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Research Article

AUTOMATIC CONTROL OF BOILER SYSTEM USING DISTRIBUTED CONTROL SYSTEM

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Abstract

A steam boiler is a sealed vessel designed for the purpose of generating steam pressure at a higher level than atmospheric pressure. "Harnessing" the steam raises the pressure and consequently the boiling temperature. This also increases the energy content of the resulting steam. Different boiler types can be differentiated either according to their design, method of combustion or type of fuel. Steam boilers are defined by their design, steam output and permissible operating pressure. Essentially, two designs are offered to generate high pressure steam with a higher output range: The water tube boiler and the flame tube/smoke tube boiler (also referred to as boiler with large water chamber). This designs conventionally used as a quick steam boiler up to approx 30 bar or as a water tube boiler up to approx 300 bar.

The boiler control which is the most important part of any power plant, and its automation is the precise effort. In order to automate a power plant and minimize human intervention, there is a need to develop a DCS. This system controls and monitors the plant and helps to reduce human errors.

Keywords: Boiler, DCS, Power plant, Automation.

Objective

- The primary objective is to automate the Boiler.
- To introduce the principle of redundancy i.e. to continue with the process even a single processor fails.
- To make the process more efficient and less time consuming by automating it with the help of DCS implementation in the plant
- To have a graphical view of the monitoring stations of the whole plant in a single computer

- So there is a strong need to automate the plant, thereby avoiding the human error.

Boiler Process Description

A boiler consists of various sections which is shown in the figure 1.1 .They are

- Economizer
- Boiler
- Super heater
- De-super heater
- Re-heater
- Steam Distribution header
- Condenser
- Cooling tower

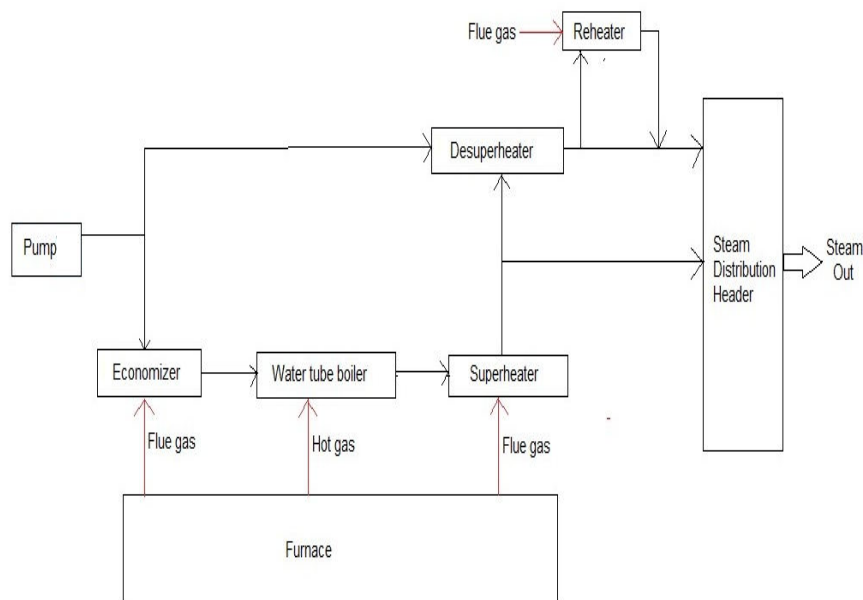


Fig.1.1 Boiler Process.

CS 3000 Software

Functional Block Diagram

A function block diagram describes a function between input variables and output variables shown in fig.1.1. A function is described as a set of elementary blocks. Input and output variables are connected to blocks by connection lines. An output of a block may also be connected to an input of another block. In FBD, program elements appear as blocks which are "wired" together in a manner resembling a circuit diagram. FBD is useful in those applications involving a high degree of information/data flow between control components such as process control. Function block diagram is one of five languages for logic or control configuration supported by standard IEC 61131-3 for a control system such as a Programmable Logic Controller (PLC) or a Distributed Control System (DCS).

Control Drawing Builder

The Control Drawing Builder is used to configure the basic control functions of the FCS. With the Control Drawing Builder, operations such as registering function blocks in the drawing file and determining the flow of data between function blocks can be performed graphically shown in Fig.1.2. CS3000 R3 system contains 200 control drawings per FCS.

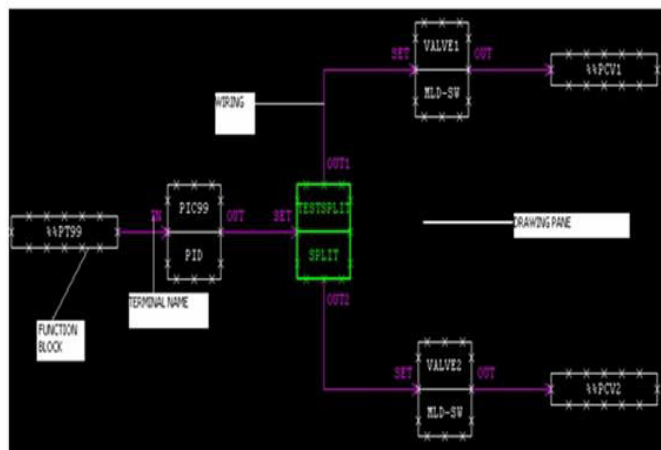


Fig. 1.2 Control drawing builder

Blocks Used in the Control Drawing Builder

MLD block:

To create a simple closed loop using MLD block in the control drawing builder is shown in fig.1.3. For a simple loop, the function blocks required are MLD, PID& PVI Manual Loader Block (MLD) displays the manipulated output value (MV) to manually operate final control elements, such as control value.

