

## JSW Steel Ltd., Vijayanagar Works, Torangallu, Karnataka, India New state-of-the-art CRM complex



JSW Steel Ltd., belonging to JSW Group, part of the O P Jindal Group with a production of 7.8 million tons per annum is one of the lowest cost steel producers in the world. It is engaged in manufacture of flat and long products viz. H R Coils, C R Coils, galvanised products, auto grade / white goods grade CRCA steel, bars and rods. A state-of-the-art cold rolling mill complex was set up at Vijayanagar Works, Toranagallu, Karnataka. JSW was the first to operate a Compact Cold Mill (CCM) in the Indian subcontinent.

This was one of the most challenging projects undertaken by ABB, in terms of technical complexity.

ABB was chosen as the sole supplier for automation and drives in this greenfield project, which consists of:

- Continuous pickling line (CPL)
- Compact cold mill (CCM)
- Electrolytic cleaning line (ECL)
- Skin pass mill (SPM)
- Two recoiling lines cum tension leveling lines (RCL)

## ABB scope of supply and services

### Power system and drives:

- ACS 6000 family of medium voltage drives based on IGCT technology, coupled with synchronous machines, for accurate torque control, for compact cold mill
- ACS 800 family of LV drives for rest of the lines
- Medium voltage switchgear system, LV distribution, UPS system

### Level 1 and Level 2 control system for mills:

- Level 1 controls based on 800xA, which is highly flexible and scalable ABB DCS problem
- Auto-adaptive model for presetting of mill
- Technological controls for delivering consistent product quality
- Flatness measurement and control system based on ABB Stressometer for the CCM and SPM
- Interactive human-system-interfaces via process operator stations
- Control for media supplies
- Level 2 consisting of production management and process control
- Inspection system for the RCL consisting of online defect logging and reporting system.
- Field devices and sensors
- Automatic sequences for optimized production and turn around time

### Advanced drive and automation technology

ABB drives control is based on the patented Direct Torque Control (DTC) concept, providing dynamic performance in terms of torque and speed accuracy. The superior performance of the drive has a direct impact on the process performance, since the drives are one of the main actuators for strip tension and strip speed. The fast reaction on torque variation allows a better accuracy in the strip tension control of the tension reel as well as between the stands.

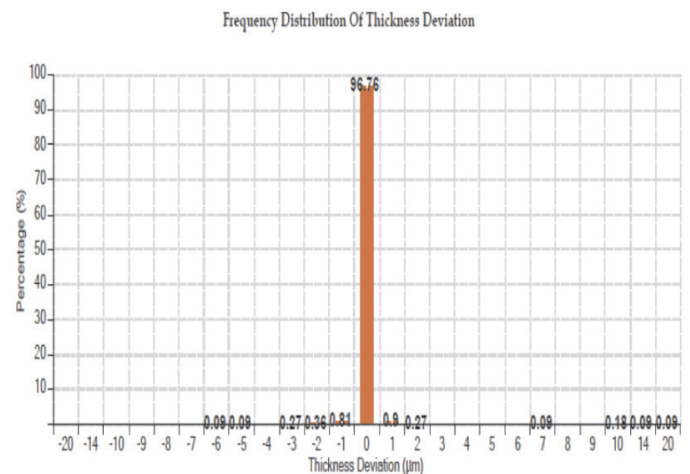
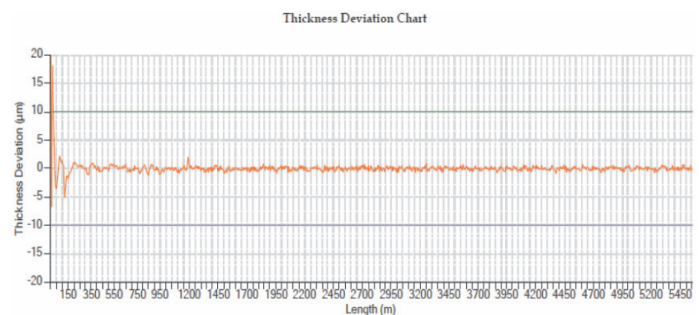
The high torque accuracy and dynamics of the drives used in combination with mass flow control leads to extremely fast correction times of process disturbances and hence to exceptional thickness quality. The tight integration of the control functions, as well as the ABB automation concept assures the following properties:

- Close process tolerances for all types of production
- Constant quality
- Increased mill productivity, thanks for higher rolling speed and faster acceleration and deceleration

## Technological controls for mills

ABB has standard software modules for the required technological controls for rolling mills consist of total integration of automation functions based on ABB 800xA control system. For the CCM the following control strategies were provided:

- Advanced thickness control based on mass flow and speed / tension feed forward control
- Tension (direct and indirect) control
- Interstand tension control
- Roll eccentricity compensation
- Roll gap control, roll bending control, roll shifting control
- Flatness measurement and control (overriding roll bending, roll shifting and wedge compensation)



### Mathematical model for the CCM

The setup model generated optimized mill start-up values taking in to consideration the incoming coil data, mill characteristics and reduction pattern. A tight integration with Level 2 is maintained for passing on the setup vales to Level 1 and also for acquisition for running parameters for online "self-learning" of model.

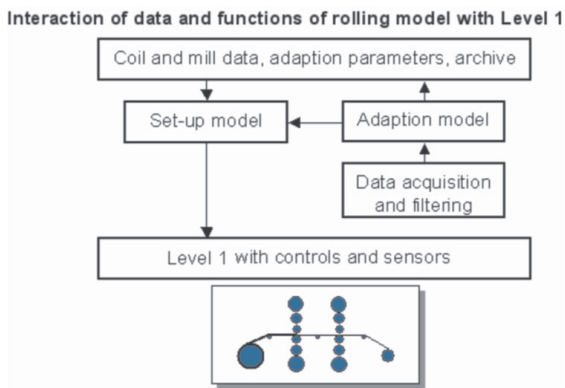
The model helps to:

- Optimize stripped quality regarding off-gauge length, surface and flatness
- Optimize output by calculating maximum speed
- Ensure that preset values remain within material and mill limitations
- Assistance for operators

The rolling model consist of a package of various sub models, which are closely connected to each other and mainly based on physical principles.

#### The main sub-models are:

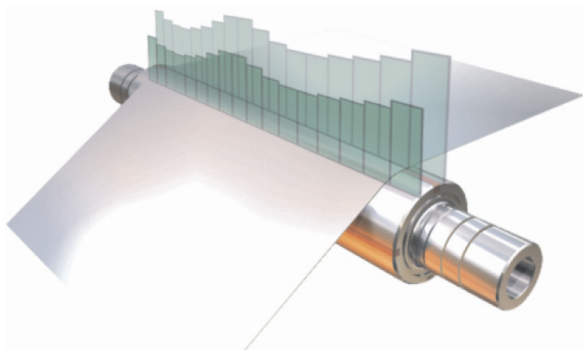
- Setup model (calculate all necessary preset values)
- Adaption model (adapt the model by measurements)



#### ABB flatness measurement and control system for CCM & SPM

ABB has provided complete flatness measurement and control system 2 stand reversing mill 'CCM' and 4 hi skin pass mill for this project. With its proven functional controls, it has helped to achieve online flatness accuracy better than 5 l units for more than 98% of rolled products in mills. The following controls were implemented:

- Multi zone cooling control
- Skewing control
- Work roll bending control
- IMR roll bending and shifting control
- Tension and wedge compensation control
- Diameter and temp compensation



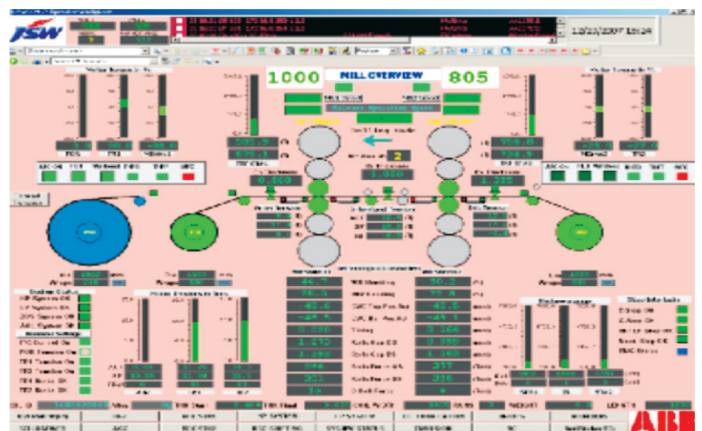
#### Unique features of ABB flatness measurement and control systems:

- Maintenance free measurement rolls with Pressductor® sensors giving unique long term accuracy and stability
- DPM – Direct parallel measurement, gives accurate measurement, undisturbed by the strip tension variation.
- SVD – Singular value decomposition, a mathematical method that ensures optimal use of the mill actuators.
- FSA – Flatness server architecture, ensures a future safe system and seamless integration with the other systems
- Upto 200 flatness target curves can be stored in the system

#### Adding value with the two stand reversible 6 hi mill (CCM)



- Economic power consumption of 56 kwh / ton
- Advance cascading automatic gauge control gives a better gauge accuracy
- Solution based on ABB's scalable 800xA DCS platform and ACS6000 medium voltage drive technology
- Dual shape meter for automatic shape control
- Latest X-ray gauging system for better gauge measurement and control
- Laser velocity meter for better speed accuracy
- High level of automation with least manual intervention for higher performance
- Jumbo coil philosophy with rollable weld increases the productivity, quality and the yield of the cold rolled product
- The solution consumes lesser space power and installation charges as compared to convention tandem mills
- Improved energy efficiency - ACS 6000 modular, medium voltage drives, in multidrive configuration designed for the most demanding multi-motor application such as CCM resulting in energy saving
- With continuous varying crown (CVC) control, increased online flatness accuracy is achieved, resulting in the best quality steel for manufacturing of products of cold rolled closed annealed (CRCA ) and cold rolled full hard (CRFH) products





CM mill data	
Type	6 hi twin stand reversing CVC mill
Mechanical supplier	SMSDemag
Process speed (max)	1350 mpm
Capacity	0.875 (mtpa)
O/p thickness range (mm)	0.3mm-3.0
I/p thickness Range (mm)	2mm - 6mm
Width (mm)	800-1650
Coil weight (t)	62 (max)
Diameter Max (mm)	2650 mm
POR tension (Max)	10,000 Kg
Coiler tension (Max)	18,000 Kg

CCM main drive data	
Uncoiler	1090kW
	333/(1400)-1559rpm
Mill stands 1 & 2	6000kW each
	406/1023 rpm
Entry and exit tension reel	4270kW each
	350/(1500) 1637 rpm

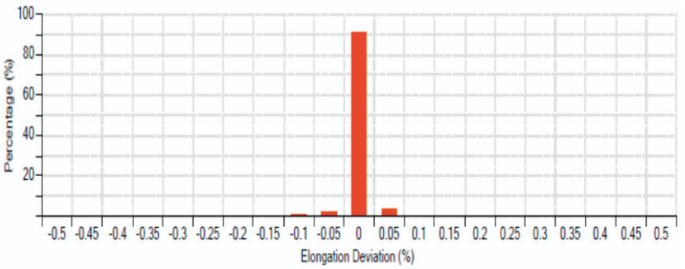


The mill is provided with the latest state-of-the-art automation technology to achieve the high targets regarding productivity and quality

### Special features of SPM

- Fully automated mill which includes automation of coil transfer, threading, threadout, elongation control, flatness measurement and control and roll changing.
- Wet type skin pass
- Removal of stretcher strain
- Online flatness achievement up to 51 units
- Bright/matt finish as per customer requirement
- Surface texturing of rolls by EDT
- Ra-2.5 urn (Max) on the surface
- RPc-40-60 on the surface (per cm)
- Interface with electrostatic oiler (0.2— 2.0 g/m2 on each side)

Frequency Distribution Of Elongation Deviation



Deviation (%)	-0.50	-0.45	-0.40	-0.35	-0.30	-0.25	-0.20	-0.15	-0.10	-0.05
Percent. (%)	0.162	0	0	0	0.162	0	0.162	0.162	0.649	2.11

Deviation (%)	+0.05	+0.10	+0.15	+0.20	+0.25	+0.30	+0.35	+0.40	+0.45	+0.5
Percent. (%)	91.396	3.571	0.325	0	0.162	0.162	0.162	0	0	0.487

Deviation(μ) in -0.1 to +0.1 = 97.726 %

SPM mill data	
Type	4 Hi single stand
Mech supplier	SMSDemag
Capacity	0.875 (mtpa)
Mill Speed (mpm)	1050
Thickness range (mm)	0.3-3.0
Width (mm)	800-1650
Coil weight (t)	31 (Max.)
Strip Surface Roughness	approx. 0.6-2.5um
Diameter (Max)	2200 mm
Tension Entry	10500 Kg
Tension Exit	10500 Kg

SPM main drive data	
TPayoff Reel	1750kW 0/415/1400(1466) rpm
Entry Bridle Bottom	240kW 0/1326/1364 rpm
Entry Bridle Top	320kW 0/1326/1364 rpm
Mill Stand	700kW 0/452/1400rpm
Tension Reel	1803kW 0/345/1355 (1450)rpm

### Improved yield and productivity with processing lines

ABB is a world leader in providing solutions for electrical and automation equipments for processing lines across all type of processes.

