MINING INDUSTRY PROCESS UPGRADES TO REDUCE ENERGY INTENSITY WHILE IMPROVING END PRODUCT QUALITY

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***Abstract* - In an environment of constantly cyclical mineral market prices, operators of sites in the global mining industry are challenged to continuously improve processes in order to remain competitive with their peers. Although not necessarily a priority in the past, the issue of energy efficiency project upgrades has moved to the forefront of mine operations. The dual benefits of both serving as a means of offsetting rising energy costs and reducing emissions to reduce environmental footprint are compelling. This paper is a case study of one such energy efficiency project recently implemented at a coal prep plant in Western Canada. The project began with a coal dryer energy efficiency feasibility study performed by a global energy services engineering company. Solicitation for the feasibility study was supported by the local utility company serving the mine site, who actually funded the cost of the study. The paper will review the analysis methods used and recommendations included in the study, followed by site implementation of one of the key study deliverables, a proposed plan to install a 6000Hp medium-voltage adjustable frequency drive to improve control of the main coal dryer exhaust fan. The paper will also describe the unique adjustable frequency drive selected for installation for this load, including an overview of the power electronics topology and resulting performance both in delivering improved energy efficiency and also process improvements. This upgrade ultimately assured both that energy and operational costs were reduced while the coal prep plant delivered a superior end-product to its customers.**

Index Terms – Mining industry, Coal preparation plant, Site energy study, Adjustable frequency drive.

I. INTRODUCTION

The Teck Coal Elkview Mine in Sparwood, British Columbia Canada has been operational for several years and includes both a metallurgical coal mine and a coal wash plant for the fine and coarse fractions, plus a fluidized bed dryer operation with dust cyclones and a wet scrubber. The coal dryer plant is operated 24/7 and the electrical energy consumption of this facility is approximately 20 to 25% of the total 22,000 kVA of total peak mine demand. Because the coal dryer is one of the site's highest energy consumers, a great deal of emphasis on energy saving initiatives has been focused on this part of the plant. In 2007, the dryer exhaust fan, the plant's single largest load at 3800 kVA, was retrofitted to trim the backward curved blades from 140.75 inches to 134 inches. This modification resulted in a reduction of energy demand of about 300 to 400 kW. The coal mine and coal drying plant are serviced by the local utility British Columbia (BC) Hydro headquartered in Vancouver, BC Canada. Like many utilities in North America, BC Hydro offers programs and funding to support energy initiatives. The coal plant leadership has worked well over the past several years in using the BC Hydro Power Smart Industrial Alliance Energy Grant Program as a means to identify energy efficiency opportunities at the mine and prep plant, then implement the programs offering the best energy savings.

Teck Coal made the decision in late 2011 to bring a globally recognized energy services company to the site to complete a thorough review of the mine and processing plant, ten recommend specific initiatives that would deliver energy savings. A tea of engineers from the energy services company visited to site for a total of four days, developing a written report of the findings that was delivered on March 2012. Included in the site team were certified energy managers (CEMs) from the energy services company, plus an engineer from an internationally recognized coal dryer consulting firm.

II. SITE ENERGY STUDY

The energy services staff included engineers from a global energy services provider. A group of three CEMs, including an engineer familiar with coal processing, visited the site for four days in December 2011 when the plant systems and operations were observed and energy measurements were taken at multiple points in the system. Also, plant and mine operators were interviewed to assure a clear understanding of current state operations and limitations. The team first worked to identify and understand the energy use and billing for the site. The local utility rate agreement included a Tier 1 and Tier 2 rate, the latter being significantly higher during peak use. Table I below shows the past and projected electrical energy usage based on projected rate increases from 2012 through 2015. The annual split of Tier 1/Tier 2 payments by the site

TABLE I
SITE ELECTRICAL ENERGY USAGE 2012 THRU 2015

Fiscal Year	Start Date	End Date	Rate Increase (%)	Blended Rate ($/MWh)	Tier 1 Rate ($/MWh)	Tier 2 Rate ($/MWh)	Demand Charge ($/kVA)
F2012	4/1/2011	3/31/2012	-	$35.33	$31.07	$73.60	$6.03
F2013	4/1/2012	3/31/2013	3.90%	$36.70	$32.60	$73.60	$6.26
F2014	4/1/2013	3/31/2014	3.90%	$38.14	$34.19	$73.60	$6.51
F2015	4/1/2014	3/31/2015	5.00%	$40.04	$36.31	$73.60	$6.83

were roughly 90%/10% respectively. The 2011 blended rate used by the facility was $0.03533/kWh. Although there was also a charge for kVA demand, this amount was negligible and added little to the monthly utility bill.