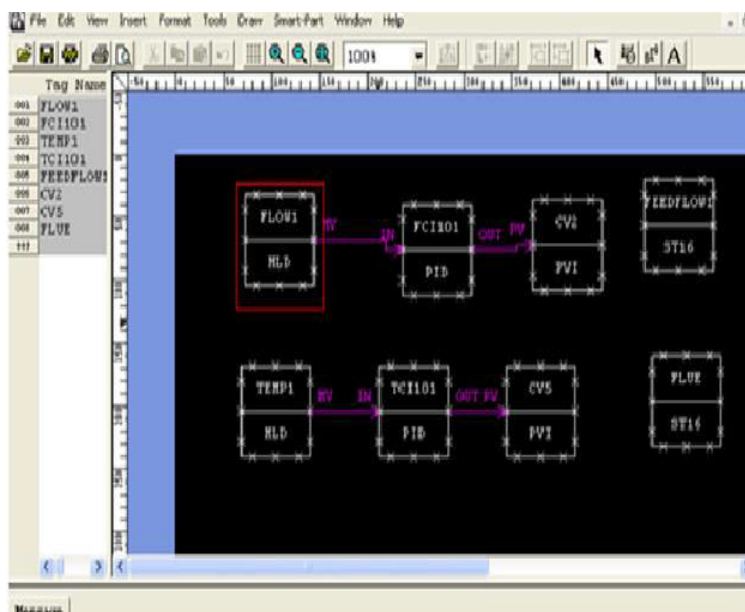


Fig1.3 MLD blocks.

PID controller block:

The PID Controller Block (PID) provides the most general control function to perform proportional integral-derivative control based on the deviation of the process variable (PV) from the set point value (SV) shown in Fig.1.4. The PID control computation is the core of the PID control computation processing, calculating a manipulated output change (MV) by using the PID control algorithms. The PID control is the most widely used. It combines three types of actions: proportional, integral and derivative. A PID controller block is shown in fig 1.4.

Splitter block

Control Signal Splitter Block (SPLIT) is capable of distributing the manipulated output signals from the upstream control loop to two output destinations via a signal distribution switch shown in Fig.1.5. This block may be applied to the loops where the upstream signal needs to be split to multiple downstream control loops with different operation ranges.

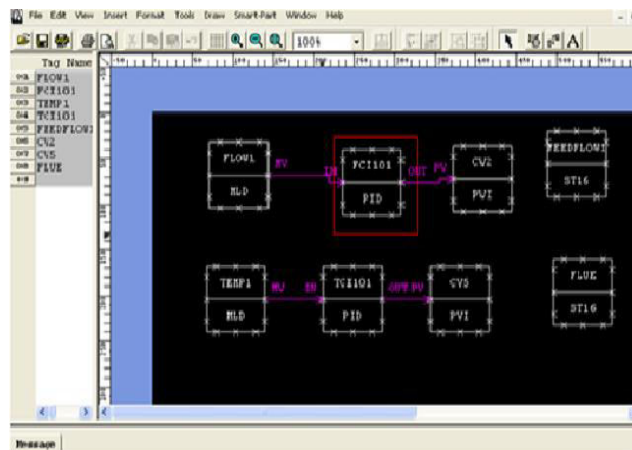


Fig 1.4 PID block.

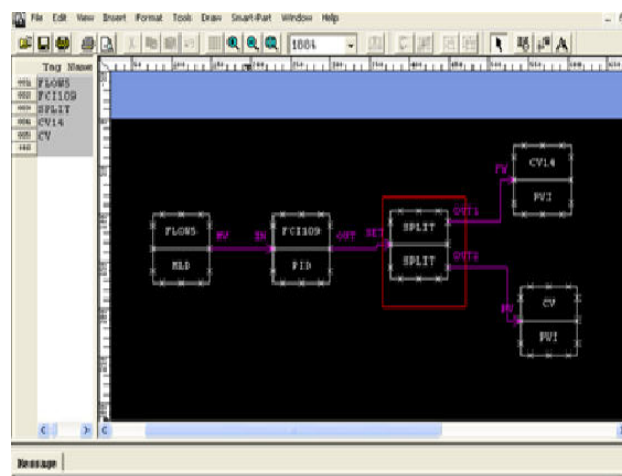


Fig 1.5 Split block.

Addition block:

The Addition Block (ADD) is used when performing addition processing or subtraction processing. Addition Block (ADD). The Addition Block (ADD) is a function block that executes addition or subtraction of input data. Here is the diagram of the Addition Block (ADD).

Temperature and pressure correction block (TPCFL)

The Temperature and Pressure Correction Block (TPCFL) is used to correct the flow rate that is measured by a differential pressure flow meter. is on the basis of temperature and pressure. The function block diagram of the TPCFL block is as shown. This block is used for flow control application which includes the temperature and pressure correction. So define a flow, temperature and pressure input. Use Process Variable Indicator PVI block to display the corresponding variables. Also take a TPCFL block. Connect all three inputs to TPCFL block. The corrected flow which is the output of the TPCFL block acts as PV for the PID block. The wiring is as shown.

Calculation block: Calculations blocks receive analog signal (analog values) or contact signals (digital values) as input values, and perform calculation according to the set parameters. The result of calculation is outputted as the calculated output value (CPV). The architecture of calculation block is shown in fig 1.6.

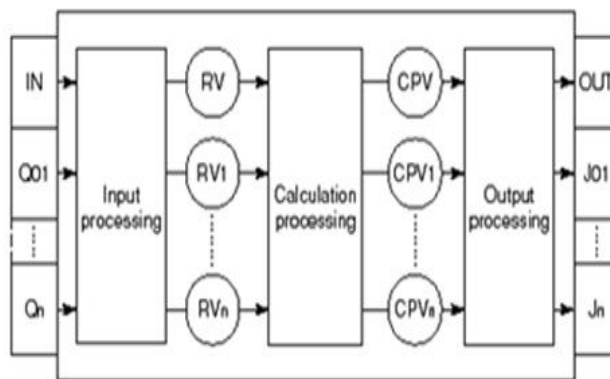


Fig 1.6 Block diagram for CALCU block.

IN: Input terminal (main input)

OUT: output terminal (main output)

Qn: Input terminal (subsidiary input)

Jn: Output terminal (subsidiary output)

RV: Calculated input value

CPV: Calculated output value

RVn: Calculated input value

CPVn: Calculated output value

Pn: Set parameter

Sequence table block (ST16):

Interlocks are Sequence of logics written to execute certain operations in a running plant. Interlocks are written using Sequence Control Blocks. Sequence Control Blocks which execute the Sequence control include Sequence Table Blocks and Logic Charts. Sequence Table Blocks include the basic ST16, and ST16E (only used for rule extension). All the interlocks are written in the Edit Detail of the Sequence Table block. Sequence Table Block is a decision table type function block that describes the relationship between input signal and output signal in a Y/N (Yes/No) fashion. By making sequence connection with other function blocks, they control the monitoring of a process and phase step sequences.

