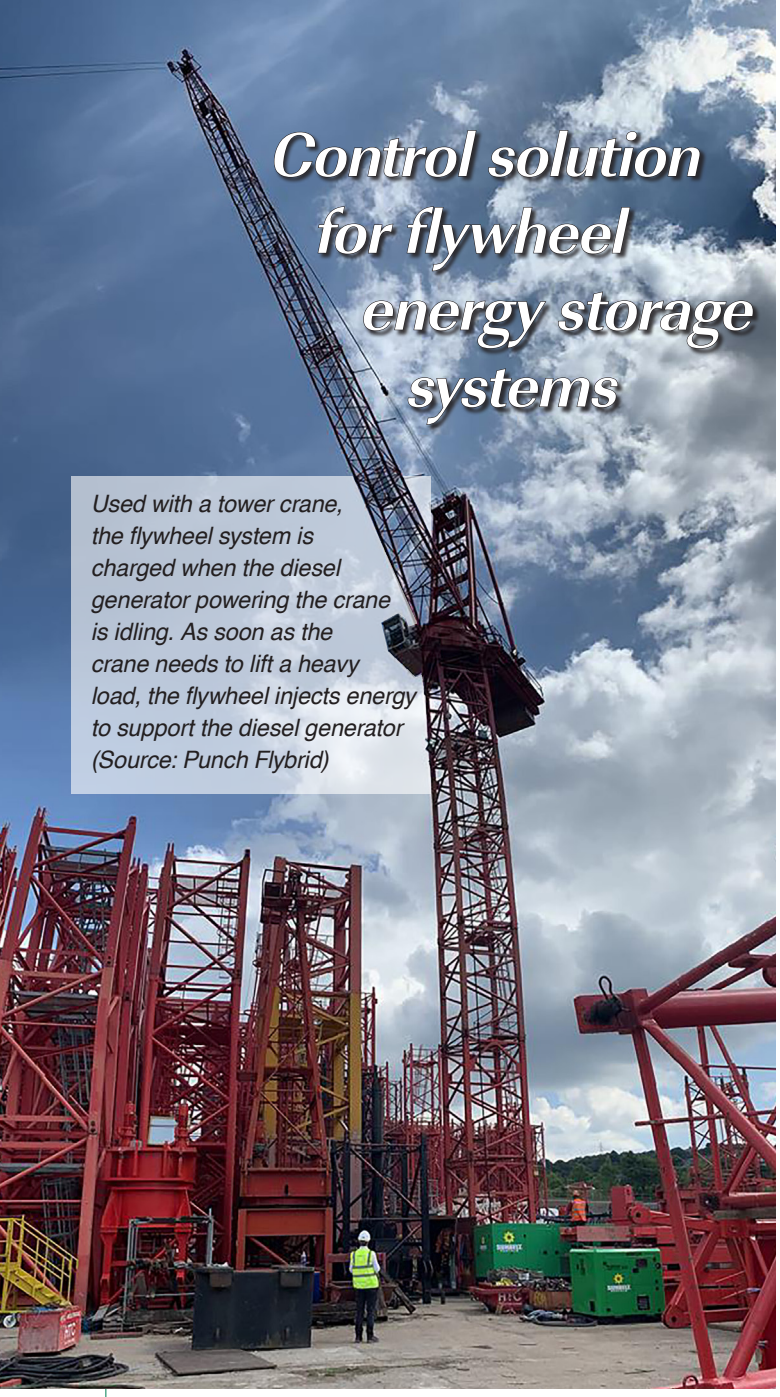
Control solution for flywheel energy storage systems



Used with a tower crane, the flywheel system is charged when the diesel generator powering the crane is idling. As soon as the crane needs to lift a heavy load, the flywheel injects energy to support the diesel generator (Source: Punch Flybrid)

To make operation of mobile machines more efficient, flywheel-based energy storage can be used. It absorbs energy during low-load periods and releases it during peak loads. Sensor-Technik Wiedemann (STW) provides control units for energy management of such systems.

Saving fuel and reducing emissions is an important aspect of all commercial operations, especially for mobile machinery. The construction and municipal machines work more efficient using flywheel-based energy storage. The German company STW from Kaufbeuren supplies the ESX.3cs compact control unit for the energy management of flywheel-based energy storage systems.

The energy storage system specialist Punch Flybrid from Silverstone (England) produces flywheel systems suitable for a range of applications in off-highway equipment, from excavators and tower cranes to mobile diesel and gas generators. The integrated flywheel system relieves the combustion engine from peak loads, and so enables smaller dimensioning of the engine and a net saving in fuel.

Optimized for tough environments

The solutions from Punch Flybrid are designed for high power density and durability, as required in construction, agricultural, and municipal applications. Ordinary batteries or super capacitors often hit their limits here. Punch Flybrid experts, who developed the first KERS (kinetic energy recovery system) for Formula 1, are very familiar with extreme power peaks. The principle of the flywheel storage system is comparable to recuperation in electric vehicles. The flywheel captures the energy that would normally be lost when braking or, for example, lowering the boom of an excavator and releases it again during the next work cycle.

