

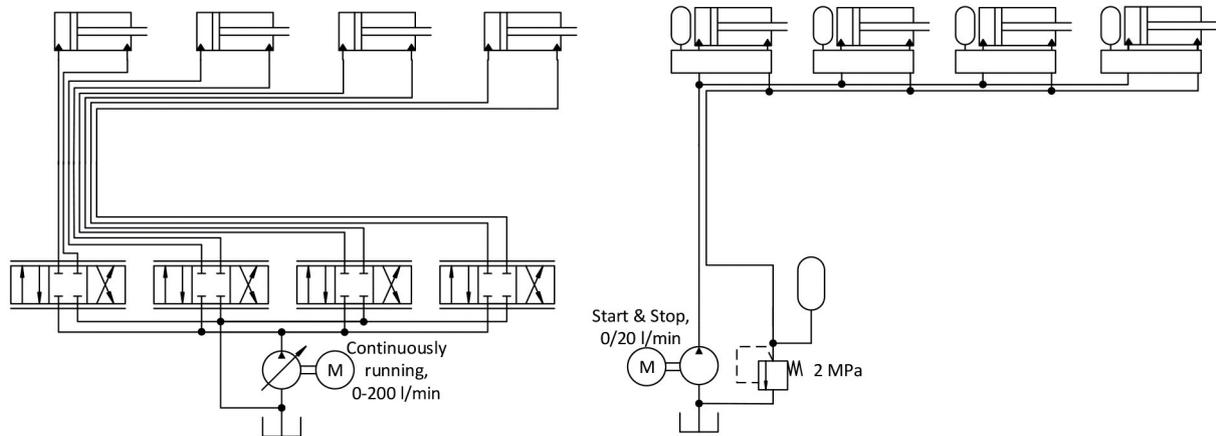
A New Energy-Efficient Hydraulic Hybrid Actuator, the Power Module



Fiellberg Oy has built a proof of concept (PoC) device highlighting the benefits of the digital hydraulic multi-pressure actuator approach. The key concept of the technology is to avoid throttling losses associated with traditional valve controlled hydraulics. Another main benefit is the fact that the device consumes only small average input power while creating significantly bigger peak powers from its local energy storage, which is a hydraulic accumulator.

The device combines the hydraulic accumulator and small asymmetric cylinders, which act as pressure converters thus efficiently creating a number of unique pressure levels. These pressure sources are connected to the working actuator (a standard double-acting cylinder) using on/off-valves. The on/off valves are controlled using a sophisticated control algorithm using simplified system model. The control and power electronics of the system are integrated to the PoC device as well and are based on commercially available controller.

The main result of the project is a working design of the concept and experimental results achieved at the laboratory of Tampere University of Technology in spring 2018. The most important outcome of the experimental research is the energy saving potential of the device. The device was tested driving a 4-meter long mobile machine boom mock-up. The experimental results show, that the concept is capable of decreasing energy losses up to 79.5 %, when compared to traditional valve-controlled systems.

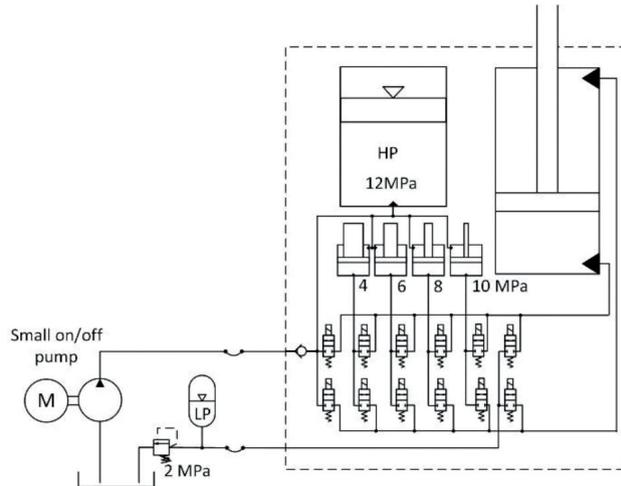


With the new solution, the losses are 58-68% smaller compared to the load sensing proportional valve, and even 80% smaller compared to a constant pressure system. A good example of its energy efficiency is that, the temperature of a hydraulic oil does not rise over 30 degrees even the peak power is 10 kW, and in addition it is operated without radiator and with a tiny amount of oil.

