THE METHOD OF RECOVERING UNUSED DISSIPATED ENERGY FROM BRAKING UNITS OF EOT CRANES & WINDERS

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***Abstract*- In pulp and paper industry once the paper making process ends at the point of reeling the paper in jumbo reels, its mainly necessary to convert the end product to a useful finishing product so that it can be utilized. For that the foremost step is to slit and rewind the paper in the core with specified needed sizes. The unit that performs the above process is REWINDER, which consists of a unwind stand where the jumbo paper reels are transported using the overhead cranes from the paper machine. Usually, a motor with the capacity of around 625kW is used to drive that unwind stand from where the paper is pulled to the next stage of slitting. Initially during the starting of the process the paper is pulled with the limited tension and once the necessary tension value is reached, the paper is pulled with full tension leads to the increase in the speed of the motor over the synchronous speed. Once the motor crosses the synchronous speed Ns its starts to regenerate the power working as a generator. The same all above the energy retrieving process can be held in EOT cranes during deaccelerating by in name of Regenerative Braking. Using the four-quadrant medium voltage converter, the induction motor can work as a generator at the optimum working efficiency all along, and the surge occurred at the transit from motor mode to generator mode of the motor can be avoided at the same time. In the paper, the topology of four-quadrant medium voltage converter and the working principle of motor in Rewinder and in EOT cranes at generator mode via using the converter are proposed and analyzed.**

I. INTRODUCTION

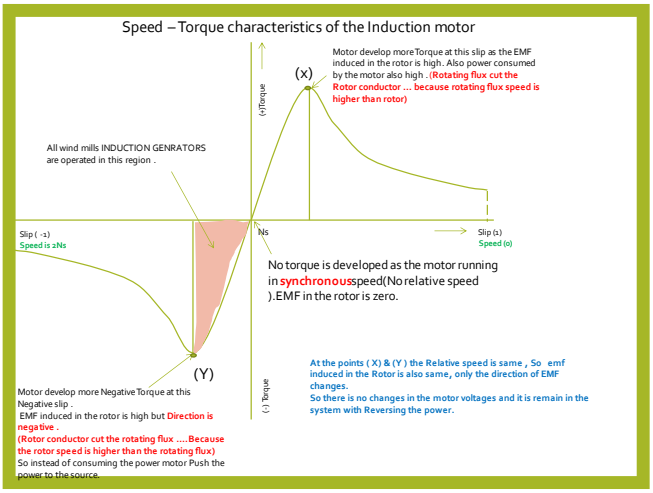
The rapid economic development and a growing population have resulted in higher energy demand. One of the energy management route is to use / partially substitute conventional energy sources with alternate energy sources The increasing cost of energy in recent times has adversely impacted the cost of paper production. As such there is a need for energy conservation . or exploring galternative sources of energy to ensure sustainability(1). One of the energy conservation route is to use / partially substitute conventional energy sources with alternate energy sources.

A single unit of energy saving per day will impact a major contribution in both cost wise and efficiency of the plant. The main role of the electrical engineers in the plant is not only to ensure the continuous power and machine availability for the production, but also to save the energy and to reduce the power cost at the most. Moving to the concept of re-winder: it's one of the most important parts of the paper making process. The winder unit should always work effectively where the papers are slitted and unwind with the required sizes. The finishing of the produced product starts from the winder unit only as it should be available all the time for its operation, if not the production has to be stopped, because the holding queue of the jumbo reels will last for only 5 numbers with the average time of 4hours. The parts of the units are

- Unwind Stand with a brake generator
- A lead in roll
- Bottom and Top Slitter units
- Front drum and rear drum
- Ejector with hydraulic motion unit
- Rider rolls
- Rejection gate and Ejector bucket
- A load cells
- Trim blower

A total load of around approximately 1.3MW is connected in the unit with the winder system. The average power consumption of the total units will be around 1300units/hour, but it will become possible to make the machine to consume only 3units of power per hour. The invention of the brake generator- actually a motor with regenerative braking process, is the most important reason for this energy savings. Also, the drive used here is the four-quadrant drive which can operate in both motoring and generating operations. The winder unit can be operated in both tension mode as well as in diameter mode.In tension mode the unwind tension of the paper is taken as the feedback for the closed loop system whereas in diameter mode the the total diameter of the jumbo reel is taken.The operator is operating the winder machine from the HMI where the DIs and DOs are synchronized with the PLC and Drives. All the slitter units are operated through the air pressure arrangements. The trim that cuts the edges are transferred to the pulper through a separate channel with a motor arrangement. Dissipation is a term that is often used to describe ways in which energy is wasted, commonly energy got wasted by terms of Braking in EOT cranes and to maintain tension in rewinders. Any energy that is not transferred to useful energy stores is said to be wasted because it is lost to the surrounding.