Timer block:

Timers are used to time a process or a sequence. They can also be used to generate delays in a sequence. There are two types of Timers: Seconds timer, Minutes timer. The timer can time a process up to 100000 seconds or 100000 minutes. The Timer Block can be inserted from Sequence Elements 1 and given a suitable tag name. Right click on the Timer block to open the Edit detail. Under the Basic tab select the Timer property as required. Update the changes done. The timer block can now be used in the Sequence table.

Relational expression block:

Actions based on the comparison of two values can also be done in sequence table. A relational block (RL) is used for this purpose. All the values that need to be compared are written in the RL block and then invoked in the sequence table. Insert the RL block in the Control Drawing sheet, and open the Edit detail window. All the values to be compared is written under the Relational Expression tab. The values to be compared are written under the X and Y column. Select the operator as CMP for comparison of values. Update and download to FCS.

Operation and monitoring window:

Information regarding the process is gathered as well as monitored by the Standard Operation windows on the HIS. There are two types of Operation and monitoring windows provided by the HIS. They are

i) System Windows: These windows are inbuilt in the system.

These includes,

- System Message Window
- Instrument Faceplate Window
- Tuning Window

- Process Report Window
- Historical Report Window
- Navigator Window
- System Alarm Window
- Process Alarm Window

ii) User-Defined Windows: These windows are defined by the user based on the applications and display contents of the operation and monitoring. These includes,

- Control Group Window
- Trend Window
- Graphic Window
- Overview Window

Graphics window uses graphic objects to provide an overall view of the plant. Graphics window can display graphic objects, control objects, overview objects, or a combination of these types of objects. Graphic objects display a graphical representation of the plant status, providing operation and monitoring environment. One can also call up various windows from a graphic window.

Methods of calling window

All operation windows can be called from the System Message Area icons. The windows can be called by using NAME icon on the system Message Area. Ex. To call any window, select the NAME icon and type the WINDOW name. Select OK. The window will be displayed on the HIS. The windows can also be called by selecting the respective keys on the Operator Keyboard connected to the HIS. To call Large size windows type WINDOWSNAME-SL. To call Medium size windows type WINDOWSNAME-SM.

System Defined Window

System message area

This window is displayed on the top of the operator screen. The details that are displayed in the system message area are, current date & time, the icons show whether there are any Process alarms, System alarms or Operator guide messages in the plant to access different types of functional windows on the HIS. System message window appears as the operation and monitoring function is started. It is a fixed window, which does not clear even when the clear screen key is pressed. The Blinking of the Process and System alarm icons prompts the operator when

either of the alarm occurs.

Instrument face plate operation

The instrument faceplate displays the status and data of a function block, an instrument or contact I/O graphically on a window shown in Fig.1.7. When an instrument is created in the engineering builder, the instrument faceplate window automatically gets created depending on the type of the instrument. To call an instrument faceplate window, select the NAME icon and type the TAGNAME of the instrument and select OK. The faceplate window appears. The faceplates of the function blocks are classified into the following display types. The display types are grouped according to their display characteristics, shown as below Fig.1.8.

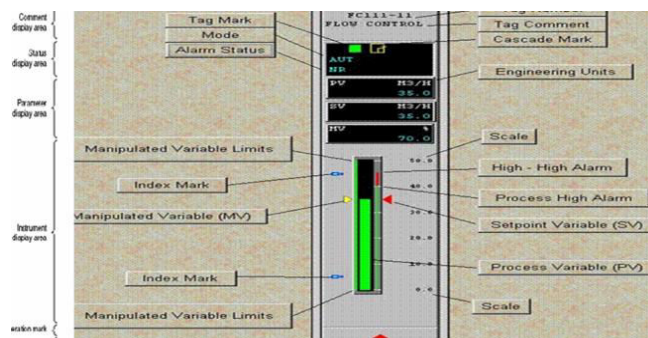


Fig 1.7 Face plate.

Tuning window

This window displays the process data status of the function blocks in detail. This window is used not only for monitoring but also to change the setting of parameters shown in Fig.1.8. Tuning window being a system defined window is automatically created when the Function block is created during system generation. Every Function block created has a Tuning window and the parameters displayed in each of these tuning windows depend on the Function block. The Tuning Window is used to set up the alarm setting as well as the loop tuning parameters shown in Fig. Only the tuning parameters indicated with a “=” in the tuning window can be changed.

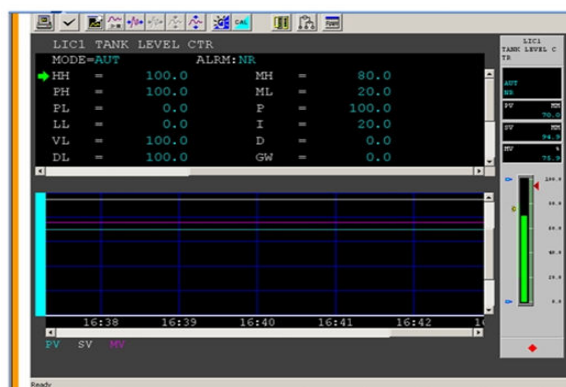


Fig 1.8 Tuning window.

User Defined Windows

User defined windows can be customized to the end user requirements. The user defined windows provided by the CS 3000 software are:

Control group window

Overview window

Trend window

Graphics window

All the user defined windows are created under the HIS. The user defined windows of Control Group, Overview and Graphics are created under the WINDOW folder under the HIS.

Control group window

The Control Group window is used to group a maximum of 8 or 16 faceplates for easy operation and monitoring shown in Fig.1.9. CS 3000 provides a default Control Group builder CG0001. A maximum of 8 faceplates can be grouped and defined in the window. The existing Control group window CG0001 can be used or a new window can be created.