In completing an Energy Efficiency Feasibility Study (EEFS), the team recognized it was important to establish boundaries for the work. Just as it was important to establish a focus on the coal drying plant as a major energy consumer for the site, it was equally important to focus on specific opportunity areas for energy improvement for the system components in the coal drying plant. Fig. 1 shows the primary elements of the coal drying system and Fig. 2 shows the major electrical energy consumers for the system. From reviewing the system operation and consumers, the EEFS scope quickly narrowed to only the Main Dryer Exhaust Fan and the Combustion Air Fan. These accounted for 81% of all estimated KVA/kW used. All other equipment listed in Fig. 2 was considered but eliminated after detailed evaluation and interviews with operating staff. The main reasons that the other equipment was not considered were:

a. The dryer systems already had adjustable frequency drives (AFDs) applied on the 8 feed screws.
b. The Scrubber Pumps, MET Transfer Conveyors and Dryer Dust Screw Conveyors were considered properly sized, with constant operation, Thereby AFD control or other measures would not be effective.
c. The Dust Screw and multiple small equipment items would deliver insignificant power savings for the scope of this study

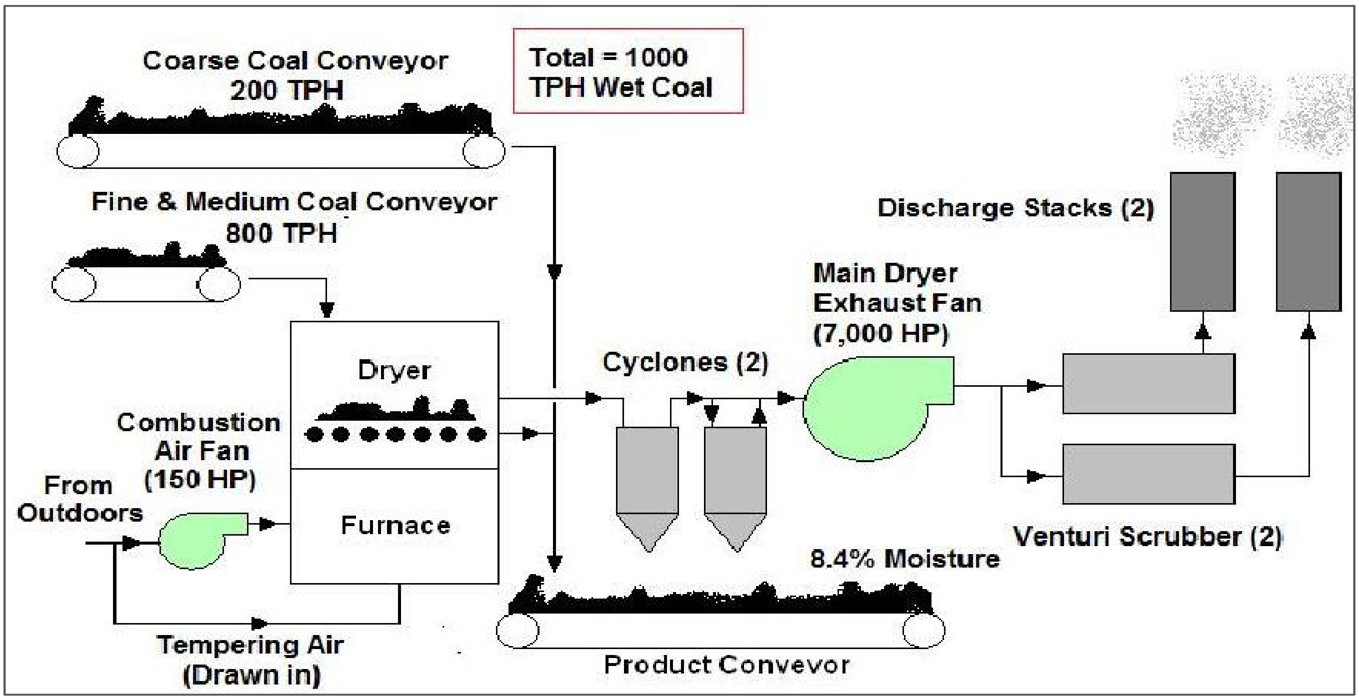

Fig. 1: Coal Drying Plant – System diagram

Dryer Equipment	Voltage	Amps Measured	HP Connected	KVA	Est Load
Exhaust fan	4160	624	7000	3780	60%
Comb Fan	575	70-80	150	82.5	62%
Dryer feed Screw Conveyors (8@25 HP)	575	NA	200	130	65%
Dust Screw	575	NA	60	30	65%
Dryer Dust Screw Conveyors (30x4)	575	NA	120	75	65%
Conveyor MET Coal	575	NA	150	100	65%
MET Transfer Conveyors (1)	575	NA	60	75	65%
MET Transfer Conveyors (2)	575	NA	120	20	65%
Scrubber return Pump N	575	NA	250	160	65%
Scrubber return Pump S	575	NA	250	160	65%
Misc (Auxiliary equipment)	575	NA	300	180	65%
Total			8660	4792.5	-

Fig. 2: List of Coal Drying Plant electrical “energy users” the scope of the study was narrowed to the Main Dryer Exhaust Fan (6,000 horsepower) and the Combustion Air Fan (150 horsepower)

III. DESCRIPTION OF SYSTEM OPERATION

