



Control Optimization with Flownex-LabVIEW Integration

This case study shows how integration of LabVIEW & Flownex was used to design controllers on a "soft" plant and eliminate the need for costly live plant start-ups and shutdowns generally used to obtain the control parameters for LabVIEW.



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PRODUCTS USED:

- The LabVIEW 8.2, PID Toolkit, LabVIEW real time module and DSC module
- Flownex version 7.009

THE CHALLENGE:

Designing a control system for a pebble bed experimental facility (Heat Transfer Test Facility (HTTF)) and testing the controllers before the plant is complete. This project and its timeous results contributed to the development of the Pebble Bed Modular Reactor.

In order to design controllers without an actual plant requires a "soft" plant where controllers are applied on a simulation of the actual plant. Ideally this simulation must be able to predict the exact plant behaviour especially during the transient events where the thermal inertia of the plant should be taken into account. This simulation must also be easy to use.

BENIFETS:

- The Flownex models can provide accurate results at faster than real time speed.
- Dynamic simulation that fundamentally accounts for thermal inertia.
- Adjustable timestep functionality for dynamic simulation.
- Flownex and LabVIEW use the same type of graphical programming elements, functions and wires.

SOLUTION:

The solution was the development of a LabVIEW-Flownex engineering simulator. An **Engineering Simulator** is used to design, implement and test or analyse certain key characteristics and/or requirements of an actual plant/works before or during the actual construction and commissioning thereof. It can also be used to assist and train technical personnel.



INTRODUCTION

Flownex is an advanced component scale systems level thermal- fluid simulation software that can deal with both steady-state and dynamic problems. 'Component scale' refers to 2D or even 3D fine porous component models in addition to 0D or 1D models in most pipe network codes. 2D or 3D fine porous component models are used to model complex heat exchangers, nuclear reactors, solid structures or flow through porous media. 'Systems level' refers to the modelling of complete thermal-fluid systems such as steam, gas turbine, combined cycle or nuclear power plants; refrigeration systems, ventilation networks or water distribution networks.

REQUIREMENTS

The requirements for the engineering simulator are defined as follows:

- Design and test controllers for a plant before the actual plant is commissioned.
- Actual plant Supervisory Control And Data Acquisition (SCADA) and controllers should be used.
- The exact dynamic plant behavior should be predicted by taking the thermal inertia of the plant into account.
- Simulation should be easy to use.
- Actual plant look and feel should be replicated in the simulator to enable training of operators.
- Should assist in fault detection during commissioning.
- Fast and user friendly implementation of simulator to contribute to timeous completion of project.
- Real time simulations.

HTTU PLANT BACKGROUND

The HTTU plant is illustrated in Figure 1 and Figure 2.

