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# Processing of Aluminium Alloys, Myth and Factualism

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**Abstract:** ***It is often assumed that aluminium alloys are only suited for household items or lightweight structures, yet their presence in aerospace design tells a very different story. In my view, what makes aluminium alloys remarkable is their unique balance of strength and lightness, which directly addresses the aerospace industry's obsession with weight reduction and performance reliability. This material not only withstands extremes of temperature and pressure but also proves highly adaptable in terms of formability and electrical conductivity. That said, the forging process is anything but simple; it requires a disciplined approach to temperature control, die design, lubrication, and post-forging treatments to avoid defects and preserve mechanical integrity. It is evident that the success of aluminium forgings lies as much in process mastery as in the properties of the alloy itself, with every step—from preheating dies to quenching and ageing—demanding strict attention. This suggests that the quality of aerospace components is not merely a function of material choice but of skilled workmanship and infrastructure. Taking this further, one could argue that the reputation of aluminium alloys in aviation rests on a delicate partnership between engineering precision and human expertise, making the selection of experienced forging manufacturers an indispensable part of the equation.***

**Keywords:** Aluminium alloys, Aerospace applications, closed die forging, Process control, Mechanical properties

## 1. Introduction

There is a common belief among people that aluminium alloy products are low in strength and are used only in non-critical areas such as household utilities, door/window frames, etc. However, many would be surprised to learn that this material plays a crucial role in aerospace and aircraft applications.

Aluminium alloys are often the preferred choice for aerospace design due to their excellent corrosion resistance and high strength-to-weight ratio. Compared to steel, aluminium is significantly lighter, making it an ideal material for a wide range of aircraft components and aerospace systems.

In aircraft and rockets, minimizing the overall weight of the assembly is critical, and the use of aluminium alloy products helps achieve this goal without compromising on functional performance.

With its lightweight properties and high strength-to-weight ratio, aluminium has been the preferred choice of metal materials for aerospace applications.

1) **Benefits that aluminium offers for aircraft applications**
   - Durability in high stressed environments, temperature and pressure extremes
   - Formability allows for easy fabrication for smaller aircraft parts
   - Aluminium alloys offer high electrical conductivity
   - Due to the lightweight properties of aluminium, it offers a cost-effective alternative to other material types. Lighter aircraft can equate to less fuel consumption and an overall cost-saving advantage
   - Forged aluminum parts exhibit excellent mechanical properties, including high strength and durability, making them suitable for demanding applications.
2) **Closed-die forging** of aluminium alloys for aerospace applications is highly challenging, as it depends on the specific aluminium alloy grades and requires strict process control throughout the operation. Die design plays a critical role in achieving the desired shape, dimensional accuracy, and quality of the forged part.

## 2. Process parameters and precautions

Since temperature plays a vital role in determining the quality of the final product, electrically heated furnaces are used to ensure controlled and uniform heating of the input material. The typical forging temperature range for aluminium alloys is between 400°C - 450°C. However, during the forging process, the material temperature can rise significantly due to adiabatic heating. This temperature rise must be taken into account, and the furnace temperature should be set accordingly.

If the material is overheated, it can lead to excessive grain growth, reduced mechanical properties, and deviations in ultrasonic quality. To prevent a rapid drop in forging temperature, the closed-die forging dies must be preheated to a minimum of 300°C, and this temperature should be maintained consistently throughout the forging process.

It is also important to note that prolonged heating times, even at recommended temperatures, can result in grain growth and the formation of internal defects. Therefore, precise control of both temperature and heating duration is essential for achieving high-quality aluminium alloy forgings.

To achieve good mechanical properties in the final product, the input material must first be worked in all directions using open die forging before proceeding to closed die forging. A minimum total reduction ratio of 10 is required.

This process ensures uniform deformation of the material, which in turn helps achieve the desired mechanical properties, refined grain structure, and ultrasonic soundness in the forged component.

During forging, due to the inherent properties of aluminium alloys, the forgings are prone to sticking to the dies as a result of material galling. To prevent this, die impressions must have a very smooth finish with generous corner and fillet radii. Lubrication is also essential to reduce friction and minimize sticking; graphite-based lubricants should be applied before forging each part.

After forging, the parts should be allowed to cool gradually to prevent the development of internal stresses and cracks. Heat treatment is then carried out based on the alloy grade and the mechanical property requirements of the final product.

During solutionizing, the rise in water temperature should be controlled through proper agitation to maintain effective quenching. The quench delay should be kept below 30 seconds to ensure optimal results. Additionally, prolonged time between solutionizing and ageing should be avoided to eliminate the effects of natural ageing.

Jobs are to be machined only after evaluating the mechanical properties. Also, before machining conduct NDT tests for ensuring defect free product.

## 3. Conclusion

The quality of aluminium alloy products can be ensured only through strict process control and disciplined practices on the shop floor. The quality of forged aluminium components largely depends on the skills of the workforce and the infrastructure capabilities of the supplier.

Therefore, selecting an experienced closed-die forging manufacturer with proven expertise in processing aluminium alloys is essential to achieving products that meet the required specifications and quality standards.

## References

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