The overall mine operating process currently uses independent circuits to process run-of-mine (ROM) coal into saleable metallurgical coal for use in the production of steel. First, raw coal is separated at a specified size, with the oversize fraction dewatered and eventually sent to the Dryer. Medium-sized material is separated with the oversize fraction going through a series of Cyclones, with product sent to the overflow where it is dewatered and eventually to the Dryer. Finally, the lowest-particle size materials are further separated by particle size and the product is then sent through additional Cyclones. The finest fraction of this product this then sent to be mechanically dewatered and eventually report to the Dryer.

Referring to Fig. 1, The thermal coal dryer is designed to decrease the moisture content of the clean coal product from the adjacent coal beneficiation/preparation plant. The moisture content of the preparation plant clean coal product is in the range of 12 to 14%. The present production rate in the dryer process is typically 800-1,000 Tones per hour. Of this 650-850 Tones pass through the dryer. Wet, medium and course coal from the preparation plant is sent by conveyor to an intermediate feed bin located above the drier inlet. The wet coal is fed from the bin into the dryer, at a controlled rate through 8 variable-speed discharge screw conveyors. The targeted product moisture is in the range of 7.5 to 8%.Only a portion of the preparation plant product is directed through the thermal coal dryer. The plus 12.5 mm fraction at nominal 5.5% moisture is bypassed around the dryer and then recombined with the thermal dryer product to achieve the desired final product moisture of 7.5 to 8%. In addition to bypassing the plus 12.5 mm fraction the process also bypasses a portion of the minus 12.5 mm fraction that would normally be fed into the dryer.

In the drying chamber, the wet coal is floated over a deck. Four natural gas combustion burners move preheated air from the Combustion Air Fan, causing an updraft chamber passing through this deck and drying the coal. Downstream of the drying chamber but before entering the Main Dryer Exhaust fan, the hot, moist air is drawn through two cyclones in parallel to capture the fine particulates. Downstream of the Main Dryer Exhaust Fan, the gases pass through two high-pressure venturi scrubbers (approximately 30 inch water gauge differential pressure) in parallel for additional gas cleaning before discharging to the atmosphere.

