INCEPTION OF IN-HOUSE AUTOMATION A MARCH TOWARDS INDUSTRY 4.0

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Introduction

ITC Limited, PSPD, Unit Bollaram is situated at Bollaram, in Sangareddy district of Telangana State. The Unit was established in year 1994 which is spread across 16.67 Acres and built up area of 2,30,000 Sq.ft. The Unit is having a production capacity of 45000 Tons per annum. The Unit has Poly Extrusion Plant-1 (Tandem extruder) with capacity of 18000 Tons per annum and Poly Extrusion Plant-2 (Co-Extruder) with capacity of 27000 Tons per annum. The Unit has 3 Sheeters with state of the art technology and Two Twin Drum Rewinders. The Sheet cutters are Synchrofly, single chop, multi slitting/multi pocket to meet the customer specifications.

Abstract

Industry 4.0 is referred to as the fourth industrial revolution. Automation and Data capturing plays a vital role marching towards Industry 4.0. As a first step, all the legacy machines and systems are Automated which will be a foundation for Industry 4.0

The Unit has taken up the below Projects to march towards Industry 4.0.

Case Study 1–Automation of Poly 1 Machine

Objective:

Enhancement of asset database for Process Digitalization in-order to connect all machines, Working pieces and systems to create Data logging compatibility and Process optimization features like Recipe Management, Alarm management and Event Logging.

Proposal:

Automation of Heating system i.e., PLC control with data recording compatibility in place of single loop PID controllers. The legacy panels were running on contactor and relay logics with hundreds of cables running across the machines which is bottleneck for data collection to understand current operating condition and detect faults and failures. SCADA installation for human machine interface and data recording.

The proposed system will provide improvements in troubleshooting and traceability areas and will have the following benefits.

1. Data logging of critical parameters
2. Event logging
3. Alarm management
4. Recipe management
5. Reduces manual intervention

The machine has 2 major sections, namely the Heating section and the Machine control.

1. Heating section.

- **Scenario before automation:**

  The legacy heating system is a closed loop system, controlled by Eurotherm controllers which has no data-logging/acquisition compatibility, were used to control the temperature in 22 zones and change in temperature is a manual process where each and every individual controller set-point is to be changed manually and any deviation in this change leads to instability in process. Process includes extrusion of solid LDPE granules passing through high temperatures to produce melt and laminating onto paper board.

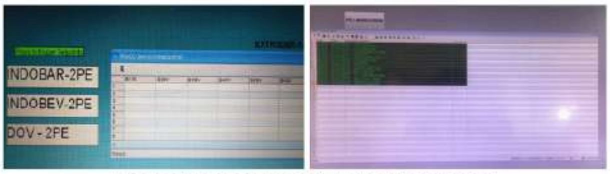
- **Automation phase:**

Heating controllers are integrated in PLC and interfaced with

SCADA, where all recipes are established as per standard process requirements.These recipes can be directly triggered and all the temperature set points are automated. The heating system in both the extruders are replaced with the Yokogawa FAM3 PLC.

Temperature feedback devices (Thermocouples) are configured in PLC and its feedback is utilized for control of process and creation of database.Installation of thyristor based linear control and configured to PLC in-order to maintain temperature as per set-point.Temperature set-point control value and Process value is displayedin SCADA which is provided at the Console station.

- These temperatures are stored in data base which are useful for decision making.
- The deviation in process are automatically detected and alarm is raised.
- The database of all critical process parameters is generated for every minute which is utilized to understand current operating condition and detecting faults and failures.



Receipe Management and Alarm Management

2. Machine Operating panels.

The legacy panels were running on contactor and relay logics with hundreds of cables running across the machines which is bottleneck for data collection to understand current operating condition and detect faults and failures. Moreover, the inherent troubleshooting of system is complex in nature and time consuming which leads to loss of productivity.

The existing logic is build up in Siemens S7-300 PLC and all the Input parameters/commands and responsive devices/ outputs are integrated so that fault diagnoses and system is able to gain self-awareness.

