

# Production Practice of C82DA High Carbon Steel Wire Rod for Conversion to Wire

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**Abstract.** Based on design of chemical composition, reasonable adjustment and optimization of smelting and continuous casting process, reheating process, rolling process and cooling process etc., Anyang Iron And Steel Group Co., Ltd. produced successfully  $\Phi$  5.5 mm high carbon steel wire rod grade C82DA for conversion to wire by 100t converter-high speed wire rod mill. The sorbitic metallographic structure of rod reached more than 90%. The wire rod is in good mechanical performance with the range of tensile strength deviation of less than 70Mpa for same heat, same nominal diameter and same rolling system. It can fully satisfy the requirements of customers.

## Introduction

C82DA High Carbon Wire Rod for Conversion to Wire is mainly used in the manufacture of cold drawing or cold rolled steel. As the framework material of rubber products of tires, conveyor belt, high pressure rubber hose etc., the steel wire rod needs to have good comprehensive mechanical properties of high strength, good toughness, anti-fatigue and shock resistance. It's the high strength wire rod for deep drawing [1]. There have more processes for production of this grade of steel wire, which are from the steelmaking to finished product covering steel smelting, refining, continuous casting, controlled rolling and controlled cooling, cold drawing, and heat treatment as well. For each process, there is big difference of requirements for mechanical and technological performance of product. This led to difficult production and high quality requirements [2]. In order to optimize the structure of variety and improve product quality, Anyang Iron And Steel Group Co., Ltd. carried through the production practice for  $\Phi$  5.5 mm of C82DA high carbon wire rod for conversion to wire.

## Main technical requirement

In accordance with the Chinese national standard GB/T 24242.2-2009: Non-alloy Steel Wire Rods for Conversion to Wire, the chemical composition (ladle analysis) of C82DA high carbon wire rod for conversion to wire shall comply with the provisions of the Table 1. Its metallographic structure is mainly sorbite structure. The allowable level of grain boundary cementite and core martensite island shall comply with the provisions of the Table 2.

**Table 1 Chemical composition /wt %**

C	Si	Mn	P $\leq$	S $\leq$	Cr $\leq$	Ni $\leq$	Mo $\leq$	Cu $\leq$	Al <sub>T</sub> $\leq$
0.80~0.85	0.10~0.30	0.30~0.60	0.025	0.025	0.15	0.20	0.05	0.25	0.01

**Table 2 Level of grain boundary cementite and core martensite island of wire rod**

Size/mm	Core martensite island/ Level M	Grain boundary cementite /Level T
$\leq 6.5$	$\leq 1.0$	$\leq 2.0$

## Process concept

### (1) Composition design

Chemical composition (mass fraction) of the designed trial steel is given as in Table 3.

**Table 3 Composition of trial steels /wt %**

C	Si	Mn	P≤	S≤	Cr≤	Ni≤	Mo≤	Cu≤	Al <sub>1</sub> ≤
0.81~0.84	0.15~0.25	0.40~0.60	0.020	0.015	0.10	0.10	0.05	0.10	0.005

**(2) Process flow**

Production process of C82DA high carbon wire rod for conversion to wire of Anyang Iron And Steel Group Co., Ltd. is as follows:

100t converter→LF refining furnace→150 mm x 150 mm billet continuous casting→walking beam type reheating furnace→high pressure water descaler→high speed wire rod mill→Inclined laying head→ Stelmor conveyer→reform tub assembly→P&F line→finishing→bundling→weighing→marking→warehousing

**(3) Items and testing method**

The chemical composition was detected by traditional wet method and ICP-AES spectroscopic analysis. Mechanical properties was tested by W-100 tensile testing machine, vernier caliper (0.02 mm) was used to measure tensile force and size, sample length was 300 mm, setup gauge length was 100mm. Misrostructures and their formation were observed by Axiovert 200 MAT metallographic microscope, and multipoint evaluation was adopted to determine the structure scale. Non-metallic inclusion and their size, numbers and surface topographic features were tested by FEI Quanta 200 scanning electron microscope, and elemental constitute was quantitatively determined by Oxford INCA X-Stream spectrum analyzer.

