Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 152 (2016) 613 – 619

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Oil and Gas Engineering, OGE-2016

The development of the alloy for an oil pyrolysis furnace coil hanger

Eremin E.N.[a], Filippov Y.O.[a], Minnekhanov G.N.[b]*, V.V.Akimov[b]

[a]*Omsk State Technical University, 11, Mira Pr., Omsk 644050, Russian Federation*
[b]*Siberian State Automobile and Highway Academy (SibADI), 5, Mira Pr., Omsk 644080, Russian Federation*

Abstract

The chromium-nickel alloy doped with niobium, titanium, aluminum and modified by titanium complex – titanium carbonitride is developed for the manufacture of the oil pyrolysis furnace cast coil hanger. The application of a modifier has led to the improvement of the cast grain structure, morphology and topography of hardening phases. These changes have provided the heat resistance increasing and the structural stability of the cast alloy in use.

Peer-review under responsibility of the Omsk State Technical University

Keywords: pyrolysis furnace coil hanger chromium-nickel alloy, casting, modifying, heat resistance, structure, properties

1. Introduction

The pipe coil is the most critical part of the furnace as the pyrolysis reaction proceeds directly in it. It is assembled from expensive centrifugal or hot-rolled seamless furnace pipes and is placed entirely in radiation and convection chambers by hangers. The working temperature of the hangers and pipes heating is about 930 °C and can reach 1000 °C in pipes coking.

Operating in the fume gases atmosphere the coil hanger system of the reaction furnace is in a difficult heat-loaded condition.

There are large composition changes in the surface layers due to the alloying elements diffusion from the metal in scale and the oxygen in metal in heating, ultimately leading to the formation of various defects such as cracks, blowholes, burnouts, the local and general loss of stability, etc. Such defects lead to the destruction of the coil system and its earlier failure. This can result in an emergency situation and the furnace unit stopping.

* Corresponding author. Tel.: +7-3812-65-2719
E-mail address: weld_techn@mail.ru

Peer-review under responsibility of the Omsk State Technical University
doi:10.1016/j.proeng.2016.07.664

The steels heat resistance is determined with their chemical composition. Chromium steels are more prone to gas corrosion than chromium-nickel ones and the higher the nickel content, the higher the oxidation resistance. Alloys differ from steels in terms of mechanical properties including heat-resistance, processability, lower tendency to embrittlement after the along exposure to high temperatures. Therefore, it is recommended to use nickel based alloys for high-temperature furnace parts where the gas corrosion may lead to their destruction. The nickel-chromium introducing greatly increases the oxidation resistance at high temperatures. The highest durability against the oxidation in nickel-chromium alloys corresponds to the presence of 40 % Cr and more. Therefore, in these operating conditions the heat resistant alloys such as H50X50, X60H40, XH60U and others are used [2]. However, the information on the use of such alloys is very limited. The aim of this work is to develop the alloy for the pyrolysis furnace coil hanger manufacture.

2. Study subject

The alloy H50X50 is considered to be the base. In addition to the heat resistance, the alloy must have the high strength and ductility. Therefore, niobium is additionally introduced in the alloy composition. It has a positive impact on the long-term strength combined with ductility, increases the thermal resistance of the solid solution and changes the solubility of γ'-phase [2]. In addition, the niobium contributes to a stronger grain refinement due to the carbides formation and has a favorable effect on the intergranular layer hardening. Additionally, titanium and aluminum, forming intermetallic γ'-phase type $Ni_3(Ti, Al)$ releasing in solid solution in the form of dispersed particles) in heat treatment are also introduced in the alloy, thereby contributing to its hardening [2].

In recent years the chromium-nickel alloys modifying technology with dispersed refractory particles is finding a wide application allowing to improve significantly the operational characteristics of the cast metal [4-9]. So, in the development of the cast alloy its modification by the Ti-TiCN complex showing the good results of the previous nickel alloys studies is used [3-5].

3. Research methods

Meltings were carried out in a furnace IST-004 with the main lining of magnesium oxide under the main flux of the following composition: CaO – 50-70 %, CaF_2 – the rest. The modifier was prepared according to the technology described previously [4, 5]. The complex was injected at 1650 °C for 3 minutes to drain ensuring the uniform distribution of dispersed particles- inoculators over the entire volume of liquid metal in the melting vessel. The metal casting was carried out at 1600 °C in the sandy form manufactured using cold-hardening mixtures.

The shape, size and distribution of phases are determined by means of the metallographic analysis methods with optical microscope Carl Zeiss AxioObserver A1m and the analyzer of the microstructure fragments of SIAMS 700 based on the microscope OLYMPUS GX41.

The static strength and ductility of the alloys were determined by tensile testing samples 5 mm in length with the calculated six times (stretching strain rate of 2.5 mm/min) on the Instron testing tensile machine.

The chemical analysis was performed on the optical emission analyzers ARG-MET-930SP by Metorex and DFS-500 (OKB Spectrum).

The techniques of transmission electron microscopy on a JEOL JEM PAM – 2100 are used to study the fine structure.

For the study of physicochemical transformations occurring in the alloy under the programmed temperature change conditions, we have applied the methods of the thermogravimetry and differential thermal analysis using a differential thermal analyzer SHIMADZU DTG–60.

4. Results and discussion

The alloys chemical composition comparative results of experimental meltings are given in Table. 1.