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Stay cool – efficient cooling system for the railway

Fan drives in rail vehicles improve energy efficiency and require less space

Manufacturers of rail vehicles require cooling systems that are more efficiently controlled in order to comply with new exhaust gas emission limits and reduce energy consumption. In order to achieve this, diesel engines air intake and electrical main drives have to maintain ever narrower temperature windows. Only adjustable fan drives in cooling systems are able to ensure this efficiently. As a result, drive systems for cooling systems have become a key technology. The latest electro-hydraulic and electro-mechanical drives control fan speed in accordance with the motor control system and the management system in a dedicated control loop. Thanks to clever design, rail vehicle manufacturers can improve energy efficiency by up to ten percent, reduce installed power and optimize the use of space. This white paper looks at current trends towards electro-hydraulic solutions for diesel engines in rail vehicles as well as variable speed drives with servo motors for electrically driven locomotives and railcars.

Roof cooling unit for locomotive

Cooling system requirements

Essentially, cooling power requirements in rail vehicles depend on the type of main drive. Diesel engines require greater cooling. Cooling systems have an installed drive power rating of up to 60 kW. 95 percent of the system solutions used by manufacturers are hydraulic or electro-hydraulic. With their modular design and unique power density, they can be used even where space is limited. With electrically driven rail vehicles, electro-mechanical fan drives with a power rating of between 10 and 25 kW are used almost exclusively. In newer models, the manufacturers of constant drives are switching to controllable solutions. These are more energy-efficient and, in many cases, smaller.

Diesel engines: efficient cooling for low exhaust gas emissions

With rail operators demanding greater sustainability and new exhaust gas emission regulations, such as the Stage V rules for diesel engines up to 560 kW, which will come into force in Europe in January 2019, more powerful exhaust gas cleaning systems and substantial enhancements in motor management are needed. This increases requirements with regards to temperature management for modern engines because the speed and cooling requirements are decoupled from one another. In many operating situations, achieving maximum cooling is not the main priority. What is important is to keep the charge air flow within a narrow temperature window in order to ensure optimum exhaust gas cleaning. In order to achieve this, engineers must make allowances for a wide range of operating situations: no fan rotation when the motor starts, then a slowly rising fan speed and greater power at higher ambient temperatures and higher altitudes.

Electro-hydraulic systems with a controllable hydraulic pump and a hydraulic motor are the current state of the art. Depending on the requirements, an electro-proportional pump controller on the hydraulic pump changes the system pressure which regulates the torque of the hydraulic motor and thus the fan speed. In order to do this, a sensor measures the temperatures in the circuits to be cooled. The diesel engine's control system communicates with the hydraulic control unit and gives command value in characteristic diagrams for the fan speeds which are then compared with the actual values on a decentralized basis. In order for this to be possible, the control units must communicate via CAN bus. The increase in the charge air temperature to between 200°C and 240°C is an important consideration here. At this temperature, aluminum, the material typically used for the coolers, reaches its durability limits. The cooling system must therefore be designed to ensure that the thermal load is below the critical temperatures.

Adjusting cooling power via software

The electronically controlled hydraulic system makes it easier for rail vehicle manufacturers to tailor cooling drives to various climatic zones and route profiles through software changes – with no changes to the hardware. This can be achieved simply by adjusting the characteristic diagrams in the control system. Reversing operation is another special feature. It reverses the fan for a short time while it is running and removes contamination from the cooling fins. As a result, the cooling power is maintained even under difficult environmental conditions with a high level of contamination. Another advantage is the option of reducing the driving power when passing through railway stations or particularly densely populated sections in order to reduce noise emissions. This too is an increasingly important requirement of rail operators in Europe.

Recent developments in electro-hydraulic solutions focus on the introduction of closed hydraulic circuits and secondary control systems with variable displacement motors. With these electro-hydraulically controlled system solutions, efficiency can be increased by up to 10 percent.

The necessary communication with the diesel engine control system and the electronic control system significantly increase the role of software. At the same time, drive know-how is becoming increasingly important for finding the optimum solutions. Bosch Rexroth offers comprehensive support and has been producing tailored cooling systems based on mass-produced components for decades. The control units used are developed in partnership with the Bosch Group, the global market leader for control units in automotive applications. This makes integrating the electro-hydraulic solutions into the E/E architecture of diesel driven rail vehicles particularly easy.