**Production process****(1) Smelting process**

Using tapped-on-carbon process, end point C is equal and less than 0.50%, P is equal and less than 0.010%. Employing secondary slag stopping, slag carry-over was strictly prohibited at nozzle and tapping hole while tapping. Top-slag lime and fluorite were added during tapping. Alloys Mn-Si was used for deoxidation alloying optimization. Calcium carbide and silicon carbide were added for end deoxidization. Use secondary slag stopping to strictly control slag carrying-over from converter, and carry out steel keeping operation when necessary to stop slag backing. At early phase of ladle furnace refining, it was mainly for oxidization, slagging and content tuning, at latter phase, it was mainly for soft stirring and temperature adjustment. In period of weak stirring after wire feeding, it was not allowed to add any alloy and additional material.

**(2) Continuous casting process**

Complete shroud protective casting was adopted for billet continuous casting to ensure Ar sealing of shroud nozzle. Using shroud nozzle gasket to keep submerged nozzle well sealed. The alignment and centering of submerged nozzle in mould must be guaranteed. Inside of tundish, double layer of covering agent was filled, neutral agent was put as lower layer and top layer covered by carbonized rice husk. Casting conducted when target superheat was lower than 30°C. Casting speed was controlled at 2.0-2.1 m/min and kept stable. Mould electromagnetic stirring and electromagnetic stirring at casting end were used and forced cooling process was used for secondary cooling.

**(3) Reheating process**

Reheating device is side-in and side-out walking beam type reheating furnace. The key combustion apparatus was introduced from Japan. The control system network is two level structures which can carry out computing and control for optimized combustion digital model. It has features of flexible production operation, good reheating quality and low cost. In order to reduce oxidation burning loss and decarburization of C82DA high carbon steel billet in reheating furnace, the reheating temperature and time for trial steel in furnace was strictly controlled. The reheating temperature is required to be under 1100°C, heating time less than 150min.

**(4) Rolling process**

The high speed non-twisted continuous rolling was adopted for this new process with rolling speed at 112 meters per second. The mill train is composed of 30 rolling stands which achieved a small

extension precise rolling. The roughing and intermediate stands are in alternatively horizontal-vertical arrangement. Pre-finishing and finishing stands, reducing and sizing stands are in 45° V type arrangement that can realize non-twisted rolling for whole line. Minimal tension or loop control was used between stands. Product accuracy can get  $\pm 0.1\text{mm}$ . Fewer rolling accident happened.

#### (5) Cooling process

In order to get content higher and homogeneous sorbitic structure, standard cooling process post rolling was applied. The cooling facility is the high air volume, high air pressure and retarded cooling type Stelmor conveyer developed by Morgan Construction Company, of which “Optiflex” plenums and 6 cooling fans were installed. P & F line for bulk coil cooling is 103.8 meters long. This could improve the metallurgical quality and homogeneity of the product, and also could control creation of the scale, which could both save step from heat treatment before drawing and reduce the degree of difficulties for surface cleaning in following process, thus has obvious social and economic benefit for improve production efficiency and cost reduction for the downstream manufacturers.

### Trial manufacture result

#### (1) Chemical composition

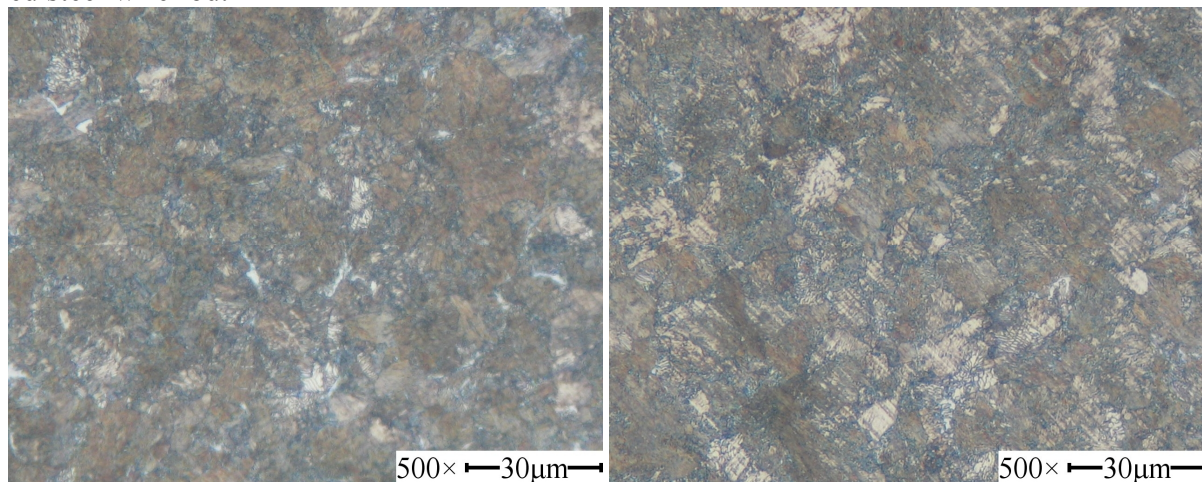
Two heats production trial for C82DA high carbon steel were conducted. Chemical contents (mass fraction) are as in Table 4. The chemical composition of the trial produced steel is fully in conformity with design criterion and national standard.