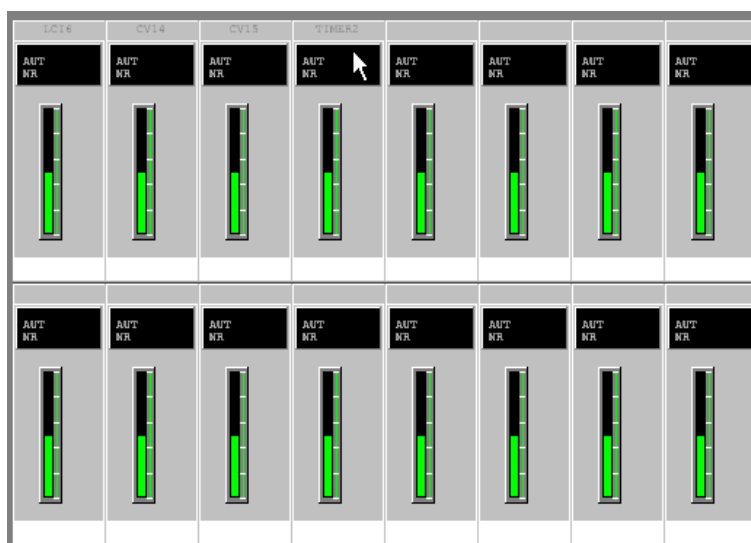


Fig 1.9 Control group window.

Over view window

The Overview window acts as an index page to access all the other windows or faceplates used in CS 3000. It has 32 operation push buttons or overview tabs which can be configured to call faceplates and windows. CS 3000 provides a default Overview builder OV0001. The existing Overview window OV0001 can be used or a new window can be created.

Trend window

The Trend window acquires different types of process data and displays time-series changes in a graph shown in Fig.1.10. The time-series changes for the acquired process data are referred to as trend data. Trend Recording has 3 sections:

- Trend Block
- Trend Window
- Trend Point window

CS 3000 provides up to 50 blocks of trend per HIS. Each block in turn consists of 16 groups or 16 trend windows. Under each group, up to 8 trend data can be assigned. Of the 50 blocks available per HIS, up to 20 blocks can be used for self HIS and the remaining 30 blocks can be defined as trend of other stations.

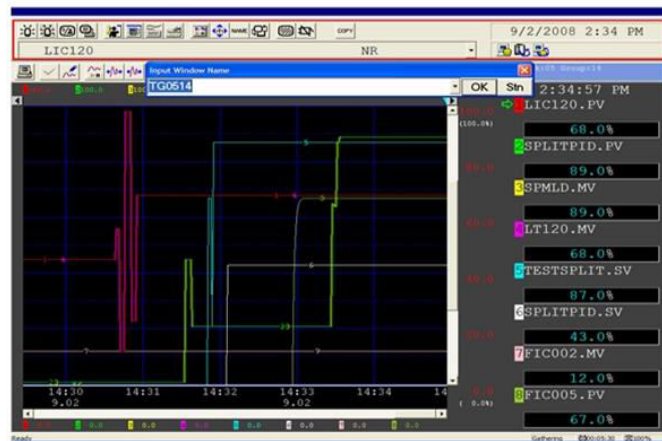


Fig1.10 Trend window.

Graphics window

Creation of graphics builder:

CS 3000 provides for a default graphic page GR0001 under the WINDOW folder under the HIS. The existing graphic page can be used or a new graphic page can be created. To create the new graphic page, select WINDOW folder and right click. Select Create New - Window. In the Create New Window that pops up the new graphic page can be created.

Properties of graphics page:

In the graphic builder page the overall view of the plant can be built. First, the properties of the graphic page need to be set. In the Graphic Builder sheet, select File-Properties. In the File Properties window that opens up select Attribute tab. Here the size and color of the Graphics page can be changed. A background image can also be set if

required. Select Insert - Background Screen Bitmap - Import. This opens the My Documents folder. Any bitmap image can be selected and set as the background. The grid option of a graphic builder page can be used for alignment of graphic objects. Select the Grid Option from the Draw tab. In the Grid Option window that opens, check Display Grid. Select grid type, color and size. Note that this is an optional feature.

Object building in the graphics builder:

Select Parts option under the Insert menu. The Parts window of a graphic page consists of various preset images. The required image can be dragged on to the graphic sheet. The image can then be modified as per the user requirement. To insert a part available in the Parts window, select the type of part that needs to be inserted from the drop down menu. Let us select Tank. The Parts window now shows various types of the selected part (tank). Select the required type of image and drag and drop it on to the graphic builder. The selected Part is now inserted into the graphic builder. Consider the modification of the image taken from the Parts window. The image or Part taken from the Parts window is made by grouping a number of graphic objects. Hence to edit the part, it needs to be ungrouped. Select the Part to be ungrouped and from the Draw menu, click Ungroup. On ungrouping the tank is as shown. Each part can be moved and modified as required.

The ungrouped images can now be edited. To edit the image, right click and select Edit Point. The Edit Point image is as shown. Drag on the points to modify the image to the desired shape. Once the required image is obtained, right click and Exit Point Editing. Here in the image shown, no modifications have been done. Once the image shape and size has been edited, the color can also be changed as required. Select the object whose color needs to be changed and from the Fill Color tab select the required color. Once the image is edited, put back the required parts and group the image. An image edited using the above options discussed is as shown. If the images available in the Parts window are insufficient or do not meet the requirements, new images can be created using a combination of the geometrical shapes like Circle, Ellipse, Rectangle. These can be drawn from the option Insert-Line or Insert-Graphic. To develop a tank using the geometrical shapes provided. First, select Rectangle from the Insert - Graphic option. Click and drag on the graphic builder to the desired size. Double click on the rectangle to open its properties window. Here, under the Fill tab the color and gradation can be selected. Under the Line tab, the thickness and color of the line can be selected, if required. Otherwise just check the transparent option. Click OK to apply the settings. The image is as shown. Now select a sector.