The below activities are initiated for converting the legacy system into PLC

- Unwinder and Winder Panel Automation: To Understand the existing legacy logic and preparing PLC logicReplacement of 230V AC operated Pneumatic panel, contactors and realys with corresponding 24V DC components to enable responsiveness from PLC. Logic build up in PLC with all the existing operation sequence along with safety interlocks.
- Console panel Automation: Identification and understanding the existing legacy logic, and preparing PLC logic.Interconnection of Unwinder and Winder system terminations with legacy console system is separated and integrated with PLC. Upgradation of console operations to PLC.

"With above upgradations, data collection compatibility is achieved for all operating sequences, which are recorded, analyzed incase of deviations and alarm generation."

3. Process Digitalization/Results:

A SCADA(Supervisory Control and DATA acquisition) is installed in the console panel where all the panels PLCs (Heating system and Machine Control), Working PC and systems are connected together.

The SCADA is configured with all the critical process parameters. These parameters are being logged on continuous basis. These parameters are saved as a daily report which can be retrieved and carry out analysis.

DATE_TIME	LINE SPEED	EXT 1 Screw RPM	EXT 2 Screw RPM	CORONA 1	CORONA 2	EXT 1 Melt Pressure	EXT 2 Melt Pressure	LAM 1 I/I Temp	LAM 2 I/I Temp	Flame 1	Flame 2	Reel length
21/09/2017 0600	121.0	0.5	38.3	0.0	6.3	0.0	0.0	29.4	11.7	0.0	4925.2	3073.0
21/09/2017 0605	120.3	0.5	34.3	0.0	6.4	0.0	0.0	29.4	11.8	0.0	4925.2	3437.0
21/09/2017 0605	120.3	0.5	34.5	0.0	6.4	0.0	0.0	29.4	11.8	0.0	4958.2	3437.0
21/09/2017 0603	120.3	0.8	35.2	0.0	6.4	0.0	0.0	29.4	11.8	0.0	4970.5	3463.0
21/09/2017 0604	120.3	0.3	35.8	0.0	6.4	0.0	0.0	29.4	12.0	0.0	4957.1	59.0
21/09/2017 0605	120.3	0.3	35.4	0.0	6.3	0.0	0.0	29.4	12.3	0.0	4948.2	220.0
21/09/2017 0606	97.2	0.8	14.3	0.0	0.0	0.0	0.0	29.4	12.3	0.0	700.5	328.0
21/09/2017 0607	120.7	0.3	35.4	0.0	6.3	0.0	0.0	29.4	11.8	0.0	5016.1	426.0
21/09/2017 0608	120.7	0.3	35.2	0.0	6.4	0.0	0.0	29.4	11.5	0.0	4998.2	556.0

DATE_TIME	Barrel 1		Barrel 2		Barrel 3		Barrel 4		Barrel 5		Barrel 6	
	Set Val	Act Val	Set Val	Act Val	Set Val	Act Val	Set Val	Act Val	Set Val	Act Val	Set Val	Act Val
[illegible]	200.0	[illegible]	200.0	[illegible]	200.0	[illegible]	200.0	[illegible]	200.0	[illegible]	200.0	[illegible]
21/09/2017 06:03	200.0	199.2	200.0	198.2	200.0	202.6	200.0	202.3	200.0	196.6	200.0	211.3
21/09/2017 06:03	200.0	199.2	200.0	198.2	200.0	202.6	200.0	202.3	200.0	196.6	200.0	211.3
21/09/2017 06:03	200.0	199.2	200.0	198.4	200.0	202.5	200.0	202.3	200.0	196.7	200.0	211.2
21/09/2017 06:04	200.0	199.2	200.0	199.4	200.0	202.3	200.0	201.6	200.0	197.8	200.0	210.5
21/09/2017 06:05	200.0	199.3	200.0	200.3	200.0	201.7	200.0	201.0	200.0	198.9	200.0	209.7
21/09/2017 06:06	200.0	199.4	200.0	201.1	200.0	201.0	200.0	200.3	200.0	200.0	200.0	208.8
21/09/2017 06:07	200.0	199.6	200.0	201.7	200.0	200.3	200.0	199.7	200.0	201.1	200.0	208.0
21/09/2017 06:08	200.0	199.9	200.0	202.0	200.0	199.6	200.0	199.0	200.0	202.2	200.0	207.2

A glimpse of data acquisition from SCADA installation is shown above.