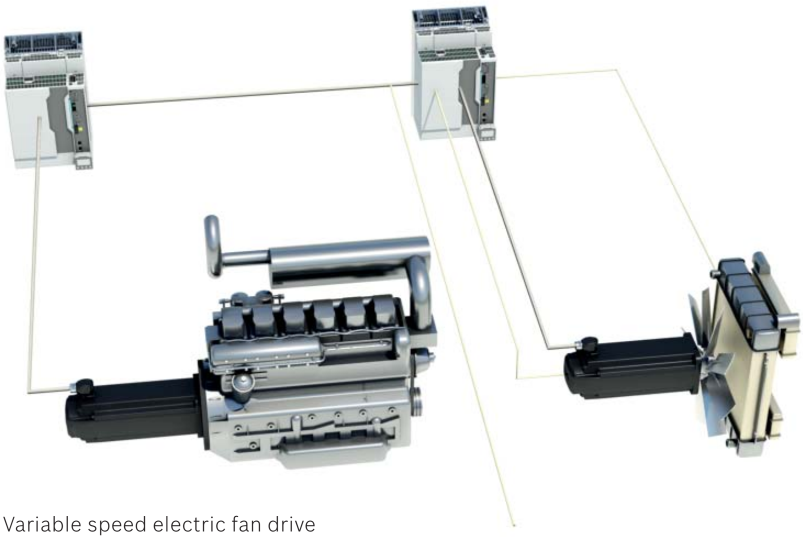
Electrical main drives: intelligent cooling control saves energy and reduces the amount of space required

With electrically driven locomotives and railcars, electrically driven fan systems are used almost exclusively. With a typical power rating of up to 25 kW, they cool the transformers and the converters of the main drive as well as other auxiliary units. Constant fan drives which work only in on/off mode or at preset speeds via three switching points are still commonplace. Currently manufacturers are systematically looking at how cooling influences energy efficiency and the durability of components in the entire drive system. The first results show that needs-based cooling via controllable drives can significantly reduce energy consumption and increase the life cycle of the components in the drive string here too.

The constant drives which were customary in the past are always designed for maximum power and therefore take up large amounts of space. On top of this, they generate unnecessary amounts of waste heat, even during partial load operation, and this in turn requires a higher overall cooling power. In contrast, controllable solutions with a frequency converter and overload-capable servo motors can provide the necessary cooling with a much lower installed power. This not only leads to a noticeable reduction in energy consumption – it reduces the amount of space required as well. Engineers can use much smaller motors. This reduces system costs as well as operating costs.

Thanks to intelligent frequency converters, engineers can now make allowances for an extremely wide range of operating situations in the software. They can parameterize fan speeds with identical hardware in such a way that the cooling power adapts to various climatic conditions or route profiles. The simplifies global manufacturers' variant management.

With carefully selected components, controllable drives meet all EMC compatibility requirements in a rail vehicle. The drives are controlled either via intelligent frequency converters or a control unit which communicates with the train's management system. This higher-level control system sets the temperature to be reached which translates the decentralized intelligence into fan drive speeds and compares them with the actual values. Bosch Rexroth, the inventor of the maintenance-free servo motor and a leading provider of drive and control systems, has preprogrammed these functions to the extent that rail manufacturers only need to parameterize them.



Variable speed electric fan drive

Outlook

The requirements with regards to cooling management are increasing both in diesel engines and electrically driven rail vehicles. They can only be met with controllable systems. As a result, the focus with cooling systems shifts from cooling physics to the intelligent control of the fan drive. Modern systems communicate with the motor control systems and management systems in order to provide needs-based cooling. This reduces the amount of energy required for cooling and, generally speaking, the components can be made smaller. On top of this, these cooling systems are so communicative that they report their operating states to the train control system. They can also report faults or imminent wear between maintenance intervals before a breakdown occurs. Rail vehicles equipped in this way can extend continual condition monitoring of the drive string to the cooling system and thus significantly increase availability and reliability. Bosch Rexroth already provides such solutions for rail vehicles and mobile machines.

Would you like to know more about efficient cooling systems? Visit Bosch Rexroth at InnoTrans 2018: Hall 20, Stand 204.

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