Click and drag on the graphic builder to the desired shape and size. The properties of the sector can also be set in a similar fashion. Once the properties are set, the sector is as shown. One more sector can be created from the existing image. Select the image, right click and flip it to get the desired alignment direction. Align all the images, select and group them together to create a tank. Pipes, valves, pumps all can be taken from the Parts Window and used in the Graphic builder. New images can also be developed using combination of geometrical shapes. A simple graphic developed using these is as shown. All the graphic objects need to be labeled and the graphic page can be given a heading. Text can be inserted in the Graphics sheet by selecting Insert-Text or by using the text icon present in the builder. Click on the graphic builder page and key in the text. Double click on the text, to open the Text Properties window. Here the text font, color and size can be set. The process value can be displayed on the graphic builder page for the convenience of the end user. This is possible using the process data character display tool. To display Process data, select Data Display - Process data-Character from the Insert menu. Click on the graphic builder page. Double click to open the Process Data Character properties window. Here, the settings for the process data character can be done. Under the Text tab, select the desired font size and color. Then select Process Data-Character tab. The Display Format would be Numerical Value. Specify the number of digits for integer and after the decimal point. If engineering unit need to be displayed, check the display engineering unit option. The value that needs to be displayed is specified in the Display Data option. The syntax is Tag name dot data item. Save the graphic builder page and call the window GR0002 from the Name Input dialog box. The numerical value displayed on the graphic page is the process value of tag FIC003. Just as a process data character can be used in the graphic builder; a process data bar can also be used. This is normally used to indicate level changes in tank. Select the process data bar from Data Display - Data Bar Display - Rectangular Bar from the Insert Menu. Drag and place at the desired position. Under the process data bar tab, specify the direction. Under the Display Data option, set the value. The syntax is tag name dot data item. Also set the range of the value. Click on OK to apply the settings. Once placed, double click and open the properties window.

Under the Fill tab, select the desired color. Save the graphic builder page and call the window GR0002 from the Name Input dialog box. The data bar on the tank moves as the process value of tag FIC001 changes. A color change can be provided to text or process data or to the graphic objects based on alarm conditions occurring in tags. Consider a requirement where the outlet valve should change to red color during HH alarm occurs in the tag FIC005. To set this change, double click and open the properties window of the valve. The color change during

specific conditions can be set under the Graphic Modify tab. Under the Color Change option select Normal Color Change and then select the color required. Under the Condition formulas specify the condition when the color change is intended. Click on Add to apply the conditional formula to the valve. Eight conditions can be added to a single graphic object. Save the graphic builder page and call the window GR0002 from the Name Input dialog box. As long as there is no HH alarm, the valve color does not change. When HH alarm occurs in the tag FIC005, the valve changes to red color. Other windows can be called from the Graphics page using either Touch target or Push Button. The touch target is an object that executes assigned functions, such as window calling. Select the Touch target from the Insert menu - Button - Touch target. The Touch target cannot be seen as a separate object on the Graphics page, hence drag the Touch target over an existing object on the Graphics sheet. Once the touch target is placed, double click on the touch target to set its properties. In the Touch target window that opens set the function of the touch target under the Function tab. One of the settings is as shown. Click on OK to apply the settings to the touch target. Another useful object in the graphic builder is the Soft key. Soft keys are used to call other windows used. To create soft keys, select soft key from the Insert Menu.

Each graphic page can accommodate 8 soft keys. The position of the soft keys is fixed at the bottom of the page. All the 8 soft keys can be assigned from a single window. Under the Soft key tab select a label for the soft key. Then under the function tab, assign the function of the soft key. Apply the assignment done. The first soft key is now assigned. Go back to the Soft key tab and change the number to 2. Repeat the assignment with a different function. Once all the soft keys are assigned, click on OK to finalize the soft key assignment. Save the graphic builder by the File - Download tab.

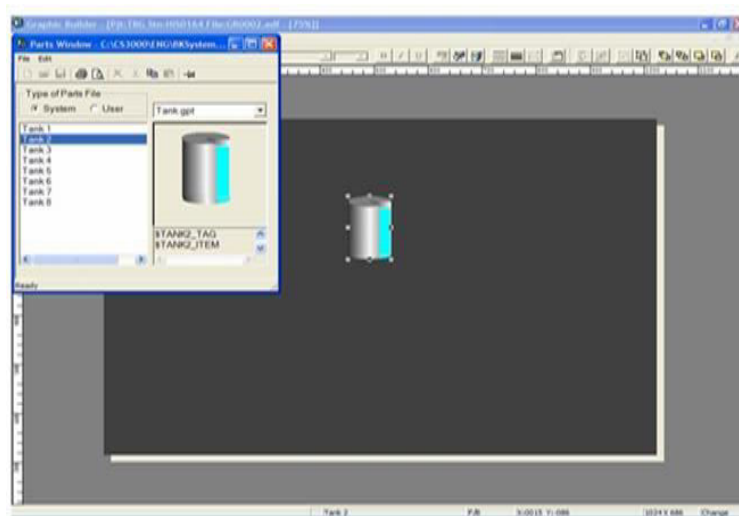


Fig. 1.11 Object building in graphics builder.

To view the graphics window

Call the graphic page GR0002 from the Name Input Dialog box shown in Fig.1.7. The soft keys appear at the bottom of the page. Click on the soft key to open the function assigned. The touch target function can also be viewed by double clicking on the process data character. Another such completed graphics is shown. All the options discussed above are combined to develop an image of the process in the system. The completed graphics is shown here.

2) Implementation of DCS in Boiler Control System

Difficulties in Boiler

Various parameters such as temperature, flow, level, and pressure has to be controlled proficiently to achieve greater efficiency. Compared to manual operation, automation prevents human errors and makes the process more efficient. So there is a need for automating the boiler control system. DCS is made use of to automate the boiler control system. The piping and instrumentation diagram of a boiler control system is shown in fig 2.2

2.1. Economizer

Economizer is designed in such a way that the pipes carrying the feed water are coiled into many loops inside the chamber as shown in fig 2.1. This is done to maximize the water exposure to the flue gas. The amount of feed water inflow is monitored and controlled by the flow indicator (FCI101) and control valve CV1. The control valve actions are shown in table 2.1.

