INTERNATIONAL MOLYBDENUM ASSOCIATION
THE VOICE OF THE MOLYBDENUM INDUSTRY

Making light of heavy vehicles

The drive to protect the planet for future generations is gathering momentum. Where possible, organizations are striving to reduce their environmental footprints. This is undoubtedly the case in the automotive industry, with initiatives like light-weighting and the development of electric vehicles. Molybdenum-containing steels enable a number of exciting improvements in efficiency, safety, and sustainability in heavy vehicles.

Lighter trucks can reduce fuel consumption, and with that, air pollution.

Tens of millions of trucks drive enormous distances each year to deliver their loads. The movement of goods is a complicated, resource-intensive affair. Despite efforts in recent years to remove freight from the roads onto alternative modes of transport, such as trains or ships, trucks remain the backbone of the industry. These heavy, gas-guzzling vehicles deliver anything from building supplies, to clothes and groceries, to fuel and heavy industrial parts. Today's world would simply grind to a halt without the constant movement of freight on the roads. Finding ways to lessen the environmental impact of trucking is therefore essential for a more sustainable transport of goods and commodities. Specialized, molybdenum-containing steels are helping to make trucks and other vehicles lighter, and therefore, more fuel-efficient.

Molybdenum – keeping things light

Molybdenum has been part of the steel structures of cars and light-weight vehicles for more than 30 years. Moreover, in recent years government agencies around the world, including the U.S. Department of Energy, have set specific targets for weight reductions in heavy trucks by 2050.

With this in mind, it is clear that molybdenum is set to play an even greater role in making trucks safer, more efficient, and more sustainable.

Such weight reduction targets can be achieved with many different materials. Carbon fiber composites, aluminum, glass fiber composites, advanced high-strength steels, as well as steel and cast-iron materials are all potential options. However, materials that are not traditionally used in the manufacturing of heavy trucks, such as carbon fiber and glass fiber composites, present significant technical challenges in terms of joining and forming. Aluminum is currently used in a limited capacity but presents a different set of technical difficulties. High-strength steels and cast-iron materials have many properties, including strength, weldability, and formability, that make them ideal for heavy vehicles. And with the current state-of-the-art manufacturing technology already in use, it is possible to incorporate these materials without having to revamp existing production facilities.

Performance criteria between trucks and cars are, of course, completely different. On average, trucks cover about 150,000 kilometers per year, and they have considerably more power and torque than cars. But the weight of the truck cab is surprisingly similar to that of a car – about 326 kilos – and uses many of the same materials.

Molybdenum-containing high-strength steels and press-hardened steels are used increasingly in both truck cabs and cars to reduce weight. More critically, new safety crash standards introduced in Europe to protect truck drivers called for improved truck designs. The use of high-strength steels provides the required levels of crashworthiness while reducing the overall weight, resulting in both a safer and greener truck.

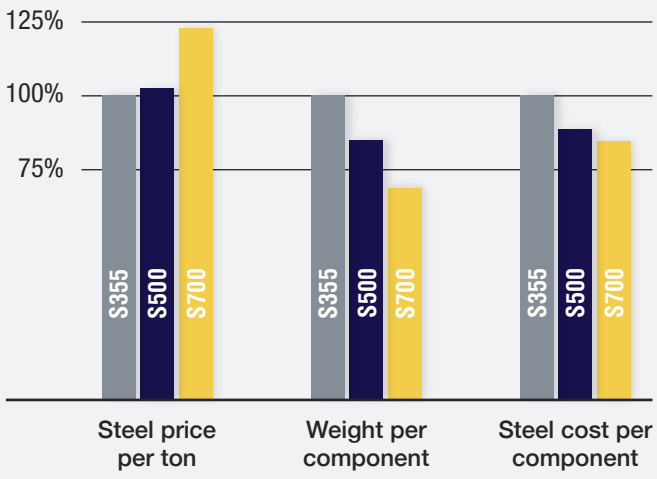
Proven performance in China

In a recent project to design new steels in China, using an improved 670 MPa strength steel reduced the weight of a truck's trailer beam by 27%, when compared to the original 520 MPa steel. This reduction was possible due to the steel – which contained 0.2% molybdenum – being stronger and thinner than the original. In this case, the higher-strength steel was found to show the best performance to cost ratio for many major truck components. These new, lighter parts are either cost-neutral or even cheaper than those made of traditional steel. The result is a "win-win" situation that has tremendous potential for both the environment and manufacturers.

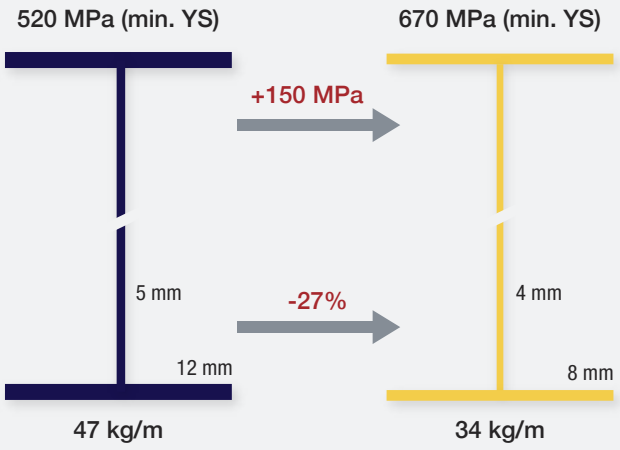
The heaviest part of the truck is the power train, which contains the drive axels. These are ordinarily made from a fairly low-strength steel (350 MPa), and weigh between 200 and 600 kilos. Current research projects in China are developing alloyed steels with increased strength. If these projects can realize the target strength of 550 MPa, it will result in a drive axel weight reduction of around 31%. The axel housings under development also allow for the use of electric engines to support the hybridization of trucks.