ABB solutions include the full range of required products, starting from electrification (e.g. transformer and MCC, drive and motors, automation system (Level 1) and MES (Level 2), as well as complete design, engineering and commissioning.

## Level-1 and Level-2 controls for the processing lines

For the control of processing lines the following strategies were implemented.

- Pilot control for co-ordinated reference generation for different line sections (entry, process and exit)
- Looper control
- Coiler control
- Bridle controls
- Tension (direct and indirect) control
- Trimmer control with lap and gap adjustment
- Tension leveler control in pickling line
- Elongation control
- Pickling process control
- In line skin pass mill control for cleaning line
- Degreasing process control including rectifier control for ECL
- Flying shear control to switch between recoilers to bring down processing time in ECL
- Inspection station and defect logging system for recoiling and tension levelling lines
- Weld point tracking and strip tracking for all lines

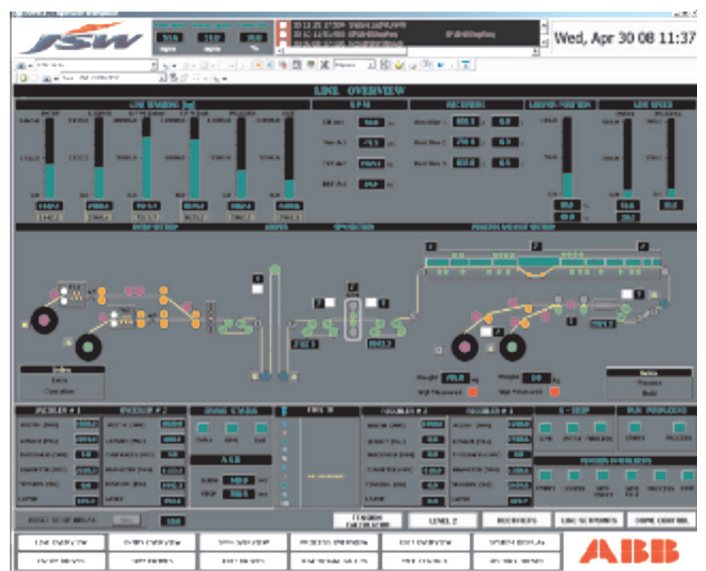
## Improved surface quality and finish with trimmed and pickled coils in CPL

- Special features of CPL
- Online trimming facility
- Interface with electrostatic oiler - 0.3to3.00 g/m<sup>2</sup> on each side
- Interface with laser beam welder (rollable)
- Tension leveller control for scale breaking facility
- Level 2 automation



### CPL line data

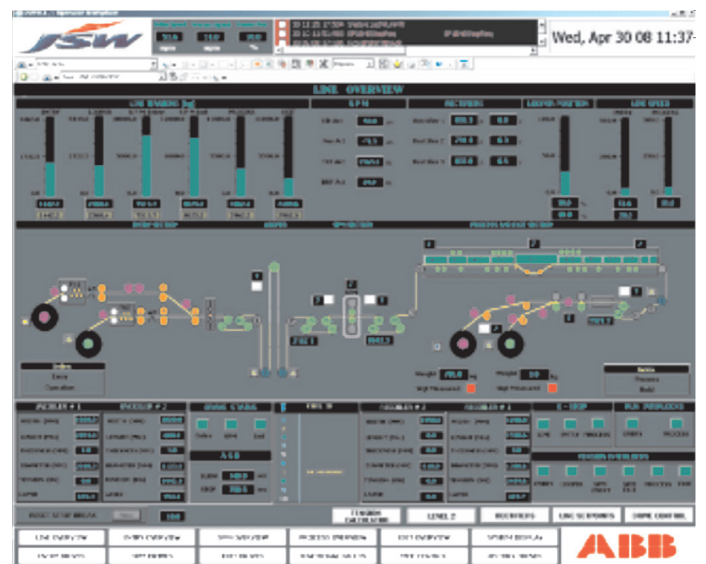
Type	Continuous Pickling Line
Mechanical supplier	FPE-CMI
Process speed (mpm)	180 mpm
Capacity	1.06 (mtpa)
Thickness range (mm)	1.2-6.0
Width (mm)	800-1650
Coil weight I/P (Tons)	31 (max)
Coil Weight O/P (Tons)	62 (Max)
Coil Diameter (max)	2650 mm
Tension Entry (Max)	4500 Kgs
Tension Exit (max)	11000 Kgs



