COMPARISION ANALYSIS OF CORROSION RESISTANCE OF VALVE STEEL X50CrMnNiNBn21-8 IN COMBUSTION GASES FROM PROPANE-BUTANE, GASOLINE AND FUEL OIL

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Abstract

The corrosion resistance of widely used X50CrMnNiNbN21-9 high-alloyed austenite valve steel, in three different combustion gases have been compared. The comparison was performed on the basis of results of kinetic corrosion of the tested steel in combustion gases from propane-butane, gasoline with 5 and 10% of ethanol additives (v/v) and fuel oil with 5 and 10% of FAME additives (v/v). The corrosion test was performed gravimetrically under thermal shock conditions by heating samples of the test steels from room temperature up to 1173 K in exhaust gases from a combustion engine, and holding them at this temperature for 2 hs and then cooling at room temperature for about 25 min. Then, the same thermal shock was repeated. After every 10 to 20 such cycles the mass of the samples were measured. This experiment simulated the working conditions of a highly thermal loaded exhaust valves in spark or self-ignited combustion engines. The analysis performed shows that the corrosion resistance of X50CrMnNiNbN21-9 valve steel in an environment of combustion gases from propane-butane and gasoline with 5 and 10% of ethanol additives (v/v) is comparable, whereas significantly worse corrosion resistance was stated in an environment of combustion gases from fuel oil with 5 % and 10 % (v/v) of FAME additives.

Keywords: valve steel, propane-butane, gasoline, fuel oil

1. INTRODUCTION

Exhaust valves belong to the most thermally and mechanically heavily loaded components working in the extremely corrosion aggressive environment of hot exhaust gases. The durability of exhaust valves mainly depends on the high-temperature creep resistance of the steels used, i.e., simultaneously, high resistance to mechanical deformation and corrosion resistance to combustion gases at high temperature [1, 2]. In case of exhaust gases from propane-butane the temperature of exhaust valves reaches up to 1200 K [3].

To ensure high heat resistance of the exhaust valves, i.e., high heat resistance in the strongly oxidizing environment of hot exhaust gases from combustion of gasoline, as well as high resistance to mechanical deformations at high and increased temperatures, i.e., resistance to low-and high-temperature creep [4], the valve heads exhaust valves are produced from austenitic valve steels having the chemical constitution specified [5]. Studies were performed at a temperature of 1173 K under thermal shock conditions, simulating operation of the exhaust valves of spark or self ignited combustion engines.

2. EXPERIMENTAL

Tests of the oxidation rate of valve steel in combustion gases from gasoline with 5 % and 10 % ethanol additives (v/v) and combustion gases from fuel oil with 5 % and 10 % (v/v) of FAME additives and propane-butane were performed. The experiment was done on samples in the form of discs of diameter 19 mm and a thickness of 1 mm. The samples were turned from industrial rods made of the highly alloyed austenitic valve steel X50CrMnNiN21-9, having the chemical composition presented in **Table 1**.

The samples for tests of the oxidation rate of valve steels in the above mentioned combustion gases were prepared as follows: Firstly discs with diameter of 19 mm and thickness of 1 mm were turned; Next a ∅ 2 hole was drilled at a distance of about 2 mm from the edge of each sample; then the sample was ground and polished with the use of suitable abrasive papers and compounds; and then it was washed in methyl alcohol and dried in a stream of compressed air; and then it was underwent oxidation in exhaust gases under conditions of cyclic thermal shocks simulating operation of the exhaust valves inside spark-ignited combustion engines, i.e., rapid heating of the samples to a temperature of 1173 K; and next, it was being held at the above mentioned temperature for 2 h and finally cooling down at room temperature for about 25 min (**Fig. 1**). After every 24 hrs the oxidized samples were taken from furnace and then cleaned mechanically and with the use of compressed air. After cleaning, the samples were weighed in an air-conditioned room with use of an analytical balance of accuracy 10^{-4} g. The oxidation rate was investigated by measurement of mass loss in the oxidized samples with reference to the initial surface area Δm/S [g/cm^2] of the samples and time of oxidation t (h) [6]. And in the following step, results of the measurements were again related to the duration of the oxidation step.