Current state conditions allow the operator to set up the dryer around four variables;

a) Set the speed of the eight feed screws to maintain a 75% level in the wet coal bin
b) Set the exhaust temperature control to maintain a nominal 150 to 160°F
c) Set the exhaust fan motor controller to maintain a nominal 3250 kW power on the fan motor and
d) Closely monitor the total product moisture – this is the moisture of the recombined dryer product and by passed material, the target is 7.5 to 8% total moisture.

Typically the variable controls or controllers are held relatively constant. The greatest variable in achieving the desired product moisture is the amount of bypass of the minus 12.5 mm material that would normally be fed into the dryer. If the total product is going below the target moisture (too dry) the operator will first start to bypass additional material to bring the moisture back up to the desired level. If the total product moisture is going above the target then the operator will bypass less and dry more material. This approach keeps the dryer operating at a relatively constant basis.

The exhaust fan is controlled by a fan motor power controller which allows the operator to input a control or power set point, this controller then modulates a set of exhaust fan inlet dampers which increase or decrease airflow, resulting in a relatively constant power on the exhaust fan motor. The power on the fan motor will change and is influenced primarily by temperature and density of the air and water vapor mixture within the drying system. Thus the exhaust fan inlet dampers modulate in response to these changes to maintain a constant fan power.

Idle conditions are those periods where the thermal coal dryer exhaust fan is kept running and there is no coal being dried (feed screws are off). Typically two out of the four furnace burners are kept operating at low fire conditions. Idle conditions usually occur when there is an operating issue with the coal preparation plant. These may be as short as 15 minutes or could last several hours. It is not practical to shut down the exhaust fan in these situations and the furnace is kept operating so the dryer facility is maintained at a reasonable temperature to prevent condensation issues and to bring back the dryer to full operating temperature within a relatively short period of time when raw material is again available.

During the idling period the exhaust temperature is maintained at about 140°F-148°F. The exhaust fan power controller is set at 3250 to 3000 kW, depending on the operator. Two out of the four burners are operating on main gas and gas input is controlled in manual.

When the dryer is in idle mode the feed screws are off and the furnace by-pass stack automatically opens and the emergency cooling air dampers in the hot gas plenum go to the open position. This results in having to burn more gas to maintain system and exhaust temperatures plus the exhaust fan power is higher due to a lower temperature and higher density air.

During these idle periods it would be advantageous to reduce the airflow through the dryer by reducing the rpm of the motor with a new VFD, thus reducing the power consumption of the exhaust fan motor. Since the potential reduction in power and gas consumption during these idle periods was unknown, a set of trials was conducted during a second site visit in January 2012 during an idle period.

IV. ENERGY STUDY RECOMMENDATIONS

Two ECM's were recommended in the final report. The first ECM recommended the installation of a Variable Frequency Drive (VFD) on the Main Dryer Exhaust Fan motor to control and vary the rpm of the motor. Controlling the rpm of the fan motor has the same basic effect of opening and closing the inlet dampers to the fan, but with higher energy efficiency. This changes the fan's exhaust air flow rate, as well as affects other process parameters such as temperatures. Controlled tests were carried out at incremental damper positions.

This ECM has two components namely, a) energy reduction achieved while operating a VFD during the continual steady-state dryer production; and b) energy reduction achieved while operating a VFD during the dryer's idling periods. The second ECM proposes to install a VFD speed control on the dryer's Combustion Air Fan motor which again would replace functionality of the current variable inlet vane and dual-damper outlet control. In addition to reduced electrical energy use as a result of replacing the inlet vane controllers with VFDs and improved power factor which would be near unity with a VFD, there were also non-electrical savings identified in the study. These included:

1) Dryer fuel consumption would be reduced as a result of lower air flows during both operations and idling periods.
2) More precise controls with the VFD addition would allow the site to achieve higher product quality through obtaining product moisture that is both closer to the desired target plus the ability to achieve that moisture on a consistent basis.
3) Enabled all the operators (3 shifts) to operate the dryer system the same way, setting the speed of the fan at the required cyclone pressure drop to regulate air flow through the dryer.
4) The VFD would reduce maintenance costs due to the controlled soft start via ramping up frequency during start-up and eliminating the reliance on mechanical components (i.e. the inlet dampers) that required frequent maintenance and adjustment.
5) Looking at Green initiatives, a savings of 2,370,890 kWh for electricity and 11,730 GJ for gas in British Columbia Canada equals a total emissions reduction (CO_2, Methane, and Nitrous Oxide) of 130 to 349 Tons per year.

