specific part of the process that borax or *Neobor* borax pentahydrate finds its greatest use.

2.1 Method of cleaning

The method generally employed for cleaning the rod consists in dipping the coils into a vat of hot, dilute sulfuric acid or hydrochloric acid. The action by which this acid removes the scale is mostly mechanical rather than chemical as black iron oxide, the chief constituent of scale, is only slightly soluble in sulfuric acid. However, the acid is able to penetrate to the metal beneath the scale where it reacts with the iron forming iron sulfate, a soluble neutral salt, and liberates a mixture of gases mainly composed of hydrogen. This action results in loosening and detaching the scale from the surface of the metal. It sinks to the bottom of the vat where it accumulates and must be removed at frequent intervals. The red rust, composed of ferric oxide and ferric hydroxide, is readily soluble in sulfuric acid and also forms iron sulfate in the pickling solution. This solution eventually becomes saturated and must be replaced.

The rods are then removed from the acid bath and placed in cold water rinse tanks for a thorough immersion to remove residual acid. After the rods are thoroughly cleaned and rinsed, it is necessary to apply a coating. The purpose of the coating is threefold:

- To prevent oxidation or rusting of the surface
- To neutralize any traces of acid which may be left on the steel
- To act as a carrier for the lubricant used in drawing

Borates in wire drawing

2.2 Method of coating

A borax decahydrate coating is applied to the rods by dipping the clean rods into a tank of hot borax or *Neobor* borax pentahydrate solution. The temperature is kept between 190°F and 200°F (88°C-93°C) and the rods immersed in the solution long enough to bring them to bath temperature. Borax decahydrate will neutralize residual acid left on the rod and will also act as a lubricant carrier in the dry drawing process with these superior characteristics:

- Longer bath life and decreased need for agitation
- Air drying
- Dust free operation
- Ease of solubility in hot water
- Compatibility with calcium and sodium soaps
- Longer die life than achieved with lime
- Superior performance on high carbon steels; eg spring wire
- Enhanced phosphate coatings
- Compatibility with electric resistant heat units
- Ease of removal from rod and wire if desired

2.3 Phosphate coatings

This type of coating is quite popular for wire to be subjected to cold heading or cold extrusion where a chemical rather than a mechanical bond between the coating and the metal is desirable. Either a zinc phosphate or an iron phosphate solution may be used. Both are applied by immersing the rod or wire in the heated solution (about 180°F or 82°C) for 2 to 10 minutes depending upon the weight of coating desired. After suitable hot and cold water rinsing, the phosphate coating is treated with borax decahydrate or *Neobor* borax pentahydrate, baked and drawn through the normal dry-drawing lubricants. This type of coating, when heavy enough, gives excellent results for heavy cold extrusions as well as long shelf life.

2.4 Baking

After the rod or wire is properly cleaned and coated, it must be thoroughly dried before drawing. Although a borax coating can be air dried, it is customary and preferable to dry by using a flash baker operating at about 550°F (288°C) for 3 to 15 minutes.

In the cleaning process, hydrogen is liberated by action of the acid upon the steel, and is sometimes absorbed by the steel. This can cause the drawn wire to be brittle, a condition known as “hydrogen embrittlement.” The baking process dries the coating so that it will function properly during dry drawing and also removes any hydrogen that may have been absorbed by the steel.

2.5 Drawing

There are several types of drawing machines but the significant feature is the die, one of the most efficient tools used in industry. It has no moving parts; it does not remove any of the metal; yet it uniformly reduces the cross-sectional area of the steel and at the same time improves the finish and physical properties. Over the years many different materials have been used for wire drawing dies such as chilled iron, steel plates, and alloy steel but in the 1920s tungsten carbide was developed and was an instant and lasting success. It has replaced all other materials except for diamond. Diamond dies are still used for very fine sizes of high carbon and alloy steels but even here, the tungsten carbide die can be effectively used.

Most wire is drawn using the dry drawing process and even wet drawn wire is first given one or more dry drafts from the rod. In the so called dry drawing process, the wire comes in intimate contact with a dry powdered lubricant—generally a calcium, sodium or aluminum stearate which reduces the friction between the rod and the die. This is the key to successful dry drawing and borax or *Neobor* borax pentahydrate, as an effective lubricant carrier, does its job by ensuring adhesion of the lubricant employed.

Technical Bulletin

Borates in wire drawing

2.6 How borax decahydrate or *Neobor* is used: The borax bath

Aqueous borax decahydrate (or *Neobor* borax pentahydrate) solutions in strengths of 5-30 wt% (or 3.8- 22.6 wt%) are prepared in a clean mild steel tank operating at 190-200°F (88-93°C). The most economical form of borate products on a delivered basis is *Neobor* borax pentahydrate although borax decahydrate is often used because it is more rapidly soluble. The equivalent borate concentrations of borax and *Neobor* borax pentahydrate are shown in Table I. In general the concentration and thickness of the borax coating required is proportional to the hardness of the steel rod and the number or drafts required to process that particular rod. Naturally, the thickness of the coating increases with solution concentration and time immersed, typically 5 to 15 minutes.

In regular use, borax bath is checked daily and makeup of borax decahydrate or *Neobor* borax pentahydrate and water are routinely performed. The life of the borax bath depends primarily on impurity level; eg chloride and iron, but, with care, usually lasts several months.

Proprietary mixes made up largely of borax or *Neobor* borax pentahydrate are also used to form the borax bath. Use of borate alone and in proprietary mixes for wire drawing applications is steadily increasing.

Further details about wire preparation as well as the borax bath may be referred to in "Borax in Wire Drawing" published by Borax Consolidated Limited, 1973.

Equivalent borate concentrations in borax decahydrate or *Neobor* borax pentahydrate bath

Borax, % by weight of solution	Borax, g/liter of water	*Neobor*, g/liter of water
5	52	39
10	111	82
12	136	101
14	162	120
16	191	139
18	219	159
20	250	181
22	282	202
25	333	236
30	429	296
35	539	364
40	669	444

Multiply by 0.0083 to obtain lb/U.S. gallon

Technical Bulletin

Borates in wire drawing

About U.S. Borax

U.S. Borax, part of Rio Tinto, is a global leader in the supply and science of borates—naturally-occurring minerals containing boron and other elements. We are 1,000 people serving 500 customers with more than 1,700 delivery locations globally. We supply 30% of the world's need for refined borates from our world-class mine in Boron, California, about 100 miles northeast of Los Angeles. We pioneer the elements of modern living, including:

- Minerals that make a difference: Consistent product quality secured by ISO 9001:2015 registration of its integrated quality management systems
- People who make a difference: Experts in borate chemistry, technical support, and customer service
- Solutions that make a difference: Strategic inventory placement and long-term contracts with shippers to ensure supply reliability

About *20 Mule Team*® products

20 Mule Team borates are produced from naturally occurring minerals and have an excellent reputation for safety when used as directed. Borates are essential nutrients for plants and key ingredients in fiberglass, glass, ceramics, detergents, fertilizers, wood preservatives, flame retardants, and personal care products.

Neobor®