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Pipeline Steels for Sour Service

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Foreword

The experimental results and literature data on the technology development for the manufacture of steels for pipes intended for the transport of H_2S-containing oil and gas are summarized.

A contemporary view of the cracking mechanisms and the factors affecting the fracture resistance of low-alloy pipe steels in H_2S-containing media is presented.

The methods improving the quality of continuously cast slabs and the effect of chemical composition on the microstructure and properties of rolled pipe steels are considered. Much attention is paid to the physicometallurgical aspects of the microstructure formation and to the enhancement of the mechanical properties and HIC resistance the plates produced by thermomechanical rolling with accelerated cooling.

The book is intended for engineers and researchers of metallurgical enterprises and research institutes, for university professors, as well as for undergraduate and graduate students of relevant specialties.

Moscow, Russia — Georgy Filippov

Preface

In recent years, the number of developed gas and oil fields with an increased content of hydrogen sulfide grows, while previously such fields were considered to be of little use for operation. This is explained by the depletion of "clean" fields, which have been the main source of hydrocarbons for many decades. At the same time, there is a growing demand for gas–oil pipes, which are much more cracking resistant in an aggressive hydrogen sulfide-containing medium, the so-called sour gas, than the steels used to manufacture pipes that transport non-aggressive natural gas or oil. To prevent damage of pipelines transmitting "sour gas" from fields to plants for its purification from harmful H_2S, CO_2, etc., impurities, special requirements have been developed for the resistance of pipe metal to failure in hydrogen sulfide-containing media. The fulfillment of such requirements is necessary to ensure a lifelong operation of the pipes.

For decades, the metallurgical industry and physical metallurgy have solved the problem of creating steels with high resistance to various types of failure in sour environments such as hydrogen-induced cracking and sulfide stress cracking. A substantial progress was achieved, which led to the development of special steels and technologies for their production in all areas, from steelmaking and continuous casting to thermomechanical processing of rolled steel and pipe manufacture.

The book presents a contemporary view of the physicometallurgical factors affecting the fracture resistance of low-carbon low-alloy pipe steels in hydrogen sulfide-containing media. The methods for estimating the resistance of steel to hydrogen-induced cracking and the requirements for sour-gas-resistant electric-welded pipes are considered.

It is shown that, to improve the cracking resistance of steel under the effect of H_2S-containing medium, it is necessary to eliminate the causes promoting the nucleation and propagation of cracks. In addition to the cleanness from harmful impurities and non-metallic inclusions, the microstructure, in particular, in the central segregation zone of rolled plates substantially affects the resistance of steel to hydrogen-induced cracking. Therefore, special attention is paid in the book to the minimization of the negative effect of axial segregation on the hydrogen-induced cracking resistance of steel. Methods for improving the quality of continuously cast

slab relative to the axial chemical heterogeneity as well as the effect of chemical composition on the microstructure and properties of high-quality flat rolled products from low-alloy pipe steels are considered.

A modern way to control the structure formation in steel is the combined process of controlled rolling and accelerated cooling. The physicometallurgical aspects of the microstructure formation and increase in mechanical properties and hydrogen-induced cracking resistance of the plates manufactured by thermomechanical treatment by the scheme "controlled rolling followed by accelerated cooling" are considered.

A vision is given of the current level of technology for the manufacture of rolled steel for sour gas pipes at a number of leading Russian and foreign metallurgical enterprises. At present, mainly pipes of grades up to X65 inclusive have found commercial use for the construction of sour-gas-resistant pipelines. Research works aimed at the development of X70 and X80 grade pipes for operation in the most aggressive media are underway.

The materials of the book are based on our own research in laboratory and industrial conditions and also include an overview of a huge volume of Russian and world literature.

Moscow, Russia

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Alexey Kholodnyi
Maxim Matrosov
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