

PRESENT STATE AND FUTURE OF MAGNESIUM APPLICATION IN AEROSPACE INDUSTRY

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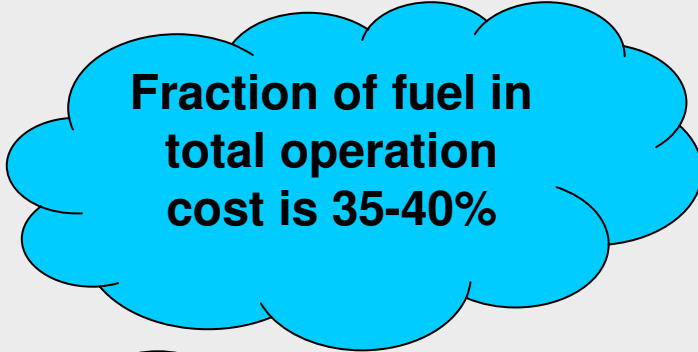
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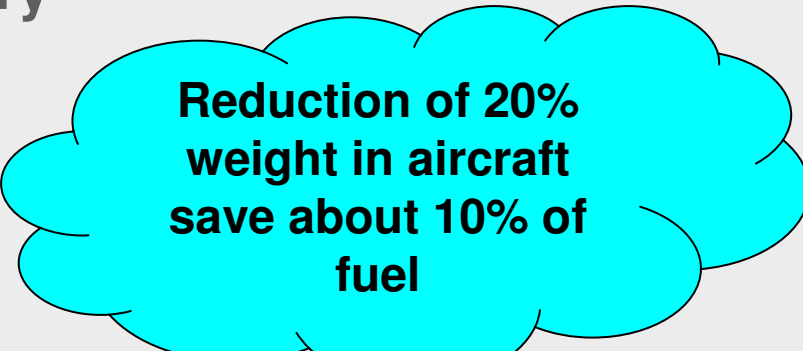
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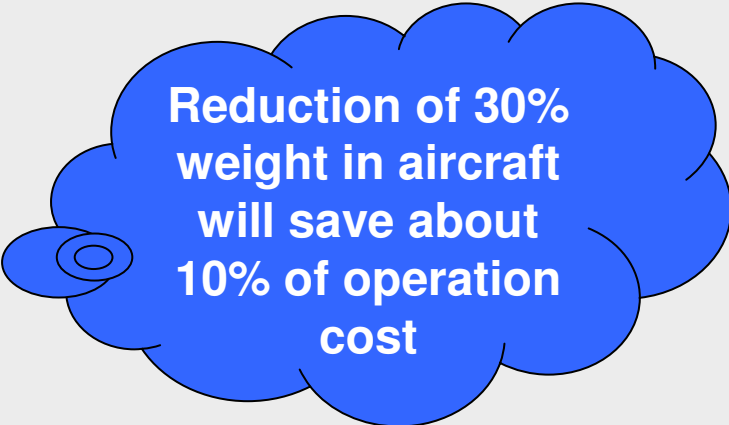
Introduction: Weight Reduction is one of the most important objectives for Aerospace Industry



Fraction of fuel in total operation cost is 35-40%



Reduction of 20% weight in aircraft save about 10% of fuel



Reduction of 30% weight in aircraft will save about 10% of operation cost

Introduction: Weight Reduction Alternatives

● Aluminium:

- Weight Reduction is more and more difficult to be reached with small advances in aluminium material development.

● Fiber Metal Laminates:

- High cost material, applied only for primary structures with highest requirements

● Low-density structural plastics:

- Limited properties under low or elevated temperatures, missing electric conductivity, low impact characteristics and low damage tolerance

Why Magnesium?

- Lightest structural metal available on Earth: 40% lighter than aluminium
- Good mechanical properties
- Metallic behaviour
- Electrical and heat conductive
- Low cost material

