January 05, 2022

Steel Oxidising: Applications of Blued Steel

Phrases such as “the blue steel of the gun glinted dully in his hand” are an integral part of almost any detective story. What is so special about this steel, though?

First, a little bit of background. When the surface of many metals and alloys is exposed to the environment, it undergoes certain changes. Very often, the colour changes. For example, copper and brass form a thin green outer layer on their surface when left in open air, which causes the appearance of monuments or roofs to change. This layer is called a patina. It forms on the metal surface because of a chemical reaction and protects the metal against further corrosion.

Iron and steel corrode in open air in most cases. This process may become uncontrollable and result in the complete deterioration of steel items from rust.

In addition to environmental exposure, the colour of metals and alloys may be controlled by adding alloying elements and treating using heat, chemical or electrochemical methods. Sometimes, this is done purely for decorative purposes. In most cases, however, the colour changes as a side effect of attaining the specific properties of the surface or the product itself.

Ferrous alloys may be also recoloured. Without consideration of natural corrosion, the most popular method for surface treatment is called **bluing** or **oxidising**. In the Ukrainian and Russian languages, the term **blackening** is also widely used. In English, this process may be called **blackening** or **bluing**.

From the scientific point of view, bluing is a process that produces an iron oxide layer on the surface of carbon or low-alloy steel or cast iron. Chemical oxidation results in the formation of magnetite or black iron oxide Fe_3O_4 with a thickness from 0.5 microns to several millimetres, which gives the surface a black, dark grey or dark blue colour. In addition to the eye-catching appearance, such oxide films protect against environmental exposure; however, with a thickness greater than 2-3 microns, they tend to peel off and degrade. Therefore, an additional oil or wax coating is applied on top of the blue finish.

Nowadays, there are a great many methods that are more efficient for protecting steel items against rust. For this reason, blackening in the modern world is usually used only for decorative finishes. Such treatment is popular among gunmakers and tool and metalware manufacturers because it gives their work a special charm.

In addition to industrial steel oxidising methods, there are others that are relatively easy to use at home. The following three bluing methods are most widely used:

- Alkali;
- Acid (rust);
- Thermal or hot.

Alkali bluing of steel involves placing the steel parts into a solution of potassium nitrate, sodium hydroxide and water that has been heated to 135-154°C. This is the standard method used for blue guns since it improves rust resistance and protects open metal parts.

Nowadays, **acid (rust) bluing** of steel is used primarily at home. In this method, an acid solution is applied to

steel parts so that they rust uniformly. For example, water-diluted nitric acid and hydrochloric acid are used. Less dangerous tannic acid and tartaric acid are used at home. The parts are then immersed in boiling water to convert the red oxide Fe2O3 (rust) to the black oxide Fe3O4 that acts as protection. The boiling water also removes any of the remaining acid solution that was applied. This procedure can be repeated several times until the required colour is achieved. This method is also used to remove minor scratches on the blackened steel surface, which may cause uncontrolled corrosion.

Hot bluing of steel is carried out at high temperatures. In small-scale production applications and at home, steel surfaces are coated with a thin layer of bituminous or oil varnish and then treated in a heated medium, such as the fumes from a mixture of ammonia and alcohol that has been heated to 520-880°C, molten salts heated to a temperature of 400-600°C or air heated to 310-450°C.

There are also other specific bluing methods, such as browning. Browning involves creating a film of red iron oxide and is also known as pluming or plum brown. Browning requires special chemical solutions.

When it comes to production-scale oxidising, plants use chemical and electrochemical oxidising mainly for finished steel items such as knives, chains, metalware or various weapons. The main method to oxidise rolled steel includes annealing in furnaces with a controlled oxidation atmosphere.

For example, cold-rolled coils undergo heat treatment on dedicated continuous annealing lines. The rolled steel is uncoiled and goes through various temperature zones in the furnace to obtain the required composition of surface oxides and colour, after which it is recoiled when exiting the line. Cold-rolled products that undergo this so-called black annealing process are used to produce pipes and profiles, industrial furnace casings, as well as to manufacture steel structures and commodities.

There is another metal treatment method that resembles bluing but uses a different process. This method is **oil annealing**, which was very popular in the past. A part is oiled and annealed using a blow torch. Light oil evaporates when slowly heated to 200-400°C. A thick oily film forms on the metal surface, which obtains a brown colour after further heating and then a black colour. This film is impossible to remove. Some advantages of annealing are that it does not emit hazardous substances, can be performed for a low price and offers relatively efficient corrosion protection.

Returning to oxidising, a completely clean metal surface is the key to success. Cleaning must be performed before chemical treatment to minimise exposure to the air. When immersing the product in chemical reagents, it is important to make sure that the chemical reagents completely cover the surface.

The final effect of blued steel comes from the special mechanical treatment of the surface through polishing and brushing. This is what gives the metal the eye-catching black lustre described in the books.