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Performance Improvements with Advanced AC Drives in Plate Shearing Line at Steel Plant

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This paper represents the comprehensive study, analysis and results achieved by various data evaluation of AC drive system over DC drive system in Essar steel limited in India. With innovations in advanced direct torque control and vector control technologies, performance of AC drives is similar to DC drives in entire speed range. Usage of these advance speed control techniques in AC drives gives excellent results to achieve desired torquespeed characteristics, dynamic response and over load capabilities similar to DC drives. In February 2010, replacement of DC drive system by AC drive system was carried out in hot rolled plate shearing line (PSL), which is cut to length application line in steel plant. Before replacement, design calculation of AC system was carried out for matching the plant requirements. By various technical and financial comparisons, it is found that use of AC drives is more economical in comparison with DC drives.AC drives ensure improvements on energy efficiency, reliability and enhancement of production with reduction in cost, maintenance and equipment down time. After replacement of DC drives to AC drives, following performancs ase observed in PSL:

- *Energy saving of 1.88 kWh/t.*
- *Production rate increased from 55 t/h to 95 t/h.*
- *Line speed increased from 19.5 meters per minute (m/min) to 23 m/min.*
- *Line stoppage time reduced from 2000 minutes to 300 minutes per annum.*

Keywords: *Direct torque control, Variable speed AC drives, Energy efficiency, Production rate, Return on investment.*

1.0 INTRODUCTION

There is a major contribution of the variable speed drives in the growth of industries. The annual consumption rate for both AC and DC type variable-speed drives is approximately 6%, while the consumption rate for only AC drives is around 8% per annum. This number shows popularity of AC drives for getting variable speed with squirrel cage induction motors. In DC shunt motors, field and armature current components can be varied independently for controlling torque and speed according to the application. Similarly, in AC motors with vector control method, direct and quadrature axis current components can be varied independently for matching torque-speed requirements [12]. In DC drive system, motors require frequent maintenance, less reliability and high-energy consumption in comparison with AC drive system. Moreover, DC motors have additional cost of consumable spares like carbon brushes, brush holders, springs and brush

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breeding stone, etc. Overhauling and repair cost of DC motors are also high in comparison of AC motors. This is due to design complexity of separate field winding, armature winding, compensation winding, eddy current balancing rings, commutator, brushes, brush holders and springs, etc. Moreover, due to non-linear loading pattern, commutator surface in DC motor is getting uneven, oblong, over heated, slot creation, scratch generation or damage, so periodic under cutting, smoothening, mica cutting, chamfering, etc. are adding cost during repair or overhaul. These all can be eliminated in AC motors, so popularities of AC drive system is increased in comparison of DC drive system [4]. Moreover, with AC drive system, control accuracy gets improved by utilizing its latest internal modeling, sharing functions, free function blocks and various inbuilt logics for various suits to site application. It is also easy to carry out integration with other automation systems for smoother operation, supervision, data monitoring and display facility [2]. It also improves the quality of plant engineering system, documentation and soft copies of parameterizations in the computers. While with older drives it was kept in hard copies, and changes were done through manual parameterization which was taking more time and mistake prone. With new drives, it is just a matter of creating back up file through the computer.

2.0 AC DRIVES

The word "drive" is used for combination of electro mechanical equipments like electric motor , gear box or pulley and to transmission shaft connected together and move a load, it is called as "drive". The term AC drive is combination of variable frequency inverter the and AC induction motor which are rotates or moves the load [14]. A variable frequency drive is an adjustable speed drive. The basic block diagram of the power conversion stage of the AC drive is shown in Figure 1. From fixed frequency and voltage, AC supply is getting converted in variable voltage and frequency AC supply in three stages. First converter unit is converting three phase fix frequency supply to fix DC supply. In converter power devices like power diodes, thyristors or SCRs are used; they may be controlled-or uncontrolled-type rectifiers, based on the power devices used in its construction. the Second stage is of DC link bus,where filters, DC bus bar, voltage measuring devices and chopper are connected. This converted DC supply is available on the DC link bus. Third stage is called as inverter, which inverts DC bus fix supply into variable AC supply with the help of power devices of Insulated Gate Bipolar transistor (IGBT). This variable supply in terms of variable voltage and frequency is fed to the motor and it runs as per the requirement of the speed. The VFD is having two compartment, power compartments: where all power devices, cooling attachments, heat sink,etc. are mounted and second control compartment, where all control, communication, referencing, displaying attachments and electronic circuit boards are mounted. Apart from these, there is a drive firmware in which basic accessible data for communication-or display-related program is available in addition to the parameterization software. These firmware and software are stored in the EPROM or EEPROM chips on the control printed circuit board. The controlled power devices are in various stages, operation loops like speed control and current control loops which function based on PID loops. In first stage of PID reference is given to the speed controller with speed limit. Speed controller creates reference to the current controller with current limiter and further square wave pulses are created in the form of pulse train which is modulated with base switching frequency, called pulse width modulation (PWM)This PWM signal train is used to fire the gate of the solid state device IGBT, which consists of PNPN semiconductor layers in its construction. Based on the pattern of firing, squarewave IGBT makes conduction and allows flow of current in the designed pattern which in turn rotates induction motor in require,speed.