With the rapid evolution of power electronics technology, medium-voltage converter with large-capacity has been widely applied in industries. And the "four-quadrant
converter technology" has gradually developed and has been widely used in the mine hoist, wind power and other occasions. Due to the emergence of four-quadrant converter technology, it is possible to make a pump to be used as a turbine generator with its highest efficiency continuously.
As the converter can adjust the frequency, voltage and phase angle of power continuously. In comparison with the variable frequency generator units, the turbine
generator using converter has many advantages. Firstly, the turbine generator can always operate at an optimal power generation mode and improve the power generation efficiency. Secondly, the converter has a high electrical adjustment precision, so the power shocks to the grid can be avoided. Thirdly, using converter can reduce the mechanical maintenance and occupied space. Finally, the soft-start of operation during the winding or Carrying Load in EOT cranes operation and regulation can be implemented by using the converter.



II. THE GENERATION MODE OF PUMP

A. Synchronous Generation

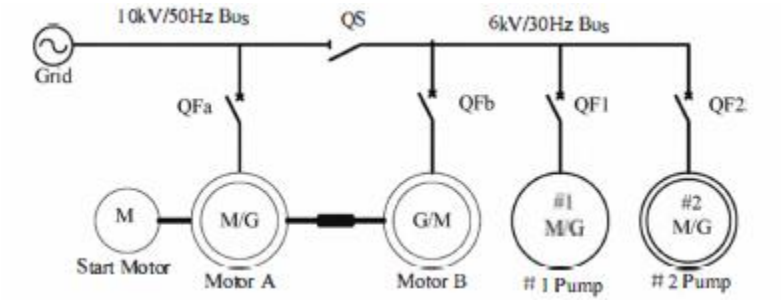
The greatest advantage of the synchronous generation operation is to use the existing equipment economically. However, the efficient run-time of winding generating generally appears when the tension of paper is higher than the tension in parent roll. The actual operation situation is that the speed in reverse generating is often lower than the rated motor speed. To a general , the synchronous generation mode has low operating efficiency, which could not make good use of winding in paper.

B. Poles increasing Operation

When a winder is operating at the generating mode, the optimal rotating speed of the unwind motor is lower than the synchronous speed. The way to achieve the optimal speed is to increase the number of motor poles. This reduces the synchronous speed and the pump is able to get high generation efficiency at the time of lower water head. But the investment will be greatly increased if the poles of the motor can be changed during the operation.

C. Operating with the Motor-Generator Units

In order to match the less Tension, the motor generator units are adopted. The rated speed of the motor is lower than the synchronous speed and the poles of generator are increased to get the synchronous speed. So, the units can generate the power with the rated frequency consistent with the grid. This operation mode can be explained through an example of a pump station with two reversible pumps. According to fig 1, # 1 pump and # 2 pump can work in pumping mode and generating mode.
Motor A and motor B constitutes generation units working in electrical and generation condition respectively, and the rated frequency of motor A IS 50Hz and the rated
frequency of motor B is 30Hz.



Before the pump is put into generating operation mode, the motor-generator unit starts firstly with the machine A which working as a motor at 50Hz and the machine B
works as a generator at 30Hz at meantime. Then, pump # 1 rotates reversely under the impulse of water flow. Close QFI when the speed is raised up to sub-synchronous
speed. Meanwhile, putting into the excitation, the pump # 1 reaches the synchronous speed and is dragged into the generation mode with the help of the motor-generator

units. At this moment, motor B is transformed from the generating state to electro motion state, which drives generator A to output a rated frequency power, The same can employed in Winding System and the tension control decides the generating medium

III. FOUR-QUADRANT MEDIUM-VOLTAGE VARIABLE FREQUENCY TECHNOLOGY

A. Converter Structure

As shown in Fig.2, the four-quadrant multi-level converter is composed of the phase-shifting transformer, power cells and controller, the integrated design is adopted.

