Beyond Automation: Infusing Human Intelligence into Paper Manufacturing

Abstract
Initially, most of the process operations used to be purely mechanical. Slowly and slowly, all segments of industry started using discrete automation using On-OFF controllers, later to PIDs, then to SCADA, PLC and DCS. The next in line are IoT, AI, ML etc., which are fast getting applied by industries. Paper industry too is gearing up towards increased level of automation. Upgrade from conventional controls to AI/ML enabled system requires a series of efforts like installation of necessary field instruments, having basic automatic controls, inclusion of suitable platforms which shall act as a foundation and backbone for the future AI systems. In addition, it is also equally important for the production team to observe themselves the outcome of these as improved process plant performance, as well as an ease of operation with such automation in place.

Not only this, most of the automation systems rely upon basic control and logic operations. In case the same automation system is already infused with relevant calculations to highlight the system performance as well as various key parameters like energy efficiency etc., the online monitoring can be helpful in optimizing process parameters to a significant level.

Keywords:
Paper Machine, Human Intelligence, Automation, DCS, AI, PLC

By:

D K Singhal,
www.dksinghal.in

Introduction

A friendly question between two friends turned into a serious discussion. The question was- "How do you plan to automate your processes for future?" The obvious answer was to implement a DCS system for each and every process. Is that very difficult? You just need to place order to a good automation system house, procure and install various field instruments, connect everything and take maximum unit operations in auto mode. "So, why are you not doing it? Is high Capex the issue?" No, automation Capex is not a big issue for many of the mills. But, still the hesitation towards automation persists.

In fact, when it comes to automation, everything seems so easy on paper. However, implementation is the real task. In fact, the journey from manual operation to automation and towards implementation of advance techniques like IoT, AI, ML etc. is really long.

The Initial Experiences

Long back, just to begin with, an AKD dosing system was installed. The idea wasn't very lucrative in the beginning. Initial cost was high (as we felt it), but as it was installed, significant reduction in AKD consumption was observed. Not only this, the Cobb stability improved a lot. For each roll, we had becoming almost sure that the system ensures a uniform Cobb value, always.

After a couple of years, it was observed that there were occasional variations in Cobb. There were few customer complaints too, which increased slowly. When the matter was investigated, it was found that there was a fault in VFD of AKD supply pump, the VFD was replaced, and that was not put in auto mode. In other words, in place of controlling the flow rate (as sensed by a flow meter), it was being run at fixed rpm, according to display of AKD flow. So, whenever there was a clogging of filter, flow reduced slightly, and operator manually increased the RPM of motor from the panel just to achieve the desired flow rate. When enquired, the operators were fully satisfied with the system, and did not consider it a significant issue at all.

The same was attended and observed that there was not even a single complaint for the next several months. Anyway, this small incident gave us a lesson that training of shop floor people is also equally important to run any automation system.

Clearing Out the Doubts

Well, when automation was planned for a new fiberline, many workers were afraid about their future and role with increase in automation. To enlighten them, a special interaction session was conducted with many shop floor workers including operators, assistants, and even the helpers. The first question was about the need. The old, experienced workers were overconfident about their capabilities. They were explained with the example of tea. "The same canteen worker prepares several cups of tea every day. But sometimes, you find sugar is more or less, sometime milk is not proper sometimes, the flavor is not that perfect." That shows the need to automate even the simplest process; particularly we expect that the future market will definitely be more and more quality cautious.

The other major issue was that many workers did not know about computers. Well, the worker who raised the question was called in the front, and he was asked if he used a smartphone, and could he show the image of a famous bollywood actress in his phone? Interestingly, he happily showed several images from the internet. Now, he was asked, "Bhai (brother), from where you got training to run a smartphone, and use such features?" The small act started creating a positive approach towards automation.

Also the team was assured that the management will support and guide them to run the system with automation, and they'd really feel more comfortable with automation.

The Fiberline

The fiberline automation was done through DCS using a SIMATIC PCS-7 PLC, but there were few minor issues in process controlling. With continuous process up-gradation, some of the equipments had been removed; some new equipment was installed, so just 65-70% of fiberline was under proper automation.