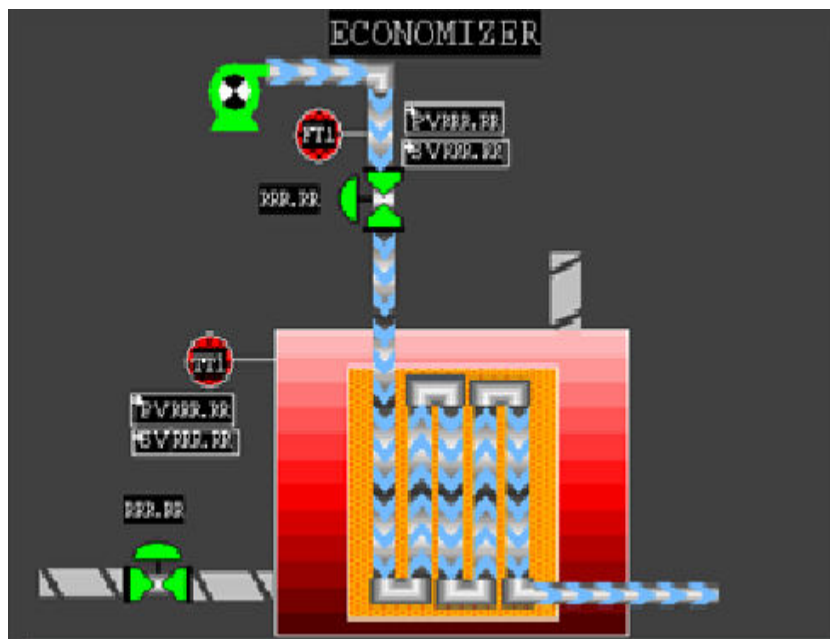


Fig. 2.1 Economizer.

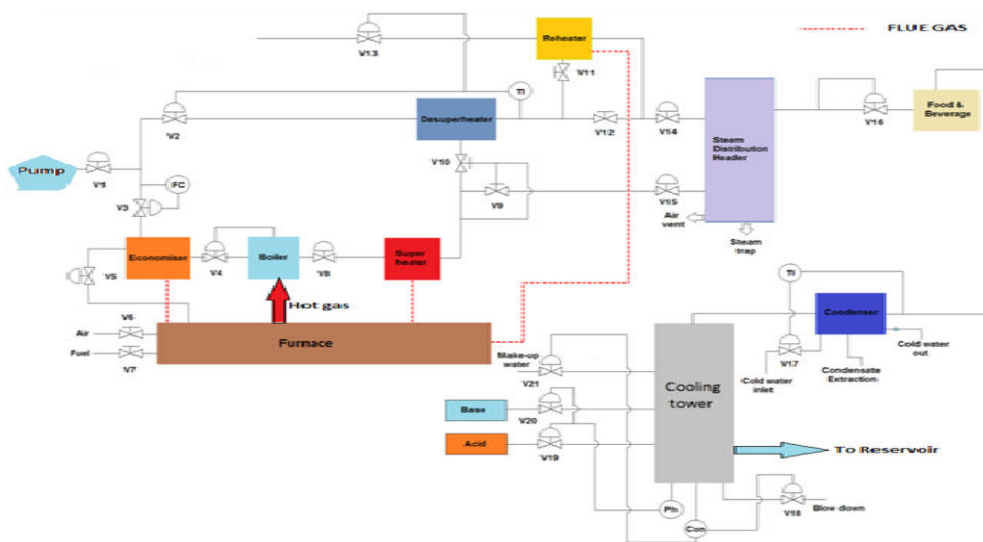


Fig 2.2 P&I diagram of Boiler Control System.

Table 2.1 Operation of control valves in economizer.

Flow (FCI101)	Open	Close
HH		CV3
NR	CV3	
LL	CV3	

The process can be clearly observed from the tabulation. The action of the control valve can be noted from the tabulation. If “FCI101” indicates “HH alarm”, which means the flow of the incoming water is very high and then “CV3” valve will be in close condition by this action the inflow is stopped. If “FCI101” indicates “NR” alarm which means the flow of the water is quite “normal”, then the “CV3” valve will be “opened” .by this action the normal amount of water is allowed into the chamber. If “FCI101” indicates “LL alarm”, which means the flow of the incoming water is very low and then “CV3” valve will be in open condition, by which more water inflow is allowed into the chamber.

Water Tube Boiler

This is the main section of the water tube boiler, which converts water into vapor. To control this section, the setup is connected in 3 element control method as shown in fig 2.3.. According to the output steam, the inlet flow is controlled; we are using Flow sensor “FT2” and valve “CV4” to control the process.

When “HH” alarm is triggered, valve “CV4” is kept closed to restrict inlet steam flow. During “NR” alarm and “LL” alarm, valve “CV4” is kept open to constantly allow water inlet. Since the connections here are made in 3-element

control, level (LCI102) and flow (FCI102) are automatically adjusted in accordance to the process. The control valve actions are shown in table 2.2.

Table 2.2 Operation of control valves in Water tube boiler.

Flow (FT2)	Open	Close
HH		CV4
NR	CV4	
LL	CV4	

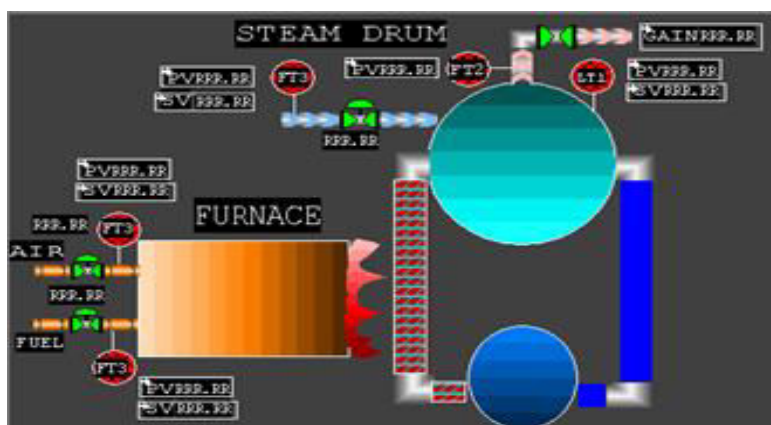


Fig. 2.3 Water tube boiler and furnace.

