RUSSULA

STATCOM Solution
(Static Synchronous Compensator)

Laminoirs des Landes

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1. INTRODUCTION ........................................................................................................................................................ 3

1.1. EXECUTIVE SUMMARY ............................................................................................................................................ 3

1.2. PROJECT HISTORY ...................................................................................................................................................... 3

1.3. PLATE MILL ELECTRICAL CHALLENGES .................................................................................................................. 4

1.3.1. ELECTRICAL GRID CONNECTION ................................................................................................................................. 4

1.3.2. ELECTRICAL SUPPLY FOR LARGE CONSUMERS ......................................................................................................... 5

2. STATCOM SOLUTION ............................................................................................................................................... 5

2.1. MITIGATING HARMONIC DISTORTION ......................................................................................................................... 5

2.2. RESIN ENCAPSULATED BAR ........................................................................................................................................ 5

3. STATCOM RESULTS .................................................................................................................................................. 6

3.1. ROLLING WITH STATCOM DISCONNECTED .................................................................................................................. 7

3.1.1. GENERAL VIEW OF 13 PASS CYCLE WITH STATCOM DISCONNECTED ........................................................................ 7

3.1.2. POWER MOTOR GRID DURING TWO PLATE PASSES ................................................................................................. 8

3.2. ROLLING WITH STATCOM DISCONNECTED AND RLC FILTER CONNECTED .................................................................. 9

3.2.1. GENERAL VIEW 18 PASS CYCLE WITH STATIC RLC FILTER CONNECTED ................................................................. 9

3.2.2. POWER MOTOR GRID FOR PASSES 7 AND 8 ................................................................................................................. 10

3.3. ROLLING WITH STATCOM AND RLC FILTER CONNECTED ............................................................................................. 11

3.3.1. GENERAL VIEW COMPLETE CYCLE ............................................................................................................................. 11

3.3.2. STATCOM SYSTEM IN OPERATION ............................................................................................................................. 12

4. STATCOM PERFORMANCE CONCLUSIONS ...................................................................................................... 13
1. INTRODUCTION

1.1. EXECUTIVE SUMMARY

In November 2016, Laminoirs des Landes (LDL) contracted Russula to supply the electrical installation, automation and a water treatment plant for its heavy plate mill located in Bayonne, France. The project had many technical challenges to overcome in a limited timetable. Since the construction began in 2008, many aspects of the heavy plate mill were already built.

One of the most debilitating challenges was that plant power connection did not comply with French electrical regulations from 2003 for low voltage installations. Without power, the heavy plate mill cannot roll. Russula overcame the challenge by proposing and implementing a Static Synchronous Compensator (STATCOM). With the STATCOM system installed and functioning, the heavy plate mill was able to start up on schedule in March, 2018.

1.2. PROJECT HISTORY

The LDL project began in 2008 with the purchase of the 10-hectare site land, main process equipment and hydraulic power stations. Subsequently warehouses were built for the heavy plate mill and storage facilities. The heavy plate mill has an estimated annual capacity of 300 kTn/year. The main equipment consisted of a reheat furnace, roller table, a reversible rolling stand driven by two 6000 hp DC motors, cooling bed and oxy-cut zone for finished product. Built in the early 60’s, both of the stand motors were reused from a plant that was dismantled in the USA.
Taking advantage of the legislative economic situation prevailing in France at that time, the electricity distribution company ERDF was contracted to supply the power at a rating of 20kV, well under the conventional 132-220kV high voltage solutions usually supplied for these types of facilities.

Due to the economic situation of the steel sector in 2010, the LDL partners decided to put the project on hold, leaving the warehouses, roller table and motors stockpiled on-site. In 2016, new investment partners reinitiated the LDL project, finalizing construction of the 20,000 sqm factory to start production in the shortest time possible.

1.3. PLATE MILL ELECTRICAL CHALLENGES

Due to the history of the project, at the time of its incorporation, Russula has had to face very strong electrical restrictions that jeopardized the project viability. The plant was sized to consume 20MW of power.

1.3.1. ELECTRICAL GRID CONNECTION

The LDL heavy plate mill produces 8-150 mm thick, up to 3.4 meters wide and 24-meter-long commercial steel plate. 250 mm plates are heated inside a reheat furnace to approximately 1100°C, where time and temperature are closely controlled. Once the plates leave the furnace, they start a cycle of passes through a reversible four-high rolling mill stand. The number of passes and pressure dictate the final product characteristics. Final quality improves with less passes, however more power is required from the stand drive and electrical installation. Peak power consumption occurs during the first passes of each cycle in periods of less than 3 seconds. Rolling of certain products can overload the motor by 280% more than the nominal rated power.

