Engineering Materials

ENGR 220

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Abstract

The mustang P-51 is an amazing aircraft that was used In the world wars, and it has truly changed the way aircrafts are made today. The mustang P-51 got its name because there was many different transformations that the artcraft went through. What makes it so special is the engineering and materials that went into creating and manufacturing the aircraft. From wheels, to wings, to the structural all the way to the shell of the aircraft. The main focus will be the shell of the aircraft to inform readers of aluminum 2024 and the basic properties it has to offer. Aluminum 2024 is very ductility and at the same time has a lot of strength. Some other topics will include mechanical properties, structural properties, and physical properties this metal has to offer. how the manufacturing process of the Aluminum 2024 T3, and what makes it so incredible as the shell of the mustang P-51.[8]

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Introduction

Aluminum 2024 T3 has many different applications whether it be truck wheels, auto parts, gears or what we will be focusing on today the P-51 mustang. Aluminum changed the design of the P-51 mustang in many ways this report will go through all the amazing ways it has transform the P-51 mustang and many more aircrafts. [4] Also go through the different physical, mechanical, and thermal properties of the metal and the strengths and weakness to the metal.

Motivation

My motivation is my grandfather he loves the P-51 mustang. When they first came into production and the military started using them, he used to clean them and was so amazed by how a simple change in metal made such a huge difference. He has told me so much about them and so many stories about them as well.

Applications

1. Definition

2024 T3 aluminum was used as the skin on the P-51 with a thickness of 0.080 toward the front of the plane and 0.040 used toward the tail. It is also a high-strength alloys and which has copper as the primary. This helps with high strength to weight ratio, it is an easily weldable metal, and fatigue resistance. [8]

2. The Class of Materials

The class of materials it would be listed as aluminum 2024 T3. [7]

3. The Structure of Atoms

The aluminum 2024 has a very fine homogeneously recrystallization structure with submicron-sized grains. Which helps make it so ductile and easy to manufacture in large quantities.[5]

1.2.2. The electronic structure of the solid: energy bands and chemical bonds

The chemical bond and the elements that go into producing aluminum 2024 are silicon 0.5%, iron 0.5%, copper 3.8%, manganese 0.3%, magnesium 1.2%, chromium 0.1%, zinc 0.25%, and titanium 015%. which have a small percentage in the metal as shown. The largest being aluminum which is 90.7%.[10]

2.Physical Properties

Density	Thermal Conductivity	Electrical Conductivity	Specific Heat	Melting Range	Thermal Expansion
2.78 g/cm³ (0.1 lb/in³).	121 W/m-K | 840 BTU-in/hr-ft²-°F.	30% IACS.	0.209 BTU/lb-°F.	500 °C	23.2 µm/m-°C

2.7.1 Thermal Behavior

The thermal behavior of the aluminum is Heat Capacity, Thermal Expansion, Thermal Conductivity, and Thermal Shock. [8]

