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Development of C & I System for Operation of a Gasifier Plant

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Abstract:
This paper presents the development of a C & I system for operation of gasifier plant using Metso hardware & Software. A Graphical User Interface (GUI) has been developed using BHEL in-house Metso ACN software engineering tools. The GUI together with operational / control logic will be used to collect various parameters of a gasifier plant such as temperatures, flow & pressure of inlet & outlet lines. Air receiver pressure, system pressure, fluidized air flow, transport air flow, steam flow, coal feeder speed, ash extractor speed are controlled through this C&I system. The collected data will be logged for future analysis and performance evaluation of gasifier plant. The GUI is designed keeping in view ease of operator interface. The GUI helps the operator to monitor both current and past data of plant at the same time. This helps in not only testing but also in analysis of the gasifier during normal operation and evaluation phase.

Keywords: *C&I: Control & Instrumentation, DAS: Data acquisition system, GUI: Graphical User Interface, PTs: Pressure transmitters, FT's: Flow transmitters, IGCC: Integrated coal gasification and combined cycle, APFBG: Advanced pressurized fluidized bed gasificr, HMI: Human Machine Interface*

1. Introduction

IGCC is one of the most promising advanced clean coal technologies for power generation wherein coal is converted into low calorific value (CV) gaseous fuel in a pressurized fluidized bed gasifier (PFBG) and combusted in a gas turbine combustor of combined cycle plant.

Gasification refers to the process of converting carbon-containing materials into syngas, which primarily comprises of hydrogen (H_2), carbon monoxide (CO) and some methane (CH_4), obtained by the process of partial combustion. Integrated gasification combined cycle (IGCC) power plant is an integration of gasification and combined cycle power plant. In IGCC, syn gas is used as fuel instead of natural gas or liquid oils. After treating the generated syn gas to the required quality, it is fed to the gas turbine (GT) combustor. The exhaust from GT has temperature of around 500 – 550 ^{0}C. Using this heat energy, Heat Recovery Steam Generator (HRSG) generates steam that in turn drives steam turbine. Because of the combined gas and steam turbine cycles, combined cycle power plants are more efficient than the conventional coal based power plants.

The Research and Development Division of M/s Bharat Heavy Electricals Limited, Hyderabad, India has designed, fabricated and commissioned a pilot-scale of the PFBG system to study the feasibility of the coal gasification process for power generation. Numerous experiments were conducted to optimize gasification performance of various feeds.

A C&I system is developed for operation of gasifier plant using Metso hardware & Software.

2. APFBG Test Facility at Moulali Site

APFBG test facility (Fig.1) was set up in 1995 at Moulali site to study coal gasification. The system consists of various subsystems such as gasifier, coal feeding system, combustor, air compressor, steam supply system, gravity recycle system, gas cleaning and cooling system and ash extraction system. The gasifer is designed for gasifying 50 kg/h of sub bituminous coal and has an internal diameter of 200 mm and consists of air plenum, distributor assembly and freeboard section. An air compressor supplies the fluidizing air required for the process. The steam required for the process is supplied by a steam generating system and passed to the fluidizing bed through fluidizing air supply line. The combustor assembly is directly coupled with the air plenum of the gasifier. The gasifier is designed to operate at 3 atmospheric pressure and 1000ºC temperature. The air-plenum acts as a header for the fluidizing media i.e. air/steam and also distribute the same uniformly into the gasifier by means of a conical distributor attached to it. The freeboard section is slightly conical with 200 mm diameter at the bottom and 250 mm diameter at the top. gasifier and freeboard sections were provided with a number of view ports and tappings for temperature and pressure measurements. Initially the gasifier is filled with a known quantity of coal particles (50 microns-4 mm). Subsequently, coal and fluidizing air/steam are fed to the gasifier through the respective

feeding systems. During the fluidization process, the gasification and combustion of coal occurs and various gases such as carbon dioxide, carbon monoxide, hydrogen, methane etc. are produced. During the combustion process, the temperature of the fluidized bed ranges from 900-1000 ºC. The mixture of gases flows upward in the freeboard section of the gasifier and passes through the cyclone system, where the fine coal particles are separated. The separated fine coal particles are fed back to the gasifier using recycle system while the gaseous mixture is fed to the wet gas cleaning system, viz. candle filter assembly. The cleaned gaseous mixture is used as a fuel gas for power generation and various other applications.