Anyway, fine tuning of operations was started. However, it was observed that the GUI (Graphic User Interface or monitor display) was not very much operator friendly. However, as the system was satisfactorily working as the workers had become used to of it. So it was decided to let it run as it is, and move towards paper machine automation.

With the fiberline automation in place, the next logical step was improving automation in the paper machine itself. Unlike fiberline, where process fine-tuning was key, the paper machine required a more structured, phased approach.

The Paper Machine

Paper machine drives were already running using a PLC but only for the drive part. It was discussed with several experts, and we found that there were basically four areas of concern-

- The vacuum System
- MG & Hood System
- Approach Flow & Headbox
- Peripherals (showers, interlocks, guide/stretchers etc.)

In place of going for the complete automation, it was planned to do it in phased manner. The reason- to ensure that the operators become familiar with one system before the second one is taken in loop. Another reason was the low investment in one go.

Paper Machine Vacuum Control

Quite obviously, the vacuum system was the simplest. Fundamentally, you need a control valve, a vacuum transmitter, and a PID controller, to control vacuum in a particular box. For all individual boxes in wire and press part, you need just 15-18 such units. In other words, there shall be hardly 35-40 analog IOs needed, maybe a few more for future needs.

Then suddenly another idea popped up. Why to get a new PLC for this? The supplier of drive PLC was called and he confirmed that the existing PLC was robust enough to take care of these IOs. All we needed was IO modules, interface modules, and of course the field instruments. So, the supplier had to supply only the required items to be mounted in a junction box like shown in fig. 1.

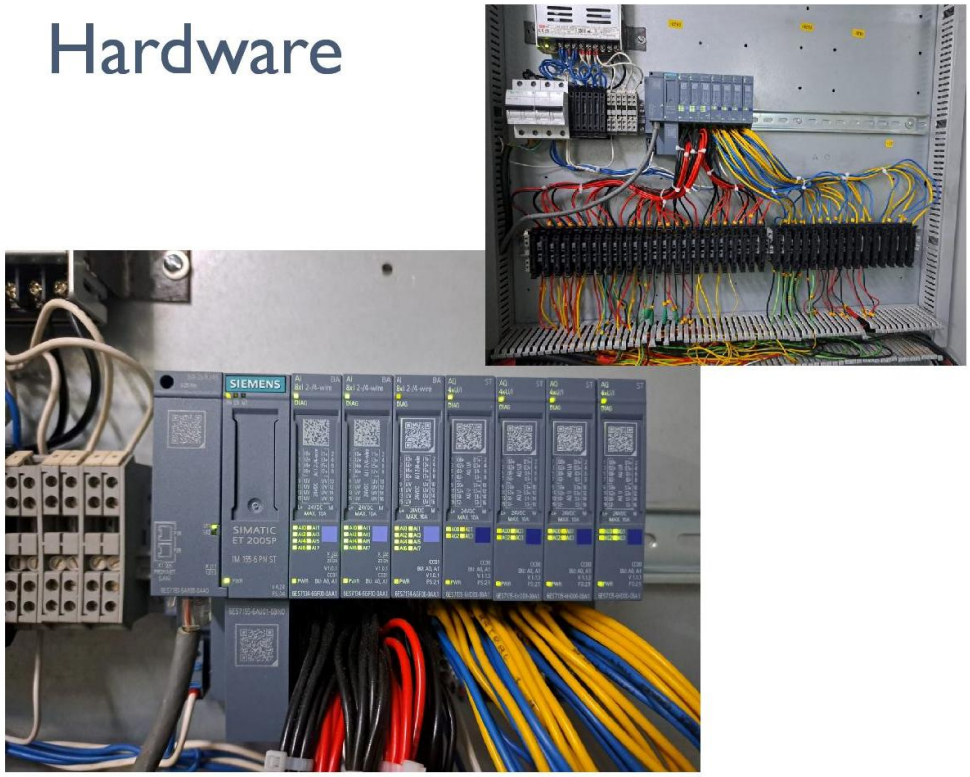

Fig. 1: Inside of the IO Junction Box

On the other hand in the plant, the concept was discussed in detail, specifically with the shop floor operators, who had to actually run the system. Several types of graphics were prepared -some based on machine layout, some based on plain display-; and finally, the most simple, (fig. 2) was preferred by operators. In fact, the discussions with shop floor operators were extremely useful. They started considering this project as their own project.

