RARE METALS USED FOR MANUFACTURING EXOSKELETONS

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Annotation: The field of exoskeleton technology is rapidly advancing, with applications ranging from medical rehabilitation to military use and industrial support. At the core of these high-tech suits lies a selection of rare metals that enhance their performance, durability, and functionality. As demand for exoskeletons continues to rise, understanding the materials that make these devices not only possible but effective is crucial.

Keywords: Exoskeletons, titanium, cobalt, tantalum, technology, vanadium, niobium.

Introduction: Exoskeletons are wearable devices that augment human capabilities by providing support for movement, strength, and endurance. They are designed to assist individuals with physical disabilities, aid in recovery from injuries, or enhance the physical capabilities of workers in demanding fields. A lot of operations in industries is still done manually due to high expense of employing robots. Industry workers are usually required to perform burdensome tasks. As a result, spine-related disorders are a huge issue to be addressed in industrial contexts. Handling loads manually is a physically demanding activity which is indeed common in many industrial scenarios. It involves jobs such as lifting heavy loads and maintaining certain postures for a long duration, which generates huge compressive loads on the lower spine, and can be considered to be a major factor responsible for injuries related to the spine. It is difficult to automate the workplaces in Construction, Shipbuilding industry and Nursing. Operators in such industries must go for heavy lifting for longer duration and suffer from lower back pain. Long-term heavy lifting activities can significantly increase the lumbar spine and waist injuries. Injuries caused at workplace not only swells the expenses of the industries, but notably have a critical influence on the life's nature of the worker.

Guidelines provided for the ergonomics and safety for the industry objectifies to minimize the physical work demand on the industry workers, which in turn results in very strict rules for workers limiting them from performing heavy load lifting tasks. The limitations on manual material handling operations are in terms of weights of objects to be handled and how often are they needed to be moved. The materials used in constructing these devices play a pivotal role in their effectiveness. Exoskeletons, which are wearable robotic devices that enhance the wearer's physical capabilities, often require advanced materials to ensure functionality, durability, and lightweight characteristics. While many exoskeletons utilize common metals and alloys, certain rare metals and materials can also play a critical role in their design and manufacturing. Here are some notable rare metals and materials that may be used in exoskeleton manufacturing:

- Titanium: Although not extremely rare, titanium is a high-strength, lightweight metal that is often used in aerospace and medical applications. Its biocompatibility makes it suitable for medical exoskeletons.
- Tungsten: Known for its high density and strength, tungsten can be used in components that require high durability and resistance to wear.
- Cobalt: This metal is often used in high-strength alloys and can provide excellent wear and corrosion resistance, which is beneficial for exoskeleton joints and hinges.

- Rare Earth Elements (REEs): Elements such as neodymium and dysprosium are used in high-performance magnets for electric motors and actuators. These magnets are crucial for the efficient operation of exoskeletons.
- Lithium: As exoskeletons are often battery-operated, lithium plays an essential role in providing lightweight and long-lasting power sources. Lithium-ion batteries are typically used in these devices due to their high energy density, allowing exoskeletons to operate for extended periods without frequent recharging. As the demand for exoskeletons increases, innovations in lithium battery technology continue to enhance performance.
- Zirconium: This metal is valued for its corrosion resistance and strength, making it useful in components that may be exposed to harsh environments.
- Magnesium Alloys: While magnesium itself is not rare, certain magnesium alloys can provide a strong yet lightweight option for exoskeleton frames.
- Vanadium: Vanadium is increasingly being recognized for its strength and toughness, making it a valuable addition to exoskeleton materials. It is typically combined with other metals to improve the overall mechanical properties of the alloys used in structural components. This strength is vital for the versatility and adaptability of exoskeletons, enhancing their effectiveness in various applications, including industrial and military fields.
- Niobium: Known for its strength and ability to withstand high temperatures, niobium can be used in specialized applications within exoskeletons.
- Aluminum-Lithium Alloys: These alloys combine the lightweight properties of aluminum with the strength and fatigue resistance provided by lithium, making them ideal for exoskeleton structures.
- Magnesium: A lightweight option, magnesium is increasingly popular in exoskeleton design. Its attributes allow for the creation of frames that are strong yet incredibly light, easing the load on users and improving overall functionality.
- Tantalum: Tantalum is another rare metal used in exoskeletons, primarily due to its high melting point and excellent chemical resistance. This metal is often utilized in the manufacture of intricate electronic components that are integral to the functionality of exoskeletons. Tantalum’s ability to withstand high temperatures makes it particularly suitable for the electronics that can control movement and response in exoskeleton systems.

The choice of materials often depends on the specific application of the exoskeleton, whether it's for medical rehabilitation, military use, or industrial applications. Each metal or alloy has its unique properties that can enhance the performance of the device. Some materials, such as Titanium alloys and Kevlar, have exceptional material performance index scores. However, when other attributes of these materials are considered, such as cost or compressive strength, they are ruled out. Al7075 and Carbon Fibre are two materials that perform well in terms of material performance index as well as other mechanical properties. Carbon Fibre, Kevlar, and Fiberglass are the most prevalent composites used in exoskeleton frames. Carbon fibre will be the most suitable material for the exoskeleton frame with the highest performance index 5.822 and with only a little variation in Z value, Kevlar comes in second.

Conclusion: In conclusion, the integration of rare metals such as titanium, tantalum, cobalt, lithium, and vanadium is integral to the development of exoskeletons capable of enhancing human performance. As the field continues to grow, the challenge will be to balance the benefits of these materials with sustainable sourcing practices, ensuring that exoskeleton technology can flourish for years to come. As technology evolves, the focus on developing lightweight yet powerful exoskeletons will likely lead to innovative materials research. Researchers are exploring alternatives to traditional rare metals, including advanced composites and recyclable materials, to reduce dependency on scarce resources. These advancements may not only enhance the sustainability of exoskeleton manufacturing but also improve the affordability and accessibility of these transformative devices.

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