Aerospace background of magnesium: West countries

**Sikorsky S-56,
Westland
Aircraft Ltd.
(1950):
115 kg of
magnesium**



**Lockheed F-80C: complete
magnesium construction**

B707, 727, 737, 747 - Boeing
- small wing components
- parts of the doors



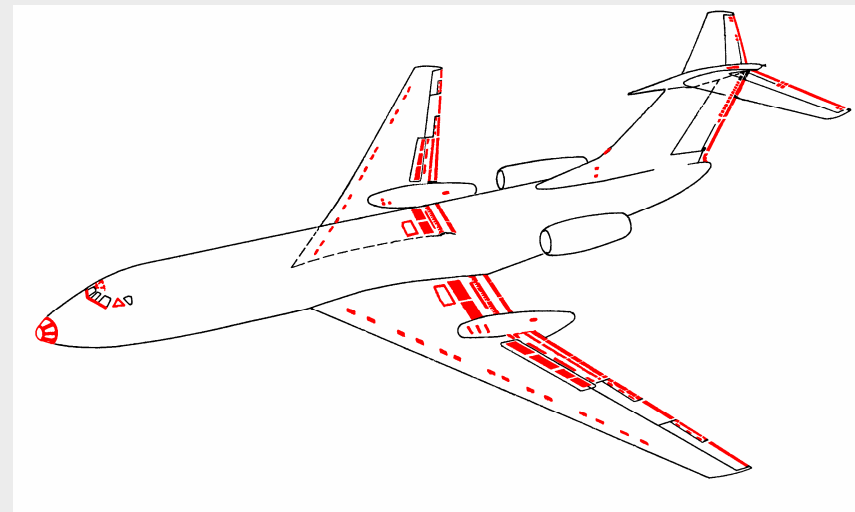
**Convair B-36 Peacemaker:
8600 kg of magnesium!**

Aerospace background of magnesium: Former USSR

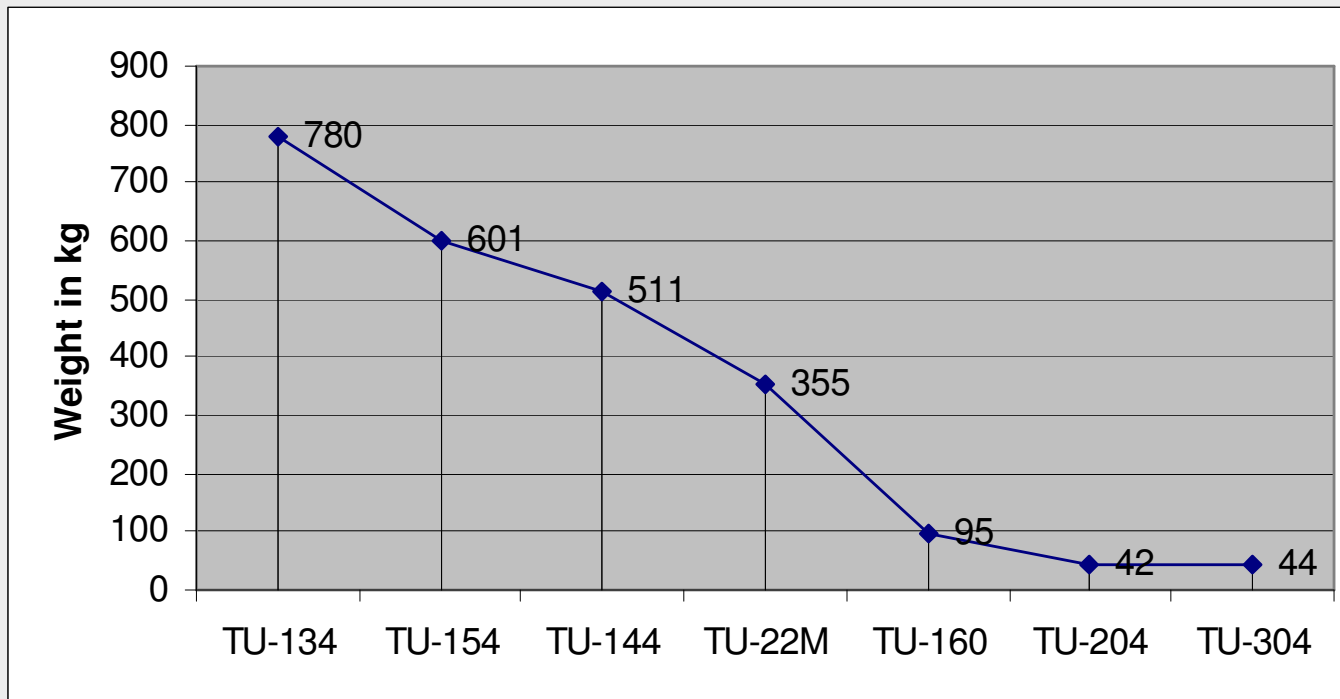


TU-95MS: 1550 kg of magnesium

**Location of magnesium components (in red) in TU-134:
780 kg**



Present situations with magnesium application in aerospace industry: Former USSR



The amount of magnesium in former Soviet aircraft industry reduced on the beginning of 90th last century from hundreds to dozens kg per plane

Present situations with magnesium application in aerospace industry: West countries

Magnesium is not used in structural application by major aircraft manufacturers: Airbus, Boeing and Embraer



Helicopter industry: magnesium is used in cast gearboxes and some other non-structural elements

Magnesium (AM50) die-cast helicopter components (IAI, Israel), PGA ALGAN 2M coating

Why Aerospace Industry reduced application of Magnesium?