The LDL plant’s power connection to the public grid was rated for 20kV and had a low short-circuit level, due to the economic benefits derived from electricity tariffs in 2010, compared to other alternatives of higher voltage installations. A weak Q/V regulation scheme (Reactive Power/Voltage) exasperated voltage drops, which resulted in the formation of flickers and harmonic emissions for the heavy plate mill. The main DC motors directly drive the stand rolls, without the use of an intermediate gearbox. The motor load would cause a sudden demand of reactive power generating high voltage drops in the system. In addition, these motors are reversible and can rotate right / left for periods of time between 3 and 5 seconds which amplifies this effect.

In 2009, the electrical contractor for the original project proposed to ENEDIS (formerly ERDF), the power grid operator in France, to install a Static Var Compensator (SVC) to mitigate these effects. The SVC consisted of an RLC filter, which blocked harmonic currents and thereby reduced the harmonic voltage distortion. The SVC would connect to the Medium Voltage network via thyristors. ENEDIS rejected this proposal because it exceeded the maximum thresholds for harmonics and flickers, according to the French laws from March 17th, 2003, and consequently could generate instability to the public grid.
ELECTRICAL SUPPLY FOR LARGE CONSUMERS

Connections to the main motors and between the transformer and cabinets required bus bar instead of cable to comply with French regulations for low voltage installations when installing more than four conductors per phase.

In order to power the main motors (6,000 Hp), coupled with the overload restrictions up to 280% of the rated power, 19,000 Amps of current at 500 VCC was required. Unfortunately, these high levels of intensity were not common in the industry nor were there many companies that have developed technical solutions at the time.

2. STATCOM SOLUTION

2.1. MITIGATING HARMONIC DISTORTION

Russula proposed the Static Synchronous Compensator (STATCOM) as a feasible solution for the power distortion issues. A STATCOM is a power electronic device using a forced commutated device, such as an IGBT (Insulated Gate Bipolar Transistor) to control the reactive power flow through a power network and thereby increase the stability of a power network. The STATCOM combined speed of connection / disconnection and regulation by means of IGBT’s and its vector control together with the installation of a static filter, RLC filtering, that would allow the mitigation of harmonic components.

The R-L-C system is a solution widely used in industry and in the sector of electric power transmission to mitigate harmonic problems. It consists of resistors-coils-capacitors grouped together to achieve harmonic current filtering according to the design frequencies required by each installation.

The next step was to establish the motor load cycles according to the planned product mix and find the optimum flicker solution to comply with French regulations. Once this was accomplished, Russula looked for a reliable STATCOM solution supplier. Two leading power electronic manufactures were evaluated: ABB-Siemens-Schneider and General Electric. GE was selected due to its track record in similar industrial facilities.

2.2. RESIN ENCAPSULATED BAR

Vilfer Eléctric supplied Resin Encapsulated Bar to power the main VCC motors sizing the system for the rated motor current to withstand up to 280% overload (7,000A with overload up to 19,600A) through the thermal inertia of the copper and the resin used, while keeping constant the thermal characteristic of the bar. During the operation phase, design calculations were validated and very conservative safety ratios were verified to ensure that the bar temperature did not exceed 5 ° C during periods of overload.
3. RESULTS

The Statcom system started operations on March 21, 2018. In prior weeks, the plant was operating irregularly, due to testing of the different production systems. Despite the downtime, several weeks of production without incidents followed the startup phase.

Russula confirmed that the STATCOM system performance met design expectations as exhibited in the following graphs. The STATCOM injected reactive energy that the plant consumed during the short periods of time that the plate passed the reversible stand, and mitigated the voltage drops that caused the formation of flickering in the 20kV rated electrical installation. Neighboring consumers connected to the same substation were not disrupted. In addition, harmonic emissions were mitigated that previously were emitted to the 20kV network and the plant itself.

The following graphs show differences between several operating scenarios of the plant with the STATCOM System connected / disconnected:
3.1. ROLLING WITH STATCOM SYSTEM DISCONNECTED

3.1.1. GENERAL VIEW OF 13 PASS CYCLE WITH STATCOM DISCONNECTED

Graph explanation:

- **STT.Drv.UeAna.ActLoadLevel (%):** Indicates the percentage of torque exerted by the reversible stand rolls, function of time to identify when the plate passes.
- **Power Motor \ Grid Q1 and Power Motor \ Grid P:** Indicates the Reactive and Active Power consumed by the plant.
- **Basis Grid. U1N RMS (kV):** Indicates the effective simple voltage of phase 1 to identify the voltage drops incurred.
- **Power Motor \ Grid. Power Factor:** Indicates the instantaneous power factor with which the plant is operating.
3.1.2. POWER MOTOR GRID DURING TWO PLATE PASSES

