Rolling Contact Fatigue of Hot-forged Steels out of Prealloyed Powders and Powder Blend

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Abstract

Powder forging is used for heavy-loaded parts (rings of rolling-contact bearings, gears etc.) production. Rolling contact fatigue is material property values of which characterize possibility of practical utilization of such parts. Rolling contact fatigue of some steels obtained out of prealloyed powders Astaloy CrM, Atomet 4601, Atomet 4901 and powder blends iron-carbon-nickel by hot forging is studied in the present paper. Effect of various kinds of heat and thermomechanical treatment on rolling contact fatigue is determined. Thermomechanical treatment provides optimal values of rolling contact fatigue. In this case steel structure contains up to 40% of retained metastable austenite which is transformed to martensite on trials. Thus typically crack is generated on residual pores and non-metallic inclusions instead of martensite zones in wrought steels.

Keywords: powder forging, rolling contact fatigue, blended powder steels, powder mixture, thermomechanical treatment

The aim of present paper is the investigation of possibility of increasing of rolling contact fatigue (RCF) of steels out of prealloyed powders and powder mixtures on the account of improving of conditions of compaction of porous preform surface layers during hot forging (HF) and applying high temperature thermomechanical processing (HTTMP) after HF.

Cylindrical samples ø26×6 mm were performed to define RCF of powder steels. The chemical composition of powder blends, used when obtained samples, is given in Table. Prealloyed powders were used: Astaloy CrM, Höganäs AB; Atomet 4601 and Atomet 4901, QMP. Reduced iron powder PZhV2.160.26, produced at the joint stock company "Staks" (Russia), was used as the base when obtained nickel steels.

RCF tests were performed on the machine LTM by the rolling of flat sample surfaces with balls at a pressure of 5000 MPa. The tests were performed up to the appearance of fatigue spalling. The treatment of tests results was performed according to GOST 2551 – 78. In order to reduce cooling of heated preforms during HF, the die was heated to 300 and 600 °C. With the aim of providing possibility to perform comparative evaluation in identical conditions the samples of wrought ball bearing steel ShH15 (the composition, mass-%: Cr – 1.5; C – 1.0; Fe – bal.) after hardening in oil and low tempering at 180 °C during 1 hour were tested. Other details of HF and heat treatment are presented elsewhere [1].

The analysis of surface porosity values (P_s) versus preheating die temperature (T_D) testifies that when T_D increases the surface porosity of samples significantly reduces. At T_D=*600 °C* surface porosity is minimum and does not exceed bulk sample porosity. Because of the fact that surface porosity makes negative effect on RCF all further tests were performed on samples, forged in preheated die at T_D=*600 °C*. The difference in quantity of retained austenite before and after tests indicates that deformation martensite transformation takes place. This difference characterizes quantity of metastable retained austenite, favourable to martensite transformation. The analysis of experimental data show that RCF increases with quantity of metastable retained austenite. The formation of metastable austenite in all steels under study was provided by the performance of HTTMP.

Table 1. Blend and Composition of Powder Forged Steels

Steel Grade	Powder Blend	Element (mass-%) Cr[2]	Mo[2]	Ni	C[1] Nominal	Analyzed
50Cr3Mo	Astaloy CrM	3.00	0.50	—	0.6	0.53
100Cr3Mo	+SG				1.1	1.01
50Ni2Mo	Atomet 4601	—	0.55	1.8[2]	0.6	0.51
100Ni2Mo	+SG				1.1	1.02
50Mo1.5	Atomet 4901	—	1.5	—	0.6	0.52
100Mo1.5	+SG				1.1	1.03
50Ni9	PZhV2.160.26	—	—	9.0[1]	0.6	0.50
100Ni9	+ Ni + SG				1.1	1.01

Notes: [1] – admixed; [2] – prealloyed.

The most values of RCF were obtained on samples out of steels 50Cr3Mo; 50Ni2Mo; 50Mo1.5; 50Ni9; 100Ni2Mo (steels are pointed in order of reducing of RCF values) after HTTMP. This circumstance can be explained by optimum combination of "soft" areas of metastable austenite and hard zones of structureless martensite with microhardness, correspondingly, 410 – 600 and 1000 – 1100 HV. The difference in RCF values is stipulated by different degree of strengthening effect of metastable austenite which depends on alloying system. It is interesting to note, that in distinction to results [2] blended powder nickel steel 50Ni9 demonstrated rather good RCF. Consequently, the areas with high nickel content did not make detrimental influence on compaction process and did not assist in local porosity retention. Most likely this is connected with the fact that forging temperature in [2] composed 980 ^{o}C, but in our tests – 1100 ^{o}C.

Good results are also obtained on samples out of steels 100Cr3Mo and 50Cr3Mo correspondingly after hardening in oil and salt water. But in this case high indexes of RCF were provided not by high quantity of metastable austenite, but minimum quantity of stable retained austenite. It's important to underline that values of RCF of all mentioned above steels exceeded corresponding indexes of wrought ball bearing steel ShH15.

By this means the performance of HTTMP of samples of hot-forged steel 50Cr3Mo on the base of prealloyed powder Astaloy CrM provides maximal RCF values.

HF performance in preliminarily heated die is the necessary condition of reaching satisfactory indexes of RCF.

The achievement of high values of RCF of powder forged is provided on the account of formation in the structure of metastable retained austenite, favourable to martensite transformation during deformation.

References

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