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Short Communication

Breakage of electrode grade steel wires during manufacturing: A metallurgical investigation

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ABSTRACT

Wire rods of Electrode Quality (EQ) steel, in sizes ranging between 5.5 mm and 12 mm, are normally produced from continuously cast billets by hot rolling in wire rod mill. These wire rods are subsequently drawn into wires with reduced section in wire drawing plants.The most common grade for EQ steels is ER70S-6 grade which is made of low carbon steel (0.06–0.08 Wt%) with high 'Mn' (1.40–1.50 Wt%) and low 'S' content (0.020 max Wt%). It is a premium mild steel wire formulated to high quality welds and trouble-free performance during applications involving heavy duty, high speed and spray transfer applications all the way to light duty, low speed and short-arc applications. Quality aspects of these drawn wires are of significance as any inherent abnormality in the material could lead to unwanted productivity losses or quality claims. In this present study, wire samples broken during manufacturing were collected from wire drawing plants for understanding their quality aspect and potential causes of breakage while drawing. Detailed microstructural investigation revealed that the root cause of breakage of the wires is related to the welding process deployed by the customer in joining the wire rods. The quality of weldment preparation needs to be paid attention because the two ends of the wires are not fused properly when subjected to welding.

1. Introduction

Electrode quality (EQ) steels consist of both rimming and non-rimming quality steels which are used for the core wire of the mild steel and low alloy steel electrodes although rimming quality steel is mostly preferred. The starting material for rimming steel core wire is ingot whereas for non-rimming quality steel core wire it is either bloom or billet. The characteristic features of the rimmed steel are high oxygen content (typically 200–400 ppm) and a rim of almost pure iron on the surface [1].

It is preferred to produce semi killed or fully killed silicon EQ steels because they are cheaper and easier to produce and also because they provide optimum performance characteristics on the electrode. Since it is possible to obtain any desired alloy steel chemistry of the weld metal by incorporating suitable alloying elements in the flux coating, covered electrode manufacturer uses a single grade of rimming quality steel to produce a wide range of mild steel, low alloy steel and hardfacing electrodes. EQ steels are having low percentage of carbon, silicon and aluminum. Further sulfur and phosphorus control is very important in EQ steels. The S + P (sulfur and phosphorous) levels must be kept very low since they can cause brittleness in the weld regionl. Integrated steel plants have established metallurgy, drawability and consistency of producing non rimming killed EQ steels by Concast route. The major advantage of this route of EQ steel production has led to tramp element free steel. The most common grade for EQ steels is

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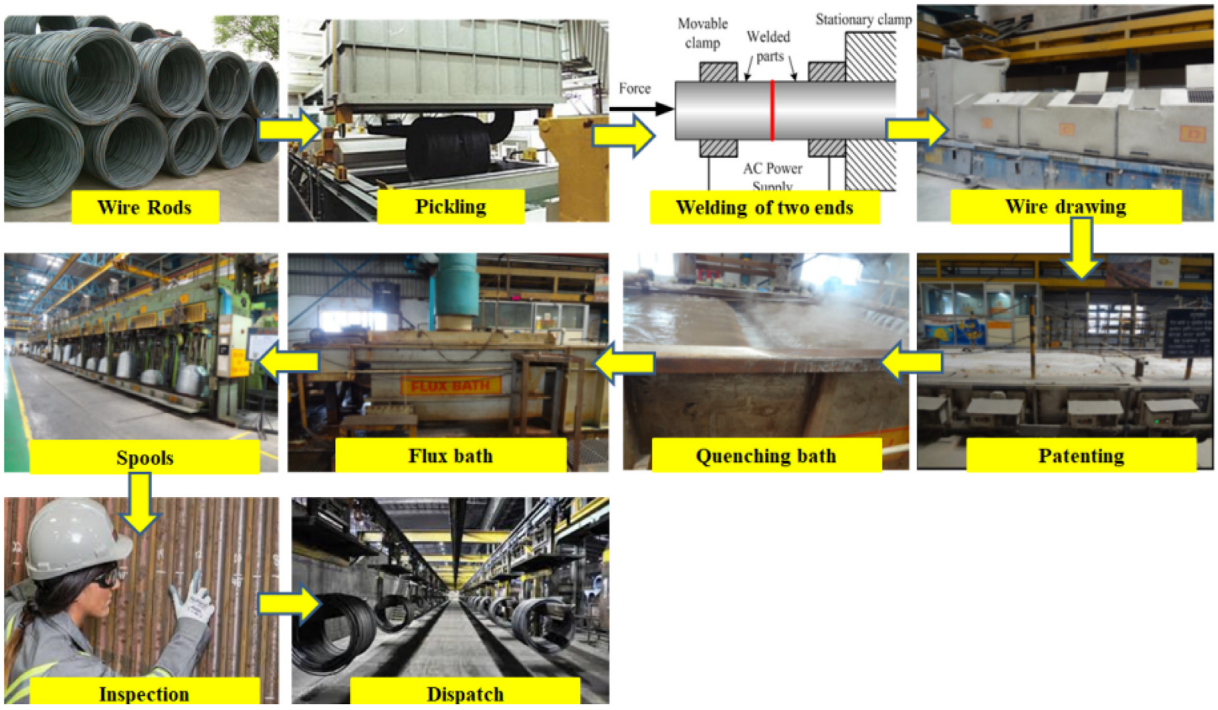

