



The Trend Towards Increasing Use of Electrical Actuators in the Aerospace and Defense Industry

Highly capable alternative meets demanding requirements and delivers superior performance

KOLLMORGEN®

Hydraulic and pneumatic systems have traditionally been the market leader in providing power in the aerospace and defense industry because of their low cost and high power density. But in recent years, attention has been focused on the limitations of hydraulic actuators including their weight, performance and high maintenance requirements, as well as concerns over their vulnerability due to security issues and other risks.

Recent advances in electric actuator technology have included improvements in permanent magnet materials and more robust, yet efficient, electro-magnetic designs. These developments have increased power density while providing superior performance in a wide range of applications and substantially reducing the cost of electric actuators. The result has been a gradual shift in recent years towards the use of electric actuators in the aerospace and defense industry.

The white paper discusses how today's electric actuators are a viable and cost-effective alternative solution to overcoming limitations found with existing hydraulic and pneumatic systems, while improving the performance of aircraft, ships and land vehicles produced by the aerospace and defense industry.

Reduced Weight Lessens Energy Consumption

The Department of Defense (DOD) is the single largest consumer of energy in the United States. As early as 2006, the DOD was spending about \$10 billion on mobility fuels.¹ In its 2010 energy plan, the Air Force set the goal of reducing demand for energy.² To achieve this goal, it was determined that reducing the weight of aircraft directly correlates to a reduction in fuel spend, by reducing drag. In 2012, American Airlines estimated that it saved \$1.2 million dollars a year in fuel by replacing a 35-pound paper manual with an iPad.³

One method of reducing weight is by changing from hydraulic and pneumatic to electric actuators. Only one energy conversion is required in an electric actuator compared to two in a hydraulic system. This eliminates the weight of the components that perform the second conversion, including the hydraulic power unit, connections and fluid.

Boeing has performed analyses that show how electrically powered technology can provide weight savings ranging from a few hundred to several thousand pounds, resulting in annual savings of several million dollars in operating and acquisition costs.⁴



Fuel savings through weight reduction is prevalent in other defense and military applications. For example, the use of electric actuators is increasing in ground combat vehicles. Typical applications of electric actuators include main battle tank and artillery gun laying systems, gun and turret drive actuators and traverse actuators. Electrical

systems weigh substantially less than hydraulic systems due to the elimination of piping, the hydraulic power unit and hydraulic fluid. Another advantage is that they run only when being used, while hydraulic drives require continuous pump operation.

The movement towards electric actuators is expected to increase with the Joint Light Tactical Vehicle (JLTV) program of vehicles that has been designed to, first complement, and then ultimately replace, the High Mobility Multipurpose Wheeled Vehicle (HMMWV) Humvee, currently fielded by the United States Marine Corps and Army. The ProPulse hybrid diesel-electric powertrain option for the JLTV maximizes the system's efficiency with improved fuel economy and generates exportable power, both while stationary, and on the move. Diesel-electric powertrains are made up of a diesel engine connected to an electrical generator, which creates electricity to power an electric traction motor, driving each axle to move the vehicle. The ProPulse powertrain can be set up to export between 30 and 70 kW of military-grade power based on mission requirements.⁵

¹ <http://www.brookings.edu/~media/research/files/papers/2007/8/defense%20energy/energy20070815.pdf>

² <http://www.safie.hq.af.mil/shared/media/document/AFD-091208-027.pdf>

³ <http://www.wired.com/2012/09/how-can-airlines-reduce-fuel-costs/>

⁴ http://www.icas.org/ICAS_ARCHIVE/ICAS2006/PAPERS/736.PDF

⁵ <http://www.oemoffhighway.com/article/10909561/pulled-into-the-combat-field>

Increased Overall Effectiveness and System Reliability Improves Performance

While traditionally non-propulsive systems on an aircraft are driven primarily by hydraulics and pneumatics, the “More Electric Aircraft” concept envisions moving to electric actuators wherever possible. High performance magnetic materials, power electronics and gear technology make electric actuators increasingly competitive with hydraulic actuators in power-to-weight ratio. This trend is accelerating as aircraft original equipment manufacturers (OEMs) collaborate with their suppliers to design new systems and implement new electrical-intensive architectures. Most new aircraft designs today use electrical actuators for the spoilers, flight controls and some flaps to replace hydraulic drives previously used in these applications.

The Boeing 787 was among the first “most electric” aircraft. The elimination of the pneumatic system in this aircraft resulted in efficiency improvements through the elimination of the need to convert engine shaft power to pneumatic power. The extraction of electrical power from the engine provides an efficient way to operate wing de-icing, secondary flight control actuators, cabin pressurization system, braking system and the engine starting system.⁶

Another advantage of electric drive systems is that they provide increased quantity and quality of data. Hydraulic drives provide only inferred feedback through the hydraulic signal, while electric drives deliver real-time feedback through the motor controllers. Electric drives can be linked to remote diagnostic systems that simplify diagnostic fault finding and can provide continuous data input for around the clock analysis.