Using a stronger steel means that the cross section of the trailer beams can be reduced, making the trailer lighter.

Economics of light-weighting with high-strength steel



Example of weight saving in a structural trailer beam (150 x 465 mm)

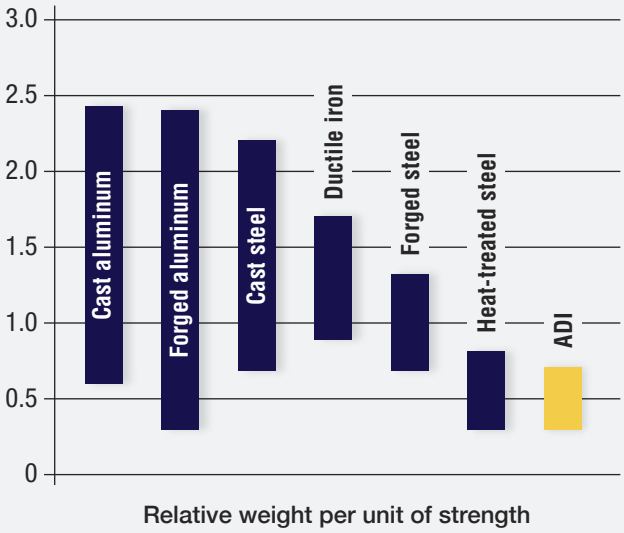


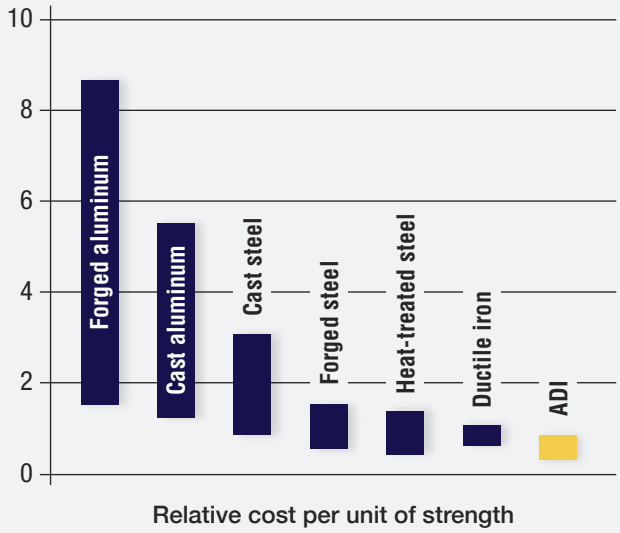
Light-weighting truck components with stronger materials can make trucks lighter, allowing increased payload and improved operator profitability.

Other applications in trucking

Trucks have many other heavy gauge parts that have to endure significant loads, shock, and wear. One example is the “fifth wheel”, where the trailer is hooked to the cab. Typically made from molybdenum-alloyed Austempered Ductile Cast Iron (ADI), it has a 10% lower density than steel, meaning it’s lighter than any steel alternative. ADI also has excellent noise damping capabilities and self-lubricating properties in dry contacts. ADI is not only used in the fifth wheel but also lends its light weight to other parts of the truck. For example, ADI wheel hubs, containing 0.3% molybdenum, are 20% lighter than comparable aluminum ones.

ADI's competitive position vs. steel and aluminum





Molybdenum also plays a significant role in one of the vital safety features of a truck: the brakes. When applied, brakes create substantial amounts of heat. Therefore, they need to be made out of a material that has good thermal conductivity to ensure that the heat is lost quickly.

Typical ductile iron truck components include wheel hubs and parts of the suspension system.

Grey cast-iron alloys are ideal metals for brake discs and drums. The addition of 0.2–0.4% molybdenum increases strength and thermal conductivity, while forming carbides to enhance wear resistance.

There is also an unyielding demand for greater engine efficiency. The U.S. Department of Energy has set stringent targets for reducing weight and increasing the efficiency of engines between now and 2050. This requires yet-to-be-developed irons and steels with higher strength specifically to support engine downsizing.

Current diesel engine efficiency is around 40%. In the future, up to 60% will be achievable, reaching similar efficiency levels as a hydrogen fuel cell. These increases in efficiency demand higher temperatures in the exhaust system and higher pressure in the cylinders. IMOA is working with Shanghai University's casting unit to develop grades of molybdenum-containing cast iron that can achieve the required results by optimizing heat conductivity, strength, and thermal fatigue resistance.

Research projects like this are an important part of ensuring trucking remains viable as a sustainable option for getting goods from A to B. It will take years, perhaps decades, and significant research and funding to achieve 60% engine efficiency. But work is ongoing, and progress is being made. One thing is clear: for millions of vehicles around the world, molybdenum's role is proving to be increasingly important. (Stratia, Hardy Mohrbacher)