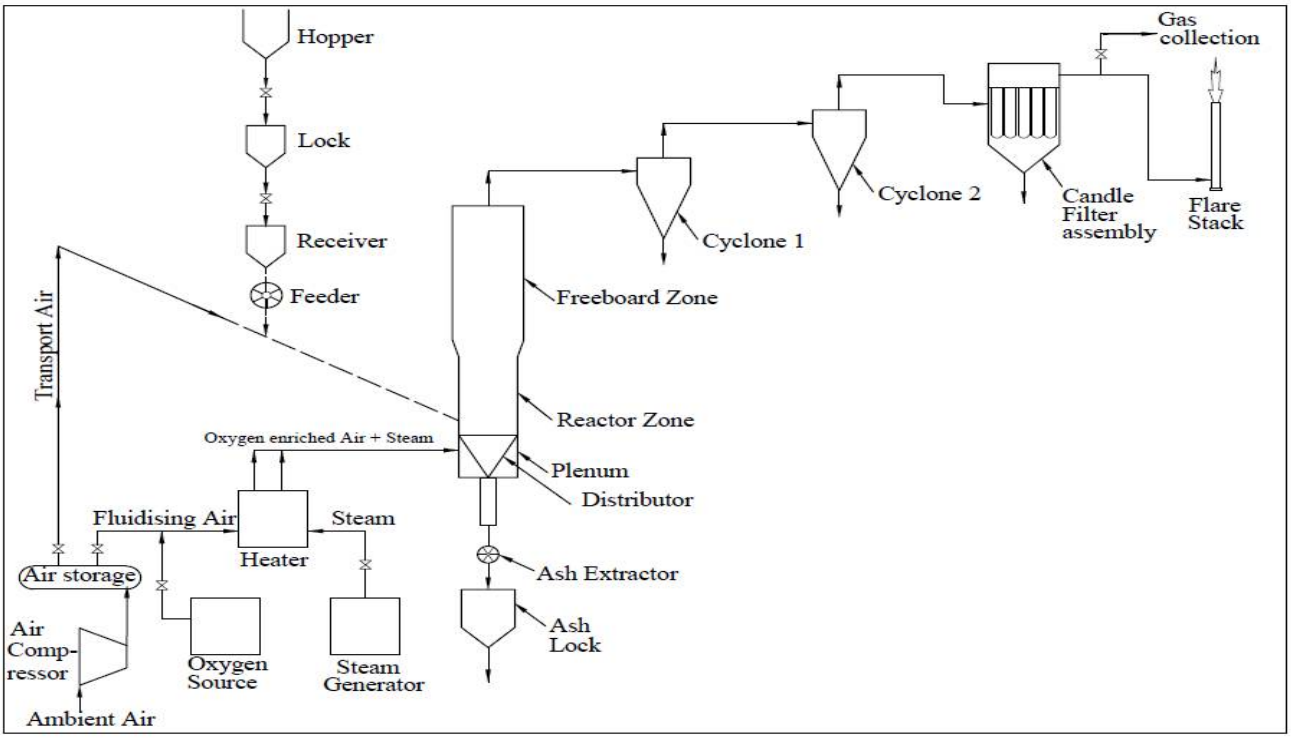

Figure 1: Schematic diagram of APFBG pilot plant facility

Uniformly into the gasifier by means of a conical distributor attached to it. The freeboard is used as a fuel gas for power generation and various other applications.

At present the Keithley hardware interface unit with indigenously developed software program is used to acquire the field signals and display the required output parameters. Flow/pressure control valves coal feeders and ash extractors are operated manually. The system has become obsolete hence a new C&I system based on Metso hardware & software was proposed.