Electric actuators are being used in the latest US naval vessels for door and hatch opening and closing, loading mechanisms, jet blast deflector control, lifts, cranes, cargo conveyors, load ramp positioning, firing pins and winches. The US Office of Naval Research recently stated: “The move to integrated, all-electric designs will significantly improve efficiency, effectiveness and survivability, while simultaneously increasing design flexibility, reducing costs and enhancing sailors’ and marines’ quality of service.”⁷

⁶ <http://www.ainonline.com/aviation-news/2006-09-12/upstarts-favor-electric-while-establishment-sits-fence>

⁷ <http://www.msstate.edu/web/media/detail.php?id=2163>

Less Complex Design Dictates Fewer Parts that Result in Reduced Downtime and Maintenance Costs

Electric actuators provide higher resolution for more accurate control and greater repeatability, as well as faster reaction time. System reliability is increased, given the reduced part count, by eliminating the need for the hydraulic power unit, solenoids, directional control valves, hydraulic couplings, filters, pressure sensors, accumulators and moving parts inside the control module. In addition, the design is much simpler, and the system experiences less downtime. The elimination of hydraulics also eliminates the need to replace and dispose of fluids.

By reducing the number of parts, an electric drive reduces the likelihood of a complex mechanical failure. Also, electric actuators reduce the burden on maintenance personnel, providing higher reliability and lower life-cycle cost. The use of electric drives also reduces installation time since all that is required is the installation of the actuator, and electrical power and feedback cables. Electrically driven systems are not affected by pressure drops like hydraulic piping systems. They have many fewer wearing components than hydraulic drives so they are less prone to failure and require less maintenance.

The use of electric motors provides the potential for a more compact, quieter, higher density design by integrating a frameless electric motor into the valve. [Frameless motors](#) are comprised of a separate rotor and stator without bearings, housings, or feedback devices. These components are intended as a kit to be designed into and become a direct part of the machine itself. This eliminates noisy, high maintenance components such as gearboxes and couplings. If the system operates as a closed loop servo, the feedback device must also be designed into the machine. An electronic drive amplifier runs the motor and manages the feedback device. The noise reduction provided by frameless electric actuators is particularly beneficial in enclosed spaces such as in submarines.

The move towards use of electric actuators is being encouraged by the increasing use of electric propulsion systems and electric weapons systems, which make it possible to achieve an all-electric ship. With electric propulsion, a generator converts the engine’s revolutions into electricity for all of the electric powered equipment on the ship.



KBM™ Frameless Motor Series

The [KBM Series frameless motor](#) is engineered to provide high performance and long life with simple installation. The direct load connection of the KBM eliminates maintenance, noise and added weight of gearboxes, belts or pulleys.



TBM Frameless Motor Series

The [TBM Series](#) direct drive frameless motor is designed for use in applications where high power is critical in a weight reduced, compact form. The TBM Series frameless motor can enable a system to have more accurate control, greater repeatability and faster reaction time.

Improved Safety and Reduced Risk

A key advantage of electric drives is the elimination of the hydraulic pumping system which requires maintenance, is susceptible to leaks, and requires special disposal of the fluids. Hydraulic fluids can pose potential health concerns through exposure to the eyes, ingestion, inhalation and skin contact.⁸

United States military uses remote operated vehicles (ROV) for search and recovery. ROVs with hydraulic thrusters have a considerable number of parts, including the hydraulic power system, compensators, valve packages and lines. A malfunction in any of these components could jeopardize the completion of the mission. In addition, the electrical power carried by the umbilical to the ROV has to be converted to hydraulic power which results in a considerable loss in energy. These challenges can in many applications be overcome by ROVs driven by electric drives. Electric motors are much more reliable because they have no need for potentially leaky couplings and tubing. All-electric ROVs also remove the risk of discharge of hazardous fluids into the environment and contribute to a more responsible “green” solution.

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http://ws.eastman.com/ProductCatalogApps/PageControllers/MSDS/Show_PC.aspx

CONCLUSION

Hydraulic and pneumatic systems have long been entrenched in aerospace and defense applications because of their higher power density. Today, electric actuator systems are closing the gap, enabling many applications to use electric motors on retrofits and new systems.

The reduced weight of electric actuators decreases fuel costs. Converting to electro-mechanical actuators delivers other performance benefits such as increased efficiency and improved data acquisition. Maintenance costs and overall life cycle costs are reduced over the lifetime of the system due to design simplicity and reduced part count. Additional benefits feature noise reduction and improved safety with an electro-mechanical system.

Designers of aerospace and defense systems are looking for a safe, more robust and effective platform which also delivers the lowest total cost of ownership. While the best solution will be different for every application, it's clear that the trend in the aerospace and defense industry is moving towards electric actuators because of their many advantages.

ABOUT KOLLMORGEN

Kollmorgen is a leading provider of motion systems and components for machine builders around the globe, with over 70 years of motion control design and application expertise.

Through world-class knowledge in motion, industry-leading quality and deep expertise in linking and integrating standard and custom products, Kollmorgen delivers breakthrough solutions unmatched in performance, reliability and ease-of-use, giving machine builders an irrefutable marketplace advantage.

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