690 V is a good alternative in the process industry

The process industry in the Nordic countries generally uses voltage of 690 V for process motors, whereas Central Europe, Great Britain and the USA usually prefer lower voltages. Considerable savings can be achieved in the investment and operation costs for equipment by using motors with 690 V voltage.

Research shows the benefits of using 690 V motor voltage. The acquisition costs of devices, the cabling costs and the run time cost losses decrease essentially. Equipment strain caused by diminishing short circuit currents decreases significantly. Another cost saving aspect is that the 690 V voltage can be used in process motors with power ranges up to 800 kW. In medium voltage distribution, significant costs can be saved by using distribution transformers of 4 MVA with 690 V when the suitable distribution transformer for 400 V is 2 MVA.

Costs caused by transmission losses can be considerably decreased by using 690 V both when using centralized distribution (all motors connected directly to a central unit) and when using distribution in stages (main unit – sub unit distribution). In certain applications, 690 V has been used as process voltage together with the 400 V distribution. The same motors run on either 690 or 400 V depending on the connection.

Energy at a lower price
In his licenciate thesis from the Lappeenranta University of Technology, Mr. Jaakko Lehtonen says that the use of frequency converters has become common because they provide improved technical control. They optimize the process, raise the production rate and save energy costs. The 690 V voltage is the most cost-effective alternative also when considering the effect of frequency converters in the comparison of costs. Power losses decrease when higher voltage is used, Mr. Lehtonen concludes.

By using 690 V voltage in the process industry, larger motors (for example chipper motors) can be connected to a more affordable and practical low voltage circuit, which allow the use of significantly larger motors up to 800 kW. At the same time, the quality of the electricity increases, the network becomes more solid and motor outputs cannot trip due to setting errors.

The voltage of 690 V stabilizes the network and the fuse limits short circuit currents, thus shortening voltage dips. The one-phase operation of the fuse minimizes the power failures within the same group of one-phase equipment and the principle of one starter-one compartment connected directly to the main bus-bar system prevents whole motor groups from stopping.

Fusible systems provide benefits
A fusible system provides economical benefits compared to a fuseless system. Planning the system and the selection of devices is much easier, since a fuse releases less energy and the current peak is smaller than when a circuit breaker is used. The size of the contactor and the thermal relay can be often smaller. A switch fuse solution does not need an arcing space. Due to all these advantages the size of the switchgear is smaller.

A fusible system can easily be made to work selectively. It is easy to fulfill the principle of one starter one compartment, thus increasing the reliability of the process function. No separate upstream fuse protection is needed due to the extensive short circuit capacity.
Of course the fuse still has to be changed when it trips. This, in turn, increases security as the reason for the short circuit must be checked before reconnection and the new fuse improves the reliability of the short circuit protection.
The life time cost of the fusible system remain low as in case of short circuit only the economical fuse link needs to be changed. The switch mechanism and the arc chambers remain fit after the short circuit.

Stora Enso chose 690 V

Already in 1977, the maintenance and repair company Varenso at the paper mill of Stora Enso in Varkaus, Finland, chose 690 V as the voltage of their processes to improve their competitiveness and industrial safety. For the same reason, the paper mill of Varkaus has systematically changed over from 500 V to 690 V in all renewing projects and new buildings since 1977.

According to Mr. **Teuvo Volanen,** General Superintendent of Varenso, the decision to change to 690 V was brave at the time. However, it was based on precise calculations regarding costs and safety. The decision was correct and the changes have been easy to implement. All low voltage motors can be purchased with the ratings 400/690 V /Y. The voltages can easily be changed by shifting the connection, which decreases the amount of spare motors needed. The old 500 V devices will be exchanged to use 690 V devices when facilities are renewed.

