

Research and Production of V-Cu-Ni Series High-strength

Steel for Pressure Vessel

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Abstract To manufacture the large ball oxygen tank, a kind of thick V-Cu-Ni series steel plates and forging kits with minimum yield strength of 460MPa have been researched and produced. The test steel plates have an obvious characteristic of aging strengthening and toughening effect after being normalized and tempered. The cryogenic toughness of the steel plates appears excellent. The mechanical properties can meet with the technical requirements of P460NL1 in the standard of DIN EN 10028-1992. Six ball oxygen tanks with the volume of 650m³ each have been made in Bao Steel using this kind of steel plates and forging kits and have been in safe operation for 4 years.

Key Words: V-Cu-Ni, thick steel plates, forging kits, pressure vessel

1. Preface

A kind of V-Cu-Ni series pressure vessel steel used for large ball oxygen tanks and forging kits is introduced in this article. The steel plates are delivered in the status of being normalized + tempered and the forging kits are delivered in the status of being quenched + tempered. The steel plates and forging kits can be made with same heat chemical compositions, so the problem of welding different grade steel in normal pressure vessel manufacturing is solved and the manufacturing cost is reduced. Comparing to the steel plate quenched and tempered, the large roll quenching equipment is not needed for this kind of steel plates and production process can be easily controlled. The properties of products are homogeneous and stable. The percent of pass in property can strike 100. Even though the carbon equivalent value is higher, the welding process is settled perfectly. The steel with high yield strength for pressure vessels can be made as well in the thick steel plate plant without the large special quenching equipment.

2. The Design of Chemical Compositions

To obtain the high strength and excellent cryogenic toughness and to ensure the good

weldability, a kind of V-Cu-Ni alloy series was designed. It is well known that the steel with high V and high VN have an obvious strengthening effect to ferrite. The ϵ -Cu particles despersively precipitated in the ferrite are also a relatively strong strengthening mechanism which has been researched and applied widely^[1-9].

To make well the yield strength improving effect by grain refinement, a trace of Nb was added into steel. The toughness loss caused by VN and V (CN) precipitation strengthening will be compensated by sufficient grain refinement. Proper amount of Ni added cannot only avoid the grain-boundary resillage in the steel with high Cu in heat treatment but also is helpful to improve the cryogenic toughness.

3. Laboratory Research

The chemical compositions of four test steel grades with high V and high N are listed in Table 1. The melting was made in laboratory induction furnace. The ingot of 50KG was forged into slab, which was rolled in two stages into plates with thickness of 14mm each in the test rolling under control. Then the normalizing and normalizing + tempering were followed separately. The basic compositions of the four test steel grade were