TECHNOLOGICAL AND PROCESS CONSIDERATIONS IN SOLUTION TREATMENT AND AGE (STA) OF TITANIUM ALLOY TI6AL4V

Introduction

Ti6Al4V is an alpha-beta alloy which can be hardened by Heat Treatment and Solution Treatment and Age (STA) is used to produce maximum strengths. In order to achieve these maximum properties very strict requirements of the process must be met. The SAE AMS-H-81200 specification describes procedures and parameters which need to be followed in order to achieve maximum mechanical properties listed in AMS4965.

The objectives of this paper are:

1) **To validate STA process by following AMS-H-81200 on two common cross sections of bar form - 25mm and 40mm diameter.**

2) **To measure the mechanical properties and compare against those required by AMS4965.**

Process

Temperature control - close temperature control is essential to make sure the Beta transus is not exceeded which will affect the tensile properties like ductility and cannot be restored by thermal treatment (Slight loss of mechanical properties after Solution treatment at 970°C is presented in table 1). Furnace pyrometry should conform to AMS2750 or BS2M54. Selection of a solution treatment for Ti6Al4V should be made based on combination of mechanical properties required after aging. See actual properties achieved by THTS on 25mm and 40mm dia. bar in table 1.

Soaking Time - Especially for complex shape components or components with various cross sections it's important to measure the temperature of the thickest section and therefore, the heat sinks of the representative cross sections should be used to control the load temperature rather than furnace. This time shall be considered to begin as soon as the lowest reading control thermocouple is at the lower limit of the specified solution treating temperature range.

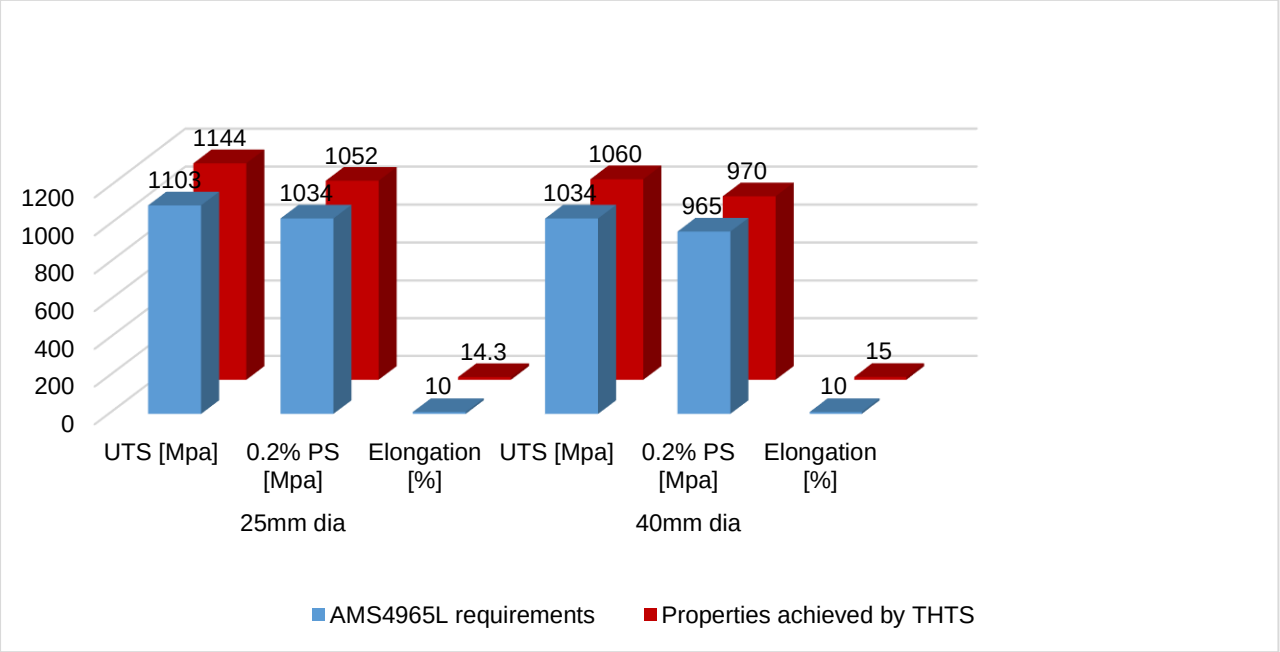
Quenching and cooling - The need for rapid quenching is emphasized by requirement of short quench delay time (transfer of Solution treated parts from the furnace to the quench tank). Ti6Al4V is particularly sensitive due to a low amount of Beta stabilizers and it's important to quench it as quick as 6 seconds. Longer quench delay time can lead to loss of tensile strength. It is also important to recognise that section size has a significant influence on hardenability or (in fact) response to aging treatment. To enhance quenching, components must have a sufficient amount of agitated water available where water temperature is maintained below 38°C. Comparison of response of different cross sections to the same treatment can be found in table 1.

Mechanical properties achieved

Each process was validated based on three test pieces mechanically tested in accordance with ASTM E 8. Summary of measured properties can be found in table 1 below.

Solution Temp.	Age Temp.	25mm	40mm	25mm	40mm	25mm	40mm
		UTS [Mpa]		0.2% PS [Mpa]		Elongation [%]	
900°C	500°C	1158	1080	1066	1000	14.2	19
	520°C	1153	1080	1069	1000	15	15
	540°C	1140	1070	1070	1000	13.5	16
950°C	500°C	1148	1060	1051	960	13.8	18
	520°C	1145	1060	1046	965	14.5	17
	540°C	1144	1060	1052	970	14.3	15
970°C	500°C	1136	1050	1023	940	14.2	19
	520°C	1132	1060	1015	955	15.1	15
	540°C	1137	1050	1032	950	13.9	17

Table 1. Mechanical properties achieved on 25 mm and 40mm dia. bar.



Graph.1 Mechanical properties achieved by THTS exceeding requirements of AMS4965.

Conclusions

1) The range of tests performed by THTS proved that following AMS standards and procedures is the best way to achieve conforming results. All processes mentioned earlier have been followed with adherence to AMS-H-81200 and particular attention to critical times and temperatures. Video recording was used to validate the quench delay time and orientation of the samples during transfer.
2) Tensile property requirements of AMS4965 have been exceeded. High tensile properties achieved on 40mm sample deserve particular attention for those who might consider increasing structural cross section above 25mm.

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