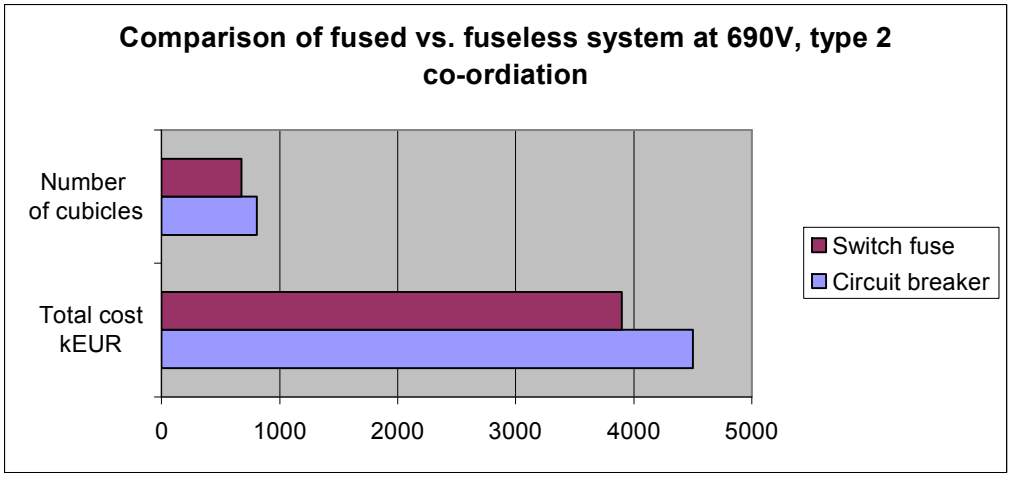
According to Mr. Volanen, it was possible to take larger distribution transformers into use as the change to 690 V voltage decreased the short circuit currents. The load currents in comparision to the effect decreased, as did the current thermal losses. Now even larger motors than before can be supplied by low voltage.

Lower short circuit currents
Since the short circuit currents per switchgear are lower today, the size of the distribution transformers can be larger, up to 3.15 or 4.0 MVA. Lower short circuit current effects for example the switchgear structure, the safety at work and the costs, Mr. Volanen tells us.

The process also needs 400 V voltage when using frequency converter controlled motors with an effect below 10 kW as well as for special equipment. In Varkaus, the solution was to use an transitional transformer downstream from the 690 V transformer. The transitional transformer provides the 400 V voltage that the motors need. In these 400 V centrals with low short circuit currents, both fused system as well as fuseless systems are used.

More safety with fuses
Mr. Volanen says that the fuses block short circuit currents better than circuit-breakers and this gives an enhanced device durability and work safety. Usually only the fuse is damaged in short circuit situations and is easy to replace.

Mr. Volanen explains that the switch fuse and the regular fuses are the most essential elements in a fusible system. They are extremely important during maintenance or repair when the clearance between open contacts stated in regulations is easy to detect with the switch fuse. A fused system over 63 A is safer, more cost minimizing and withstands higher short circuits currents. The selectivity of a fused system is better compared to a circuit-breaker. The installation is also less complicated.
Rauni Riippi

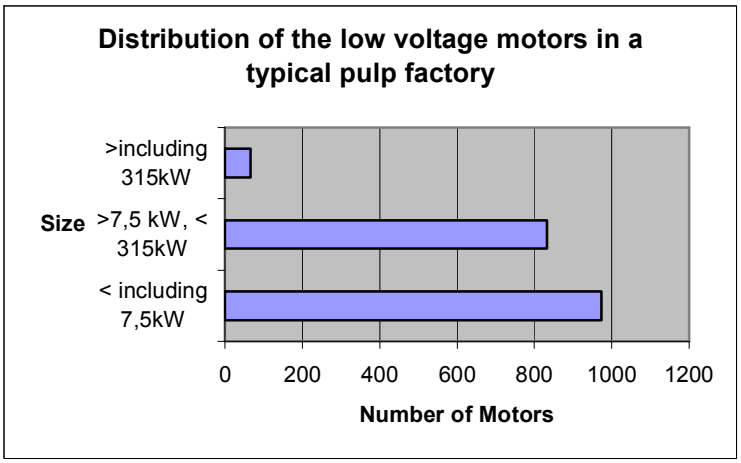


Comparison of total cost and number of cubicles of motor control centers in a green field pulp factory project by 690 V, 50 kA and type 2 co-ordination.