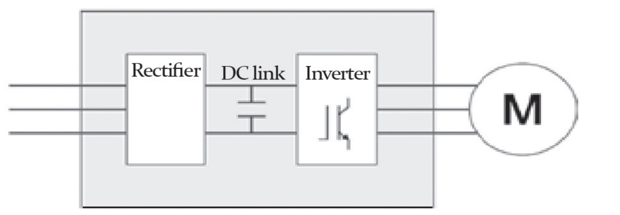

FIG. 1 BASIC BLOCK DIAGRAM OF AC DRIVE

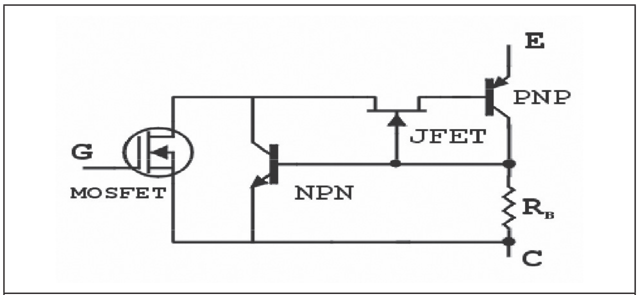

FIG. 2 IGBT INTERNAL CONSTRUCTIONS

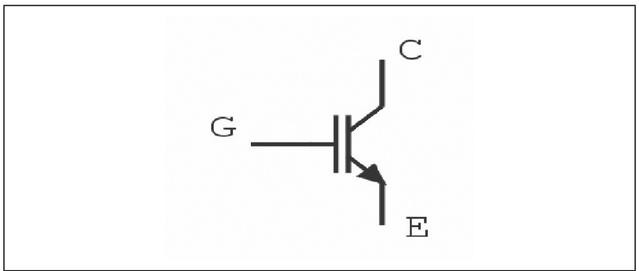

FIG. 3 IGBT SYMBOL

Figures 2 and 3 represent IGBT internal construction and symbol, respectively. It is having three terminals gate, collector and emitter.

In this paper, the performance comparison of AC drives over DC drives in PSL of Essar steel is evaluated. AC drive system has increased the production rate to 95 t/h from 55 t/h in comparison with DC drive system. Effects on other performance parameters such as energy consumption, line speed and line stoppage time are discussed in detail.

3.0 PLATE SHEAR LINE

Hot rolled PSL with production capacity of 0.335 million tons per annum was installed in steel complex during 1997. It is a start stop, down cut type shearing machine for length wise cutting of steel material. Plates and sheets of various sizes 0f 3–20 mm thickness, 700–2000 mm width and 1000 –14000 mm length are produced from hot rolled coils. These plates are used for fabrication of structures, beams, pipes, wagons, ships, containers, rigs, platforms, vessels and boilers, etc. In PSL, 17 numbers DC drives of 5.5 kW to 181 kW range were replaced with 17 numbers variable speed AC drives of 7.5 kW to 200 kW range. Figure 4 shows an overview of

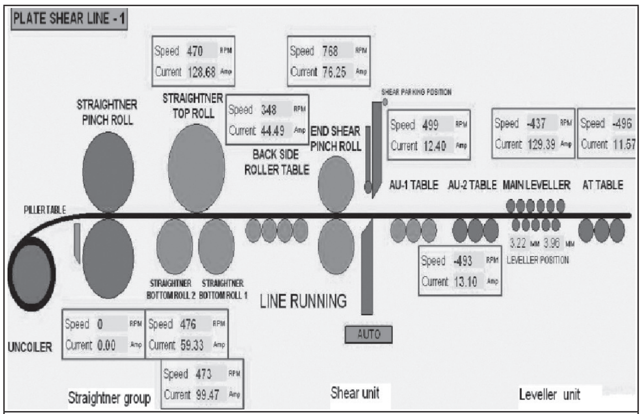

FIG. 4 AN OVERVIEW OF DRIVES USED IN PSL

PSL with current, speed and location of variable speed drives. In the entry, a group of four drives (called straightner) makes feeding of material, preliminary shape improvement and partial leveling. Length measurement is carried out with the help of incremental pulse encoder at the end shear pinch roll and shear cuts the plate according to the requirement. After shear, there are different conveyor tables and leveller units. This leveller unit makes proper leveling of the materials for final utilization. For all types of materials, variable frequency drive (VFD) group up to the shear is operating at a speed of 23 m/min. After shear, VFD group operates at 24 m/min.