Regarding the last item, the range takes into account variations in the source of power generation in the Province. The majority is very low-carbon emitting hydro-electric generation, mixed with supplemented conventional fossil fuels. The carbon conversion factors are from 10 to 40 times lower than other locations in North America. If the power was generated by fossil fuel the carbon savings equivalents would be 1,500-3,000 Tons per year. Fig. 3 below summarizes the total project savings summary considering both electrical and non-electrical impact. Total installed costs estimates were also included in the study, which delivered simple payback values as shown in Fig. 3 for both the Dryer Exhaust Fan VFD upgrade and the Dryer Combustion Fan upgrade. Because the Exhaust Fan VFD offered the best energy saving opportunity and also would assure the process delivered a product with better moisture consistency, the site owners made the decision to go ahead with the larger of the two VFD upgrades first.

V. Selection and Installation of the VFD

One condition of completing the energy study that was part of the initial work contract was that the services provider's recommendations not be aligned with installation of any specific manufacturer's products. In the energy services professional community, this is standard practice to assure the results are linked to energy improvement as opposed to selling a specific product. The site owner went through a request for proposal process for the new 6,000Hp Dryer Exhaust Fan VFD and after reviewing available Technology and service/support capabilities, a decision was made to install a new VFD manufactured by the energy services company that performed the study. This company also offered capabilities in manufacturing a broad range of low-voltage and medium-voltage power distribution assemblies including the needed 4,160 volt, 7000Hp medium-voltage VFD.

A. VFD Selection Criterion

One important factor in VFD selection was the design/ topology. Since the planned installation was inspired by energy savings, the mine owner was looking for a design that was very high efficiency. Near unity input system power factor was desired and also very low input harmonic distortion to assure there was no potential interaction between the new VFD and other electrical equipment installed at the site. Since the installation was planned near the coal mine site, a very robust design that was impervious to coal dust, moisture and other airborne contaminants was also desired. Although the new drive would be installed into a pressurized control room at the site, past experience had proved that often times doors are left open, filters are not cleaned/replaced and a "clean" environment for sensitive power electronics was virtually impossible to achieve. Finally, the serviceability of the new drive was very important. Since a drive failure would effectively shut down not only the dryer but also ultimately the preparation plant and coal mine, it was important in the event of a failure that the time to return the VFD to service would be kept to a minimum.

Total Project Savings Summary													
		Electric					Natural Gas		Maintenance-Other		Payback		
Measure No.	Measure Description	Demand (Avg kW/mo.)	Energy (kWh/yr)	Demand Savings ($/yr)	Energy Savings ($/yr)	Total Electric Savings ($/yr)	Energy (GJ/yr)	Total Gas Savings ($/yr)	Electrical $/yr	Maintenance, $/Yr	Total Cost Savings ($/yr)	ECO Cost ($)	Simple Payback
ECM-1	VFD for Exhaust Fan Motor	239.7	2,273,381	$ 16,868	$ 82,319	$ 99,187	10,170	$ 53,766	$ 2,000	$ 8,000	$ 162,953	$ 990,570	6.1
ECM-2	VFD for Dryer Combustion Fan	33.5	97,509	$ 2,361	$ 3,531	$ 5,892	1,563	$ 8,266	$ -	$ 1,000	$ 14,158	$ 48,828	3.4
Total		273.2	2,370,890	19,229	$85,850	$105,079	11,733	$62,032	$2,000	$9,000	$177,111	$1,039,398	5.9

Fig. 3: Total Project Savings Summary for addition of VFDs for the dryer Main Exhaust Fan and Dryer Combustion Fan