Superheater and Desuperheater

The Super heater section exclusively consists of 3 control valves and as the name suggests, performs the action of de-superheating the inlet hot steam as shown in fig 2.4. According to the indication of the temperature sensor (TT5) the control valves CV9 and CV10 are controlled to monitor the steam flow. Control valve CV9 is connected to the steam header. When the temperature sensor “TT5” reads “HH alarm” and “CV10” valve will be put into “open” and valve “CV9” is closed to restrict inflow. If “TT5” indicates “NR” alarm which means the temperature of the steam is quite “normal”, then the “CV9” valve will be “opened” .by this action steam flows into the steam header correspondingly, valve “CV10” is “closed” by this action steam is stopped from entering the desuperheater. There is no “LL” alarm here, because either the temperature is “high” or “normal” but never “low”

According to the reading from temperature indicator “TT6”, control valve “CV2” is opened accordingly to allow cooling water into the desuperheater chamber. This process works on “direct” action and alarm conditions are not required here. The control valve actions are shown in table 2.3.

Table 2.3 Operation of control valves in heating section.

Temp (TT5)	Open	Close
HH	CV10	CV9
NR	CV9	CV10
LL		

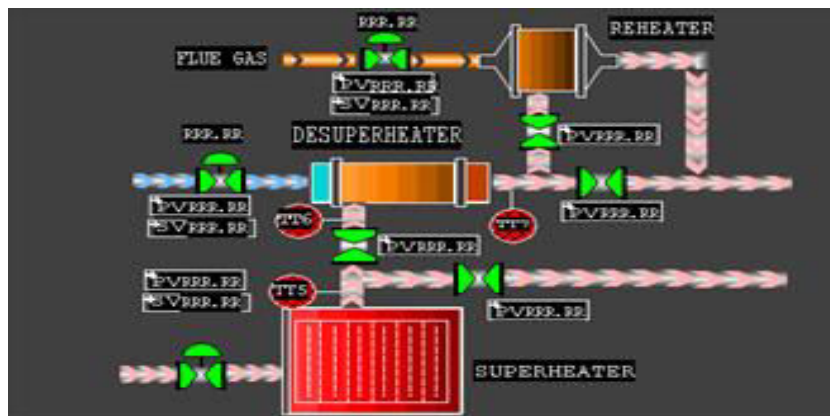


Fig. 2.4 Heating sections.

Reheater

Reheater section consists of 2 Control valves and it is shown in fig 1.4. It performs the action of the “reheating” when inlet steam temperature is low. Reheated steam is later sent to the steam header. Temperature indicator “TT7” and control valves “CV11”, “CV12” AND “CV13” are utilized in this process. Pertaining to the reading from temperature indicator “TT7”, control valve “CV13” is opened accordingly to allow cooling water into the reheater chamber. This process works on “reverse” action and alarm conditions are not required here. When the temperature is in “NR” region, then the valve CV11 is opened and the steam is sent directly to the steam distribution header as shown in fig 2.4 and CV12 is closed. When “LL” alarm occurs, then the valve CV12 is opened and the steam is sent to the reheater as shown in fig 1.4 and CV11 is closed.

Table 2.4 Operation of control valves for reheater section.

Temp (TT7)	Open	Close
NR	CV11	CV12
LL	CV12	CV11

Steam Distribution Header

Stream distribution header serves as a storage tank for steam collected from super heater, desuperheater and reheater as shown in fig 2.5.. Besides storing steam, steam header performs the task of delivering the right amount of steam at the needed pressure. Steam flow is indicated by flow transmitter “FT5” and controlled by Valve “CV14” and “CV15”.

Pertaining to the reading from temperature indicator “FT5”, control valve “CV14” and valve “CV15” are opened accordingly to allow steam flow into the application area. This process works on “direct” action and is self-operated hence alarm conditions are not required here. Valve conditions are tabulated in table 2.4.

Table 2.5 Operation of control valves in steam distribution header

Flow (FT5)	Open	Close
HH		CV14, CV15
NR	CV14, CV15	
LL	CV14, CV15	

Table 2.6 Operation of pressure control valves in food and beverage system.

Pressure(PT6)	Open	Close
HH	CV21	CV22
NR	CV22	CV21

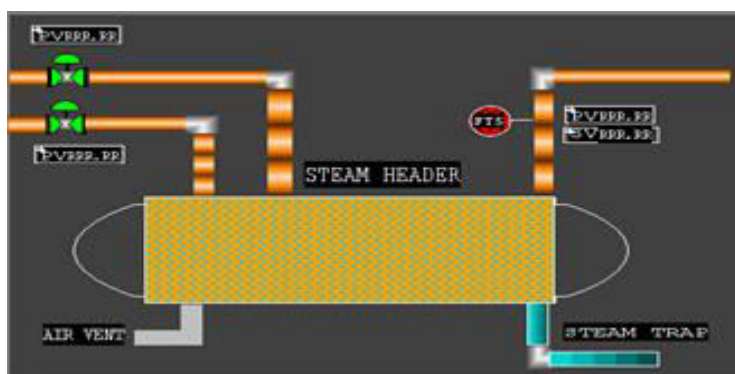


Fig 2.5 Steam distribution header.

Food and Beverage System

In this system the high pressure steam from the steam distribution header is filtered and is used as “filtered steam” for various purposes such as heating, cleaning etc. The piping and instrumentation diagram for food and beverages system for filtering steam is shown in fig 2.6.

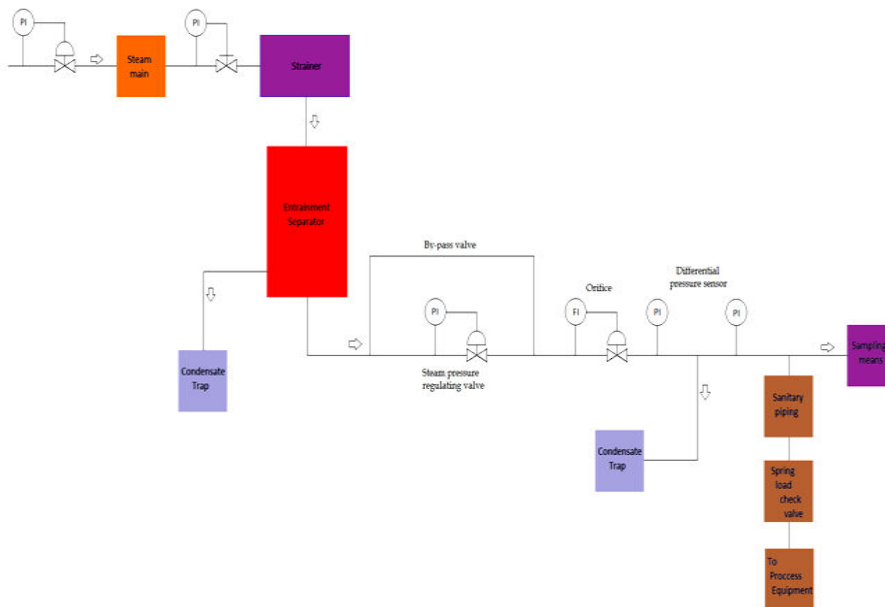


Fig 2.6 P&I diagram of food and beverages system.