Case Study 2 – PasabanSheeter Upgrade

Objective:

To upgrade the electrical system of paper cutting machine achieving data acquisition, machine safety and easing operations avoiding OEM dependency. Also remarkable reduction in R&M Cost as upgraded system as it made indigenous.

Need:

Below problems are faced with existing system (OEM)

1. No data can be fetched machine to evaluate machine OEE.
2. No machine parameter can be logged in machine to analyze complaints and NCP (Non conformity product).
3. Frequent breakdown related to electrical system leading low machine production
4. High cost and lead time of spares due to import from OEM and lack of indigenous service support.
5. Existing spares got obsolete and High cost of upgradation (6 times higher than indigenous)

To address above issues it is proposed upgrade the electrical system (Drives and PLC) of machine. Apart from addressing above issues, this automation provides following benefits

1. Reduction in losses of machine due to minimization of set up time
2. Reduction in NCP and customer complaints

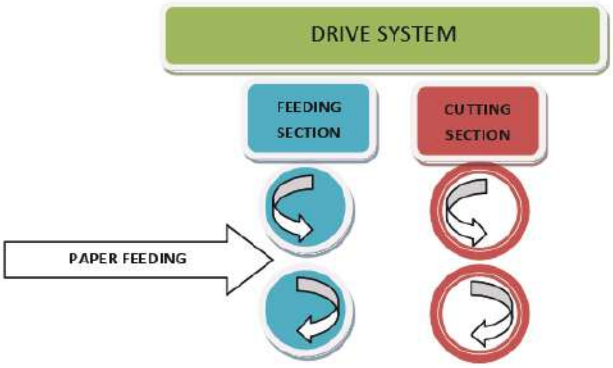
Proposal:

It is proposed to replace OEM (Spain) made PLC, Drives and control set up with indigenous system in Paper sheet cutting machine where accuracy of cutting, data logging plays major role.

List of Activities:

In sheet cutting machine, cutting accuracy play major roles which is a result of combined performance of Drives and motion control system. These systems should work in synchronization with each other to give best results. So, we have planned to replace both the systems.

1. A brief on Drive system:



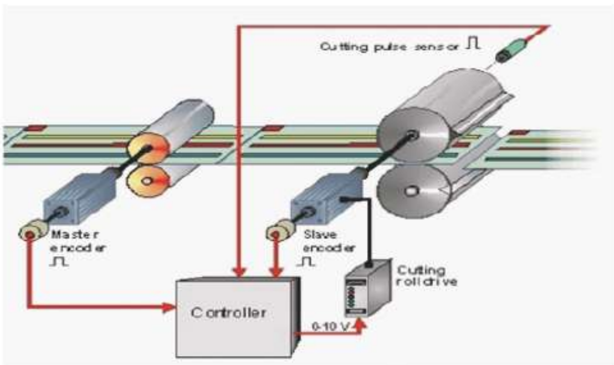
Drives system mainly consists of two sections

i. Feeding section:

This section feeds paper to cutting section at uniform rate as per desired cut length. This is drive by a motor through timer belt transmission

ii. Cutting section:

This section cuts the paper with an accuracy of +/- 0.5MM as per the desired cut length. This is drive by a motor through gear transmission.



These sections are controlled by individual drives in a closed loop system using a motion controller. While feeding system feeds paper at uniform rate while cutting section changes its speed based upon the desired cutting length. Synchronizing these two sections to give required cutting accuracy of +/- 0.5mm is a major challenge while upgrading these sections.

Since the existing cutting motor drive, feeding motor drive, motion controller and PLC system got obsolete and are not compatible for data logging, it is proposed to upgrade the system. Since the cost of upgradation proposed by OEM is very high (1.6 Crores Apprx), indigenous upgradation is proposed.

2. Finding equivalent equipment:

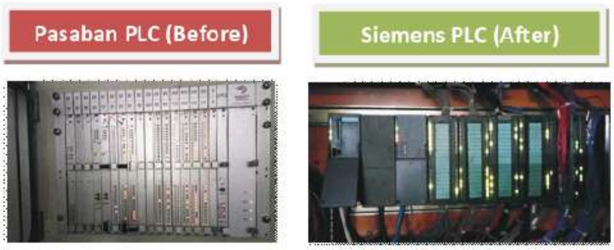
The main challenge is to find indigenous equivalent equipment which can replace OEM without compromising on performance. We have approached multiple MNC companies regarding equipment suitable for our application. Most of the reputed MNCs could not able to supply equivalent component owing to complexity of operation.