3. C & I system

A C&I system for gasifier is developed using Metso DNA hardware & software. Metso DNA is an automation and information platform for process control and is designed to meet the following requirements:

- High system reliability.
- Flexible usage.
- Sophisticated analysing and reporting needs.
- Advanced control tasks and algorithms.

The C&I system collects the data from thermocouples, Pressure transmitters, Flow transmitters and speed sensors located in different locations in the plant.

The following parameters are continuously monitored during experiment.

- temperatures at different heights of the gasifier,
- pressure drop across the distributor and bed
- transport and fluidizing air flow measurements
- steam and coal flow

PID controllers are provided through which parameters like air receiver pressure, system pressure, and fluidized air flow, transport air flow, steam flow, coal speed, ash extractor speed, are controlled.

The pictorial representation of a typical PID in Metso is shown in Fig 2.

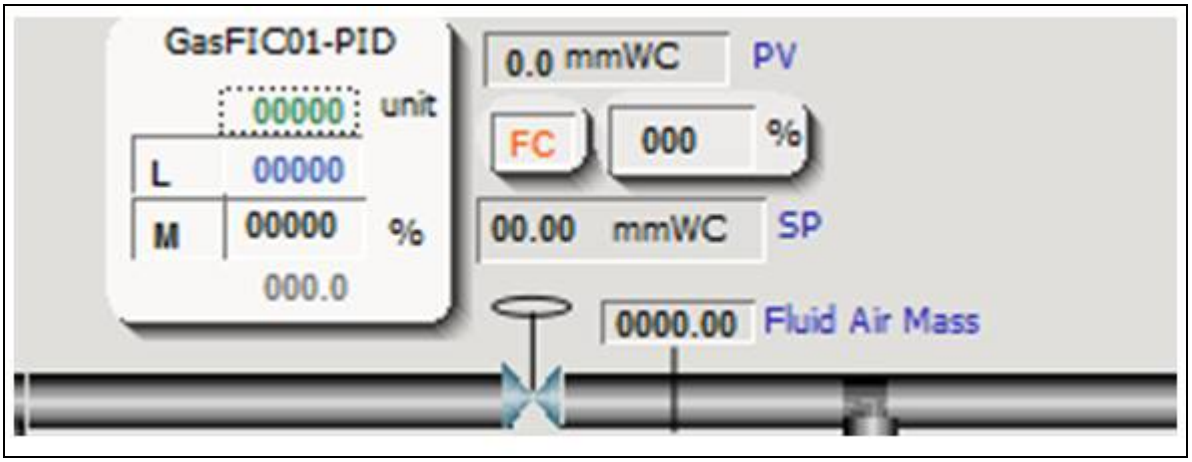

Figure 2: PID Control Scheme for Fluidized Air Flow

The PID controller function block generates its control output on the basis of Active setpoint and measured value. The control signal typically drives a control valve. The function of PID is to keep the measured value equal to the set point regardless of any disturbances. Measurement and control are normally connected directly to field through an I/O module.The PID controller has basically two operating modes: MANUAL and AUTOMATIC. In manual mode the value of the controller output is given manually from the HMI. In automatic mode it is calculated on the basis of measured value, active set point, feed forward channel and bias.
FC is force control mode and when the value of FC is 1, the value of the FCIN input is copied to the controller output.
After getting primary data from sensors, required parameters such as fluidizing velocity, air to coal ratio, fluid air mass ,steam mass, Coal mass, ash mass are calculated automatically by the C&I System.