Steam from the steam distribution header flows through the filtered section which is shown in fig 2.7. Pressure of the steam is measured by pressure transmitter “PT6”, “HH” alarm is triggered when the steam pressure is “high” correspondingly ON/OFF valve “CV21” is open and “CV22” is closed to reduce the steam pressure rate. During “NR” condition the “CV22” is open and “CV21” is closed. The action of control valves CV21 and CV22 are shown in table 2. Flow of the steam is measured by the flow transmitter “FT7”, “HH” alarm is triggered when the steam flow is “high or LOW ” correspondingly “CV23” is closed. During “NR” condition the “CV23” is opened. The action of control valve CV23 is tabulated in table 2.6.

Table 2.7 Operation of Flow control valve in food and beverage system.

Flow (FT7)	Open	Close
HH		CV23
NR	CV23	
LL		CV23

2.8 Cooling Section

Condenser

Used steam from the application is collected and sent to the condenser section. The impure steam is condensed to its water state in this section as shown in fig 2.8, Temperature indicator “TT8” and flow controller “FT8” are made use for this purpose.

Temperature of the steam inflow is measured by the temperature indicator “TT8”, “HH” alarm is triggered when the steam temperature is “high” and correspondingly cold water inlet “CV17” is opened to enable more faster cooling. Likewise, “LL” alarm is triggered when inlet steam temperature is very low, control valve performs “closing” action, since not much cooling water is needed to condense the low temperature steam. During “NR” alarm conditions, valve “CV17” is 50% open. The actions of control valve CV17 is tabulated in table 2.8.

Table 2.8 Operation of control valves in condenser.

Flow (FT8)	Open	Close
HH	CV17	
NR	CV17 (50%)	
LL		CV17

Cooling tower

Water from the condenser is of a high temperature probably consists of boiling water. Cooling tower cools the water and also adjusts the “pH” and “conductivity” as shown in fig 2.8, so that the water is suited for reuse. Water should be at the “pH value of 7”, for reusability. pH is corrected by using a set of 2 control valves and one sensor. pH is measured by “pH sensor “. Provisions for adding acid and base chemicals are provided, control valves “CV19” and “CV20” respectively.pH of the inlet water solution is measured by “pH sensor”, when pH is very “high”, “HH” alarm is triggered followed by opening of acid valve “CV19”. This neutralizes the high pH solution, similarly when pH is “low”, “LL” alarm is triggered followed by opening of base valve “CV20” which neutralizes the low pH solution. The output water leaves at a “neutral pH 7”. The actions of control valve CV19 and CV20 is tabulated in table 2.9.

Table 2.9 Operation of pH control valves in cooling tower.

pH (PHC109)	Open	Close
HH	CV19	CV20
NR		
LL	CV20	CV19

Water should have a normal conductivity for faster heat absorption and getting converted into steam. To stabilize conductivity, Corresponding amounts of “make-up water” is added. For this purpose, conductivity indicator “COND” and valves “CV18”, “CV21” are used.

When inlet conductivity is very “high”, “HH” alarm is triggered and in response, valve “CV18” opens and this water is drained out and valve “CV21” is kept closed all the time. Similarly, when “LL” alarm is triggered, valve “CV21” is opened to allow more make-up water to neutralize conductivity, keeping valve “CV18” closed all the same. The actions of control valve CV18 and CV21 are tabulated in table 2.10.

Table 2.10 Operation of conductivity control valves in cooling tower.

Conductivity (COND)	Open	Close
HH	CV18	CV21
NR		
LL	CV21	CV18

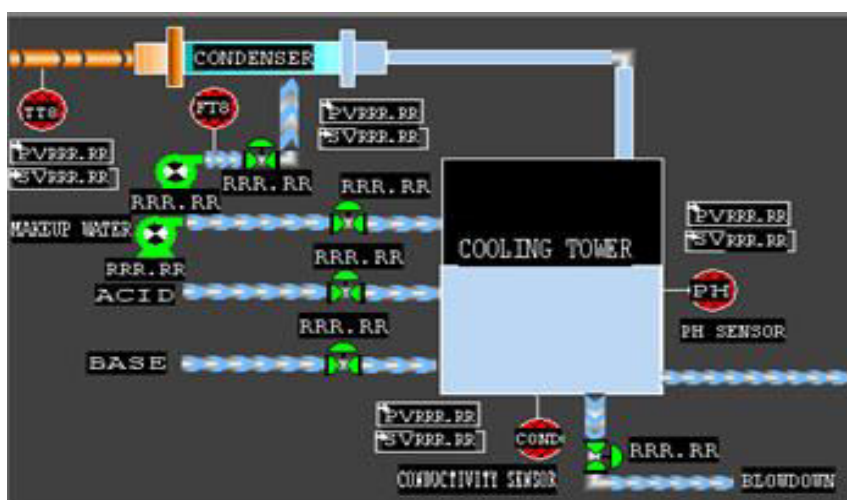


Fig. 2.8 cooling section.

3. Conclusion

3.1 Steam Result

After proper control of parameters like temperature, flow, pressure and level in numerous sections of the boiler with the assistance of “Distributed control System” (DCS), the output steam from the steam distribution header encompasses a temperature of 1300-1600 degrees Celsius and a pressure rate over 3200 psi. This output steam is filtered and used in food and beverages industry. The low pressure steam obtained from this application is then condensed and is re-circulated to the reservoir/tank.

3.2 Future Development

In this process, the high pressure steam from the steam distribution header is filtered and used in food and beverage industry as filtered steam. Here only one boiler is used. Since there is a steam distribution header, many boilers can

be used. Since more boilers are used more steam is obtained. So the high pressure steam obtained can be used in food and beverage industry even as pure steam and clean steam at the same time for various purposes.

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