ALLOYING Cr – Ni – Mo STEELS WITH RARE EARTH METALS

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It has been shown in recent years [1] that steels can be improved by alloying with rare earth metals.

Alloying with rare earth metals improves the plasticity and ductility, the strength characteristics remaining unchanged.

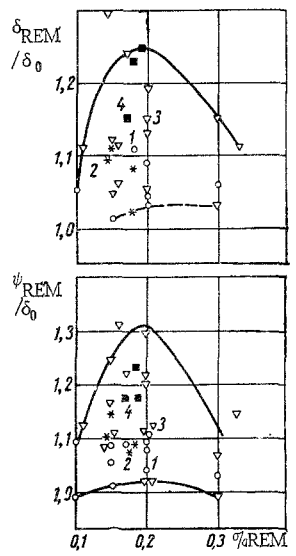

Fig. 1. Plastic characteristics of 18KhGSN2M steels with different concentrations of rare earth metals. 1) Steel with lanthanum; 2) steel with cerium; 3) with ferrocerium; 4) commercial heat with ferrocerium.

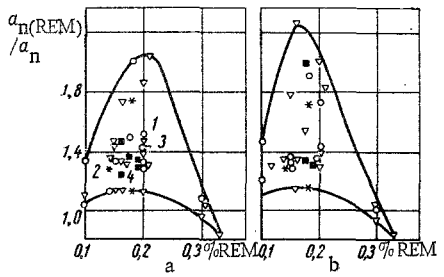

Fig. 2. Relative change of impact toughness with rare earth metal concentration. Symbols the same as in Fig. 1. a) Tested at 20°C; b) at –40°C.

We studied the effect of rare earth metals on the mechanical properties of Cr–Ni–Mo casting steels of the 18KhGSN2M type. The rare earth metals used for alloying were cerium, lanthanum, ferrocerium, and misch metal.

The heat treatment was as follows: normalization at 910-940°C, tempering at 680°C, quenching from 900°C, tempering at 650°C, and cooling in water. In analyzing the results we calculated the relative change in the strength and plastic characteristics of steels with and without rare earth metals. It is found that with the addition of 0.15-0.20% rare earth metals the relative value of the strength changes from 0.91 to 1.09, i.e., remains almost unchanged. The relative values of the plastic characteristics at the same concentration of rare earth metals are 1.25-1.30 (Fig. 1), the impact toughness varying from 1.3 at 20°C to 1.4 at –40°C (Fig. 2).

Figure 3 shows the variation of the mechanical properties of Cr–Ni–Mo steel with the tempering temperature. The plastic characteristics (δ, ψ) of the steel with rare earth metal are superior to those of the steel without rare earth metal at all tempering temperatures.

The strength of the steel with rare earth metal is somewhat higher than that of the steel without rare earth metal at tempering temperatures up to 400°C; at higher temperatures it is somewhat lower. The impact toughness of the steel with rare earth metal is higher than that of the steel without rare earth metal throughout the entire range of tempering temperatures. The statistical data for more than 350 tests of 30 commercial heats of the alloy with rare earth metal tempered at 550-600°C are given in Table 1.

It can be seen from the data in the table that the steel with 0.15-0.20% rare earth metal tempered at 550-600°C has higher strength characteristics at the same plasticity and ductility by comparison with the steel without rare earth metal tempered at 650°C. Thus, the steel with rare earth metal can be raised into a higher strength class, and the plasticity and ductility retained, by reducing the tempering temperature from 650 to 600°C.

Krasnoe Sormovo Plant; Gor'kii Polytechnical Institute. Translated from Metallovedenie i Termicheskaya Obrabotka Metallov, No. 3, pp. 66-67, March, 1969.

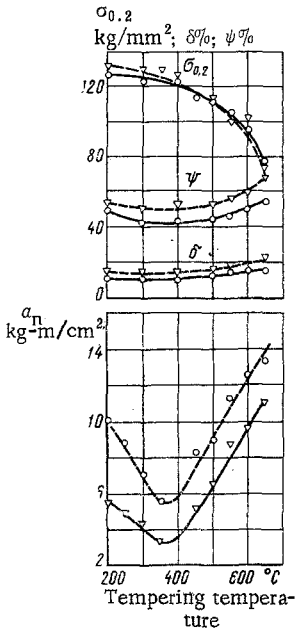

Fig. 3. Variation of strength and plastic characteristics of steel 18-KhGSN2MA with tempering temperature. ——) 0% Misch metal; – – – – –) 0.18% misch metal.

TABLE 1

Tempering temp., °C	% REM	$\sigma_{0,2}$ kg/mm²	σ_b kg/mm²	δ %	ψ %	a_n, kg-m/cm²
650	0,0	77,5	87,8	15,6	50,4	10,0
650	0,15—0,20	75,3	86,2	19,2	61,3	14,9
600	0,15—0,20	103,5	108,2	15,8	56,1	10,3
550	0,15—0,20	114,2	118,6	14,5	50,7	8,9

It was also found that the addition of rare earth metal leads to substantial grain refining. In the steel without rare earth metal the average grain diameter was 0.088 mm, while with 0.20% rare earth metal it was 0.022 mm. The addition of rare earth metal also reduced the sulfur content by 27%.

CONCLUSIONS

1. We determined the optimal amount of rare earth metal (0.15-0.20% by weight) to improve the plasticity and ductility of steel 18KhGSN2M.

2. We found that steel 18 KhGSN2M alloyed with rare earth metal can be raised to a higher strength class by reducing the tempering temperature.

3. The addition of rare earth metals refines the grain and desulfurizes the steel.

LITERATURE CITED

1. Rare Earth Elements in Steels and Alloys [in Russian], Metallurgizdat, Moscow (1959).