4. Human Machine Interface

Human Machine Interface (HMI) is a graphical user interface based and has been developed using software engineering tools of BHEL in-house Metso platform. The HMI together with operational / control logic software will be used to control and collect various process flow rates, speed, pressures and temperatures. The collected data will be logged for future analysis and performance evaluation of the gasifier. The HMI is designed keeping in view ease of operator interface. The GUI helps the Operator in not only testing but also in analysis of the system during normal operation and evaluation phase. The collected data is displayed on the computer screen. It provides an overview of the gasifier plant consisting of flow, pressure, temperature and speed signals. It indicates the ON/OFF status of the valves in the plant.
The GUI developed has six user interface screens, for the following sections:

1. Coal feeding & air/steam supply screen
2. Gasifier & Combustion screen
3. Gas cleaning screen
4. Pressure & Flow screen
5. Temperatures screen
6. Status of valves screen

4.1. Coal Feeding & Air/Steam Supply Screen

It provides an overview of the coal feeding system and air/steam supply system to the gasifier. It displays all measured parameters like temperatures, pressures, and flows etc. It also displays the control loops for controlling coal flow, air flow & steam flow to gasifier. A snap shot of the HMI screen is shown Fig 3.

4.2. Gasifier System

It provides an overview of gasification system. It displays all measured parameters like bed temperatures, bed pressure, flow, and pressure after combustion etc. It also displays the Air, hydrogen flows & exit temperatures of catalytic combustor used for startup purpose. A snap shot of the HMI screen is shown in Fig 4.

4.3. Gas Cleaning System

It provides an overview of the cleaning system of the gasifier. This system consists of primary cyclone, secondary cyclone, candle filter, gas cooler and flare stack. It displays all parameters like temperatures & pressures in primary & secondary cyclones, candle filter, ash cooler etc. A snap shot of the HMI screen is shown in Fig 5.

- Gasifier Pressure & Flow: It provides all the measured Pressure/Flow parameters in a single screen.
- Gasifier Temperatures: It provides all the measured temperature parameters in a single screen.
- Valves Status: It provides Status of various valves in the system in a single screen.

5. Simulation and Execution

The functionality and verification of application program developed for acquiring various signals like temperatures, pressures, flows & speed and control loops were done using Function Test Tool (FTT). The FTT is a graphical testing interface for engineers. It shows the live data in a CAD diagram, enabling the user to see how the control application is working. The data can be retrieved either from the real process (real-time production environment) or integrated testing environment – virtual MetsoDNA. The tool can be used for either reading data from the runtime environment or writing data to the runtime environment.
Based on previous reports given by IGCC Lab the application program developed for computations were validated.

6. Data Logging

The Metso platform is equipped with a database which records the data, at user specified interval. Critical data is logged and trends are used to display long term data. The stored data can be exported to Excel or PDF formats for further processing.

7. Installation & Commissioning

The C&I system is installed and commissioned at site. The field signals temperatures, pressures, flows & speeds are tested with the C & I system. The PID controller loops are also tested in the field for proper operation of control valves for air receiver pressure, system pressure, fluidized air flow, transport air flow and steam flow.

8. Advantages

The primary aim of the development was to replace the obsolete DAS system with a state-of-the-art system using in-house technologies. The other advantage is that the system is scalable and can accommodate any future enhanced requirements of the plant.
The C&I system has high performance data management system for collecting process data at high speed. Collection cycles are from 100ms to 60s. Collection cycles can be defined independently for each signal and the maximum storage capacity is dependent on the database configuration and hardware disk size. Historical data is stored in a compressed format in the disk, and actual values are retrieved and shown in the trend curves and reports.

9. Conclusion

This paper describe the project in which the Metso DNA hardware & Software was employed for developing a state-of-the-art C& I system for BHEL's gasifier plant at Moulali site. The C&I system is equipped with a database which records the data, and trends are used to display long term data. The stored data can be exported to Excel or PDF files for further processing.
The system can be easily upgraded for future I/O additions and software changes.

10. Acknowledgements

The Authors thank the management of BHEL for encouraging to take up development work on C&I system for operation of gasifier plant using Metso hardware & Software. The authors sincerely acknowledge the support provided by different departments in BHEL Corp. R&D and IGCC Lab for providing vital inputs at various stages of the project.