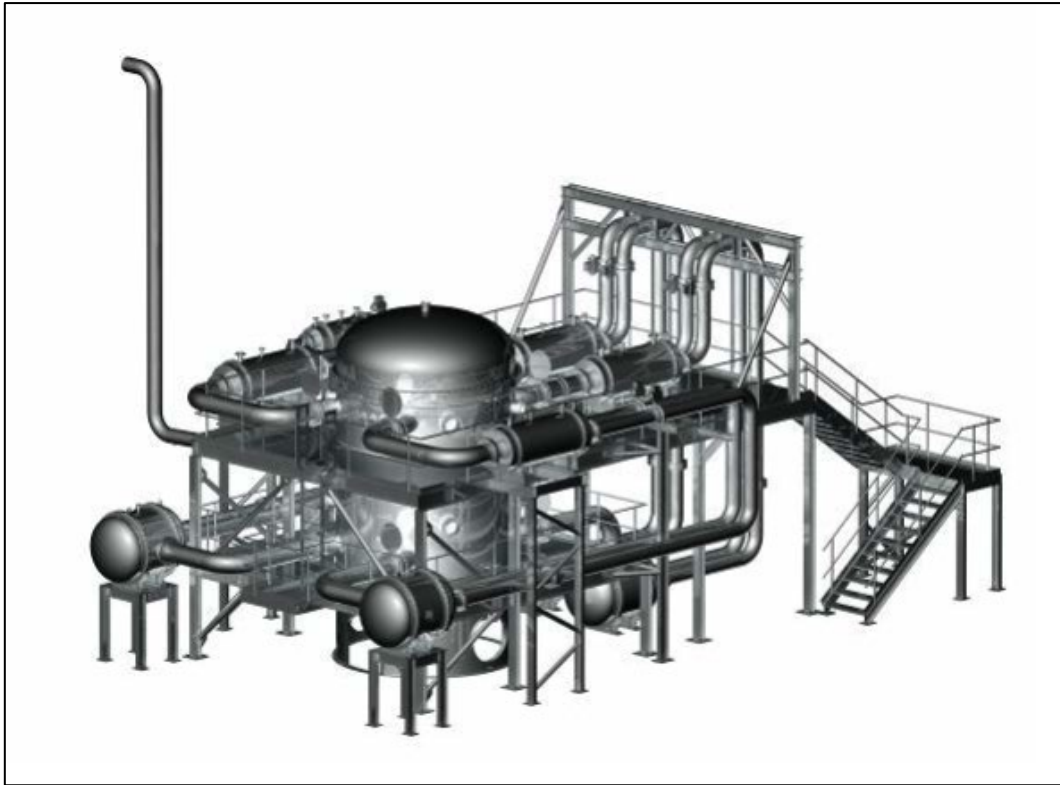


Figure 1: HTTU in the design phase

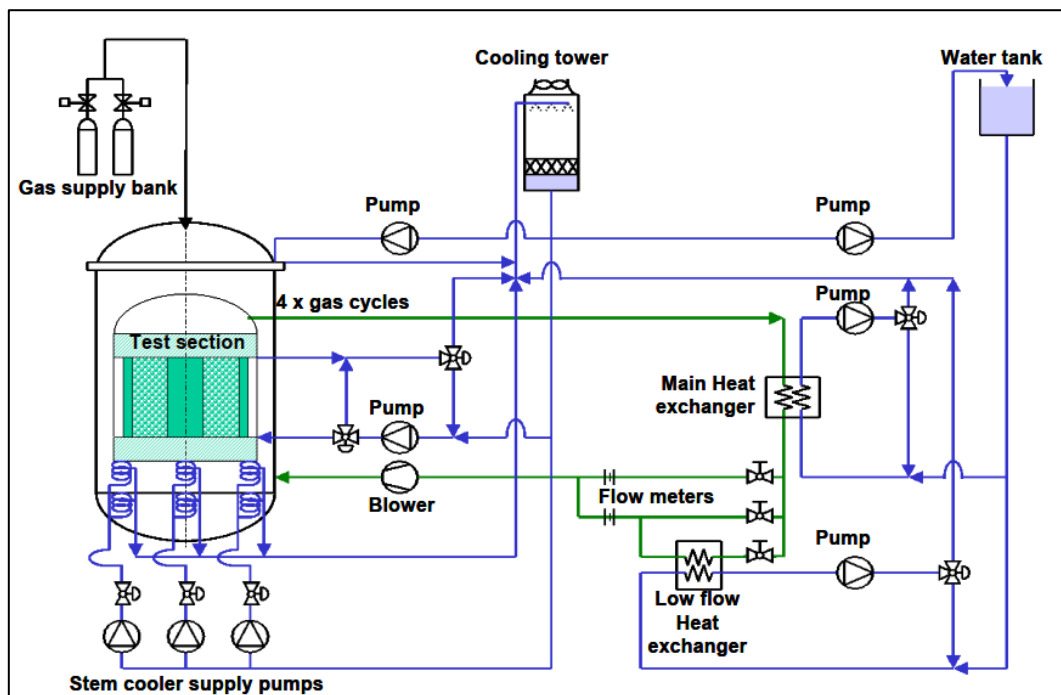


Figure 2: HTTU basic plant layout

The HTTU project required a real time simulator that can be used to design and test the controllers and control algorithms before the construction of the plant is complete.