B. Review of Selected VFD Topology

The new 6,000Hp Dryer Exhaust Fan VFD selected was a 24-pulse voltage source design, the schematic for which is shown in Fig. 4 below. The drive input is powered by 3-phase, 4,160 volts AC, 60 cycles and the output is also 3-phase, with variable frequency and voltage up to 60 cycles and 4,160 volts necessary to produce a variable speed output for the 3-phase 4,160 volt squirrel cage Exhaust Fan induction motor. Note from Fig. 4 that the input section of the VFD includes a 24-pulse input rectifier. The 24-pulse design includes a multi-winding transformer with a single primary winding and four secondary windings. The secondary windings are wound on the common core and each is wound with an intentional phase shift: + 22.5° (electrical degrees), -7.5°, +7.5° and -22.5° each with respect to the primary winding which is aligned with the fundamental input frequency at zero degrees. The four secondary windings each have a common load consisting of a full-wave bridge diode rectifier. In this configuration, the four rectifiers each share 25% of the total load. Although the 24-pulse converter section requires a total of 24 power diode devices versus a total of 6 that would be required for a 6-pulse converter design. Because the power devices are called upon to conduct only 25% or the total load current, the devices can be rated for a lower current carrying capacity. Because of this, although the device count is 4 times a 6-pulse design, the total size and cost using a 24-pulse is nearly equal to the 6-pulse. The phase-shifting design of the multi-winding input transformer enables harmonic cancellation [1] and ultimately reduces the input harmonics on the system that are attributable to the VFD. Both current and voltage harmonics using this approach are reduced to levels below those recommended by IEEE 519-1992 [2]. Total Harmonic Distortion limits as defined by this Standard are important to assure the addition of a large non-linear load like the new 6,000Hp VFD does not have adverse effects on other components included in the electrical power system [3].

Following the 24-pulse rectifier is the DC Link. This fixed voltage source of the drive system operates at approximately 5616 volts DC, effectively the converted DC peak voltage of the 4,160 volt RMS AC input voltage. The DC Link includes a resistor-capacitor network, which serves as a filter to smooth the ripple current of the rectified sine-wave input. Note that the design also includes a clamped neutral point whereby the DC Link voltage is effectively divided about a grounded neutral point which is also carried through into the inverter circuit.

The inverter section of the drive converts the fixed DC from the DC Link to adjustable frequency and voltage AC. This is accomplished with Insulated Gate Bipolar Transistors (IGBTs) that are connected as shown in Fig. 4 and switched to develop a quasi-sine wave output. The motor is designed for 4,160 volts at 60 hertz, so operation over an adjustable speed rage from 2 to 60 hertz requires that the voltage/frequency or Volts to Hertz ratio remain constant at 4,160V/60Hz = 69.33. This assures the proper amount of flux in the machine to develop a constant torque output over the defined speed range.

Other elements shown in the schematic include the Pre-Charge Circuit used to ramp voltage onto the DC Link before the drive is energized and output current transformers used for feedback used in regulator controls and also drive output/motor overload protection.