Fig. 1. Schematic diagram of wire drawing production chain.

ER70S-6 grade low carbon steel (0.06–0.08 Wt%) with high 'Mn' (1.40–1.50 Wt%) and low 'S' content (0.020 max Wt%). It is a premium mild steel wire formulated to high quality welds and trouble-free performance during applications involving heavy duty, high speed and spray transfer applications all the way to light duty, low speed and short-arc applications. ER70S-6 is intended for use with several gas mixtures such as 100% CO_2, 75/25 Ar/CO_2 or 98/2 Ar/O_2. Even in the most difficult applications ER70S-6 produces a smooth steady arc with low spatter, producing a weld bead that ties in evenly with the sides and has a smooth surface finish. There is wide range of application for this grade like fame fabrication, automotive structures, farm implements, construction equipment, pressure vessels, pipe fabrication, railcar construction and repair, general fabrication and it is also widely used in high-speed robotic and automatic welding applications and semi-automatic applications.

ER70S-6 grade steel is drawn in the range of 1.8 mm to 0.8 mm as per customer's requirement. This EQ grade is produced from continuous cast billet of size 150 mm * 150 mm and then hot rolled into size of 5.5 mm diameter wire rod. Mechanical descaling or pickling is carried out before drawing according to the customer requirements. The end of one coil and front of another coil is welded together by means of flash butt welding to make the drawing process continuous. The wire rod is then fit through the die; and pulled through successive die maintaining proper lubrication and cooling of die. Each stage of drawing consists of a drum and a die (which help in drawing drafting). The speed of each drum is maintained at higher speed than the previous one. Generally calcium soap is use as a lubricant. The drum helps to decrease the temperature which rises during drawing operations thus proper cooling of the die. The drum also acts a buffer for storage of wires. During wire drawing through the die, the diameter of wire decreases and the length increases making the volume constant. Usually the wire requires more than one draw depending upon the end use, to reach the desired size [2]. Schematic diagram of the detailed process is shown in Fig. 1.

The various types of wire breakages that occur during cold drawing may be attributed to improper metallurgical quality of the input wire rod/wire, inadequate lubrication, improper die profile, excessive reduction in cold drawing, and other material/operational factors. The material unsoundness, entrapment, and segregation in the input wire rods must also be within tolerable limits for suitable wire drawing. Additionally, wire rods that are heat treated for subsequent drawing must be of suitable microstructure, dimensionally appropriate, and free from surface defects such as laps, seams, and fins and micro flaws [3,4].

In actual industrial practice, however, undesirable microstructures such as coarse pearlite, bainite, martensite may develop as a result of improper heat treatment, patenting (e.g., inadequate/excessive soaking during austenitization, high/low lead bath temperature, etc.) [5,6]. These undesirable microstructures certainly impair drawability and may lead to wire breakages during subsequent cold drawing operations. The present work has been focused on analysis of breakage of wires during drawing of ER70S6 grade.

2. Experimental procedure and results

Failed sample was collected from the drawing mill for investigations. The sample was cleaned with acetone to remove dirt for visual examination prior to metallographic sample preparation. Transverse and longitudinal specimens were made from the breakage