Advanced Simulation Solutions for Pulping & Recovery Operations

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The increased complexity of process operations in the Pulping and Recovery plants has mandated the use of user-friendly IT tools for increased productivity and efficient plant operations. Advance dynamic simulation with effective operator training simulators offer the best option to achieve these objectives. One such simulation package is Prodyn, which provides opportunities for entire process plants dynamic simulation using a powerful simulation engine in the background and to ensure properly trained operators, who understand the dynamics of the plant very well and also are knowledgeable in plant safety management procedures for safe and efficient plant operation. This provides a user-friendly interface, which allows the user the capability to train, learn and test the various dynamic operations of a process model. The dynamic simulation capability facilitate study of what-if scenarios, evaluate technology options and builds up effective start-up and shut down procedures as key elements of operator training. Case studies have been discussed to bring out typical benefits to the Pulping and recovery operations.

INTRODUCTION

The Indian Pulping and Recovery operations have some unique problems. Weak and minimal quality of instrumentation and control result in wide variations in quality of sectional outputs. Variation in quality of inputs, poor/inefficient/outdated multiple equipment multiplies the quality-control challenges. With increased competition, it is essential that any pulping and recovery operation use all available resources to run the plant efficiently, with minimum down-time, effective start-up and shut down procedures to minimize product losses and operate and maintain plants within the allowable environmental and effluent norms. This calls for a team of highly competent operating staff, who understand the dynamics of the plant operations and are able to run the plant with maximum uptime, reduced accidents and minimal abnormal situations. They should be aware of full testing protocols for plant operation and start-up/ shut down.

The above requirements calls for effective use of available IT resources, which are increasingly becoming part of any process operations. Dynamic simulation together with an effective operator training simulator makes the best use of such IT resoures. These user-friendly IT tools form the key elements in building up an efficient plant operational staff. Dynamic simulation engine recreats the dynamics in an operating plant by incorporating all the equipment, until operations, valves and controls together with the pipefittings to bring out a realistic process model. (1,2). The process model is built based on first principles of engineering and reproduces the rigorous dynamic operation of pulping and recovery operations. The dynamic simulator recreates the actual environment in the DCS, which the operator will face. The OPC (Object Embedded Linkage Process Control) nature of the present day simulators allows for direct transfer of data from the DCS to a process simulator, which runs in the background. Thus Process simulators/training tools such as Prodyn with a background simulation engine such as CADSIM Plus, can use the actual plant information to emulate the plant DCS. Over and above, they have a facility for "event control" for recreating typical disturbances that occur during any plant operation and training the operator to deal with such disturbances effectively. Unlike classical plant operations, where subjective opinions make a big chunk of what is called "gut feeling", operator training simulators build up capability in operational staff by letting them run the plant "virtually" and see the effect of their actions. The in-built plant process model simulates plant performance as it should be run and the operating staff skill building then becomes knowledge based, rather than subjective assessments.

Technological features

Some of the key technological features are listed below:

1. The process simulation is rigorous and based on engineering principles. This includes all the equipment, valves and fitting and control systems in the plant as per plant P & ID as shown in figure 1. This way it can model the entire plant in a dynamic mode. Effect of

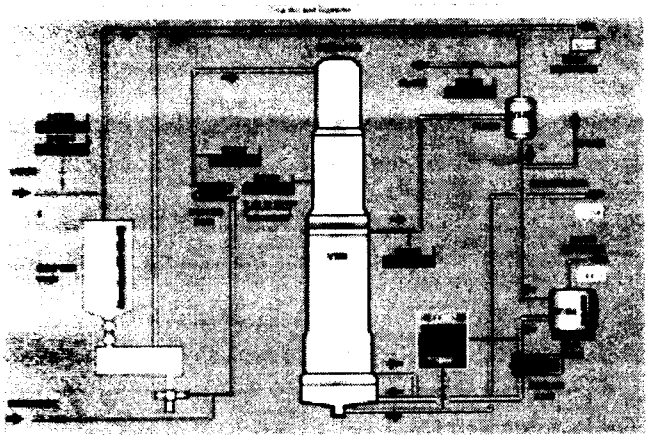

Figure 1 : Typical Process Plant screen on DCS

factors such as effect of raw material changes arising from normal procurement from different sources or the result of recycle streams, which may show increasing build up of unwanted solids etc, utility variations such as a water quality changes due to seasonal changes resulting in increased solid concentrations during summer months and increased suspended solids and turbidity during rainy season etc on plant performance can be easily visualised.