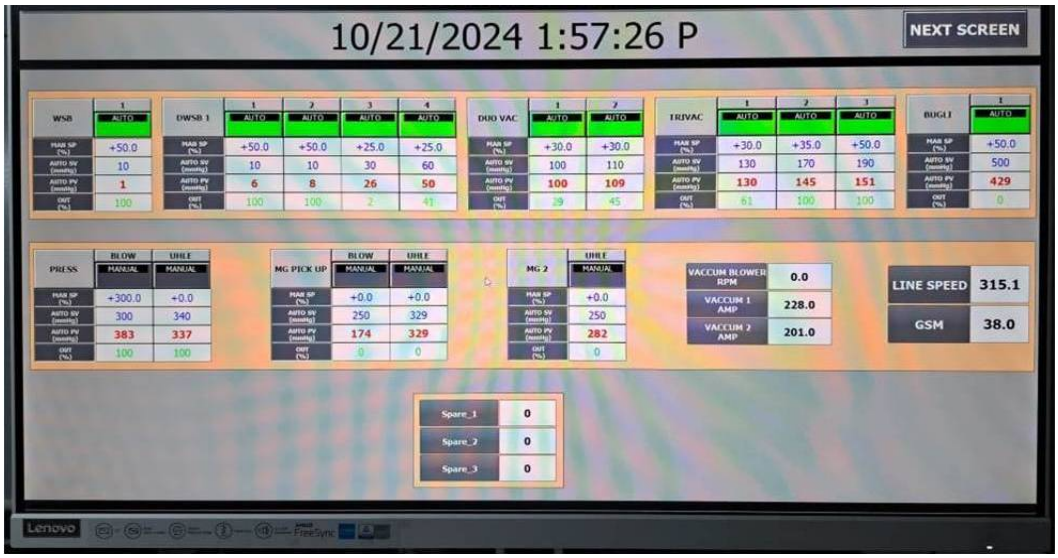

Fig. 2: User Display of Vacuum Control

The Start Up

Well as expected, the startup was very smooth. As the machine was started after implementing the system, the wire part control valves adjusted automatically as per the set point. It was decided to observe the performance of the same for a few days before starting the next work.

After a week, during a review meeting most operators were too happy with the system. One said that when they wanted to change the basis weight from say 40gsm to 70gsm, they usually had to adjust the vacuum as desired. Also, when they tried to adjust vacuum in second box, the vacuum already set properly in the first box got disturbed. But with the new system, (in their own words)- "We don't need to do anything. Valves automatically slowly adjust themselves. We are feeling very much relaxed."

Press Part Vacuum

Initially, press part vacuum was available for display only, and control was not provided. Provision was made in the system to install control valves and start controlling the same, if required in future.

The measurement was fairly reliable, as with normal bourdon tube gauges, the operators often read inaccurate values depending upon from which side of the gauge they were standing at. After all, the significance of the readings was just to fill up the log-books.

However, when digital display was available, the measurements became more reliable. An analysis of the data indicated that the press felts uhle box vacuum level increased for 6-7 shifts regularly, and then it became constant for another 6-8 shifts (fig.3). After the wire and felt washing was done, the vacuum levels dropped again and the previous trend was observed. This indicated that the felts were getting choked too early.