Figure 5 shows a single-line diagram of different motors connected to inverters. These inverters are connected to a common DC bus. DC bus is fed through the regenerative rectifier unit (RRU)

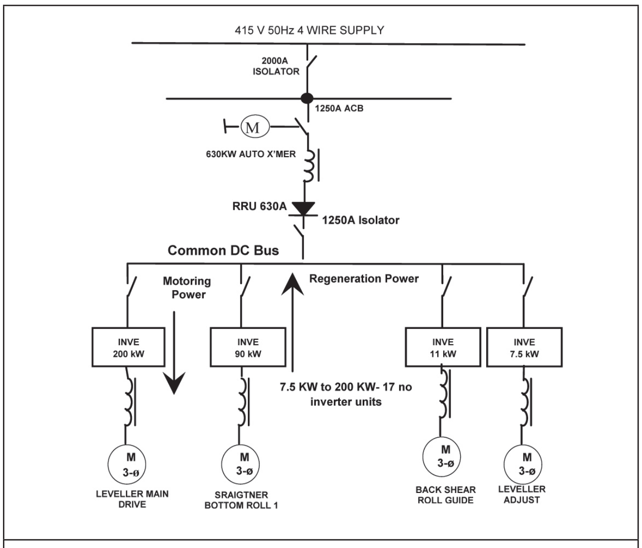

FIG. 5 SINGLE LINE DIAGRAM FOR PSL DRIVES CONNECTED TO COMMON DC BUS

of 630 A capacites. In upstream of the RRU, there is a 1250 A air circuit breaker which is supplied from 2000 A incomer isolator. This DC bus arrangement enables to use regenerative energy, which is generated during each deceleration and stoppage of the plate [11]. This regenerative energy on the DC bus can be utilized by other inverters in motoring mode on same bus, which reduces the overall intake energy from the incomer [13].

4.0 SELECTION OF MOTORS AND DRIVES

During proposal stage for replacement from DC drives to AC drives in PSL, it was needed to select the drive system correctly so that line can run at the rated speed of 23 m/min. Previously ,line was never run at a rated speed due to length accuracy-related issues because of poor old-age DC drive tuning, which is discussed later in this paper. Moreover, it was needed to keep future provision to increase speed up to 30 m/min. By keeping this provision, the production capacity of the line can be increased by carrying out bare minimum mechanical equipment modifications. With an increased speed of 30 m/min, material can be moved fast hence shearing capacity and in turn production capacity can be increased without any major finance investment or modification in electrical equipments. By keeping this view, motors and drives selection calculation was carried out. It is known that for DC motors, kW calculation is based on the constant torque requirement of the load and base speed. If there is a requirement of increase in speed more than the base speed, than flux in the motor is required to reduce and motor needs to run in field weakening mode. In this reduced flux mode, torque gets reduced and power becomes constant.

For DC motor,

$$\text{Actual Speed } N \alpha \frac{Eb}{\phi} \alpha \frac{Va}{If} \quad (1)$$

Where N is operating speed of DC Motor; Eb is back emf generated in motor.

ϕ is flux of DC motor; Va is armature voltage at moto; *If* is field current of motor.

Considering equation (1), after starting the DC motor and increasing the speed, up to the rated base rpm, field current *If* is kept constant and armature voltage V_a is increased. So motor runs in constant torque zone. Further increasing the speed beyond base rpm, as voltage has reached to peak value, it is kept constant and there is a reduction of flux hence field current. In this mode, motor runs in constant power zone with a reduced torque [10]. In PSL, it is difficult to move or pull the plate which is pressed in rollers, with a reduced torque. So it becomes very much critical to make proper selection of the entire AC drive system.

Now for any rotating equipment, maximum power,

$$P\max = \frac{2 \times \pi \times Nbase \times T\max}{60} \quad (2)$$

Where, Pmax is maximum shaft output power; Tmax is maximum torgue at output shaft; Nvase is base speed of the DC motor; Nbase is base speed of the DC motor.

Converting equation (2)

$$\text{Torgue } T\max = \frac{P\max \times 60}{2 \times \pi \times Nbase} \quad (3)$$

Based on the formuls (2) and (3) torque and power calculations for all motors to run the line at 30 m/min speed had been carried out.

For better understanding, an example of straightner bottom roll-1 DC motor is discussed here. This DC motor was rated for 56 kW at a base speed of 475 revolutions per minute (rpm). Its gear box ratio is of 20:1 and roll diameter is 310 mm. From equation (3) maximum torque T_{max} of this motor is 1126 Nm. In the PSL plate, travelling speed or line speed is the function of roll diameter and roll in rpm. So considering the gear box ratio, line speed and corresponding motor rpm are tabulated in Table 1.

TABLE 1					
CALCULATION OF MOTOR RPM WITH RESPECT TO THE LINE SPEED FOR STRAIGHTNER MOTOR					
Line speed	**974.28 mm per min (πd)**	**1 m/min**	**19.5 m/min**	**23 m/min**	**30 m/min**
Motor rpm	20	20.5	401	472.3	616.15

As seen in Table 1, while running line at a speed of 19.5 m/min, DC motor rpm is well rated base below rpm, so it was always running in a constant torque region. But if with the same motor, line speed is increased to 30 m/min than required rpm of motor is 616.15 rpm which higher than rated 475 base rpm. Hence, it would be rotating in constant power region with a reduced torque and may not be able to pull the plate or material of high yield strength. Thus, it is need to calculate new power rating of DC motor without reducing torque for trouble-free working of the machine.

$$\text{Pnew} = \frac{2 \times \pi \times \text{Nbase} \times \text{T max}}{60} \quad (4)$$

where Nbase=616.15 rpm from Table 1; Tmax = 1126 Nm from equation (3).

By substituting these value in the equation (4), a new DC motor of power 72.6 kW is required to run trouble-free operation at the speed of 30 m/min.

