GOOD PRACTICES IN SME

Modernizing separators

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Where are separators used?

A separator is a device used for separating suspensions and emulsions through centrifugal forces. They are used, among others, in the dairy industry to separate cream from whole milk and in laboratories to separate blood components and in the energy industry for uranium enrichment.

Pic. 1 forum mleczarskie: Dairy separator

Pic. 2 prodoreko: separator for clarifying juices

How to modernize separators?

Separators are characterized by a high moment of inertial, meaning their highest power consumption is their acceleration. During deceleration, the separator also loses a lot of energy. Regenerative breaking and returning the energy into the network can decrease energy loss during deceleration.

Modernizing separators can consist of replacing the separators drive, control system, using a power inverter, or a mechanical refurbishment of the mechanical subsystems.

A separator can use a:

- direct power drive – with a direct current motor or,
- alternating power drive – with a induction motor (squirrel carriage rotor) power with alternating current from a power inverter.

Direct power drives are characterized by higher energy consumption; however, they are the cheaper solution. Motors using alternating current have the more favourable technical and operational parameters.

Source: „Nowoczesne układy napędu elektrycznego dla wirówek cukrowniczych", Ireneusz Filip, 2002

Example for modernizing an industrial separator (cottage cheese separator)

The DSC/1 separator of East German production in the „Maćkowy" dairy cooperative in Gdańsk was modernized by completely replacing the control circuit, an MMB power inverter and a refurbishment of the mechanical components.

Before the modernization: The separator DSC/1 was driven by an induction motor with Y/D starter switch. The drive provides about 6000 RPM. Its significant weight, high rotational speed and the primitive starter, all mean that it needed about 18 minutes to achieve the required speed. This extended start was due to the motor's starter low moment of inertia. Another adverse effect was the engine heating up, due to the high current and losses. Deceleration was also unfavourable. The motor's winding was connected correctly and powered with direct current which led to energy losses both in the winding and the rotor. In consequence deceleration also took place at low inertia and took about 30 minutes. The kinetic energy of the motor was lost as heat emissions from the motor, requiring cooling before the next spin up and breaking. Breaking caused significant heat build-up, meaning the next spin-up was only possible after 3 hours. If, due to technological reasons, another deceleration was required, the time until the next start could first take place after 8 hours. Difficult spin-up and breaking could be reasons for frequent motor failures.

Modernization options: Modern separator motors use transistor converters. Converters available on the market consist of a diode converter and a power inverter. Using a transistor converter to modernize a separator with a large moment of inertia requires the use of a resistor with a resistance equal to the motor's power which would be used to disperse the energy during breaking. Regulating the motor's speed during the spin-up and breaking of an object with a large moment of inertia requires using a cascade control with a subordinate control circuit for the motors torque. This in turn can limit the maximal voltage on the inverter and rectifier output, down to about 83% of the supply network's voltage, in itself requiring either a motor with a lower voltage rating or using higher powered motor, changing the transmission and limiting the maximal rotational speed. Moreover, The output voltage reported by the inverter's supplier equal to the voltage of the supply network is achieved by over-modulation, which is only possible using constant U/f control. Such a inverter must have at least twice the power of the motor, which significantly increase the modernizations cost.

Using the two inverters, one from the supply side and the other from the motor side connected by a shared direct current circuit ensures proper control of the motor within its full rotational speed range Most companies offer two inverters as a set with the appropriate software and powered with direct current. This type of circuit allows returning energy to the network but is quite expensive.

After the modernization: The converter for powering induction motors developed by MMB Drives in cooperation with the Gdańsk University of Technology and used to modernize the separator's drive consists of two power inverters connected into one circuit. The inverter connected to the supply network ensure bi-directional power flow and ensures the right voltage for the direct current condenser circuit. The angular speed controller of the separator is connected to the rotational speed controller in its full range. A sensorless controller with a proprietary speed regeneration method was used. The structure of the controller circuit is based on a multi-scalar motor model which is a generalization of the commonly known vector model. The converter used ensures bi-directional energy flow and superior dynamic speed regulation with rotational stabilization in transition states. At constant inertia, the separator needs 5 minutes to spin-up and 4 minutes to decelerate to full stop. Breaking energy is returned into the supply network. Both with the engine running and during breaking sinusoidal current is ensured on the supply side. The method of controlling the power inverter and the filter on the supply side ensure lower higher harmonic values on the supply side. Modernizing the separator's drive was combined with a total replacement of controllers and their wiring, machinery and the control cabinets. The new control cabinet made out of stainless steel was designed individually to accommodate the ergonomics of the work-station at the separator. Additionally, a separate enclosure for the inverter was placed with place less exposed to environmental hazards. Using the MMB inverter to power the DSC/1 separator decreases energy consumption, accelerates cottage cheese production and improves the working conditions of the employees. Most of the technical solutions used in the MMB inverter have been developed as part work by employees at the Gdańsk University of Technology and research projects funded by the Ministry of Science and Higher Education, which were implemented by MMB Drives sp. z o.o.

Source: „Modernizacja napędu elektrycznego wirówki do twarogu typu DSC/1", Zbigniew Krzemiński, MMB Drives sp. z o.o.,2018