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Enhancing the energy efficiency of paper machine drives

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When seeking to maximise the energy performance of a paper machine drive, it is not enough simply to select the most energy efficient components. Correct dimensioning is critical, and complex interactions between components mean that the system as a whole must be carefully designed. Attention must also be paid to the control software, which plays a key role in availability and can therefore have a major impact on overall energy efficiency.

A large paper machine drive can consume up to 30 MW of power. With production running continuously for very long periods, even a relatively small incremental improvement in energy efficiency can produce considerable savings over the long term.

ABB supplies a comprehensive portfolio of low voltage AC induction motors. The motors in the process performance range are designed to deliver excellent lifetime reliability and meet the requirements for either efficiency class IE3 / Premium or IE2 / High (comparable to the former EFF1), as defined in the new efficiency classification standard, IEC 60034-30. The efficiency values of ABB motors are now calculated as specified in the latest efficiency testing standard, IEC/EN 60034-2-1:2007.

The company also offers permanent magnet motors, which form the basis for the Direct Drive System – a drive without gears. Most Direct Drive installations feature a mix of permanent magnet and conventional AC motors, both of which are designed for highest efficiency with ABB's ACS800 VSDs (Variable Speed Drives) with DTC (Direct Torque Control).

Variable speed drives can produce remarkable increases in energy efficiency in certain applications by adjusting the speed of the motor to match the demands of the process. ACS800 industrial drives feature high efficiency with the latest IGBT (insulated gate bipolar transistor) technology and DTC. DTC provides several advantages over other motor control modes, including the capability to optimise the switching pulses for better overall efficiency.

Another way in which VSDs can help to save energy is regeneration. In applications with successive acceleration and deceleration cycles, regenerative drives produce electricity during the braking phases and feed it back to the network. ACS800 regenerative drives are available with an active supply unit to enable full power flow during both motor and generator modes. ACS800 VSDs can be liquid cooled, which can dramatically reduce the energy consumed in air conditioning and cooling electrical rooms. Liquid cooling can decrease energy losses to the air within the electrical room by as much as 98 %. Other advantages of liquid cooling include a higher power density and compact drive cabinets, and higher protection class enclosures offer increased options for VSD placement.

In larger installations the drive control system coordinates the operation of hundreds of VSDs and motors. ABB supplies reliable drive control systems with many built-in functions that help to boost availability and efficiency. Control system can also take mechanical wear and tear into account, and process optimisation functions can for example optimise acceleration and deceleration for more efficient operation.

In order to optimise the energy efficiency of a paper machine drive it is important to look at the system as a whole. This is because efforts to boost the efficiency of a single component in isolation may end up causing increased losses elsewhere. The relationship between motor efficiency and VSD efficiency, for example, always involves a trade-off. Using a low switching frequency will deliver higher VSD efficiency, but will result in greater losses in the output filtering or motor. It is therefore crucial to understand how the type of power supply, VSD switching frequency and output voltage, and the motor design, affect total system efficiency. Achieving optimum energy efficiency involves much more than simply comparing the catalog values of alternative components.

The drive control system can significantly impact overall energy efficiency

A central element in good energy efficiency is correct dimensioning. The power requirements specified by machine builders are often estimated, and this can lead to over-dimensioning if the load cyclicity is not correctly accounted for. The result is lower overall efficiency because no-load losses increase. On the other hand, if the components used are too small for the job then they will constantly run near the maximum limit of their operating range and, again, efficiency will be impacted. Correct dimensioning therefore requires extensive expertise on the part of the drive system vendor. It is possible to boost overall efficiency by 2 to 2.5 % by combining information on the load (e. g. overloading and cyclic loads) and speed requirements with detailed data on the motors, VSDs, supply units, cooling method, cabling, etc. and then selecting the right components to minimise the total losses of the system.

This requires sophisticated procedures and knowledge of both the process and the behaviour of the entire system. In particular, design engineers must have an in-depth understanding of drive and motor loadability, switching frequency and iron losses in the different power components, and the ways in which running, acceleration and deceleration loads affect the heating and cooling of different parts of the system. In the case of cyclic loads such as winders, correct dimensioning is even more complicated than for constant loads, as it involves the short-term over-loadability of drive components. ABB meets these challenges by maintaining close working relationships with machine builders to ensure it has the most accurate information possible on load and speed requirements, and it has also developed its own specialised dimensioning tools and methods.

On average, ABB starts up two paper machine drive systems every week. Turnkey deliveries include commissioning, training, and, in some cases, installation. In-depth knowhow of production and finishing processes and the required machinery and equipment enables ABB to tailor drive systems to deliver the optimum performance and energy efficiency in the customer's application. ■)

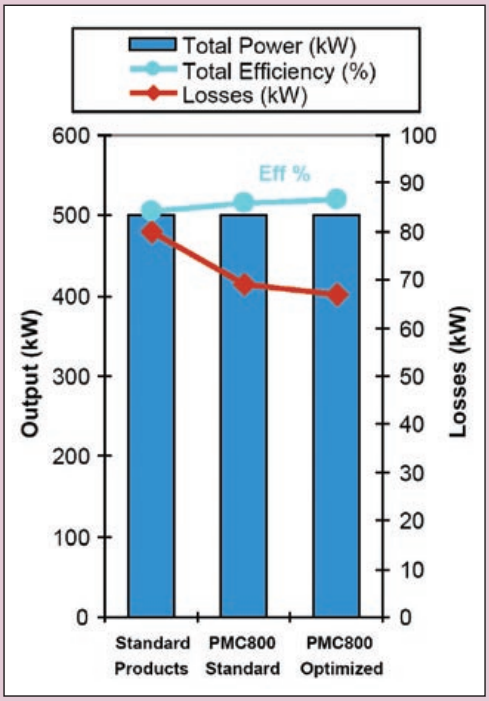
Boosting the energy efficiency of 500 kW drive system

The figure shows total efficiency and losses for three different dimensioning methods applied to a winder with a required drive capacity (rdc) of 500 kW.

Standard products: Dimensioning is done in the conventional way. The supply section, inverter and motor are selected based on catalog data and 150 % over-loadability during acceleration. With optimal selection of high efficiency products, the sum of calculated losses is 80 kW and the total efficiency is 84 %.

PMC800 Standard: Standard catalog products are again selected, but this time taking into account detailed data on the equipment and application, as well as information on loading, cooling, and system behavior. Losses are reduced to 69 kW and efficiency rises to 86 %.

PMC800 Optimised: The design of the motor is modified so that its electrical performance matches the specific application (requires extensive experience and knowledge of the process). Otherwise standard catalogue equipment is used. Losses are further reduced to 67 kW and efficiency increases to 86.5 %. This demonstrates that, in this case, optimisation can increase efficiency by 2.5 %, delivering annual savings of approx. 13 kW x 8700 h = 110 MWh.



Optimised dimensioning with ABB's PMC800