Now for AC induction motor, it is required to understand synchronous speed of induction motor. It is the speed of rotating magnetic field when three-phase supply has been given to motor [9]. It depend, up on frequency and number of the poles of the motor winding,

$$\text{Ns} = \frac{120 \times f}{p} \quad (5)$$

where f is frequency which is 50 Hz in India; p is Number of pole (it is always in pair.)

from equation (5), for running motor at 616.15 rpm, the nearest synchronous speed of AC induction motor is N_S = 750 rpm (8 Pole machine). However, actual speed of the AC induction motor is little less due to the slip of rotor. During running of induction motor, this slip depends up on load and its internal rotor design. The moment when three-phase supply is given for motor to start from stand still condition or zero rpm, initially rotating magnetic field gets generated [5]. When rotor starts rotating at that time, actual speed of rotor is little lagging behind synchronous speed of the rotating magnetic field. This is called as slip and it is always measured in the percentage of the synchronous speed.

$$\text{Slip S} = \left(\frac{\text{Ns} - \text{N}}{\text{Ns}}\right) \times 100\% \quad (6)$$

where here,

S is slip of induction motor

Ns is synchronous speed of motor

N is actual speed of the motor

Generally, value of slip is in the range of 1.5–3%. For straightner bottom roll, 8 pole motor base rpm is 737 rpm, so its slip is 1.7%. By utilizing equation (4), various power calculations in accordance to the base speed are made by keeping torque requirement constant at 1126 Nm.

TABLE 2				
CALCULATIONS OF MOTOR RPM AND POWER RATING FOR STRAIGHTNER MOTOR				
Type of motor	**DC motor**		**AC motor**	
Data type	**Original name plate data**	**For 30 m/min speed**	**For 8 pole motor**	**Standard rating available**
Speed of the motor (rpm)	475	616.15	737	737
Motor kW	56	72.6	86.8	90

From Table 2, it is seen that for AC motor power rating is 86.8 kW, which is already higher than actual power requirement of 72.6 kW for 30 m/min line speed. As new motor rating is already higher side, so there is no need to keep any safety factor for few occasions of overloading condition during operation. With reference of this basic calculation, new AC motor rating is selected to the nearest available standard rated power of 90 kW, which can be easily available from any major motor manufacturer. By similar method, each motor ratings and rpm calculations are carried out. The list of the equipment-wise selected motor power rating is attached (Annexture 2). Ratings of the drives are equal or the nearest standard higher side of the motor rating, which can be available with drive manufacturer. This little higher side selection of drive may help to prevent any failure of power devices of the drive during occasions of over loading.While for considering AC to DC converter for the common DC bus as shown in Figure 5. there are three options available. First is diode supply unit (DSU), in which no possibility to back feed the regenerative power to the main source, as its design having power diodes. Second option is of regenerative rectifier unit (RRU), which is a controlled rectifier and in its design, power thyristors are used; so, with a reverse bridge it can be possible to back feed the extra power on DC bus to the main power system [13]. The third option is active front end (AFE), which is totally controlled with the help of IGBT used in its construction, so only power is required to feed the DC bus as per the load requirement, so intake power itself gets reduced [3]. Out of these three options,the best option for PSL application is RRU, as DSU is only passive device and AFE is very costly option, as its cost is three to four times higher in comparison with RRU. So option of RRU is widely used in industries where regeneration is possible during process. For finalizing the rating of RRU, it is needed to calculate the connected load of the drives. Moreover, it is good to install hot standby converter in the scheme for mitigating the breakdown or maintenance situation of one unit. The other available unit in the scheme, can take the load without interrupting the process during maintenance. Here for PSL, three numbers of 630 A RRUs are kept in the scheme. These RRUs are connected in the center of the panels, and on both sides, there are different inverters for maintaining DC voltage balance on either side of the DC bus.

Figure 6 shows arrangement of PSL electrical panels. More photographs of the panel internals are added in Annexure 1 along with the old drives. In PSL, presently two RRU and under use as per the load requirement are one is kept as hot standby, which in case of requirement can be made on manually or through software program without interruption of the process.

FIG. 6 NEW DRIVES PANEL WITH CENTER FEED CONVERTER RRU

5.0 DIFFICULTIES IN RETROFITTING

Initially, it was planed to construct a new electrical panel room install all new panels, laying of the cables, put the motors beside to running DC motors and get commission of entire AC drive system parallel to the existing DC drives system without making down of production. It was having two benefits: one, final erection and commissioning time can be reduced as panels are already installed and commissioned before taking change over shutdown. By doing this, only motors installation part is balanced and second, problems during drives commissioning can be solved without affecting the production, hence stabilization of the AC system is proved before changeover. Estimated cost of construction of the new panel room and cable galleries was 80 lacks and it was a considerable amount for this kind of project and management was not getting convinced to provide such big amount for a new panel room construction a as in later stage old panel room was going to be of less use. After a lot of brain storming, it was decided to utilize same panel room and move according to same plan of commissioning without making down of production. Further moving according to plan, some space was created by shifting of motor control center panel and shifting of one column of the panel room. This was done There was very much A difficulty as space in the panel room was very much confined during erection of all panels. All these panels are installed in front of existing DC drives panel by keeping bare minimum space for man movement for doing all other activities. After erection all new panels are charged, cables laid, motors put besides running DC motors and commissioning has been done. Now two systems were running parallel. Speed and operation of new motors are tuned as per existing system without disturbing existing running system. After 15 days running, majority of the new drives; commissioning-related problems got solved, now only motor erection part was balanced. Shutdown taken for 4 days and all motor erection has been carried out by doing base modifications, alignment of motors with gear box, operation testing with machine. Out of 17 motors, 2 motors heights are more in comparison of running DC motors, so its base removed and new base provided. For rest of motors, the shims or plate to increase the heightare added. This dimensional calculation was also carried out well before and required attachments were made. For each motor, there was a plan of each activity in detail, so minimum time is required during change over. On the fifth day morning, first plate was cut accurately as system was well stabilized and tuned before taking shutdown. This was a big and unique achievement.