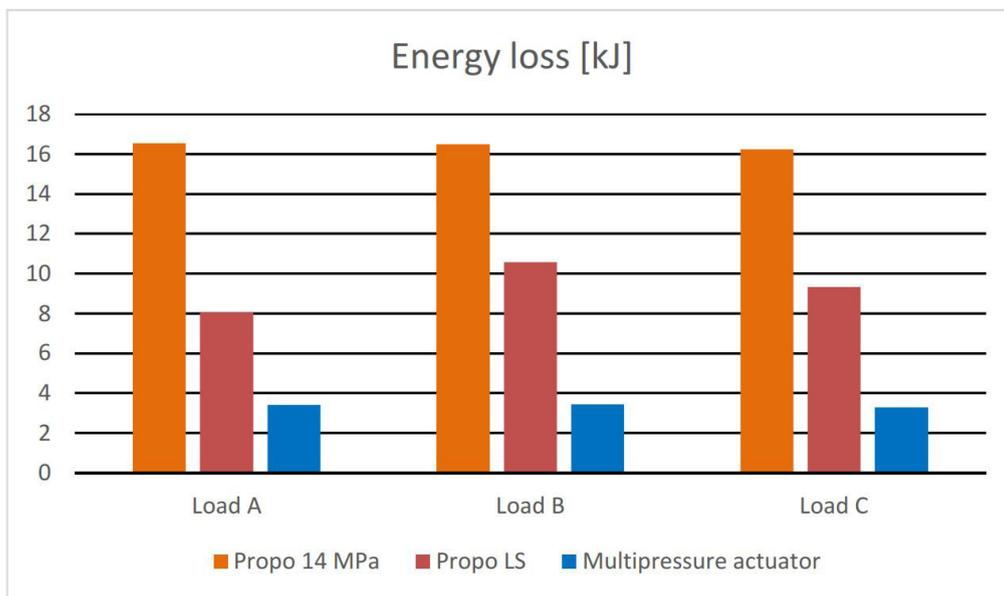
The impact on the size of the pump unit is radical as it needs to produce only average power. This compared with huge energy savings, it makes the solution's price competitive. In summary, it can be stated that this is the most energy efficient hydraulic actuator in the world, It is capable to adjust the power directly without loss of flow. It also can store energy from lowering loads and breaking loads.

Existing systems have tanks, pumps and pipes dimensioned by maximum capacity flow, whereas new solution decreases the sizes of those to a fraction. The principles of the traditional solution and the new solution are shown on the picture above. For example, the traditional excavator has hundreds of meters of pipes that are dimensioned by peak capacity flow. The new solution is CAN bus controlled and due to its operate principle pump and pressure line can be dimensioned based on average power.