The phase shifting transformer supplies power to each power cell on the input side. At the output side, each cell's U and V outputs are connected in series to form a star

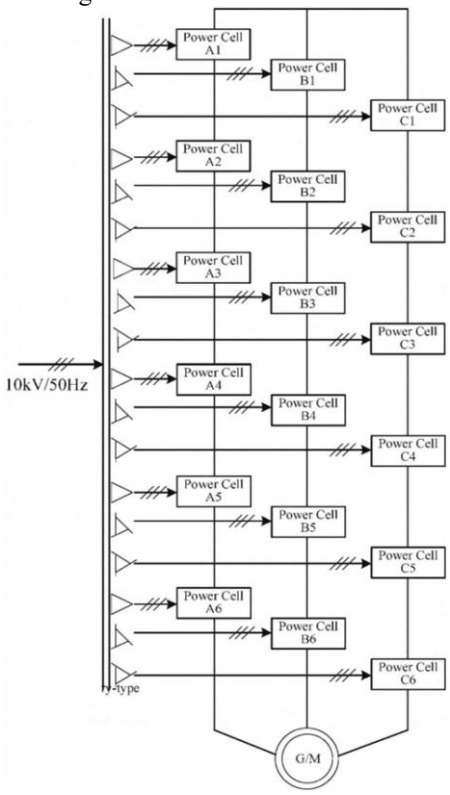
connection to supply power to the motor. Each phase of power output is composed of 6 power cells. Such a converter is characterized by its both medium-voltage

inputs and medium-voltage outputs: firstly, the reduced high grid voltage serves as the power supply for power units after the phase-shifting transformer; secondly, the

medium voltage outputs of the converter could be attained

by means of connecting a certain number of power units in series. The structure of each power unit adopts the topology of AC-DC-AC Voltage Source Inverter with 3-

phase inputs and a single-phase output. The three legs of the converter constitutes as Y -shaped in order to supply the variable voltage variable frequency power for medium voltage motors.



B. Phase-shifting transformer

The transformer's secondary windings are divided into nine different phase groups, where the 36-pulse rectifier mode is formed and the harmonics of the order below 35 is eliminated in theory. This multi-pulse overlap rectifier mode greatly improves the line current waveform quality, and the load power factor can be improved up to near 1. In addition, the independence of the transformer's secondary makes the power cells' main circuit relatively separated.

C. Power cell

The variable frequency power unit adopts the topology of AC-DC-AC voltage source converter, which consists of a 3-phase controlled rectifier, DC-link capacity and single-phase inverter. Such power units are available for the implementation of bidirectional energy flow.

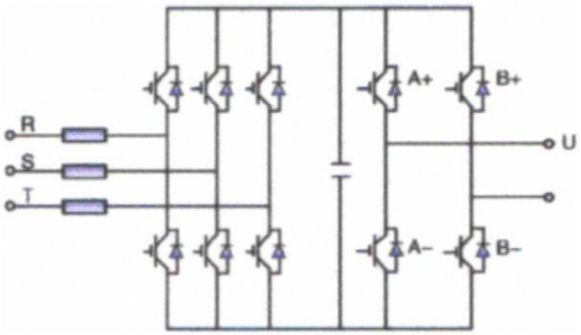


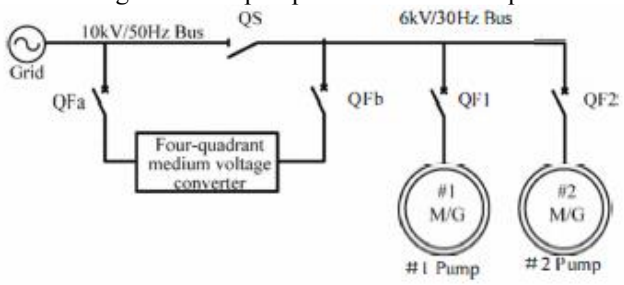
Fig3. The power cell of four-quadrant medium voltage converter

IV. POWER GENERATING OPERATION OF MEDIUMVOLTAGE VARIABLE-FREQUENCY TECHNOLOGY

A. System Structure

Take the system structure of the pump station with two generating units as example, as shown in Fig. 4. The generating power of pumps in motor operating mode is six
times as much as the power in inverted power generation mode. Therefore, it is feasible for several motors to share one four-quadrant converter. The rated power of the converter is the sum of generating power from all the generators. Technical difficulty in implementing pumps' power generation mode exists in how to connect to the grid, which results from the transient process from motor operating mode to power generation mode when pulling the motor into step. There are three operation modes: self-synchronization mode, startup synchronization mode and quasi-synchronization mode.