After elaborated research it was planned to get different equipment from different companies who were expertise in particular field. Motion control system supplied by German based company where as drive system is supplied by Italy based company.

3. Erection and commissioning (E&C):

Since this kind of upgradation is first of its kind, we have made a detailed list of activities to be followed along with criticality. Gantt chart has been made to carry out time bound activities.

Before E&C:



After E&C:

After commissioning, we started developing PLC program for machine. Since OEM program is not accessible to end user, we need to develop new program considering safety, productivity and quality. It almost took 4 days to develop program which can run the machine with utmost safety.

After developing basic program, we started the most critical activity of upgradation which is synchronization of drive systems. First we tuned the individual drives to get best performance as individual. Then we started tuning motion controller which is critical for synchronization. After setting up motion controller, we ran the drive system in synchronization mode and we found error is within limits. Then we fed the paper to check the results on cut length. After cutting paper we found paper cut length was accurate.

Then we applied PDCA cycle to tune motion controller for every 10% increment in speed. We could able to get required results up to 80% speed within 3 days. After this it was very difficult to further tune the parameters of system due to knowledge limitation on new system. Meanwhile we started commercial production with 80% speed. We started taking intermittent trials to uplift the machine speed. We almost made 23 changes in system and took 35 trials to get 100% speed.

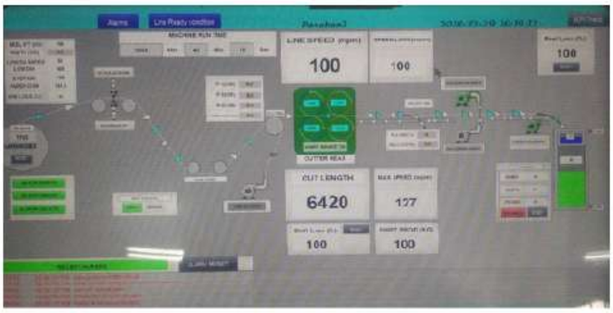
Advantages of Modified system:

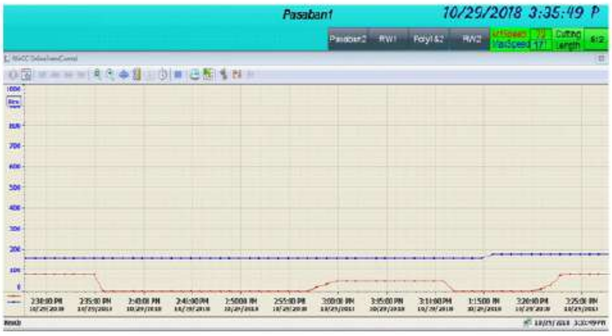
- Maintenance is planned based upon machine run data which is captured on daily basis
- Customer complaints are analyzed easily with auto captured data

- Daily reports are generated by machine which will help production to analyze machine performance
- Machine downtime reduced significantly (MTBF improvement), set up time reduction by 30% which reduced process loss by 0.5%
- Low cost of upgradation (25% of cost proposed by OEM)
- Low cost indigenous spares and service availability (R&M Cost reduction)

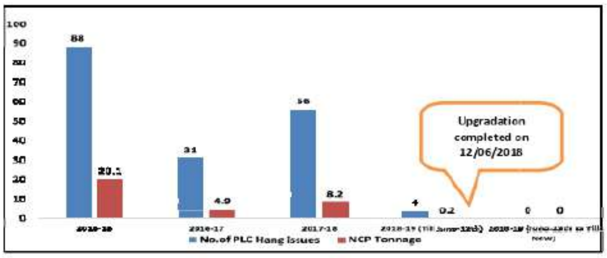
Machine online data capture:

Online tracking of machine critical parameter





Results:



Every PLC Hang issue results in NCP which has been completely eliminated after upgradation

Case Study 3 – Web Inspection System

Objective:Automation for Quality and Marketing Optimization

Need:

There is an increased sensitivity for defects considering the product being use as primary packaging for food and food dispensing. Physical defects like poly missing, black spots, other contaminants generated online during poly extrusion process are of utmost criticality and are very sensitive from both Quality front and Marketing front. Marching towards Industrial revolution, database of all the physical defects is to be created and plotted with input parameters (in event of generation of process defects). The above approach results in improvement of Quality standards of the product which is Customer centric.