2. Typical malfunctions or disturbances that occur in any process plant can be effectively recreated to enhance operator's reaction to such disturbances. Illustrative example of this would be sudden stoppage of steam or pump and consequent plant disturbances or emergency shut-down procedures.

3. An important feature of any training operation is its use to inculcate proper start-up and shut down procedures, which result in minimal product losses, recyling and reprocessing and avoid prolonged unsteady-state conditions.

4. Alarm Management Systems : Suitable alarm levels are included to indicate the degree of seriousness and appropriate management systems built-in to train the operators for dealing with seriousness and appropriate management systems built-in train the operators for dealing with these alarms for effective plant control.

5. Graphical display : A picture conveys effectively what reams of reports can convey. Hence graphical display and 2D and 3D trends are incorporated to display that effect of various changes that could occur. Typical illustration is shown in figure 2.

Plant operational reports together with actual vs. simulated performance can be created in the form of reports, which could form the basis for plant performance monitoring. These reports could form the basis for performance, rather than breakdown maintenance. These performance analysis reports could help to identify heat-exchangers which are prone to scaling and would help planned cleaning and improve downtime. Another factor that could facilitate improved productivity is by helping to identify the nature of scale

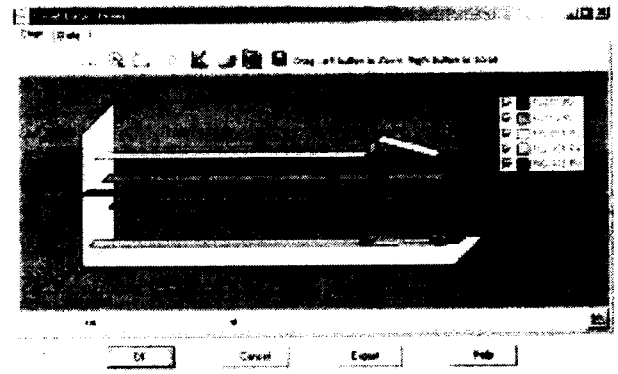

Figure 2 : Graphical Trend Display

deposits and track the source of these contaminants in actual operation. Typical examples could be silica contamination and progressive scaling due to deposit formation.

6. The OPC nature of these simulators helps to export data to third party applications. One such example could be to connect the plant data with the laboratory for virtual plant monitoring, e.g., to indirectly monitor chlorine-di-oxide concentration in a bleaching plant and conclude on the performance of the plant, rather than take laborious lab samples for extensive laboratory analysis. Of course, in the begining, some amount of extensive laboratory investigations may be nessesary to derive the right conclusions.

Plant Applications

Typical applications of these advanced process simulation tools are in the following areas:

- Early identification of problems and equipment
- Control configuration validations
- Smoother and faster start-up & On-spec products
- Increased safety & fewer incidents
- Operator Training and cross training
- Improved handling of abnormal situations
- Energy reduction
- Waste water recovery

CASE STUDIES

There are various applications for such training and simulations tools. Some of these are illustrated below:

1. What-if studies

A What-if scenario helps the plant operators to assess and evaluate the consequence of their operations. These consequences could have great economic implications in day-to-day operations.