11. References

i. IGCC reports on APFBG
ii. Metso Documentation

Annexure

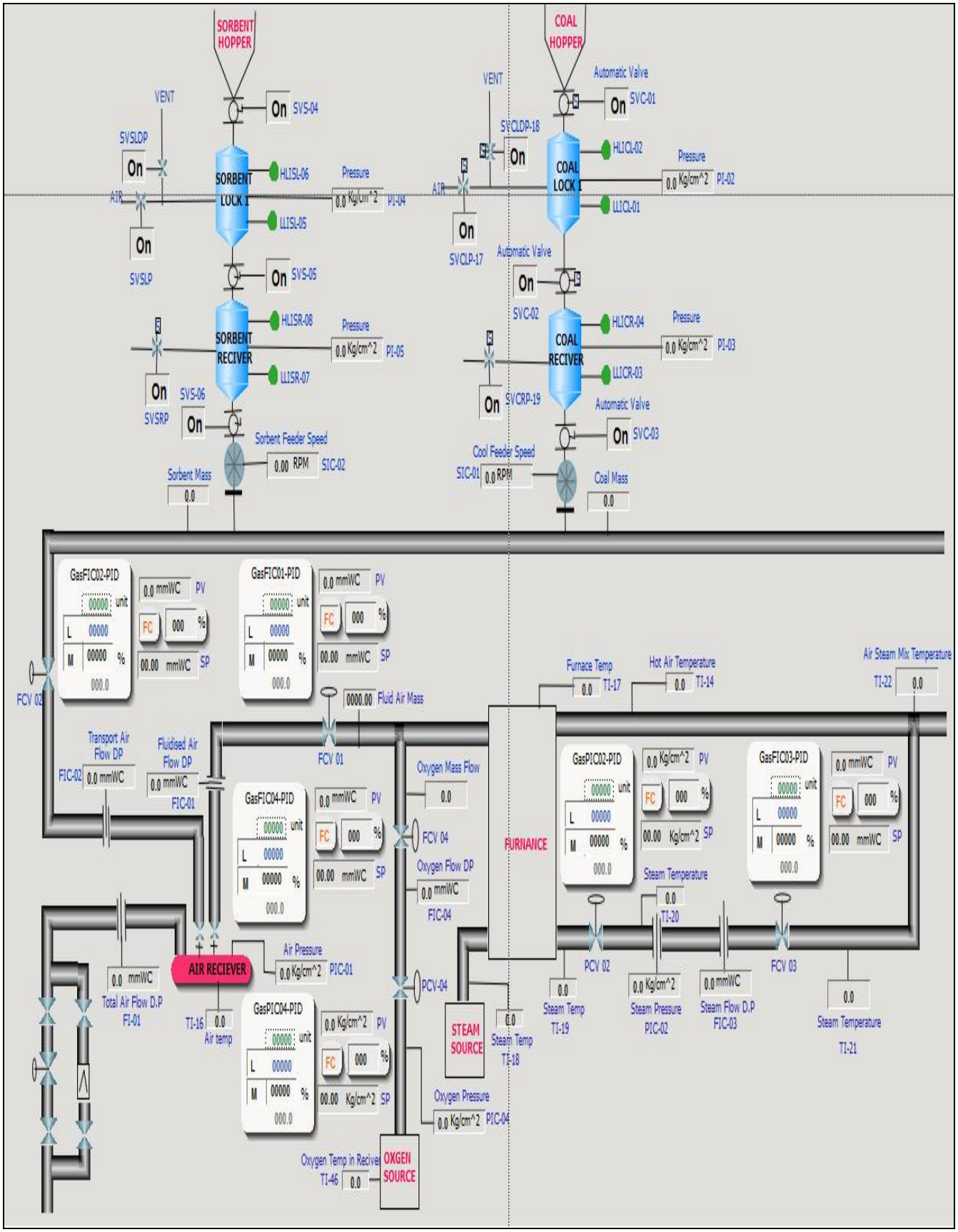