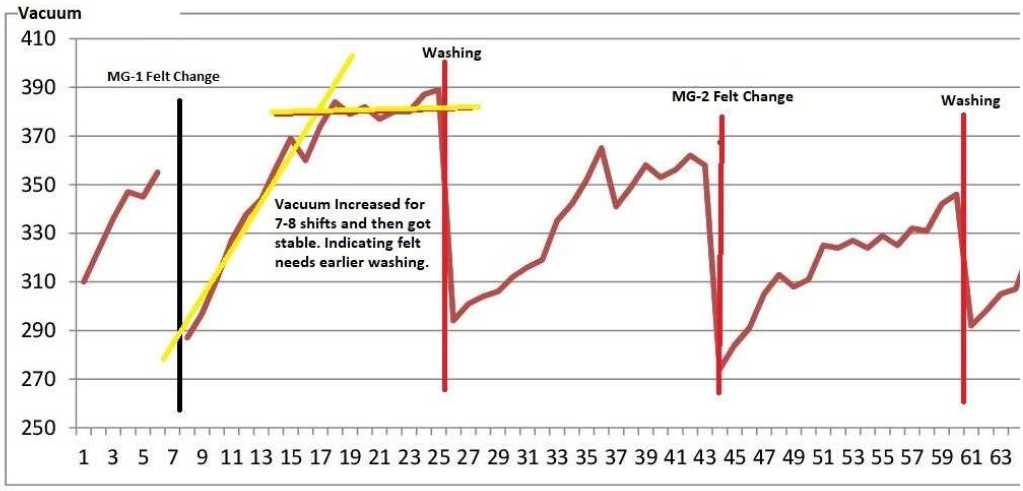

Fig 3: Press Felt Uhle Box Vacuum Levels

A thorough review of felt conditioning was made and after discussing the issue with the felt supplier, shower supplier and other experts; some process alterations were made, after which the rate of felt choking was reduced.

MG and Hood System

Encouraged with the previous work, an automation system was planned for MG and hood of the paper machine. The recently installed hood had already been fitted with various field instruments, and a model had already been developed by the mill to estimate the consumption ratio of steam in hood and MG, determination of overall system efficiency etc. Earlier, the necessary data was being recorded manually and using the Microsoft Excel, the calculations were being made.

Such calculations gave a better idea on how to operate and optimize the hood operation for better efficiency, reduced steam consumption etc. However, it was a little difficult to implement on the shop floor, as the fear of unexpected often tied the hands of operators. For example, when trying to reduce hood recirculation air temperature, or blower speed, the shop floor people were afraid that it might result in increased moisture in paper or they might have to reduce the machine speed.

The manual control scheme being used earlier was simple. There was a PID controller for MG steam pressure control, with a facility to have two set points- one for the normal run and other for the web break. However, the set points could be adjusted during the concerned operation only, i.e. you can alter the normal run set point when the paper is running, and the web break set point can be adjusted only when there was a web break. Anyway, operators were used to of it. So again, the operators did not find much scope for improvement at the beginning.

For hood recirculation air temperature, steam heaters were provided with automatic control valves, RTDs and PID controllers. The desired set point can be set in PID, and system works well. The blower RPM were being set by potentiometers, and usually, no major change in blower speed frequently.

As in earlier case, the supplier was consulted, and asked for addition of several more I/O modules, in the existing PLC. For determination of various performance figures, complex calculations were needed. The supplier also confirmed that the existing PLC PLC software Siemens TIA Portal had the facility to compute as per the details calculations provided by us.

So, necessary work was initiated and hardware panel was installed. (Fig.4)