6.0 IMPROVEMENTS WITH AC DRIVES

After replacement of the DC drive system with AC drive system, there is a reduction in energy consumption and increase in production. These two major benefits are elaborated in detail.

6.1 Reduction in Energy Consumption

By data analysis, it is observed that the specific energy consumption is reduced by 1.88 kWh /t. Thus, with AC drive system, for annual (year 2010–2011) production of 315187 tons, energy consumption is reduced by 592551 kWh/annum. Figure 7 shows a comparison of specific energy consumption in the PSL before and after replacement of AC drives. It is seen that after up gradation in February 2010, a noticeable reduction in specific energy was observed. With DC drive system, the specific energy was in the range of 5–7.5 kWh,/t while with AC drive system, it is in the range of 4 –5.5 kWh/t. Earlier, with all DC motors, the field winding and blower supply were kept charged continuously even during production gaps. This was to ensure the readiness of the equipment for the operation. Due to this, the base energy (energy consumption without any work) of the line was high up to 189 kWh/hour. While with AC squirrel cage motors, there is no need to keep supply charged, as there is no field winding and blowers. So, base energy is only 26 kWh/hour. As PSL is a batch process line, actual running hours of the line are in range of 8–10 hours in a day, even though line continuously operates for the whole day. Other than actual running hour s, line remains idle, so a reduction of base energy makes major contribution in reduction of overall energy consumption. Moreover, in DC motors, energy losses were high because of separate field winding, armature winding and mechanical commutation. Mechanical commutation losses

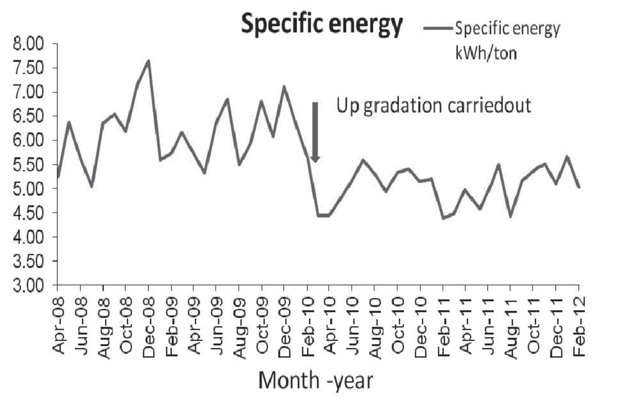

FIG. 7 SPECIFIC ENERGY CONSUMPTION BEFORE- AFTER COMPARISON

get eliminated with AC squirrel cage motors [8]. Figure 8 shows production and energy before and after comparison. With AC drive system, it is possible to carry out flux optimization which reduce, the noise and make, efficiency improvements. It is observed that for full load condition for DC motor, efficiency is in the range of 80–85 % while for AC motors, it is in the range of 93–96%. Hence, AC motors are more energy efficient than old DC motors of 1970s [7].

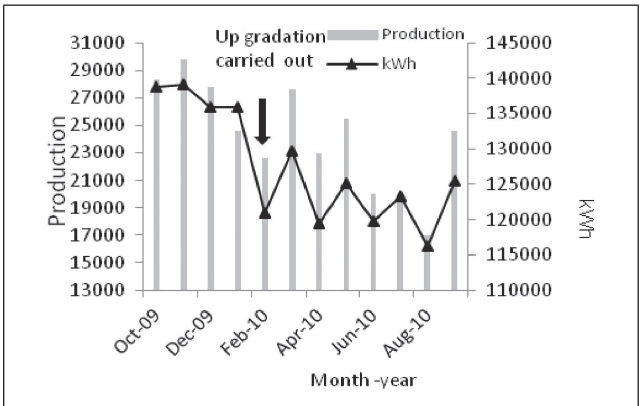

FIG. 8 PRODUCTION AND ENERGY COMPARISON

FIG. 9 SNAP OF LESS EFFICIENT OLD DC MOTOR

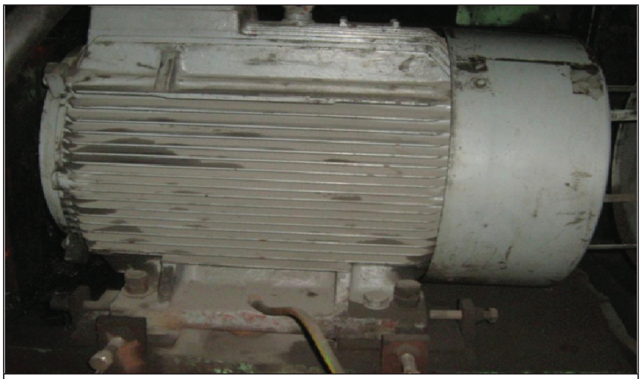

FIG. 10 SNAP OF HIGH EFFICIENT NEW AC MOTOR

Figures 9 and 10 show the less efficient DC motor and high efficient AC motor respectively.