Figure 3: Coal Feeding & Air Supply System

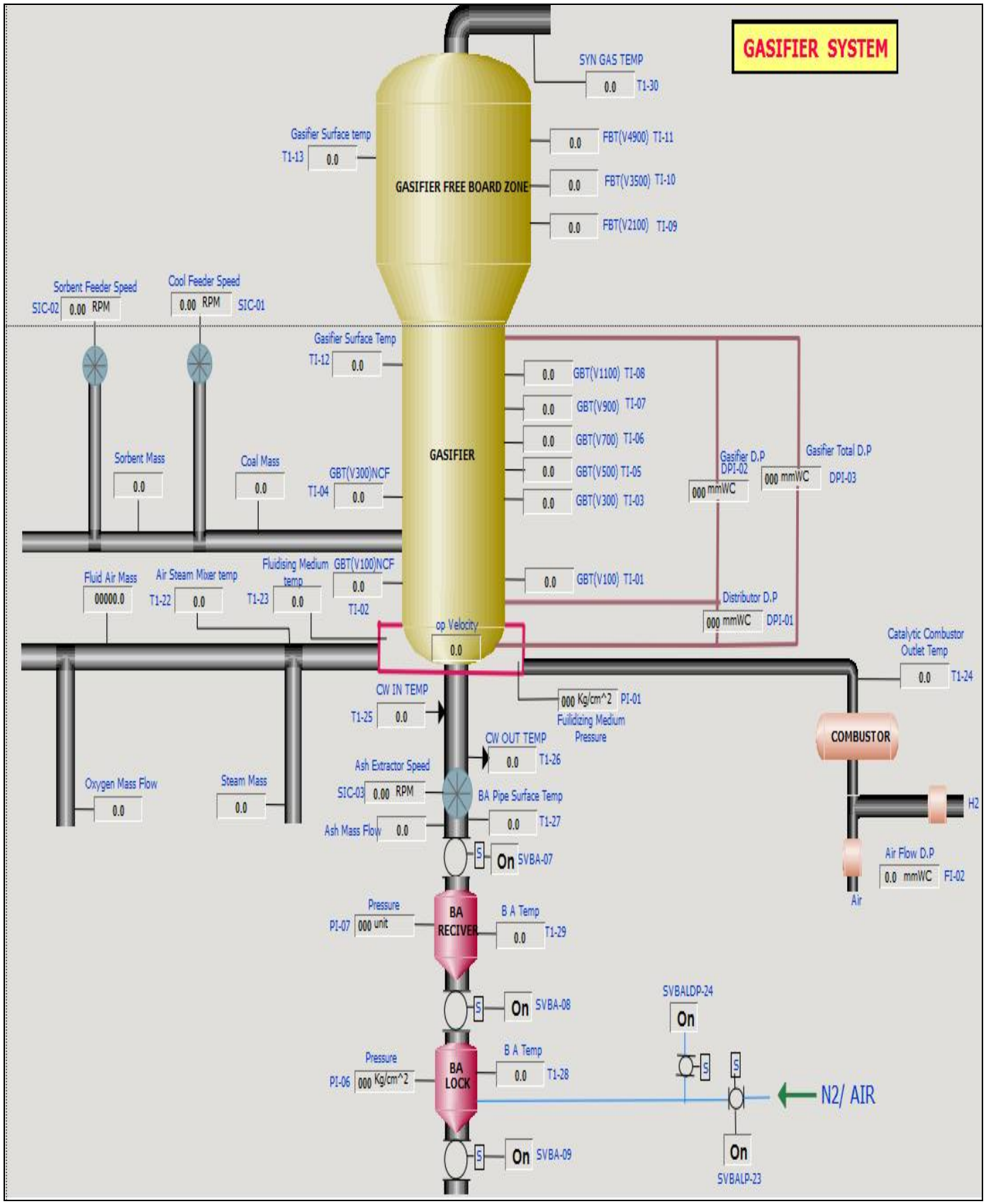