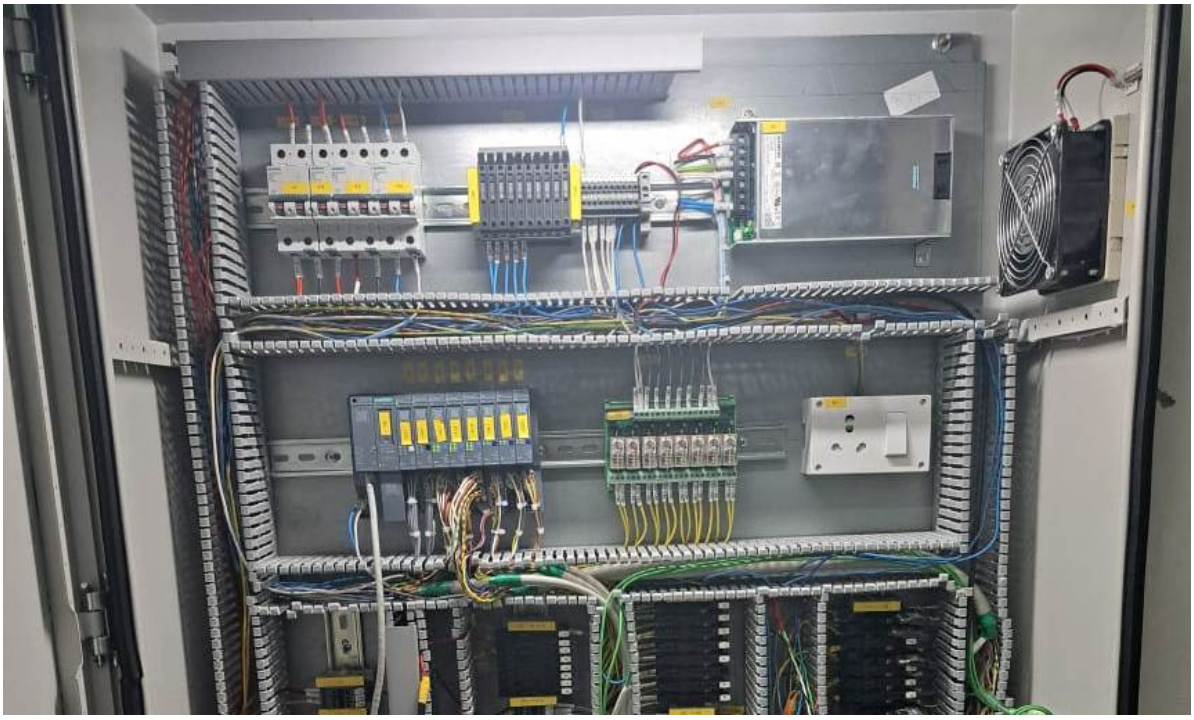

Fig4: Hardware Panel for MG and Hood

A dedicated PC was set to display the Steam and Condensate System GUI (fig. 5) so that the operators can run the machine with it properly.

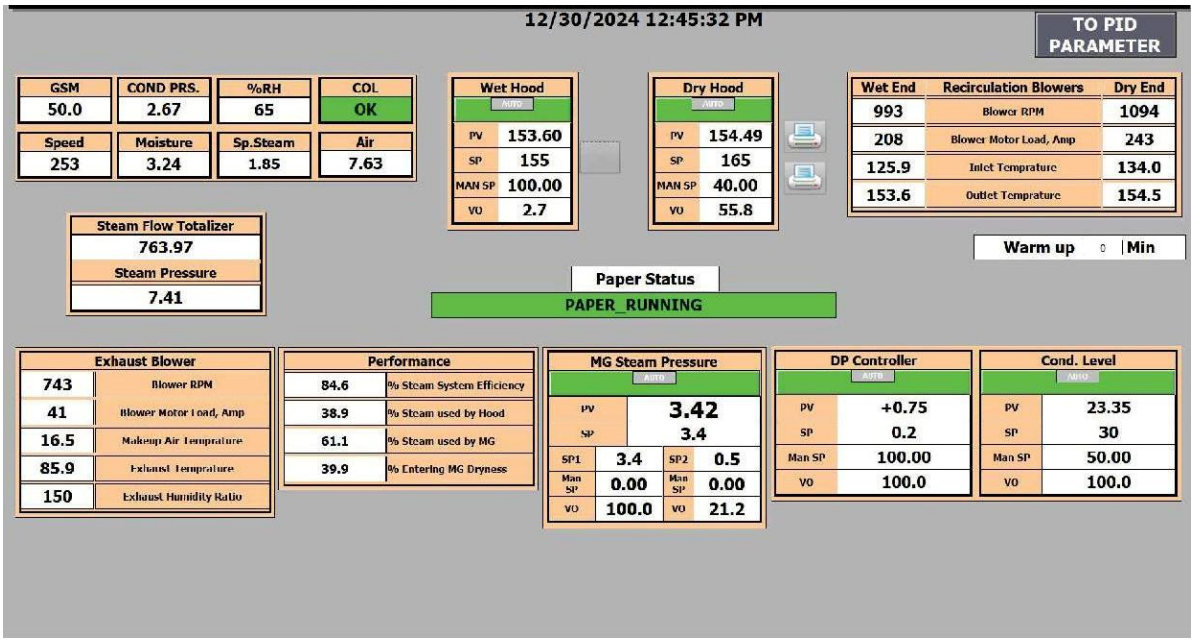

Fig.5: Operator Display for MG and Hood Control

The system was set up, necessary software were installed and upgraded on the dedicated PC for this. To ensure a trouble free startup, the operators were allowed to change the set points, make Auto/Man toggle work etc. with dummy signals. Meanwhile, the paper machine was running with existing system. This gave them a feel of running an actual system in a simulated atmosphere. After everyone was confident, the wiring connections were made in a couple of hours, and machine was started.