LabVIEW was used to develop the SCADA system for the HTTU and in order to simulate any control scenario correctly, the simulator had to use LabVIEW for its control applications.

THE LABVIEW-FLOWNEX SIMULATOR

The motivation to use LabVIEW and Flownex for the simulator involved the following:

- Flownex is a very accurate systems CFD thermal fluid code.
- Flownex is an easy to use systems CFD code and has much faster simulation times compared to its contenders.
- Flownex and LabVIEW use the same type of graphical programming elements, functions and wires.
- Data logging is handled by LabVIEW through shared variables logging functions, thus no extra data logging programming is required which simplifies the setup of the simulator.
- By using the same language for the simulator and the control system the developed controllers or PID control algorithms can only be downloaded directly to the compactFieldPoint controller.
- This simulator setup does not require any pre-determined simulation sets. This implies that the user can adjust any variable at any time.
- The user can investigate any plant behaviour without putting the plant at risk.
- The user can also increase or decrease the speed of the simulator to get the optimum performance and accuracy.

For very large or complex simulation models the simulation times can become slower than real time, for example the model of the High Temperature Test Unit. The Flownex network shown in Figure 3 is a simplified network of the complete HTTU plant. This model consists of very accurate and detailed models for each system in the plant as the data acquired will be used for controller design. This included models for the pebble bed, the heat exchangers, the water jacket model, auxiliary systems, etc.

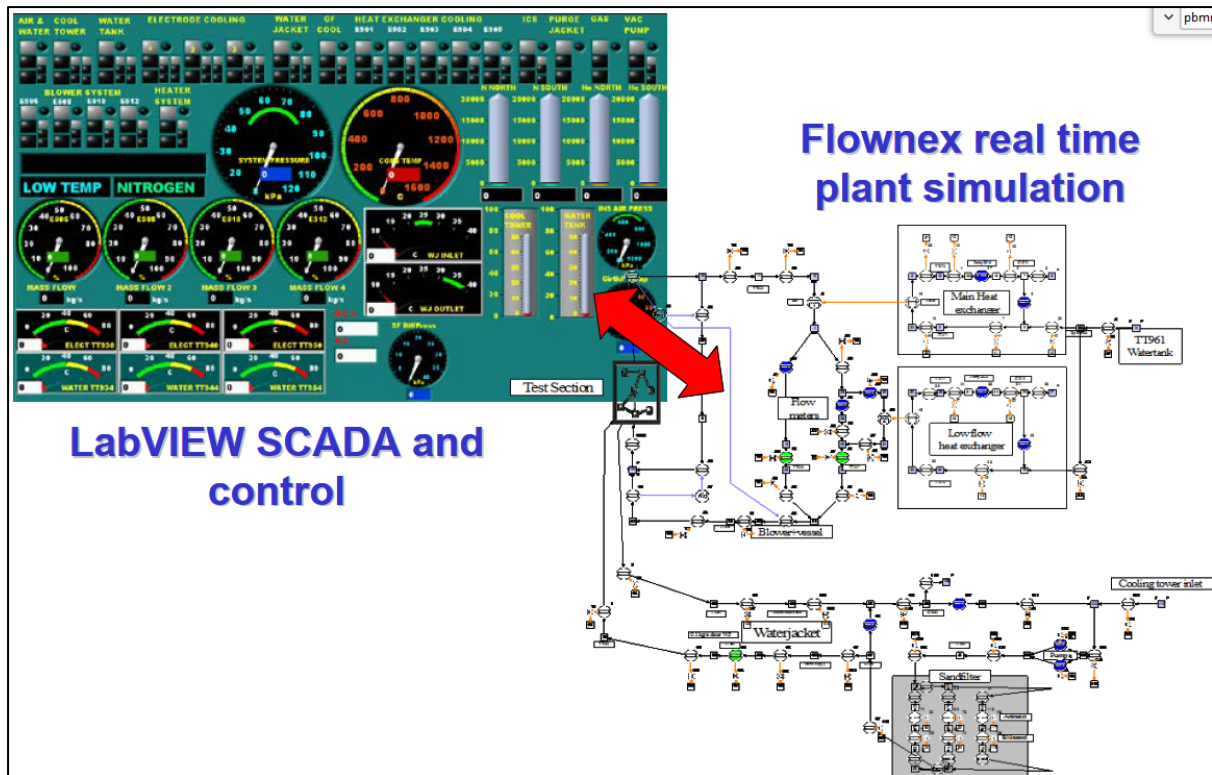


Figure 3: LabVIEW – Flownex engineering simulator provides the integration between the soft plant and the actual LabVIEW user interface