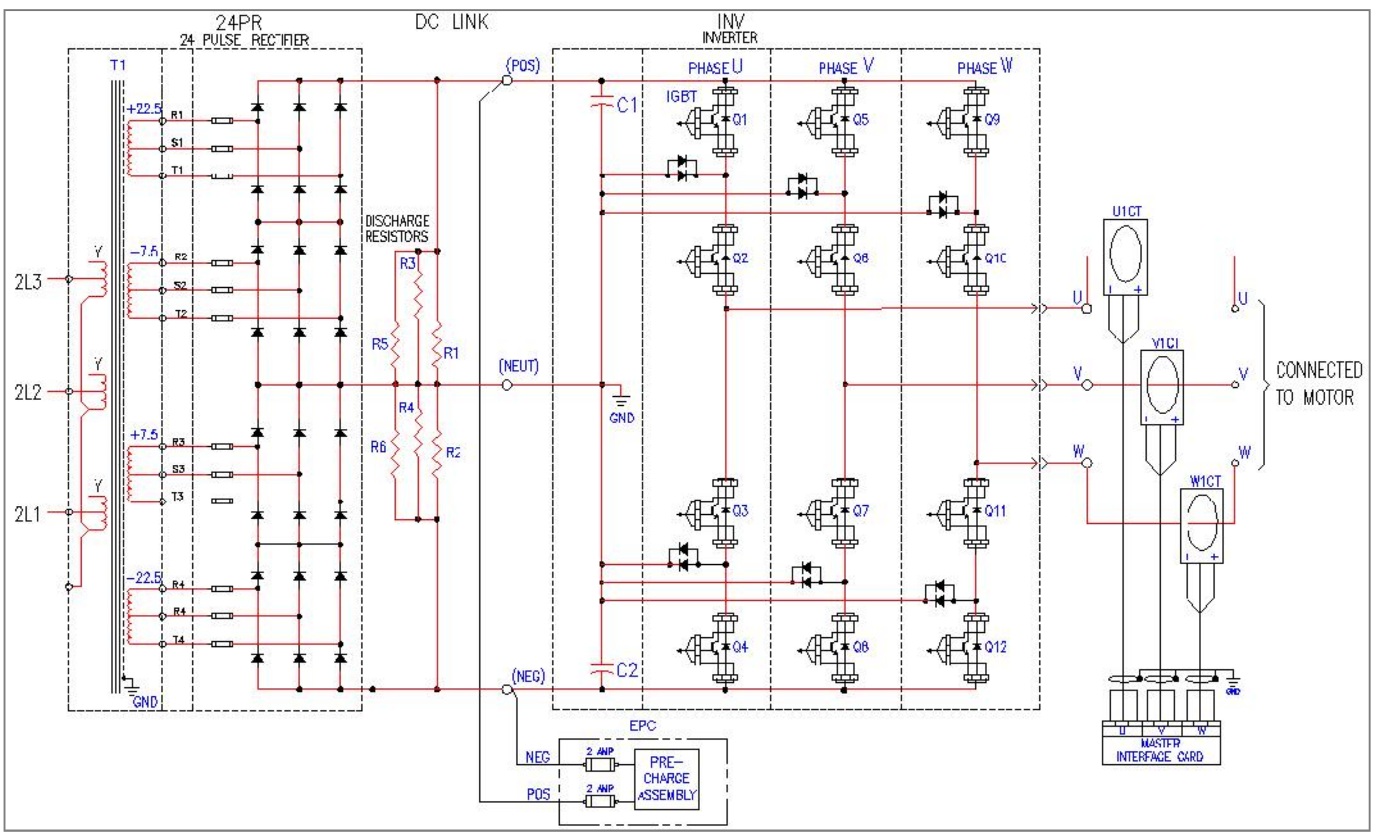

Fig. 4: Schematic of the new 6,000Hp Dryer Exhaust Fan VFD

C. Other Drive Design Considerations

Fig. 5 shows the new 6,000Hp Dryer Exhaust Fan VFD on the manufacturer's factory floor prior to shipment. From left to right, the vertical sections include:

1) 4.16kV incoming line section
2) Input disconnect and vacuum contactor
3) Multi-pulse input magnetics & rectifier
4) Dual inverter sections
5) Output dv/dt filter

The dv/dt filter is a factory optional device used to effectively smooth the VFD output waveform and reduce the rate of rise of voltage with respect to time. For applications where the VFD terminals are a great distance from the motor terminals, this filter helps reduce the possibility of an escalated voltage at the motor terminals. This is caused by a standing wave phenomenon prevalent with non-sinusoidal VFD output waveforms such as in this case. The addition of a dv/dt filter is recommended when the cable distance between VFD and motor is extensive. The design also includes exterior door-mounted filters to assure that internal contamination due to the site environmental conditions is kept to a minimum.

Fig. 5: 6,000Hp Dryer Exhaust Fan VFD

The inverter subassembly removed from the VFD is shown in Fig. 6. This design includes a roll-in/roll-out module which includes the entire three-phase inverter assembly. The modular design allows the plant operators to quickly remove and replace the entire power section should there be a component failure. The total change-out time is less than one hour. Another notable feature is the protection of sensitive power electronics from the elements. Note from mid-section of the inverter shown in Fig. 6 that then entire power section including the IGBT semiconductors and the respective gate drive printed circuit boards are encased in a transparent silicone gel. This allows fast visual indication of a failed power device encased within the silicone and also assures that a failed device will not propagate a fault to adjacent devices, each which is protected within the silicone gel. Heat is extracted from this subassembly via heat-pipe management system. Heat pipe construction consists of both evaporator and condenser sections. Heat enters the heat pipe at the evaporator where it causes the working fluid to vaporize. Then the vaporized fluid creates a pressure gradient, forcing the vapor toward the condenser section of the heat pipe. Heat exits the heat pipe at the condenser where the fluid is cooled