Proposal:

The Online measurement of surface defects is installed on the machine to capture defects and its data acquisition. This system enables identification of defected portion of final product which will be segregated in subsequent packing/conversion delivering defect free product to customer.

Approach:

Defect identification system Pre-implementation period:Visual inspection is carried out at various sub-process stages of manufacturing and recorded in log books and segregation happens at subsequent stages. Size and visibility of physical defect, speed of manufacturing machine play a vital role in identification/assessment of the defect in this manual process. Lapse in identification may result in slip of defected portion to customer. In-order to avoid this slippage, machine speed may get hamper. Input reel may have many defects that segregation may not viable and lapse in such defect identification may increase process loss. Rework is also involved in some cases to meet customer order in full.The following is the trend of complaints lodged due to physical defects prior the implementation of project. Various defects in this context are Scratch line, Blade line, Blowing, Calendar stamping, Crease, Dielines, White patches, Yellow spots, Oil spots, Base hole, Base black patches, Black spots and Insects.

Physical Defects trends:

Technology Utilization:

The integrated defect inspection and signal monitoring are conducted with help of swift high-resolution CCD camera, Digital Image processing and precision optical equipment.

Samples with all mentioned defects are analyzed for greyscale and gradient variation in different grades of production (Indobev, Indobarr and Eco grades) and the grayscale difference between template image and inspected image was performed to determine the defect in the non-edge region according to the grayscale difference threshold of non-weighted neighborhood. Then, the gradient difference between the template image and inspected image was employed to determine the edge defect according to the grayscale difference threshold of weighted neighborhood. Finally, the difference artifacts were effectively eliminated by the two different image fusions and the real defects were retained.

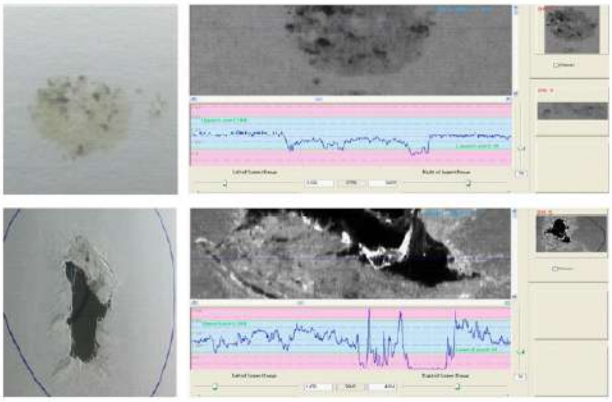


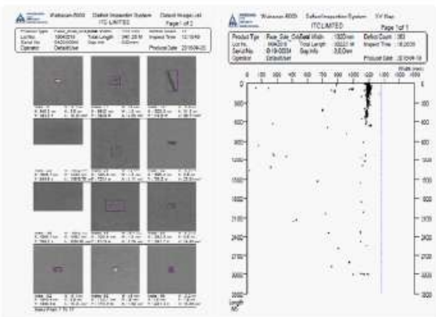
Fig showing image of physical defect and its greyscale

Results:

Quality inspection detects abnormal, repeat and random defects avoiding manual intervention and provide complete statistics with defect classification.

Database is created with defect type along with position coordinates of defect. The advanced database is designed with functions in terms of defect image search, image amplification, yield statistics

- Defect Range: 1mm2 -100mm2
- Lighting: Transition / Reflection light



Images of Web Inspection Report Output

Conclusion:

The above explained three Case Studies created a platform by enhancement of Assets in all machines of the Unit which enabled us to create a network of "Process Data Hub" where critical data is logged and can be monitored.

Prior to this, all the data from the machines is to be captured from each individual location. Marching towards Industry 4.0, an internal link is build up within all the machines. This helps in accessing the critical monitoring points of all the machines at a single point.