THE MANUFACTURING OF AIRCRAFT-QUALITY HYDRAULIC TUBING WITH THE Ti-3Al-8V-6Cr-4Mo-4Zr ALLOY*

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Introduction

The aerospace industry has a need for materials which offer improved performance at less weight. Titanium alloys are attractive for aircraft hydraulic systems because of their high strength-to-weight ratio.

Ti-3Al-2.5V alloy has been used in aircraft hydraulic lines for the past several years. The Ti-6Al-4V alloy has greater strength but processing it into seamless tubing is more complicated and very costly.

Ti-3Al-8V-6Cr-4Mo-4Zr alloy, developed by RMI Company is a heat-treatable metastable beta alloy with certain improvements over existing beta alloys. This alloy offers a good combination of meltability, producibility, formability, tensile properties and fracture toughness with a relatively low density.

The metallurgy of Ti-3Al-8V-6Cr-4Mo-4Zr is similar to other metastable beta titanium alloys. Solution treating retains the more-ductile, body-centered-cubic beta phase and aging treatments can be used to produce a wide range of higher strengths at surprisingly high ductility levels.

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The main purpose of this program was to make available to the aerospace industries a titanium alloy tubing with higher strength and better forming characteristics than possible with existing titanium alloys.

**Tube Production and Evaluation**

**Production of Tube Shells**

Eleven 7-inch diameter, 80-pound billets were produced for this program. The billets were press forged from a 30-inch diameter production heat of Ti-3Al-8V-6Cr-4Mo-4Zr alloy.

All of the billets were machined to 64 RMS with a 0.75-inch radius on the outside lead edge to facilitate entry into the extrusion press. A 1.775-inch diameter center hole was drilled in nine of the billets and a 2.0-inch hole in two of the billets. The billets were then canned with steel and heated in an electric furnace at temperatures ranging from 1700 to 1800°F. All of the extrusion work was done on a 3,850-ton Loewy extrusion press. The tube shell sizes produced were 2-inch O.D. by 0.200-inch wall and 2.625-inch O.D. by 0.375-inch wall.

Following the extrusion, all tube shells were declad in a 5%HF-35%HNO3-60%H2O pickle solution. Sample shells were then air annealed at temperatures ranging from 1500 to 1700°F to establish the optimum annealing temperature for subsequent tube reduction.

**Tube Reduction**

The seamless tubing produced in this program was manufactured by the tube reducing method. Variables that were investigated in the tube reducing phase of the program included: 1) initial and intermediate thermal treatments, 2) surface quality of tube shells, 3) reduction schedule, 4) percent reduction, 5) feed rate, and 6) die design.

The finished sizes were 0.75-inch O.D. by 0.042-inch wall and 0.540-inch O.D. by 0.030-inch wall. The smallest size tubing, 0.375-inch O.D. by 0.025-inch wall, was cold drawn from 0.540-inch O.D. by 0.030-inch wall.

**Testing**

Of the three finished tubing sizes, one size, 0.75-inch O.D. by 0.042-inch wall was tested extensively to determine the optimum annealing cycle.