2.9 Optical properties

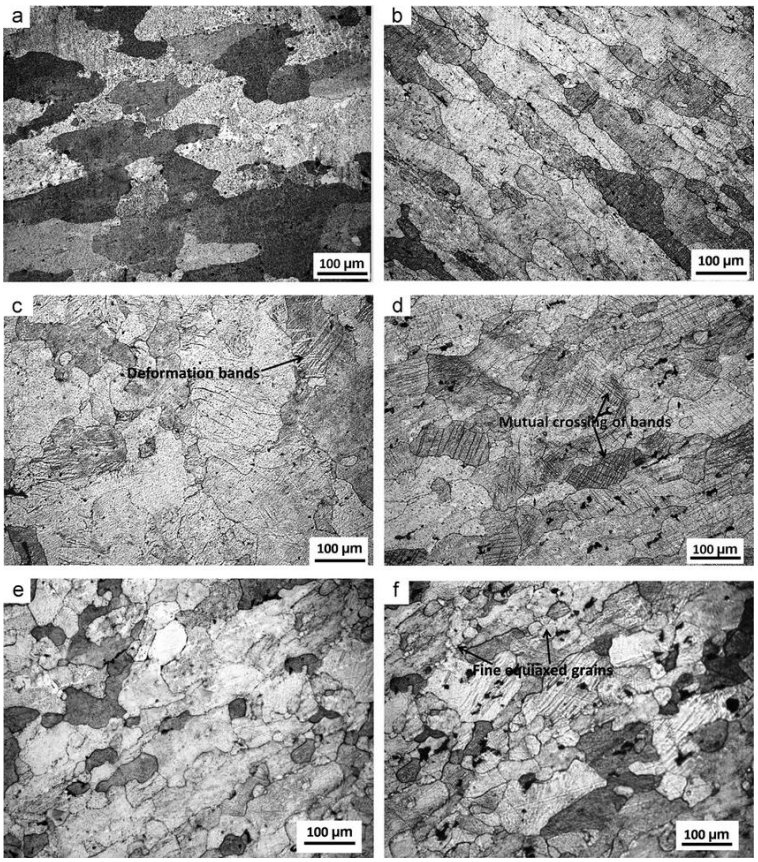

Figure 4. Aluminum 2024 under a mircoscope[9] . ..... Error! Bookmark not defined.

The picture above shows the microstructure of aluminum 2024 T3. Each Figure points out different impurities or failures with the material. Figure, one shows the metal with no impurities or failures after solution treated. Picture two shows the metal after Cred with no impurities or failures. Figure three shows the metal after MAFed-2 showing some deformation bands forming. Figure four shows the metal after MAFed-4 now the metal is showing mutual crossing of the bands. Figure five shows the metal after MAFed-2bAged at 200 degrees for 40 minutes the metal is showing more deformation bands and mutual crossing bands. Figure six shows the metal after MAFed-4bAged at 200 degrees for 40 minutes the metal is showing fine equiaxed grains.[9]

2.10 Corrosion resistance

This type of aluminum is very prone to corrosion. That's why for the P-51 they painted the metal it helps it not corrosion as much. [8]

3.0 Mechanical Properties

3.1 Yield strength

The yield strength of the aluminum is 270–280 MPa. [10]

3.2 Tensile strength

The tensile strength of the aluminum is 400–430 MPa. [10]

3.2.3 Plastic Deformation

The results show no strain rate effect on plastic deformation up to strain rates of about 5000 s^{-1}. Strain rate effect is observed in compression tests at strain rates above 5000 s^{-1}. Tests at various temperatures show decrease in stress with increasing temperature. No strain hardening is observed at temperatures of 300 °C and 450 °C. Effective stress vs. equivalent strain curves generated from tension, compression and shear tests do not coincide indicating a discrepancy with the prediction of the flow theory based plasticity models. Experimental results from tension and compression tests on specimens machined in different orientations relative to the plate rolling direction show that the 2024-T351 plate has anisotropic properties with regard to plasticity. The experimental data can be used for the evaluation and development of constitutive models for plasticity. [8]

Shear Strength	Elongation	Young's Modulus
41000 psi	10–15%	73 GPa

3.7 Ductility

The ductility of aluminum is good. It is a very workable metal and is easy to machine. [10]

3.8 Impact strength

The impact strength of aluminum is high. This is a high strength metal when its heat treated,[10].

3.9 Fatigue resistance

The fatigue resistance of aluminum is excellent [10].

3.10 Hardness

The hardness of aluminum is for a Brinell machine 120, for a Knoop 150, and for a Rockwell 46.8.[10]

3.11 Failure Analysis and Prevention

The failure analysis and prevention of aluminum is

4. Manufacturing Process

The manufacturing process of aluminum is hot working the stock, annealing at 725-875° F., cold rolling, solution heat treating, cooling, holding for at least 12 hours at room temperature, and cold working from about 4% to 7% thereby producing a product having increased strength and toughness properties.[8]

4. Summary

After reading this report that goes over all the different physical properties, mechanical properties, and basic properties. You can see how the aircraft industry selected aluminum 2024 T3 as their shell for the mustang P-51. This metal is very durability, strength and light weight compared to other metals.

5. Appendices

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