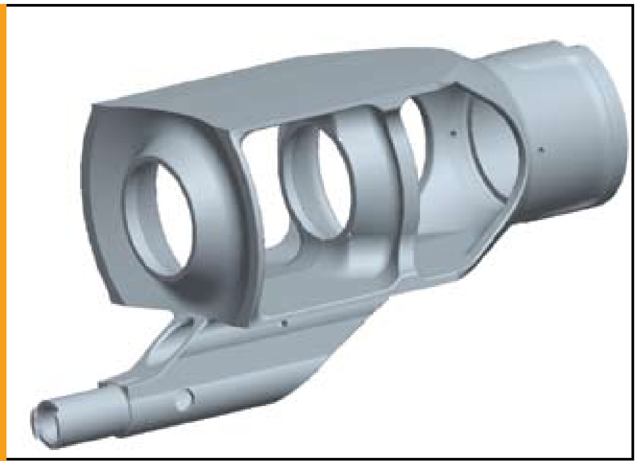
Aerospace Materials for Ground Vehicle Applications

Tough, Lightweight, and Corrosion Resistant



Machined single-piece muzzle brake assembly casting. Joint Program Management Office photo.

Background

The aerospace industry has long required specialized materials to meet strict quality and safety requirements. To address these requirements, materials certified for aerospace use typically exhibit high strength-to-weight ratios, superior fatigue strength and enhanced resistance to corrosion. In addition, the materials must be free of defects that could potentially cause failure of key components or systems mid-air.

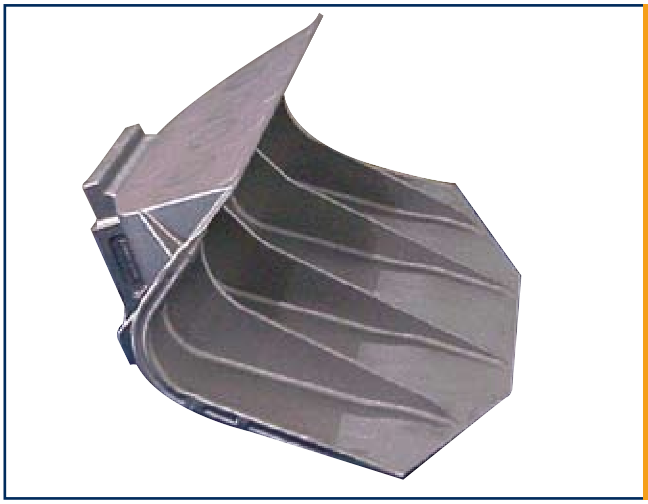
Due to the high cost of manufacturing materials with these properties, past demand for them was usually limited to and dependent on the aerospace industry. While many of these materials may have been appropriate for non-aerospace applications such as military ground vehicles, the prohibitive cost and lack of designer experience with them impeded implementation.

Technology

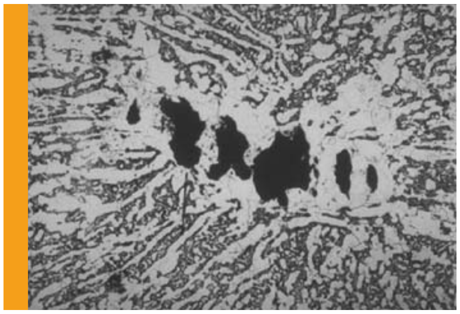
Times are changing. As manufacturing technologies improve and traditional aerospace materials become more affordable, their use outside of the aerospace industry is being promoted.

One of the most critical issues faced by the aerospace industry is the elimination of material defects. Hard alpha and high density inclusions in titanium are two examples of such defects. These imperfections can reduce fracture toughness, fatigue resistance and ductility, thereby potentially causing catastrophic failures if they find their way into critical systems such as turbine jet engines. The 1989 crash of a DC-10 in Sioux City, Iowa, is one of the most well-known examples of such a failure. According to National Transportation Safety Board report No. NTSB/AAR-90/06, a crack emanating from a hard alpha inclusion in the titanium fan hub in one of the engines caused the component to fail. The resulting shrapnel severed hydraulic lines and ultimately caused the plane to crash during an attempted emergency landing.

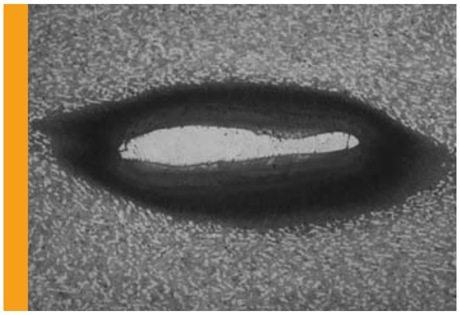
To prevent such failures, highly controlled hearth melting processes, as well as rigorous testing and inspection, are



M777 Lightweight Howitzer spade. CTC photo.



Hard-Alpha Inclusion



High-Density Inclusion

Material defects, including hard alpha (left) and high-density (right) inclusions, can alter the effectiveness of aerospace materials. GE Aircraft Engines photo.

employed by the aerospace industry to improve material cleanliness. Because military ground vehicles typically do not have the extreme fracture toughness and fatigue requirements that aerospace components do, such defects present less of a problem. As a result, material processing and inspection procedures can be tailored to the less stringent ground vehicle application requirements, thereby making the materials more cost-effective to implement

Two additional aerospace material characteristics that are being considered in the design of military ground vehicles are strength-to-weight ratio and ballistic performance. Faced with the challenge of creating transportable vehicles that provide superior protection at the lowest possible weight, designers are considering aerospace materials such as titanium (Ti) and aluminum-lithium (Al-Li) alloys.

Applications

Titanium, a ubiquitous aerospace material, recently found a home on several ground systems including the Stryker Mobile Gun System and the M777 Lightweight Howitzer. One of the key performance factors of the Stryker vehicle is its need to be transportable by C-130 cargo plane, allowing it to be deployed anywhere in the world within four days. To help reduce the vehicle weight to meet this requirement, Ti is being considered as a replacement for steel on components such as the gun pod and elevation arm.

The M777 is a Ti-intensive design that exploits high-strength alloy Ti-6Al-4V, which enabled the M777 to be approximately 6,000 lbs lighter than its 16,000 lb. steel-intensive predecessor. Work by the Navy Metalworking Center (NMC) has enabled large near-net shape Ti-6Al-4V castings to significantly reduce parts count and welding lineage, resulting in a lower cost, more robust weapons system.

Al-Li alloy 2195—the main structural alloy on the External Tank of the Space Shuttle—and its sister alloy 2094 are being transitioned to military ground vehicle applications by NMC. Their high specific strength, stiffness, and damage tolerance have made them effective in reducing weight on aircraft and space launch systems. The weldability, fracture toughness and strong ballistic performance of 2195 landed it the distinction of being the first Al-Li alloy to be seriously considered for use on a military ground vehicle, as evidenced by its use on the Future Combat System-Wheeled (FCS-W) prototype.

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