## Electrolytic cleaning line with inline skin pass mill

### Special features

- In line skin pass mill for roughness transfer
- Inline flying shear for dynamic switch between recoilers reducing turnaround time



### ECL line data

Type	Continuous Electrolytic Cleaning Line with inline SPM
Mechanical supplier	FPE-CMI
Process Speed	500 mpm
Capacity	0.6 (mtpa)
Thickness range	0.3 - 3.0 Width (mm) : 800-1650
Coil weight (t)	31 (max)
Oil and dirt	10mg/ sqm
Iron fines	15mg/ sqm
Diameter POR	2650 mm Diameter TR : 2200 mm
Entry Tension	3460 Kg
Exit Tension	6000 Kg

## Recoiling cum inspection and tension levelling line

### Special features

- Accurate tension control with ABB Pressductor load cells for quality winding
- Operator friendly defect logging and reporting system
- Interface with Electrostatic Oiler (50mg—2000 mg/m2 on each side)
- Inline tension leveling and edge trimming mode (up to 1.6mm)
- Wash and brush unit for improved surface cleaning

### Strip defect inspection system

Inspection system is capable of giving quality decisions on the coil inspected as per the data logging and the defined parameter table. These details are required by end users in white goods and auto industry.

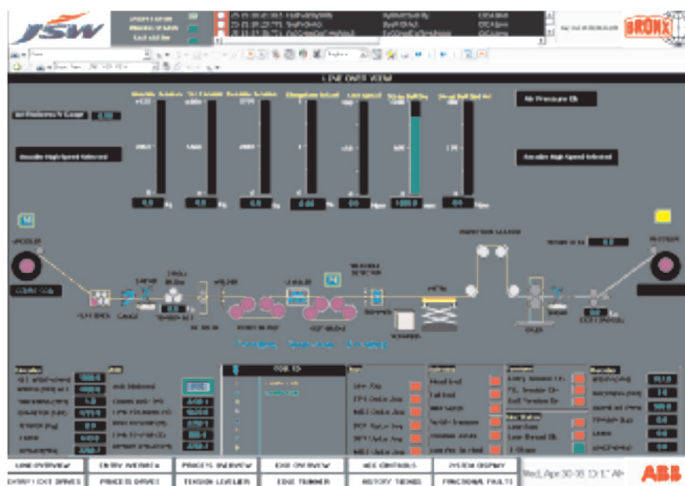
The online inspection system enables the inspector to log surface defects, its location with respect to width and length of the strip & severity against each coil in the touch screen.

- Horizontal and vertical strip inspection system is equipped with the following facilities
- Touch screen with writing pad and pencil for operator data entry for the defects with a facility to select the type and the severity of the defect
- Display for width gauge, thickness gauge and running length on the screen



### RCL line data

Type	Recoiling cum trimming
Mechanical supplier	Bronx
Capacity (Both Lines)	(0.35 mtpa)
Process Speed (mpm)	150(tension)
Leveling	300 (recoiling)
Thickness range (mm)	0.3 - 2.5
Width (mm)	690 - 1650
Flatness afterleveler	5l units
Tension Entry	4200 Kg
Tension Exit	6000kg
Diameter	2200 mm



### Production planning and management

The Level 2 automation system is implemented in a client-server configuration for entire CRM complex of JSW It consists of a frontend developed with C#.Net and Oracle 1 Og. as relational database management system.

This system is also known as manufacturing execution system which does following functions:-

#### 1. Production order management

Here the production order details are downloaded to Level 2 from Level 3 as PDI (Primary Data Input) data for the coils e.g. Coil ID, ID, OD etc. with that order.