After the startup, as usual, the exhaust blower rpm were kept 988 as running earlier. The exhaust blower speed was reduced to nearly 740 rpm, thus a significant reduction in blower load was observed. It was observed that the overall efficiency was to the tune of 71%, which increased to 84-85%, after reducing the blower speed. The exhaust humidity ratio increased from 88-90 to 150 gm/kg dry air.

The increased in humidity ratio meant reduced exhaust (and hence intake) air, which was being heated from 16 degC to 85 degC, thus wasting a significant amount of energy. In fact, the overall savings showed that the payback shall be within a few months only.

Infusing Human Intelligence

If you look above cases, these appear just as application of simple automation methods. However, if you have a look at the block as shown in Fig. 6, you'd observe that it shows some critical parameters related to steam and condensate system operation.

Performance	
84.2	% Steam System Efficiency
64.7	% Steam used by Hood
35.3	% Steam used by MG
38.1	% Entering MG Dryness

Fig. 6: Steam & Condensate system Performance

The steam supplied to paper machine goes either for the hood or for MG drying cylinder. Having known the hood recirculation blower capacity, inlet and outlet temperatures etc., steam consumption in hood is calculated. Out of total steam consumption, the rest is for MG. Similarly from the exhaust blower air flow rate, temperature, exhaust air moisture ratio, it is possible to calculate the amount of water vapour removed. Makeup air is also calculated and on the basis of its temperature and %RH, entering water vapour is also calculated. All these information indicate how much water vapour was removed, and having the machine production rates from speed, basis weight and deckle; it is quite easy to calculate the % entering MG dryness.

In fact, such an intelligence applied to the system helps a lot. The steam system efficiency increased from 73% to 85%, indicating more than 10% savings in paper machine steam consumption so far. Being it a new system, and further optimization under progress, we hope to reduce steam consumption a little more.

Another unimaginable outcome of infusion of applied human intelligence was having live information on '% Entering MG Dryness'. Usually, the paper machine crew had a habit of taking samples after every 3-4 days to check dryness, but from the data gathered no useful outcome was possible. Taking samples manually and checking these for dryness are susceptible to human errors. A close observation of this indicated that entering MG dryness slowly reduced by nearly 3% with time; and after the regular felt washing it increased again. Now this was a great outcome. It indicated that we need to keep our felts cleaner and by that only we can increase machine speed by 10-12% or even more.

Live Energy Audit

What exactly is an energy audit? You collect some data from the plant sensors, get some data from hand held instruments at the site, take necessary measurements if required, and do the calculations work to find out a single parameter- efficiency of the system. However, when the data are changing frequently depending on paper machine speed, quality and basis weight being produced, any one efficiency figure cannot give correct information. For example, during hot and humid season, the entering air to hood may carry as much as 40-70% moisture compared to the water vapour removed from paper.

In fact, without having information and understanding of process parameters, either there is significant steam wastage and/or there is a reduction in output in hot and humid weather. With the system installed, operators can decide the optimum speed of the exhaust blower.

AI Implementation

It has already been observed in the past that plenty of data is usually available for any process operation, which can either be recorded manually in form of log books or can be captured automatically using PLC based SCADA or DCS system. As often stated, “Daily Data Powers Production”, availability of such data can be used to build customized models for different grades of paper produced at different operating conditions; and on the basis of that significantly improved process control can be achieved.

Conclusion

It is not possible to jump over the mountains in a single step. Exactly the same way, any mill has to take several small steps towards automation with a focus to achieve a well automated system before implementing the latest technologies. Furthermore, for AI-based automation to succeed, human expertise must complement technology. As machine learning algorithms evolve, integrating real-time adaptive control and predictive maintenance will further enhance efficiency and reduce downtime.

D K Singhal

Digitally signed by D K Singhal
Date: 2025.02.16 12:09:00 +05'30'