A typical illustration could be the type of water that is being used for stock cleaners. Due to presence of 40-50 micron silica particles, there was sever up-steam

corrosion equipment. The plant had a set of hydro-cyclones in its steam. However, these hydro-cyclones were not able to remove the 40-50 micron particles. Process simulation studies with another set of hydrocyclones in series were evaluated. But the hydro-cyclone supplier had no previous experience with silica contaminants of that nature and hence was unable to provide guarantees. Dynamic Modeling helped in freezing specs and sizes before minimum pilot study and final implementation after validation.

2. Process Troubleshooting

A dynamic simulation model facilitates scientific process troubleshooting and the consequences. This could be the increased solid concentration arising out of recycling operations or scaling due to solid contaminants and their effect on heat exchanger performance. This may give good idea of when certain heat exchangers need to be taken off the steam for cleaning.

3. Equipment evaluation

In a large Pulping mill in British Columbia in Canada, the problem was loss of steam generating capacity due to fouling over a period of time (3). Existing three production lines had lot of fresh water and water recyling and many interconnected systems making any practical analysis difficult. Fouling over a period of time had reduced steam availability and steam from Heat recovery systems resulting in higher steam generation requiring increased energy cost.

Dynamic simulation of the entire plant produced effective solution.

- About a dozen alternatives identified and analyzed.
- The Paper mill expects to save 4.3 MGJ annually.
- Fresh water reduction by about 9% annually.
- Green house gases emission reduced by 25000 tonnes annually.
- Capital cost required for implementation about C$2.1 Million.
- Total Capital expenditure for this about C$1.3 Million.

4. Process Analysis & Troubleshooting

This case study refer to a large Canadian plant, where Supply and distribution of steam is continuously variable, as shown in figure 3. A good amount of steam was being supplied by the thermo-mechanical pulping section. When a problem arises in the thermo-mechanical pulping section, it results in a sudden loss of steam from its heat recovery section. Also sudden demand for extra steam results in pressure loss in MP steam header, giving rise to difficulties in level control in the gas fired boilers. Some times due to severe frothing, operator tends to drain the steam drum for froth control, resulting in loss of overall steam availability.

Dynamic simulation models helped in analyzing what-if scenarios and equipment evaluation with concomitant cost implications. Some of these situations are outlined below:

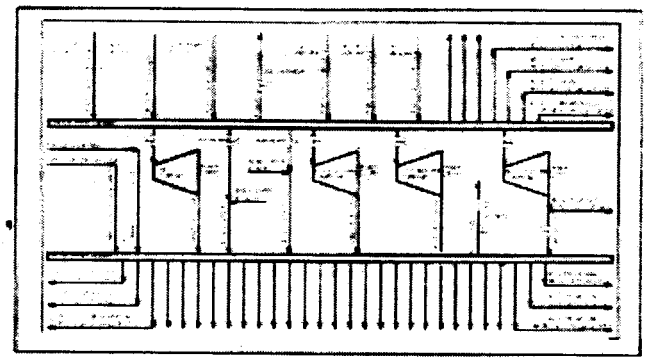

Figure 3 : Case study : Process Analysis & Trouble shooting - Steam Distribution system

1. Firing control for existing boilers.
2. Steam accumulator between MP and LP header - What Size?
3. Possibility of fast start-up electric boiler on stand-by.
4. LP header vent arrangement to vent extra steam from Heat recovery unit to LP Header.
5. Replacement of existing turbine drive of pump by electric drive.

Final solution

- Dynamic simulation helped economic analysis for all above options.
- Steam accumulator found to be most cost effective.
- What size of steam drum for better control?
- Various size analyzed for capacity & good level control.
- Available steam drum found inadequate at certain operating levles.
- New 4m x14m accumulator gave best results.

CONCLUSIONS

Dynamic simulation together with operator training simulators offers a powerfull, yet very user-friendly tool for effectively using IT for production plants in the pulping and recovery units. They provide cost-effective solutions via virtual plant performance analysis, analysis of what-if scenarios, evaluation of equipment and technology implications etc. Some of the target areas in the pulping sections could be (i) pulping when there are pulp quality variations, (ii) better understanding of modern pulping digester operation, (iii) control of colour in conventional batch digesters etc.

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