- Flammability of magnesium
 - Opposite to common opinion, flammability never was the main reason for magnesium restriction.
 - Magnesium meets all requirements of FAR/JAR standards for flammability resistance.
 - There is no case of aircraft/helicopter accident because of magnesium ignition.
 - **Magnesium is not fire-dangerous metal! This is a psychological problem.**
- Corrosion resistance
 - The real reason for magnesium restriction in the past.
 - Neutral salt spray test (ASTM-117) has much higher acceleration rate on magnesium than on aluminum.
 - New surface treatment technologies such as PGA ALGAN 2M and composite coating Gardobond® X4729 from Chemetall GmbH provide for magnesium the similar to aluminum level of protection.
- Lack of high-strength magnesium alloys:
 - Recently developed by Magnesium Elektron Ltd. (UK) new high-strength alloys Elektron 21 [and Elektron 675 have comparable mechanical properties with aerospace aluminium structural alloys

Future of magnesium: Intensive R&D in European Aerospace industry

- **Aeronautical Application of Wrought Magnesium (FP6 AEROMAG):**
 - Started on March 2005
 - Coordinated by EADS Innovation Works, Germany
 - Consortium partners: EADS Innovation Works (France), Airbus Deutschland (Germany), Eurocopter (France), Alenia (Italy), AMTS (Israel), Magnesium Elektron (UK), Otto Fuchs (Germany), Salzgitter Magnesium Technologies (Germany), SMW Engineering (Russia), VIAM (Russia), VILS (Russia), ENSAM (France), INPG (France), UNI Naples (Italy), UNI Patras (Greece), Technion (Israel), UNI Thessaly (Greece), TU Vienna (Austria).
- **Forming and SPF technologies development for introducing wrought magnesium applications in aerospace (FP6 MagForming):**
 - Started on August 2006
 - Coordinated by Palbam AMTS, Israel
 - Consortium partners: Airbus Deutschland (Germany), EADS Innovation Works (Germany), Israeli Aviation Industry (Israel), Liebherr Aerospace (France), Alubin (Israel), Chemetall GmbH (Germany), Magnesium Elektron (UK), SMW Engineering (Russia), Ultratech (Poland), UNI Hanover (Germany), UNI Prague (Czech Republic).

FP6 AEROMAG: Project objectives

- Development of new Magnesium wrought products (sheets and extrusions), that provide significantly improved static and fatigue strength properties. The strength properties of these innovative materials are required to be as high as AA5083 for non-structural applications and as high as AA2024 aluminium alloys for secondary structure applications.
- Simulation and validation of forming and joining technologies for the innovative material and application.
- Corrosion problem will be solved with newly adapted and environmentally friendly surface protection systems and advanced design concepts.
- Flammability will be investigated and solved with addition of chemical elements and special surface treatments.
- Development of material models and failure criteria for the prediction of forming processes, plastic deformation and failure behaviour of components.
- The technological objective is a weight reduction of fuselage parts, systems and interior components up to 35%. The strategic objectives are an increase in the operational capacity of 10%, a reduction in the direct operating cost of 10% and finally a reduction in the fuel consumption of 10% and therefore a reduced environmental impact

FP6 MagForming: Project Objectives

- Methodologies for the preparation of the raw material for plastic deformation: solidification processes, rolling processes, extrusion and annealing processes, etc.
- Development of special lubrication technology based on easy-removed, high-temperature stable lubricants.
- Development of special heated dies that will have the correct temperatures and temperature gradients and will be controlled by special controllers.
- Development of cooling procedures to attain the best qualities for the manufactured part, as required by the specifications and, at the same time, keeping the press machine far from damage.
- Development of the exact methodology of applying the press loads: strength of force applied, temperature regime, duration of the application of force, process total speed etc.
- Modifications of the parts, using modeling software, to make sure that the magnesium part meets the same specifications required by the end users.

Some of aerospace components target by MagForming



"New Challenges in Aeronautics", Moscow, 2007

Samples of magnesium aerospace components



● Back panel of aircraft door:

- Magnesium AZ31B
- Manufacturing: SPF by Palbam AMTS
- Coating: Gardobond® X4729 by Chemetall GmbH

Samples of magnesium aerospace components



● Aviation Segment

- **Material:** Magnesium sheet 2.0 mm AZ31B. Ring casts from magnesium alloy AZ91C
- **Fabrication (Palbam AMTS):** Deep drawing, rolling, GTAW welding, spot resistance and automatic peripheral welding.
Size: 644x 490 mm
- **Coating:** OXSILAN® MG-0611 (Chemetall GmbH)

Samples of magnesium aerospace components



- **Momentum wheel bracket for Satellite**

- **Material: full bar extruded ZK60A-T5. Fabrication (Palbam AMTS): 3D accurate machining, very thin wall structure. Size: 250 x 150 x 80 mm**
- **Selective coating: PGA ALGAN 2 plus OXSILAN® MG-0611 (Chemetall GmbH)**

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