One of the company's products is the Punch Power 200 (PP200), which is used for power generation applications. In this case, the flywheel storage system increases the efficiency of the generator, and the additional power can be used either as a boost function or to save fuel.

Benefits for construction machinery

Tobias Knichel, Managing Director at Punch Flybrid, explains typical application scenarios of the flywheel system: "Our solution is particularly advantageous in construction machinery with its recurring work cycles. A tower crane, for example, constantly alternates between idling and maximum power. The flywheel system is charged when the diesel generator powering the tower crane is idling. As soon as the crane then needs to lift a heavy load and therefore demands high power from the diesel generator, the flywheel injects energy at high power to support the diesel generator. As a result, a smaller, more efficient diesel generator can be used in combination with the flywheel energy system.

Depending on the application, this load-balancing concept can reduce fuel consumption by more than 50 percent. Thanks to the flywheel system, a smaller main engine can be installed. This downsizing means the engine is operating with a higher base load, with increased efficiency. Excavators and other machines can also benefit from downsizing.

As with the tower crane, an excavator continuously performs cyclic work processes. The energy released as the excavator's boom is lowered can be captured in a Punch Flybrid energy storage system, whereas usually this excess energy is released as heat and is lost. The stored energy can then be used when the boom is raised again, reducing the load on the combustion engine. Tests have shown fuel savings of up to 30 percent. Other applications for the flywheel storage system can be found in power grid support or pump applications. ▷

Figure 1: The Punch Power 200 is used as energy storage system for power generation applications (Source: Punch Flybrid)

Control solution

For this approach, a dynamic control solution is needed that reacts quickly to the operator's control signals. Punch Flybrid opted for a control system from the automation specialists at STW. "We use the ESX.3cs as the managing controller in our Punch Power 200 system. The controller provides the necessary high-speed signal processing that we need for our solution. It also monitors the entire system, including cooling" explains Tobias Knichel.

"The Punch Power 200 system provides the additional stored energy within 10 ms to 20 ms. The ESX.3cs was the optimal solution for us. It handles the management of the power electronics, is robust enough for use in harsh environmental conditions and is compact enough to be easily integrated it into our system."

In the ESX.3cs, a 300-MHz 32-bit micro-controller with a 4-MiB flash and an 8-MiB SRAM handles the signal processing. External signals can be connected via two CAN interfaces, a serial interface, Ethernet, or LIN interface. The CAN interfaces can be used for communication with the in-vehicle CAN networks typically applying the J1939 or CANopen higher-layer protocols. Bit rates up to 1 Mbit/s are supported. A second independent processor monitors various system voltages and the program execution. If necessary, it switches off all outputs via a second shutdown path or can reset the main controller. Digital and analog feedback for almost all signal branches allow comprehensive diagnosis of the system, including both inputs and outputs. Thanks to these features, functionally safe applications according to EN ISO 13849 and IEC 61508 can be implemented with the ESX.3cs. This is an important aspect for highly automated applications, as increasingly found in mobile machines.

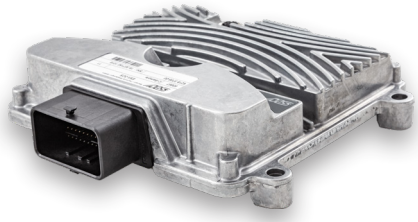


Figure 2: The ESX.3cs manages the energy in the Punch Power 200 system (Source: STW)

The application suite for the ESX.3cs is available for the developers to program the user application. Numerous functions, for example current controller and ramp functions for outputs, or frequency averaging for inputs, are already integrated in the programming environment.

STW is an internationally active company producing solutions for the automation and digitalization of mobile machines for more than 35 years. The manufacturer offers a modular system of generic and customer-specific products, systems, and software solutions. The ESX.3cs control system within the PP200 helps to provide machines with the capability to operate more efficient. The result is a reduced fuel consumption in the combustion engine and lower emissions. This benefits both the machine operators and the environment. ◀

Source

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Brief news: Sensors

- ***Magnetic encoder:*** The IP6K9K-rated WV3600M rotary encoder by CiA member Siko (Germany) for mobile machines has a 36-mm diameter. The single- or multi-turn product comes with a CANopen (CiA 406) or a J1939 interface. Optionally the absolute encoder supports CANopen Safety or J1939 safety.
- ***Satellite receiver:*** The PCAN-GPS FD by CiA member PEAK-System (Germany) can be connected with GPS, Galileo, Beidou, and Glonass navigation systems. It can determine position (with an accuracy of 1,5 m), orientation, and acceleration values. The programmable (C and C++) device comes with a CAN FD interface, which sends periodically the sensor data.
- ***Rotary encoder:*** The HTx36E by Megatron (France) features CANopen and J1939 connectivity. The Hall-effect sensor provides a single-turn resolution of up to 16 bit and a multi-turn resolution of up to 43 bit. The IP67-rated housing measures 36 mm (diameter).
- ***Radar sensor:*** CiA member Pepperl+Fuchs (Germany) has introduced a CANopen-connectable sensor measuring distance, speed, and direction of target objects at a distance of more than 25 m. The IP68/69-rated radar sensor is specified for an extended temperature range and suits therefore for mobile machines.

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