Fig4. Simplified electrical diagram of the pump station with Four quadrant medium voltage converter



B. Self-synchronization mode

When the converter is put into operation, the frequency of its output voltage should be set to the frequency value of generator's output voltage (30Hz) in order to construct a small grid system. When the speed of the first motor driven by pump reaches its 95% rated speed (30Hz), switch on QFl and connect the motor to the small grid system. Other motors are sequentially connected to the grid in the same way. As water flow impulses the water turbines increasingly stronger, the four-quadrant converter works in energy feedback state. In self-synchronization
mode, the imposed generators would cause much shock to the converter as well as to the generators themselves. For the purpose of reducing shock and soft cut-in gridconnection, it is essential to add a synchronization device, which allows the output voltage of the converter auto-track the working condition of pump generators.

C. Startup synchronization mode

In this mode, the converter operates in motor working condition and starts two motors directly. When the speed of motors reaches the rated speed of generators, water gates are turned on to drive the water turbines and energy begins to flow reversely to generate power. This mode could make full use of the features of the four-quadrant converter and realize the soft cut-in grid-connection. Meanwhile, the converter could adjust the frequency of generating voltage in order to place generators to the highest efficiency.

D. Progress simulation

Base on theory of startup synchronization mode, simulation research on the working condition of the four-quadrant converter is made under MATLAB/Simulink background. The rated voltage of pump motor is lOkV; rated power 3000kW and rated speed 150r/m. when the motor works in power generation mode, the output
voltage is 6kV; output power 500kW and speed 90r/m. It is calculated that the pump has the highest efficiency at 30Hz. Consequently, the converter should be operated at 6000V output voltage and 30Hz output frequency. The motor initially is driven by the converter to its steady state. At the time of 0.15s, the motor begins to transfer its working condition from motor working condition to power generation mode and the energy flow of the converter changes automatically. Fig.5 illustrates the voltage
waveform of generator and Fig.6 indicates the current waveform of generator. According to Fig.5 and Fig.6 the voltage of generator keeps invariant and the current
direction of generator reverses from motor working
condition to power generation mode.

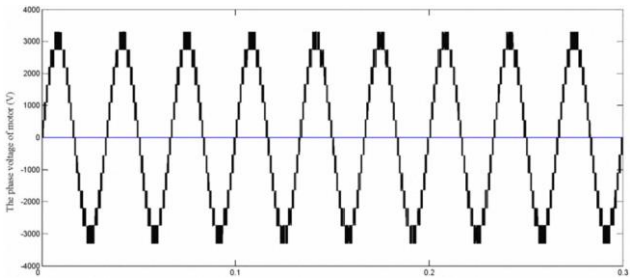


Fig S. The Phase Voltage of Generator

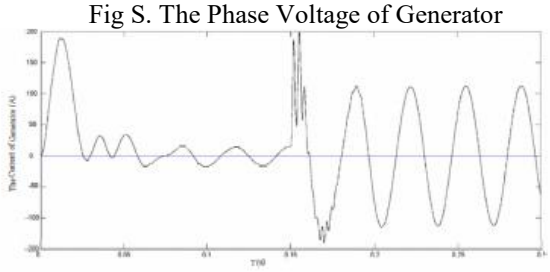


Fig6. The current of Generator

V. CONCLUSIONS

The four-quadrant medium-voltage variable frequency technology provides an entirely new operation mode for pumps in pump stations, which allows pump
generators to work in their highest efficiency and can be easily soft-connected to grids and in the same manner we can conserve and retrieve energy from winders and in EOT cranes by using their tension and it can be applied to the induction motors to regenerate the power.

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