Graph explanation:

- At the moment the plate enters the rolling stand, the active power increases rapidly up to approximately 4MW. Simultaneously, the Reactive Power absorbed by the AC / DC drives that feed the DC motors, also increases.
- This increase in Reactive Power generates a voltage drop in the power supply line to the plant due to its Inductive Reactance, (XL), which reaches a value of 5.5%. This value is very high considering that only 4MW are consumed, and the plant is sized to consume up to 20MW.
- On the other hand, we also observe that the plate mill power factor is low compared to other industrial facilities. Therefore, the objective is to reach values between 0.98 inductive and 0.99 capacitive.
3.2. ROLLING WITH STATCOM SYSTEM DISCONNECTED AND RLC FILTER CONNECTED

3.2.1. GENERAL VIEW OF 18 PASS CYCLE WITH STATIC RLC FILTER CONNECTED

In this operating scenario, we have connected the static harmonic filter R-L-C. Since the power consumed in the plant is low with respect to the sizing power, the net energy generated by the filter capacitors is positive, thereby injecting reactive power into the network, thus improving the plant voltage. That is, the plant has a capacitive power factor. We should note that the power registered in the seventh rolling pass exceeds 12MW compared to the 4MW registered in the previous case.
3.2.2. POWER MOTOR GRID FOR PASSES 7 AND 8

In the following graph, passes seven and eight are discussed in detail, in which the singular functioning of the STATCOM system can be observed, maintaining a capacitive behavior.

Graph Explanation:

- The seventh pass exceeds 12.5 MW of active power. These are usual load ratios in the types of product that are rolled in the plant.
- Before beginning the pass (idle motors), as a consequence of the permanent and fixed connection of the R-L-C filter, the plant is injecting approximately 3MVAR into the network. This ensures that the supply voltage, (20kV), remains very stable against the power oscillations that are consumed in the auxiliary services of the installation; and therefore, the non-proliferation of oscillations to the rest of the consumers connected to the electric company's substation.
- During rolling, one observes how the reactive energy changes direction being consumed by the network. Logically, the consumption threshold is lower than that which existed in the first case due to the filter connection; despite this, 4MVAR is exceeded in the seventh pass when the active power exceeds 12.5MW.
- As a result of the sudden variations in net reactive power, a 6.7 % voltage drop is produced, which is very high both and generates flickers in the system.
3.3. ROLLING WITH STATCOM SYSTEM AND RLC FILTER CONNECTED

3.3.1. GENERAL VIEW COMPLETE CYCLE

In this cycle consisting of 12 passes, despite the fact that in the first 3 passes more than 15MW of power was consumed by the plant, the voltage remained constant. In this operating mode, the STATCOM system is controlling the powers absorbed by the motors as well as the reactive power injected by the capacitors of the filter R-L-C, thereby stabilizing the voltage at a quasi-permanent setpoint value. This is the normal mode of operation of the plant regardless of whether it is rolling or not, the STATCOM system will always be connected.
3.3.2. STATCOM SYSTEM IN OPERATION

Graph explanation:

- Before beginning the pass (motors idle), as a consequence of the R-L-C connection and the regulation of the STATCOM, the reactive consumption is slightly positive; that is, the power factor is slightly inductive.
- At the time the pass begins, STATCOM regulates in such a way that the system generates the reactive energy consumed in the plant. In addition, the net flow tends to zero.
- In this way, the voltage remains quasi constant and exact during rolling. It increases by approximately 100V approximately compensating the voltage drop in the line due to the ohms law effect.
- The STATCOM system is operating according to expectations by quickly and dynamically compensating the reactive demands, avoiding voltage drops and thereby mitigating flickers and voltage oscillation problems upstream of the installation.
4. STATCOM PERFORMANCE CONCLUSIONS

During the post startup phase, Russula vigilantly monitored and analyzed the performance of the STATCOM system according to the production rate, product demands and new restrictions imposed by the electrical company. The validation of the STATCOM solution for the LDL plate mill broadens Russula’s portfolio in offering effective electrical alternatives for new rolling installations, and especially for existing plants connected to weak electrical networks; where the current solution is to adapt the rhythms of production to the capabilities of the network. The main benefits of incorporating the STATCOM system into the LDL manufacturing are:

- Increase production rate
- Produce new products that, due to electrical grid restrictions were previously impossible
- Reduce operating incidents caused by instability in the electricity network
- Reduce electric power costs
- Improve electrical grid stability in the area where the plant is located