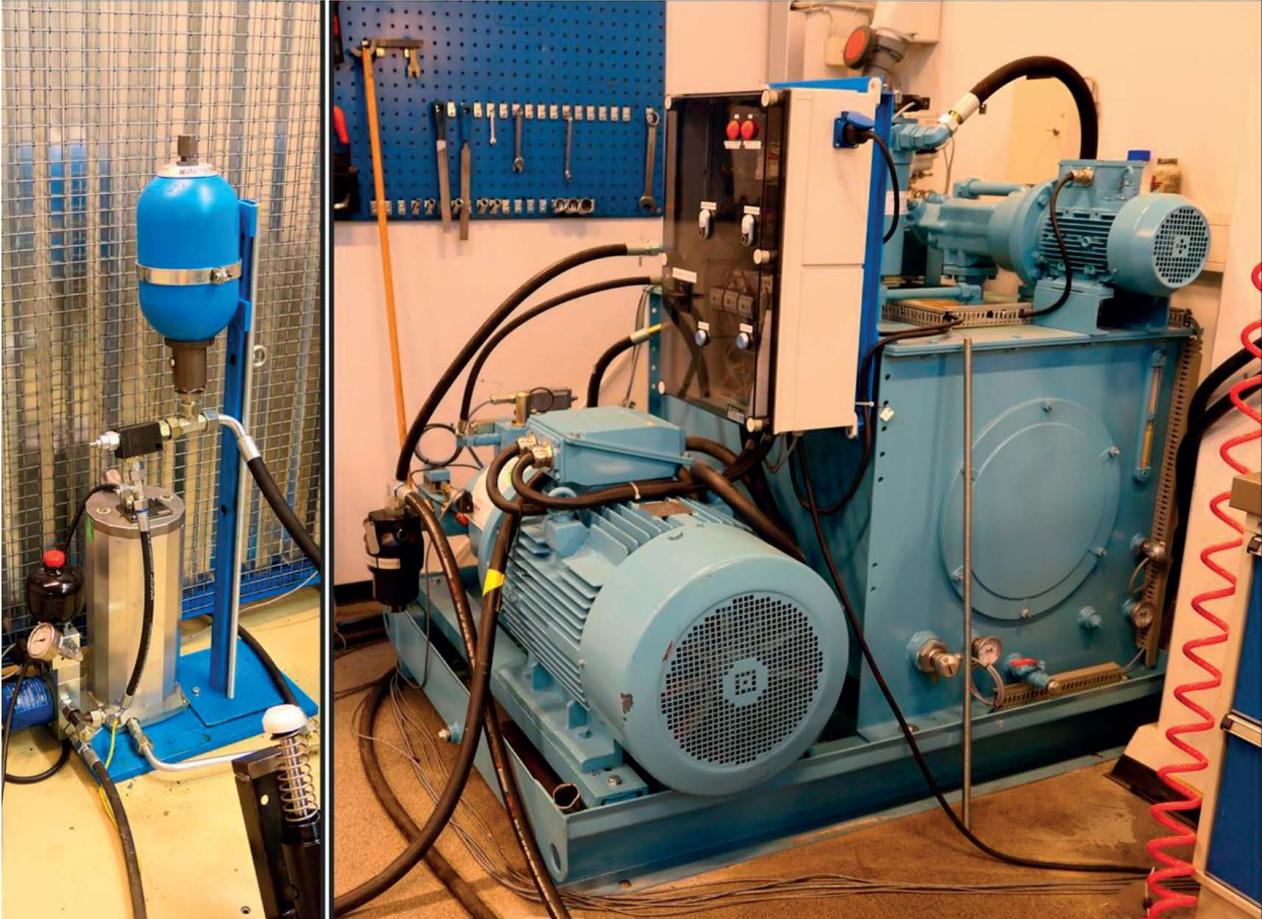
An average power is produced with small on/off pump unit and big capacity power is produced with pressure accumulator. Every actuator is capable to store energy in the pressure accumulator, the energy is recovered when controlling inertia, such as lowering loads. The challenge of the new solution is how to adapt the pressure accumulator's pressure and the required power of the cylinder. Fiellberg has however solved this problem with the new Power Module.



The diagram shows the principle of the solution. Small hydraulic pump charges high pressure (HP) accumulator on demand. This pressure is decreased to several smaller pressures with assist of convertor cylinders. In addition, low pressure (LP) return line is in use. For example, with four convertor cylinders can be produced LP and HP, as well as four interjacent pressures. By switching these pressures to the A- & the B sides, can be attained 36 different forces/powers. It's essential that the adjusting is done with/ by logic valve without a loss of flow and the adjusted quantity is directly the power of a cylinder.



The comparison of energy loss of the constant pressure, load sensing proportional valve and the new solution shown in the picture above.



Fiellberg Oy has studied new hydraulic hybrid actuator technics together with Tampere University of Technology (TUT). The technics bases on a combination of a basic hydraulic cylinder, a pressure accumulator and digital hydraulics. The idea is, that power peaks are created by the pressure accumulator and only an average amount of a power is fed to the system. For example, excavators have easily 40-50 kW power peaks, whereas the actuator needs on average only a few kW.

Simulations and prototype was used to proof the concept. The prototype was used to proof its energy-efficiency and adjustability, which both showed to be excellent. The calculation is implemented by standard mobile controller and also adjustment of logic valves and sensor information is also implemented by the same controller. TUT's mobile machine boom mock up is used as a loading actuator. Its effective inertia is around 50 000 kg and maximum load power is 40 kN. The peak power of the system is around 10 kW, but it can be operated only with 1.5kW mini pump unit. This pump unit is normally off and turns on only rarely.

Adjustability is excellent. The new solution reacts instantly to changes of a target speed as it does not have to wait until the rising of a feeding pressure. Full power is immediate-ly usable. Also, the amount of vibration is significantly smaller than with traditional load sensing proportional valve and pressure peaks do not exist. This solution that combines energy efficiency and adjustability is unique in the world of hydraulics.