Glotka O., Olshanetskii V., Belikov S.
(Zaporizhzhia Polytechnic National University, Zaporizhzhia)

IMPROVEMENT OF CARBIDE PHASES IN WELDED NICKEL-BASED SUPERALLOY

E-mail: Glotka-alexander@ukr.net

The most negative influence on the embrittlement of the metal is exerted by carbon, which is released in the form of graphite, and sulfur, which is released in the form of nickel sulfide. When welding nickel and its alloys, it is necessary to increase the groove angle, in comparison with steel welding, since the metal of the weld pool of nickel and nickel alloys is less fluid and melted to a shallower depth of. Also, when welding Ni-Cr-based alloys, a refractory chromium oxide film may form, which impedes the formation of a weld. Thus, among the main tasks arising in the welding of nickel and nickel alloys are ensuring reliable protection of the welding zone from atmospheric gases, the use of high-purity welding consumables, as well as deoxidation and degassing of the weld pool.

The change in the temperature of the carbide liquidus for carbides of the MC type is practically not observed when Ti is added to the alloy. However, this leads to a change in the composition of primary carbides and, at a content of more than 4%, to the precipitation of the η-phase (such as Ni-17Ti-4Nb-1Al-0.22Cr). The introduction of more than 2.7% Ti leads to a change in the base of the carbide from niobium to titanium, while the titanium content in the carbide increases to 55% (Fig. 1).

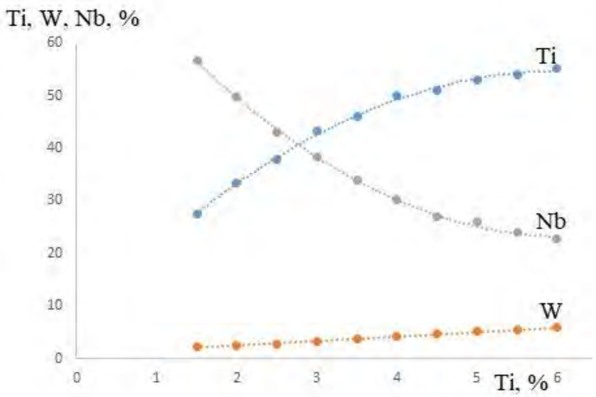

Fig. 1. Dependences of the amount of titanium, niobium and tungsten in MC carbides on the titanium content in the alloy composition

Chromium is an element that influences the formation of secondary carbides; it has a noticeable effect on the temperature of dissolution (precipitation) of carbides. It was found that the corresponding dependences have a complex character and are described by the following equations.

Secondary carbides are formed at a chromium concentration, in this system, at the level of 10%. With an increase in the Cr content in the alloy, the temperature of dissolution (precipitation) of carbides increases, as does its content in the secondary carbide. In this case, the concentration of nickel and molybdenum decreases to 3.5 and 8.8%, respectively, according to parabolic dependences. When the concentration of chromium in the alloy is 31%, a solid solution based on Cr is formed, thus chromium ceases to dissolve in nickel.

The chemical composition of carbides was determined experimentally by X-ray spectral microanalysis, with the help of which the intensity of X-ray radiation was recorded as a function of the energy keV. It was experimentally established that the composition of carbides includes titanium, niobium, tungsten, molybdenum, nickel and chromium in the following ratios in comparison with the calculated values (Table 1).

Table 1 – Chemical composition of carbides calculated from the obtained dependences and obtained experimentally by X-ray spectral microanalysis at 20°

Method of obtaining results	Element content, % wt.						
	Ti	Nb	W	Mo	Ni	Cr	C
Estimated composition MC	25,11	59,09	2,4	-	-	0,49	12,58
Estimated composition $M_{23}C_6$	-	-	9,31	8,62	3,54	73,47	5,06
Experimental composition MC	23,52	51,3	5,76	-	-	6,92	12,5
Experimental composition $M_{23}C_6$	-	-	8,85	8,86	6,0	71,2	5,05

Table 1 shows that the calculated and experimental data are in good agreement with each other for almost all elements. An increased content of chromium and nickel is observed in primary and secondary carbides, respectively. Such values can be caused by an increased content of these elements in the alloy. Thus, the calculated data for determining the type and chemical composition of carbides showed good convergence and agreement with the experimental data obtained by electron microscopy.