MECHANICAL PROPERTIES OF Ti–Al–Cr AND Ti–Al–Cr–Mo ALLOYS

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We investigated Ti–Al–Cr–Mo alloys with a constant concentration of the α stabilizing element (3% Al) and varying amounts of β stabilizers (Cr and Mo). Chromium was added in amounts nominally equivalent to the amount of molybdenum calculated by the formula $C_{Cr}^{C+XMo}/C_{Cr}^{Mo} = Y_{Cr}$, where $C_{Cr}^{Cr} = 6\%$ and $C_{Cr}^{Mo} = 11\%$ are the critical concentrations of β stabilizing elements required to stabilize 100% of the β phase in quenching from the β region.

We also investigated the VT15 alloy (Ti 3Al 7Mo 11Cr).

The alloys were melted from TG-105 titanium sponge, A00 aluminum, an aluminum–molybdenum alloy (30.35% Al, 68.4% Mo, 0.65% Si, 0.68% Fe), molybdenum powder, and electrolytic chromium.

The alloys were melted by vacuum arc remelting with a consumable electrode and cast in ingots weighing 6 kg. The ingots were forged to rods 20 mm in diameter after heating to 1050°C and then to rods 12 mm in diameter after heating to 900°C.

The temperature of the polymorphous α = β transformation ($t_p$) was determined by metallographic examination from the change in structure with quenching from temperature in the α + β and β regions (see Table 1), with holding for 2 h; the transformation temperature of alloy VT15 is 750°C.

Alloys Ti 3Al 6Mo 3,6Cr and Ti 3Al 7,2Cr (equivalent to 12% Mo) and alloys with larger amounts of β stabilizers quenched to β phase from the β region. The concentration of β stabilizing elements is supercritical in these alloys. Alloys with smaller concentrations of β stabilizers (subcritical concentrations) quenched to martensite from the β region.

We investigated the effect of alloying on the mechanical properties of Ti–Al–Cr and Ti–Al–Cr–Mo alloys (see Fig. 1a) annealed at $t_p -50^\circ$ and $t_p -100^\circ$ for 1 h. After annealing at a temperature 50° below $t_p$ and cooling in air the ultimate strength was highest for the alloy with 7.2% Cr and with 5% Mo + 3% Cr ($\sigma_b = 120$ kg/mm$^2$).

The curves showing the variation of the yield strength coincide at the maximum ultimate strength ($\sigma_b = 110$ kg/mm$^2$) in alloys with β stabilizers in an amount equivalent to 12% Mo.

After annealing at $t_p -100^\circ$ the strength of the alloys increases with the amount of alloying elements up to 12% Cr and 10% Mo + 6% Cr. With annealing and cooling in air the unstable β phase in alloys with supercritical concentrations of β stabilizers may be partially transformed to martensite, which is accompanied by an increase of the strength. Annealing at higher temperatures with cooling in air leads to the formation of a large amount of martensite, and consequently to a higher strength.

After annealing at higher temperature, alloys with supercritical concentrations may have a lower strength, which is due to more complete removal of cold working resulting from forging.


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In alloys with subcritical concentrations the variation of the plasticity is similar. Increasing the amount of \( \beta \) stabilizers above the critical concentration leads to a sharp reduction of the plasticity in alloys of the Ti–Al–Cr system.

Increasing the amount of stabilizers in the range investigated leads to an increase of the strength (almost double) and reduction of plasticity, the elongation decreasing by 25–30%. The difference between the ultimate and yield strengths in the annealed condition does not exceed 12 kg/mm\(^2\), and is only 2–5 kg/mm\(^2\) in almost all the alloys investigated.

The mechanical properties of the alloys were determined after quenching from temperatures 50 and 100° below and 50° above the \( \alpha \rightarrow \beta \) transformation temperature (Fig. 1b). The strength of alloys with