CCM Level 2

Welcome : operator

CCM Level 2

Tuesday, May 06, 2008

1:48:57 PM

Production Ordering

Network

Select All

OK

Filter

Value

Exit

Disable Filter

Enter Coil ID

Search Coil

S.No	Coil ID	BatchNo	Batch Seq. No	Line No	Status	AlloyCode	Customer	Entry Thickness	Exit Thickness	Input Width(Inch)	Weight (Tons)	TSP	SPN	Schedule Status
1	R41210000	264	3	1	W	DQ	JSW TOL	3	1.80	1480	23.72	AN02	AUTOMATIC	2
2	R41214000	262	4	1	W	DQ	JSW TOL	5	1.80	1480	22.65	AN02	AUTOMATIC	3
3	R41220000	261	2	1	W	DQ	JSW TOL	1	2.81	1480	22.93	AN02	AUTOMATIC	4
4	R41210000	262	5	1	W	DQ	JSW TOL	3	2.81	1480	23.74	AN02	AUTOMATIC	5
5	R41210000	262	4	1	W	DQ	JSW TOL	3	2.81	1480	23.72	AN02	AUTOMATIC	6
6	R41210000	262	3	1	W	DQ	JSW TOL	4	1.80	1480	23.75	AN02	UNASSIGNED	7
7	R41210000	262	2	1	W	DQ	JSW TOL	4	1.80	1480	23.81	AN02	UNASSIGNED	8
8	R40360000	258	15	1	W	DQ	HYDELIN	3	2.87	1270	28.68	F004	UNASSIGNED	9
9	R10970000	231	15	1	W	DQ	HYDELIN	3.15	6.34	1250	33.86	AN01	AUTOMATIC	10
10	R4093000	259	34	1	W	DQ	UNHAR	5	3.82	1250	3.95	AN01	AUTOMATIC	11
11	R4101000	268	2	1	W	DQ	PENVAR	3	3.82	1250	4.8938	AN01	AUTOMATIC	12
12	R0947000	244	15	1	W	DQ	PERVAR	3.68	1.21	1250	4.94	AN01	AUTOMATIC	13
13	R1087000	233	2	1	W	DQ	SANGUPT	3.68	1.21	1250	8.85	AN01	AUTOMATIC	14
14	R2677000	231	12	1	W	DQ	COBOL	2.98	0.71	1250	16.75	F004	AUTOMATIC	15
15	R4078000	254	22	1	W	DQ	GURVAY	2.10	0.49	1250	10.22	AN01	AUTOMATIC	16
16	R4140000	255	14	1	W	DQ	HYDELIN	2.98	0.58	1250	22.17	AN02	AUTOMATIC	17
17	R41220000	262	13	1	W	DQ	NSLA	3.68	1.21	1180	30.87	AN01	AUTOMATIC	18
18	R30387000	231	3	1	W	DQ	NATIONAL	2.28	0.36	962	3.58	F001	AUTOMATIC	19
19	R41320000	271	5	1	W	DQ	SAGAR E...	2	0.34	1000	18.81	F001	UNASSIGNED	20
20	R41320000	271	6	1	W	DQ	SANGUPT	2	0.34	1000	18.83	F001	UNASSIGNED	21
21	R41410000	272	3	1	W	DQ	Z.K.A.TEE	2.48	0.44	1000	18.28	F001	UNASSIGNED	22
22	R41420000	272	4	1	W	DQ	SANGUPT	2.48	0.49	1000	18.81	F001	UNASSIGNED	23
23	R41432000	272	6	1	W	DQ	SAGAR E...	2.48	0.54	1000	18.33	F001	UNASSIGNED	24

From

View To

Print

Print PDF

Delete Coil

Assign Sched.

Update PDF Status

Reset Coil in Production

Unload Coil

Close

Production Order

Schedule Editor

Reference Editor

Equipment Monitor

User Management

Roll Management

Material Tracking

DownTime

Report

Exit

ABB

Coil ID: R41210000

After Coil ID:

Entry Thickness: 3.15

Coil Thickness: 3.15

Exit Thickness: 3.15

Input Width: 1480

Weight: 23.72

Material: AN02

Coil Status: OK

#### 2. Set point management

This module gets set points or pass schedule data by requesting the Mathematical Model with AMI (ABB Message Interface) messages.

#### 3. Downtime management

This module keeps a record of the time when the Mill/ Processing line downtime with defined reason (the downtime codes are pre configured).

#### 4. Roll management

This module is applicable to mills. In this module, system keeps record of the available rolls, active rolls and roll which were used earlier in the mill. The data about the available rolls is taken from Level 3 and then after roll change the used roll data is transferred to Level 3.