**Table 4 Chemical composition of trial produced wire rod /wt %**

Heat number	C	Si	Mn	P $\leq$	S $\leq$	Cr $\leq$	Ni $\leq$	Mo $\leq$	Cu $\leq$	Al $\leq$
201531	0.82	0.19	0.53	0.012	0.001	0.04	0.01	0.01	0.02	0.002
201532	0.81	0.20	0.52	0.011	0.003	0.04	0.01	0.01	0.02	0.001

#### (2) Metallographic structure

The hot-rolling structure of the trial steel by controlled rolling and cooling is sorbite (principal)+pearlite +ferrite. By the optical microscope observation, the content of sorbite reached over 90% and no network cementite and martensitic structures were found in the central area, as shown in Figure 1. Sorbitic structure has higher strength and better plasticity. It has excellent drawing performance. The higher sorbitic rate is, the more suitable for drawing [3]. The higher content of sorbitic structure ensured the good mechanical property and drawing performance of the trial hot rolled steel wire rod.



**Fig.1 Metallographic structure of trial produced wire rod**

#### (3) Mechanical property

The trial produced steel was completely rolled to wire rod of size  $\Phi 5.5\text{mm}$ , the tested mechanical property is given in Table 5. The mechanical property of rod had fully conformed to the requirement of national standard by tensile strength within deviation of less than 170 MPa for same heat, same nominal diameter and same rolling system [4].

**Table 5 Mechanical properties of trial produced wire rod**

Size/mm	Tensile strength, Rm/MPa	Reduction of area, Z/%	Deviation of tensile strength /MPa
Φ5.5	1180~1250	42~51	70

**(4) Surface quality**

For any visible external defects on wire rod surface would cause the serious effect to single wire drawing and wire netting along with deep drawing proceeding in process of producing rubber hose steel wire, their top and tail parts with harmful defects, therefore, should be cut off. The surface of wire rod must be smooth [5]. Via testing, there were no crack, pincher, fin, blister, pit, lamination, dent, physical scratch, uneven scales and more severe rust, etc. appeared on surface of wire rods. In addition, the dimensional accuracy and surface decarbonized layer of wire rods were strictly controlled, their diameters and out-of-roundness deviation were controlled respectively within  $\pm 0.15\text{mm}$  and  $\pm 0.25\text{mm}$ , the decarburized layer was controlled below 0.05mm.

**Summary**

The production practice showed that  $\Phi 5.5\text{mm}$  of C82DA high carbon steel wire rod for wire making produced by 100t converter-high speed wire rod mill of Anyang Iron & Steel Group Co., Ltd. was featured with small control range of chemical composition, pure steel quality, low content of harmful elements such as w(P),w(S),w(Cr) ,w(Ni),w(Mo) ,w(Cu),w(Alt), etc. The continuous casting process control was reasonable. The superheat of liquid steel controlled strictly. Casting speed stabilized at 2.0-2.1 m/min. Billets quality was good. With the testify of users, the trial steel wire rod was proved to have good surface quality, low decarburization, strictly controlled dimensional accuracy and surface decarburization layer. There were no surface defects affecting its use, such as crack, pincher, fin, blister and pit, etc. The sorbite proportion of metallographic structure of wire rod was highly over 90% which is suitable for deep drawing manufacture of finished product. It has uniformity of mechanical performance and proper strength. According to the result, it can fully satisfy the requirement of customers.

**References**

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