Figure.11 shows the power factor comparison of the AC and DC drives in the entire range of the speed starting from zero to maximum. It is seen that AC drives operate with a good power factor in the entire speed range. While DC drives having a poor power factor of 0.1–0.5 in lower speed range [6]. Figure 12 shows power factor scatter readings comparison of the PSL incomer panel. It is seen that with DC system, power factor is in the range of 0.6–0.65, while with AC drive system power factor readings are in range 0.90–0.95. This shows that there is a drastic improvement in power factor which can reduce the energy consumption and improve on energy efficiency.

Moreover, the regenerative energy of common DC bus as displayed in Figure 5. is one of the contributors in the reduction of total energy consumption.

6.2 Increase in Production

Figure 13. represents the comparison of the

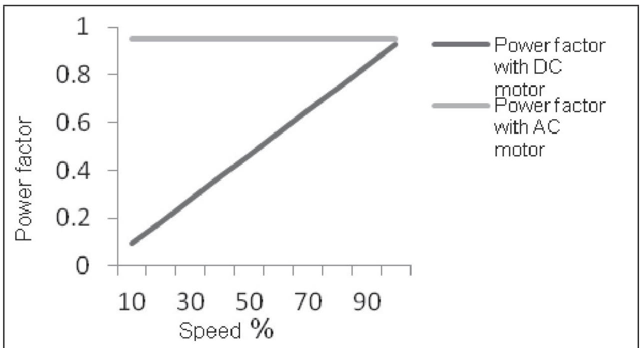

FIG. 11 POWER FACTOR COMPARISONS OF DC AND AC DRIVES IN ENTIRE SPEED RANGE

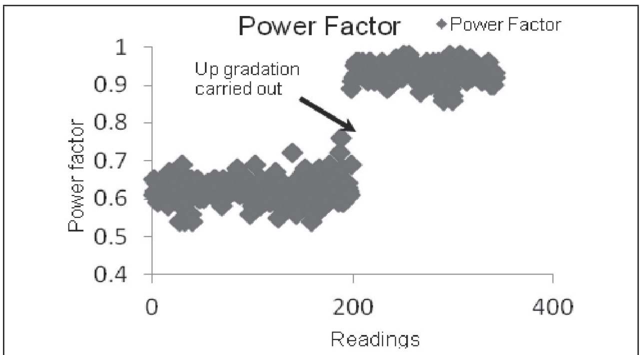

FIG. 12 BEFORE- AFTER COMPARISON OF THE POWER FACTOR SCATTERS

production rate (t/h) before and after replacement of AC drives. It is seen that after February 2010, the production rate became nearly double. Before replacement of AC drives, production rate was 55 t/h and after it was increased to 95 t/h. This is mainly due to are increase in line speed and enhancement of line available time for the production by reducting of various breakdowns and shutdown delays.

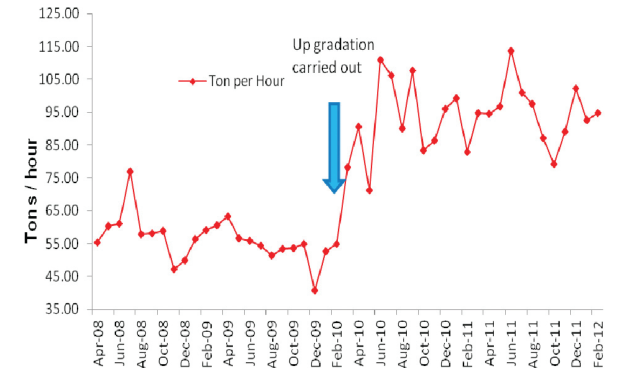

FIG. 13 COMPARISON OF PRODUCTION RATE IN T/H BEFORE AND AFTER AC DRIVE REPLACEMENT

Reasons for enhancement of the production rate are described here.

With DC drive system, for achieving plate length cutting accuracy, line was tuned at a speed of 19.5 m/min, while AC drives with are excellent dynamic response, and drives are tuned to run line at optimum speed of 23 m/min with accurate length of the final product. Moreover, with older system acceleration and deceleration time were kept as high as 10 seconds for getting correct a length. And a minor disturbance to this time was creating a length inconsistency. In a new system, due to high frequency of switching of IGBT, there is a quick response of the drives ,so this time is kept as low as 3 seconds. Both these factors contributed to increase the line speed. Also, the process time for each plate is reduced, and more production time is available, and hence more production opportunities are created. There is a reduction in breakdowns ,so available time for production also increased. Bar graph in Figure 14 shows a quarterly unplaned down time in minutes for PSL. With old age DC drive electronics and DC motors, the breakdown time was approximately 2000 minutes/annum, while with AC drive system, it is less than 300 minutes/annum. Solid line in Figure 14 shows a quarterly frequency of the stoppages, which is also reduced to 6 occurrences from 19 occurrences on an average. A drastic reduction is seen for the unplanned down time which has increased line operation time availability and created more opportunities for the production. Moreover, earlier, annually 288 hours (monthly twice × 12 hours) planned shutdown time was required to carry out various maintenance activities.