CCM Level 2

Operator

Tuesday, May 06, 2008 2:22:55 PM

### Roll Management

Roll ID	Position	Roller [mm]	Progress [mm]	Profile [mm]	Roll Rate ID	Material	CHICK ID - OS	CHICK ID - IS	Max Dia [mm]	Min Dia [mm]	ROLL TAPER	BDL THICK OS	BDL THICK IS	BDL THICK OS
C1000001	TOP	1230.00	0	CCM_RR_...	C1000001	302 Tg IS	C100000001	C100000001	1230.00	1230.00	0.00000000	0	0	0
C1000002	BOTTOM	1240.00	0.00	CCM_RR_...	C1000002	302 Tg IS	C100000002	C100000002	1240.00	1240.00	0.00000000	0	0	0
C1000003	TOP	1240.00	0.00	CCM_RR_...	C1000003	302 Tg IS	C100000003	C100000003	1240.00	1240.00	0.00000000	0	0	0
C1000004	BOTTOM	1230.00	0.00	CCM_RR_...	C1000004	302 Tg IS	C100000004	C100000004	1230.00	1230.00	0.00000000	0	0	0

Sheet 1

Roll Change

Sheet 2

TOP Roll ID: [ ] Change RIT Top RIR: [ ] Activate: [ ]

BOTTOM Roll ID: [ ] Change RIT Bottom RIR: [ ] Activate: [ ]

Active RIR: [ ] RIR ID: C1000001

TOP ID: C1000001

BOTTOM ID: C1000001

Send PDO Refresh

Insert PDO Delete Close

Production Order Schedule Editor Reference Editor Equipment Monitor User Management

Roll Management Material Tracking DownTime Report Exit

Coil ID: 8516770000 Alloy Code: [ ] Entry Thickness [mm]: 2.00 Exit Thickness [mm]: 0.00 Run: [ ] RIR Status: [ ]

## 5. Equipment monitoring

This module keeps the details of critical equipments with details like life time and usage of the equipment. Also the maintenance triggers are generated based on the equipment usage.

## 6. Statistical process control

Statistical process control generates charts which demonstrate how consistently process is performing and whether it should or not be adjusted. The charts generated are thickness deviation chart, range control chart and thickness frequency distribution histogram.

## 7. Reporting

For the analysis and records the various reports e.g. Coil Production Report, Monthly Production Report, Production report between two dates, Down Time Report.

Coil Production Report				Batch No :	455
Coil ID : 8516770000				Shift in Charge :	ADMIN
				Rework :	No
Width [mm]	903	Weight [Kg]	0	Thickness at OS Edge	0
Thickness [mm]	2	Inner Dia [mm]	610	Thickness at Center	2.02
Length [m]	1141.2750	Outer Dia. [mm]	1803.9870	Thickness at DS Edge	0
Preparation Start	6/2/2008 12:00:00 AM	Preparation End		Avg. Line Speed [mpm]	83.3050
Feed Start		Feed End		Avg. Elongation [%]	0.01
Weld Start	6/1/2008 11:54:55 PM	Weld End	6/2/2008 12:16:35 AM	Avg. Entry Tension [Kg]	4000
Process	6/2/2008 12:37:32 AM	Process End	6/2/2008 12:59:38 AM	Avg. Exit Tension [Kg]	7000
Tank No.	Conductivity [%]	Temperature (°C)	Wedge	-2.0180	
1	2.0330	83.31	Crown	2.0170	
2	2.06	73.0330	Trim Status	1	
3	2.8880	79.8540	POR Tension	4000	
4	5.6190	80.1060	Outer Coil Length	0	
5	11.7260	82.0820	C0	0	
6	16.4430	78.1830	C1	0	
Rinse 5	91.1270	69.8290	C2	2.0170	
			C3	2.0180	
			C4	0	

## 8. Storage of PDO (process data output)

After the rolling of the coil the process data e.g. Coil output weight, Average Tension, Average Roll Force etc for each coil is collected and transferred to Level 3.

## 9. User management

In this module various users can be configured based on authorization levels. There can be three main user groups:-

- Operator group : Operators with rights required for normal operation
- Supervisor Group in which shift in-charges will be there
- Manager Group in which line in-charges will be there.
- Administrator : To create user, user group or assigning rights to various users

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