Figure 4: Gasifier System

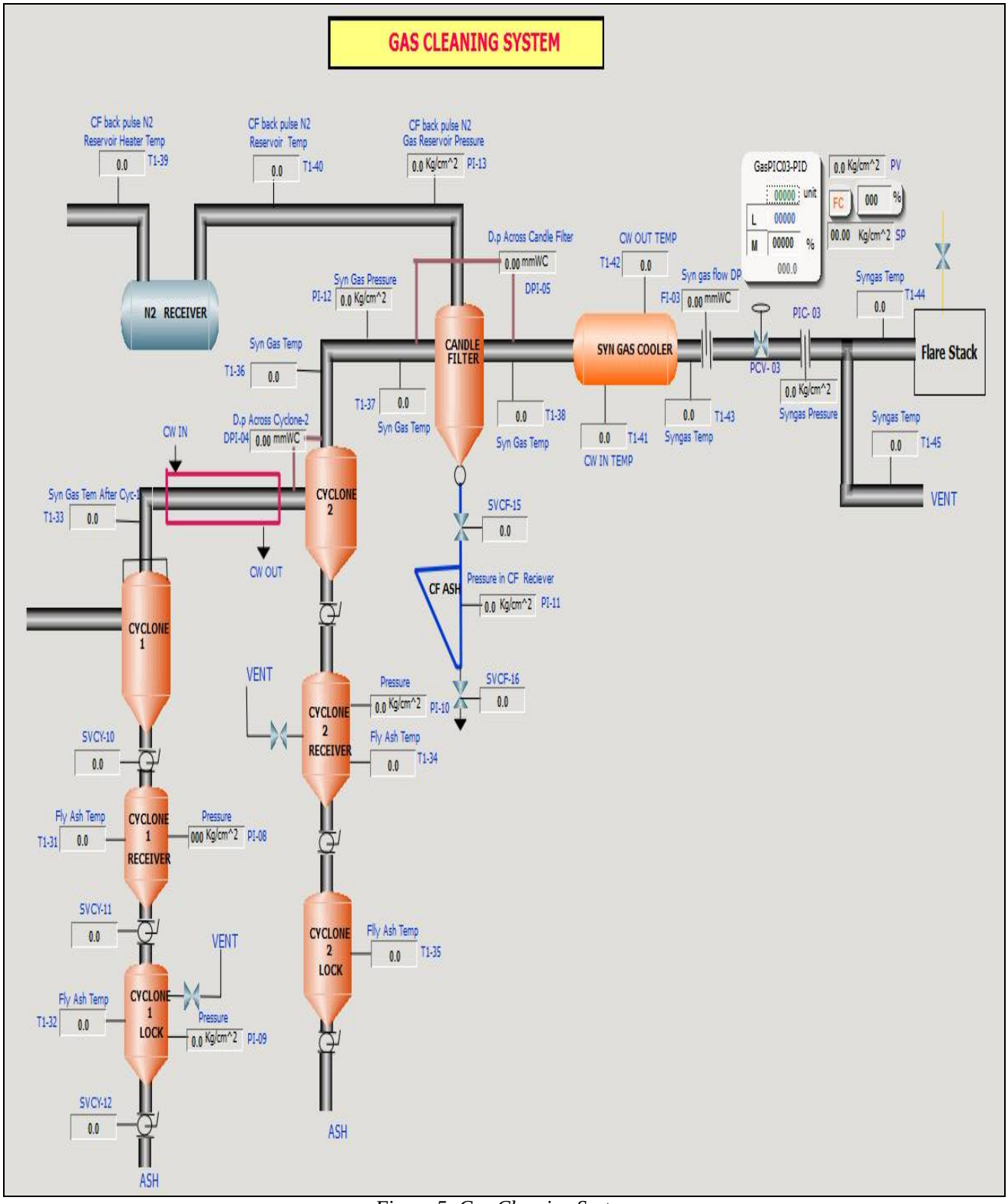

Figure 5: Gas Cleaning System