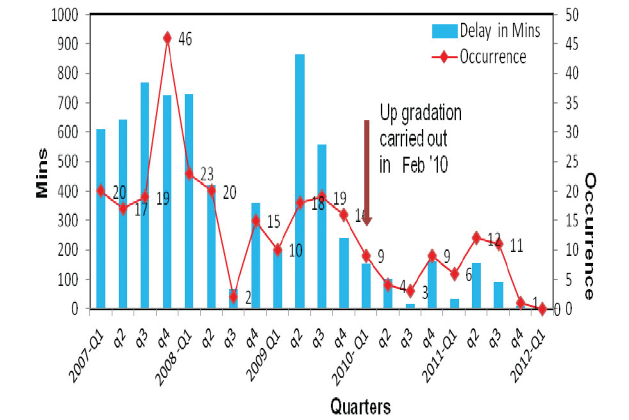

FIG. 14 DELAY TIME AND FREQUENCY COMPARISON BEFORE AND AFTER AC DRIVE REPLACEMENT

DC motors are more maintenance-prone and require frequent inspection or replacement of brushes, spring tension, leads and commutator surface checking, etc. With AC system, only 12 hours (once 6 hours in 6 months) per annum planned shutdown is required for terminal checking and greasing of motors. This has saved 276 hours which has added the production available time. Moreover, with older system, annually 48 hours were required for the drive speed mismatch tuning, as old analog drive electronics with analog tacho generator were highly thermal and environment -sensitive. It creates disturbance in control of speed and current loops and in turn creates roll speed mismatch, roll marks and scratch generation in the products. With new AC drive system there is no false tripping in comparison with old DC drives, and good trouble shooting facility can be hooked up for fast diagnosis as new drives can be interfaced with the PC and also online running characteristics can be observed in the drive windows. So, this entire time is saved with AC drive system, which also has contributed to production available time and created the production opportunities.

7.0 RETURN ON INVESTMENT (ROI)

As the DC motors and drives were old and obsolete, some of the DC motors were manufactured in 1967 spares of these motors and drives were not available in the market. Due to aging , it was needed to get special motors manufactured and requirement to refurbishment of panels with their switch gears. Estimated cost for refurbishment activities was Rs. (L) 258. The new system with advance AC drives, motors, new panels, cables were costing Rs. (L) 165. So, the selection was made for AC drive system. Calculations for planned and un planned time saving and created production opportunities in terms of value are Rs. (L) 291 per annum (Annexation 3). For this ,ROI was set 7 months (Annexure 4) with energy conservation of Rs. (L) 29.61 at a rate of 5 Rs/kWh.

8.0 CONCLUSION

With invention of advance direct torque control technique, torque-speed performance of squirrel cage AC induction motors gives similar torque-speed and dynamic response like DC shunt motor, which are main work horse in industrial applications.

Various results discussed in this paper state that there is,

- An Improvement in energy efficiency
- Reliability of machine improves
- Enhancement of production and increase of production rate
- Increase of line speed
- Old bottlenecks are eliminated during design phase of change over
- Reduction in machine breakdown and shutdown period
- Less ROI

These reasons are encouraged for replacement of old DC drive system with AC drive system. This type of replacement of old DC motors can be implemented in all type, of industries, where loading patterns are nonlinear, high peaks and fluctuating load vary with respect to time. Cement industries, rolling and bar mills, pulp and paper mills, aluminum, rubber and plastic industries have such nonlinearity of load. Also,it is useful in cranes in ports and jetties for loading and unloading of material. One time replacement with AC drives gives various described benefits for maintenance team with good savings.