Table 1 Chemical composition of the austenitic valve steel examined

Grade of steel	(% wt.)									
	C	Cr	Ni	Mn	Si	W	Nb	N	S	P
X50CrMnNiNbN21-9	0.54	19.88	3.64	7.61	0.30	0.86	2.05	0.44	0.001	0.031

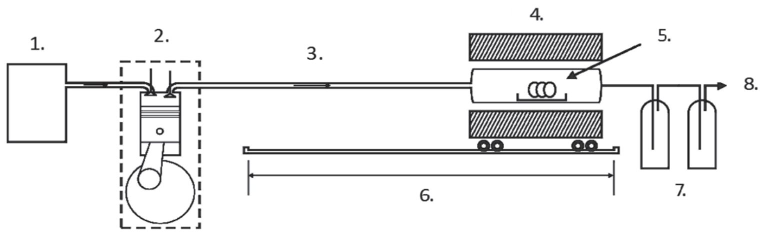

Fig. 1 Scheme of setup used in corrosion tests: 1- fuel tank, 2 - combustion engine, 3 - delivering pipe of combustion gases, 4 - furnace, 5 - reactor with samples, 6 - range of funeral movement, 7 - combustion bulbs, 8 combustion outlet

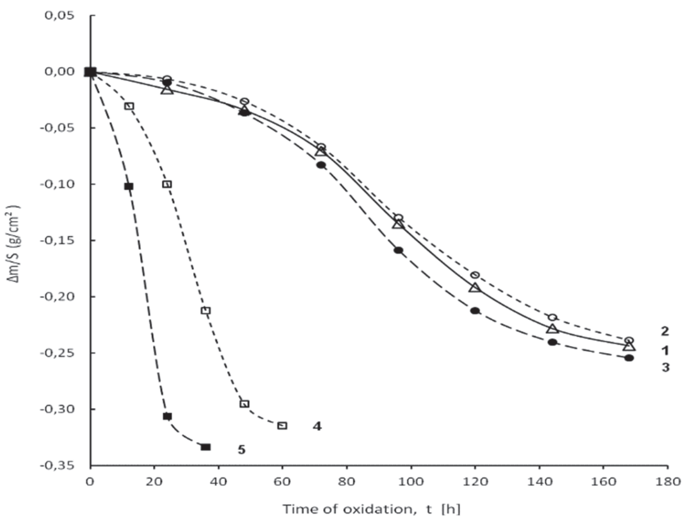

Fig. 2 Corrosion behaviour of X50CrMnNiNbN21-9 under thermal shock conditions from 1173 K to room temperature carried out in combustion gases: gasoline with 5 % and 10 % ethanol additive (v/v) (1, 2); fuel oil with 5 % and 10 % FAME (v/v) (4, 5) and propane butane (3).

3. RESULTS AND DISCUSSION

The results presented in **Fig. 2** of the corrosion behaviour of X50CrMnNiNbN21-9 in combustion gases from gasoline with 5 % and 10 % ethanol additive (v/v) (1, 2) and from propane butane (3) show that corrosion resistance of tested steel is comparable in mentioned above gases (**Fig. 2** curves respectively 1, 2 and 3).

Further examinations show significantly decreasing of corrosion resistance of tested steel in combustion gases from fuel oil with 5 % and 10 % FAME (v/v), where average loss of weight of samples yields respectively 0.2954 and 0.3061 g/cm^2 after oxidation for 48 and 24 hrs., subsequent oxidation for 12 hrs causes complete destruction of samples (Fig.2, curves respectively 4 and 5).

CONCLUSIONS

The results presented of the corrosion behaviour of X50CrMnNiNbN21-9 valve steel in **Fig. 2** in combustion gases from in combustion gases: gasoline with 5 % (1) and 10 % (2) ethanol additive (v/v); fuel oil with 5 % (4) and 10 % (5) FAME (v/v) and from propane-butane (3) allow to conclude that:

1. corrosion resistance in combustion gases from gasoline with 5 % and 10 % ethanol additive and propane-butane is comparable; (**Fig. 2**, curves 1, 2 and 3),
2. corrosion resistance in combustion gases from fuel-oil with 5 % and 10 % FAME (v/v) is significantly worse than in combustion gases from propane-butane (**Fig. 2**, curves 4, 5 and 3).

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