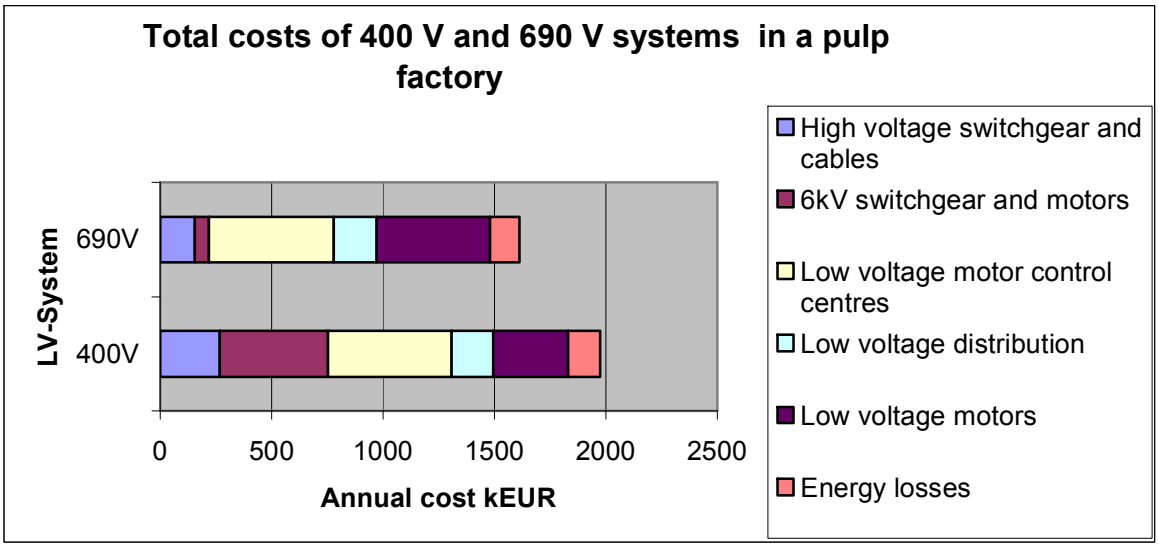
The power consumption of the Stora Enso paper mills in Varkaus is about 150-160 MW. About 20-25 per cent is produced at the mill and the rest comes from the national grid. The amount of squirrel cage motors is about 7000. The unit that needs most power is the Thermo Mechanical Plant (TMP). The effect of the main grinder motors at stages 1 and 2 of the new line in the TMP is 64 MW in total.
Picture Stora Enso, Photographer: SCan Foto.

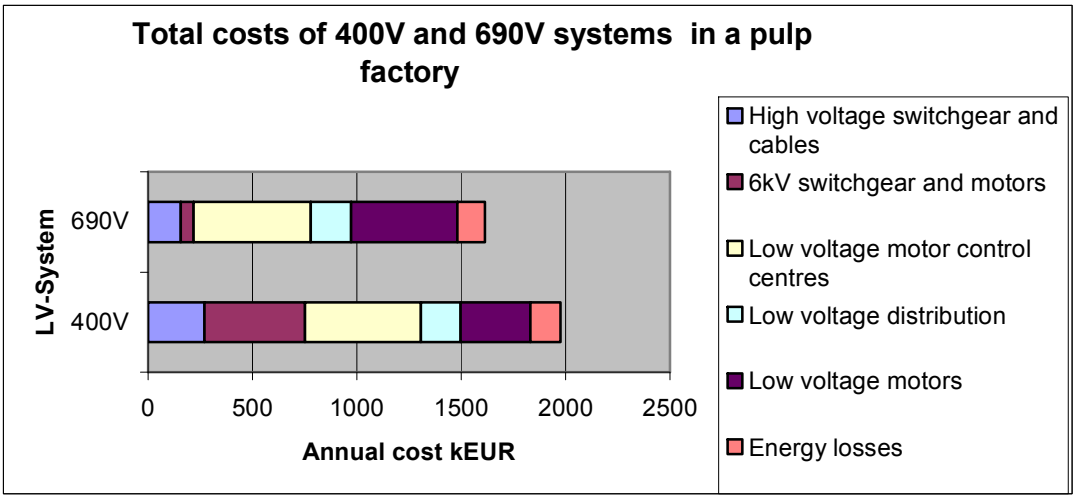
Photos by Rauni Riippi:
”Keeping up with the competitors is important to Stora Enso in Varkaus. In an electrical network, everything from selecting switchgear and components, individual motor drives and cabling of equipment to the maintenance of the network has an impact on competiveness. Cost minimizing is essential, since the manufacturing of mechanical wood pulp needs a lot of energy”, General Superintendent Teuvo Volanen says.

The short circuit currents are lower with 690 V voltage. This affects the construction of the switchgear, which is smaller today than before, and facility space can be used for other purposes.



Low voltage motors in a typical pulp factory divided into main categories





Comparison of total investment and power losses of 400 V and 690 V systems calculated on an annual basis during 15 years running time in a pulp factory
Source LTY Lis (Tekn) 621.316.1