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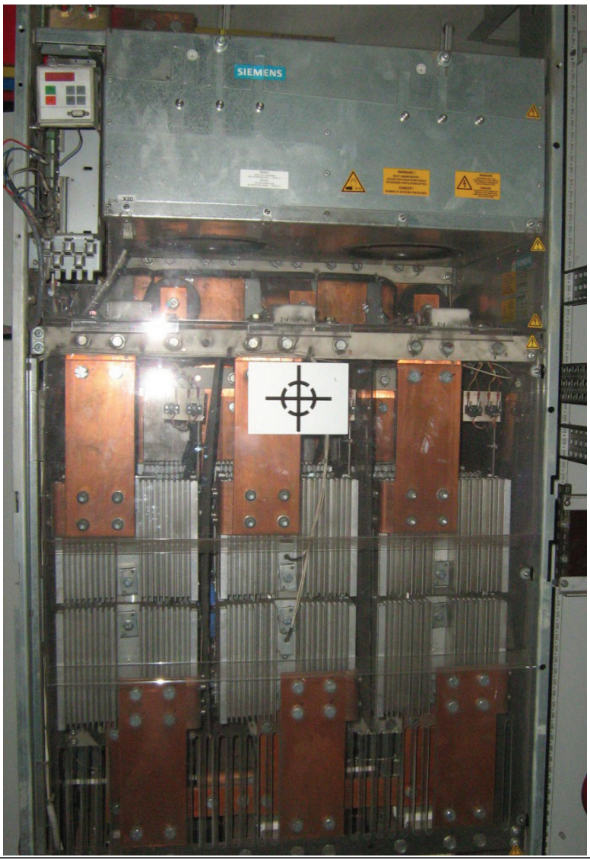
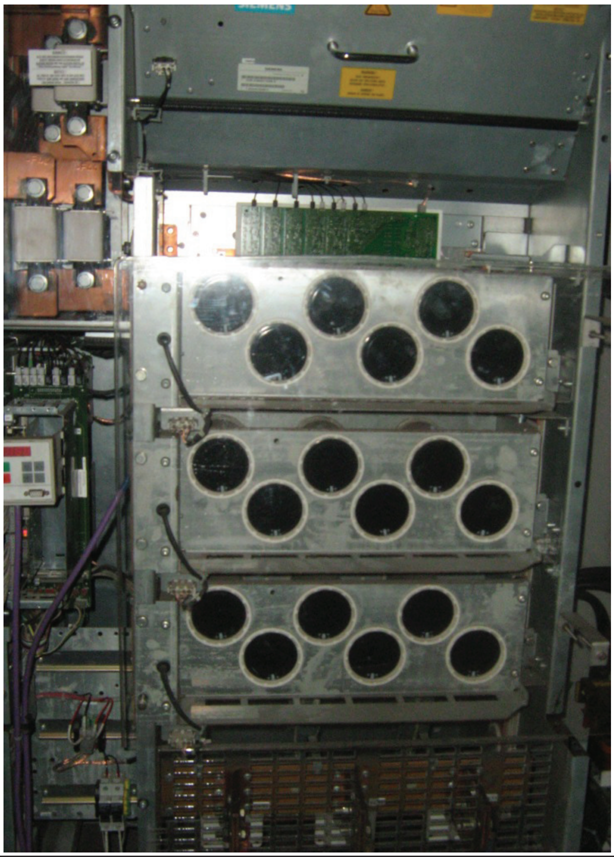
ANNEXURE 1

Photograph of the new and old drives

	
STRAIGHTNER BOTTOM ROLL 1 DRIVE	PACK RUN OUT TABLE AND ROLLER TABLE EXTENSION DRIVES



REGENERATIVE RECTIFIER UNIT



LEVELLER DRIVE

STRAIGHTNER BOTTOM ROLL DRIVE WITH SWITCH GEARS

OLD DC DRIVE

ANNEXURE 2

Equipment wise-kW rating and rated synchronous speed.

Sl. No.	Equipment name	AC motor (kW)	AC motor synchronous speed (rpm)
1	Straightner Pinch roll	90	750
2	Straightner Bottom Roll-1	90	750
3	Straightner Bottom Roll-2	90	750
4	Straightner Top roll	200	750
5	Crop shear Pinch roll	90	1000
6	Back shear roll table guide	11	1000
7	Back Shear roll table	75	750
8	End Shear Pinch roll	90	1000
9	Table AU-1	15	750
10	Table AU-2	15	750
11	Leveller Pinch roll	15	750
12	Leveller main	200	750
13	Leveller entry gap Adj.	7.5	750
14	Leveller exit gap Adj.	7.5	750
15	Table AT	15	750
16	Pack run out table	37	750
17	Roller table extension	37	750

ANNEXURE -3

S.No.	Description	Value	Unit
1	Breakdown time saved	1700	Min.
		28	h
2	Shutdown time saved (288 h–12 h) but considering minimum required time for other maintenance activities	180	h
3	Older drives speed tuning time saved	48	h
	Total Saving of hours	256	h
	Production in saved h at the rate of 95 t/h	24320	t
	Minimum value addition per ton (₹ 1200)	29184000	₹
		291	₹(L)

ANNEXURE-4

ROI CALCULATION TABLE OF PLATE SHEAR LINE -1		
Hindrances of old system		
Sl. No.	**Description**	**Cost in ₹(L)**
1	One time spare motors purchase cost of old DC motors, which spare not available (Five spares for 17 Motors)	120
2	Consumable cost for DC motor maintenance	5
3	Over hauling cost of the old DC motors	5
4	One time cost of the DC drives panels refurbishment with switch gears	20
5	One time cost of the new purchase of DC drives as existing are obsolete	80
6	Refurbishment cost of the control desks	10
7	Break down repair cost of drives and motor failure	18
	Total cost for running old system	258
New system costs		
	Description	Cost in ₹(L)
	One time purchase cost of the New AC drives/motor/Control desks / panels/cables	165
Saving with new system		
	Energy conservation (Considering 1.88 kWh/t of production 3.15 Lakhs ton at the rate 5 ₹/kWh.	29.61
	Production availability time (Annexure 2)	291

ROI
ROI = Investment/Recovery of investment
= 165 /(29.61+291)
= 0.51 year
= 7 months