Fig. 6: VFD Inverter Subassembly

via the fan assembly, it then condenses and is drawn back into the evaporator, beginning a new cycle of heating, rising and then cooling and falling. The heat pipe and top-mounted fan assembly extracts heat from the power semiconductors, assuring device junction temperatures are held within factory specifications. Forced air circulates up and out of the inverter unit and is continuously circulated within the enclosure to assure proper cooling. Overall wire to wire efficiency of the VFD is on the order of 97.5%, which assures that the energy saved in controlling the centrifugal dryer exhaust fan is not consumed by inefficiencies in the drive assembly.

Fig. 7 below shows a picture of the existing 6,000Hp, Dryer Exhaust Fan motor. Interesting to note that this is an older wound-rotor machine that includes slip-rings, commutator and

Fig. 7: 6,000Hp Dryer Exhaust Fan Wound-Rotor Motor

carbon brushes as traditionally found on these machines. The motor was employed a soft-start feature by the use of a liquid rheostat as shown in Fig. 8. This device effectively adjusted resistance at the rotor winding to voltage to assure the motor came up to speed slowly, reducing the inrush current and reducing mechanical stress on the coupling and drive load during start-up. The liquid rheostat was effectively obsolete and many parts were no longer available. Because the new VFD offered a soft start feature that was superior to the rheostat start via ramping up the frequency applied at the motor stator windings on start-up, the rheostat was no longer necessary and therefore removed from service. Secondary windings of the rotor of the 6,000Hp machine were effectively shorted so that the motor operated similar to a squirrel cage induction motor.

Fig. 8: Existing liquid rheostat for 6,000Hp motor which was decommissioned as a part of the VFD upgrade

VI. Help with Economic Justification

One key factor in completion of the site energy audit and ultimately the installation of a new energy 6,000Hp Dryer Exhaust Fan VFD was assistance from the utility serving the site. As mentioned previously, the serving utility has some very forward-looking programs including the Power Smart Industrial Alliance Energy Grant Program. As is true with most utilities, it is important to consider the avoided cost of the incremental generation assets [4]. Often times, saving electrical energy and passing a component of the avoided cost on to rate payers can be the prudent choice. One unique characteristic of the generation assets serving this site is that most energy is generated from hydro-electric power, considered a clean energy source, because of this, the serving utility has an opportunity to wheel power into higher priced markets including California USA where energy rates are appreciably higher than Western Canada and rate payers are willing to pay a premium for a clean energy source. To this end, helping to fund the energy program at the British Columbia mine site offered an attractive alternative for the utility to not only avoid the cost of adding new generation but also brought forward the opportunity to sell the saved megawatts to other consumers at higher rates. Truly a win—win for both the rate payer and the serving utility.

VII. Conclusions

The global mining industry is constantly working toward ways to reduce costs and operate efficiently. Saving energy offers a dual benefit of both offsetting rising energy costs and also reducing emissions which ultimately delivers a reduction in environmental footprint.

Qualified energy services companies such as the global service provider involved in this case study at Teck Coal's Elkview Mine in Sparwood, British Columbia bring needed expertise in site investigation, measurement, identification and recommendation of energy savings opportunities. In this case, site process improvements yielding a more consistent and valuable end products were delivered along with significant energy savings. The highest site energy user was upgraded with a new VFD which delivered enhanced operating reliability, process improvements and the predicted energy savings.

Utility service providers should always be included as a part of any energy initiative at a plant site such as the one in this case study. Often times, the serving utility will offer incentives to reduce the energy footprint of a served industrial facility. In several cases, the utility stands to actually benefit from a reduction in consumed electrical energy delivered as a part of an energy initiative as described in this paper.

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