The only method of increasing the speed of any simulation is either increasing the computer performance or decreasing the simulation accuracy. The LabVIEW-Flownex simulator had the solution for this well-known computer performance problem. By subdividing the models of the plant into separate Flownex models, the plant can be simulated separately and if the user wants to investigate the effect of the plant as a complete model the subdivided models can be linked together. If the user requires to increase the performance of the simulator even further as a result of a much larger and more detailed plant, the models can be divided between more than one computer.

Figure 4 illustrates the expandability of the LabVIEW-Flownex engineering simulator. The user executes the divided Flownex models on any number of workstations. The LabVIEW-Flownex interface VI collects all the input and output data and connects them to Shared variables. The user interface can run on any of the model workstations or a separate workstation (depends on the free resources of a workstation). The user interface uses the binding ability of shared variables to connect to all the model's shared variables.

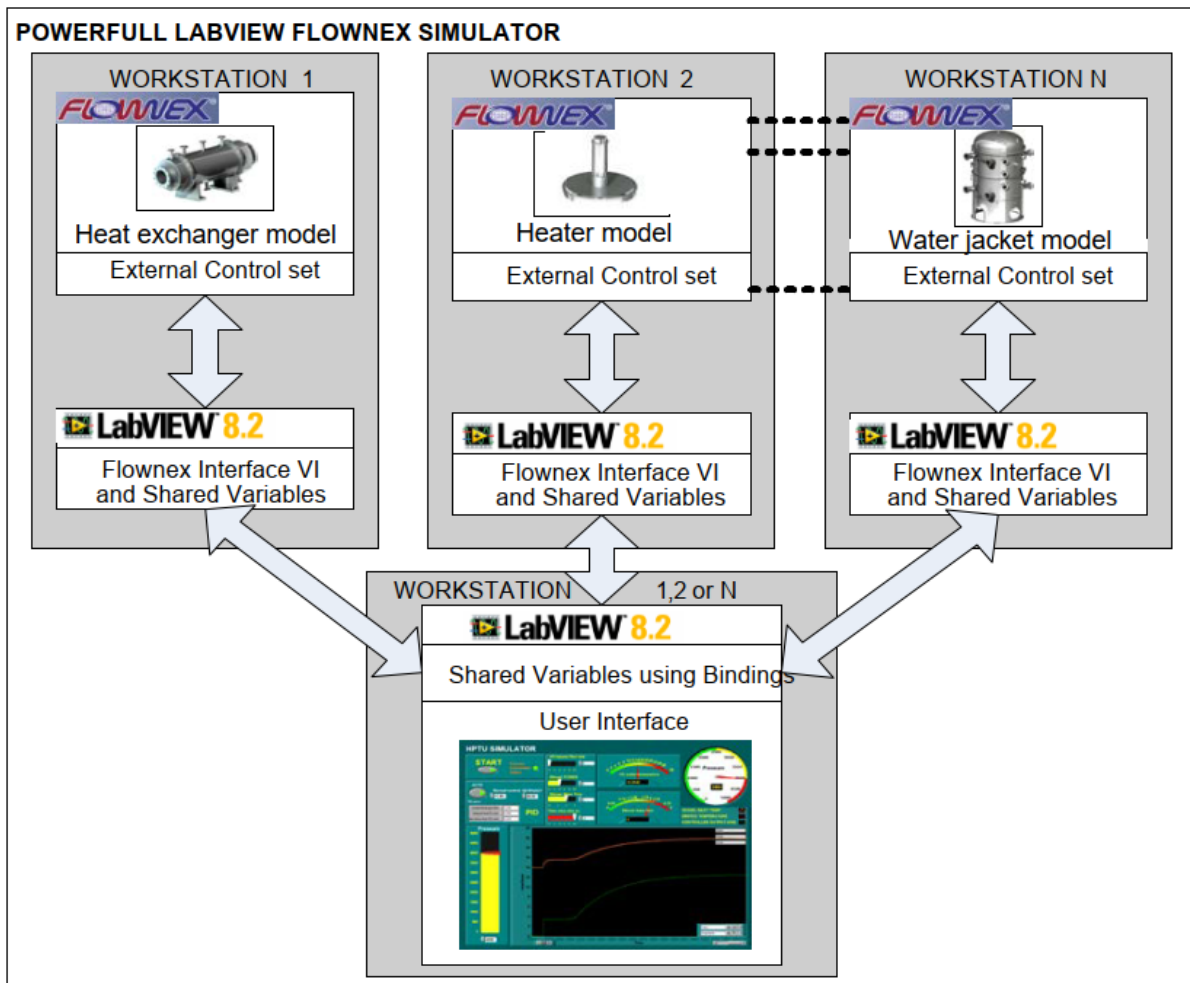


Figure 4: Expandability of LabVIEW-Flownex simulator

The heater element, for example, is positioned in the centre of the annular graphite pebble bed as shown in Figure 5.

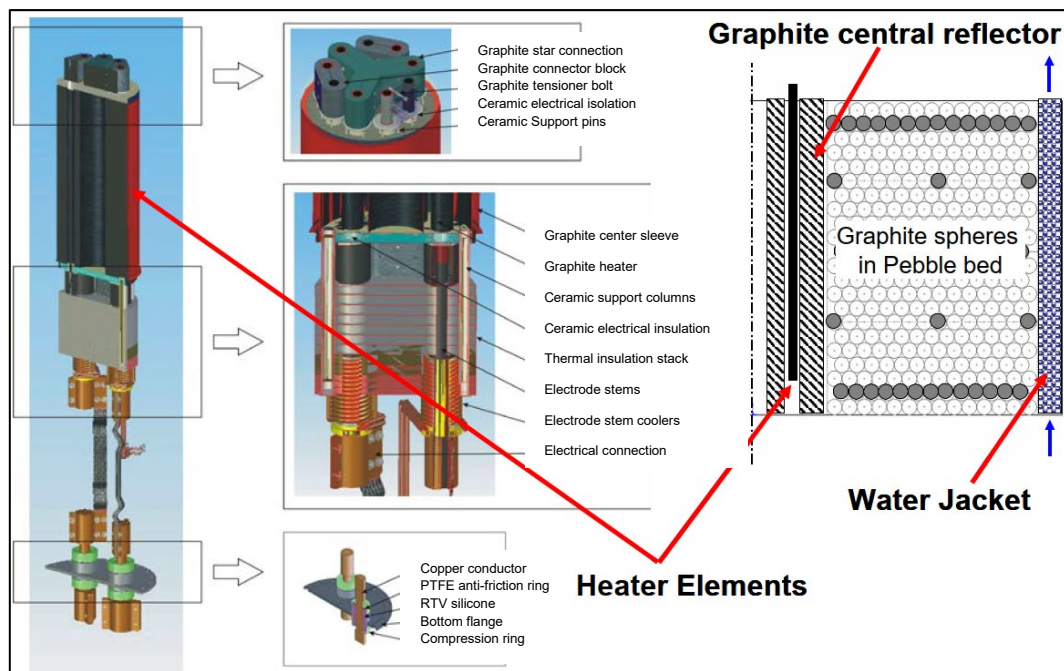


Figure 5: Heater element position relative to the test section and water jacket

The heater element, pebble bed and water jacket, which forms only a part of the main thermal fluid Flownex network shown in Figure 3, can thus be modelled as a separate Flownex model as shown in Figure 6.

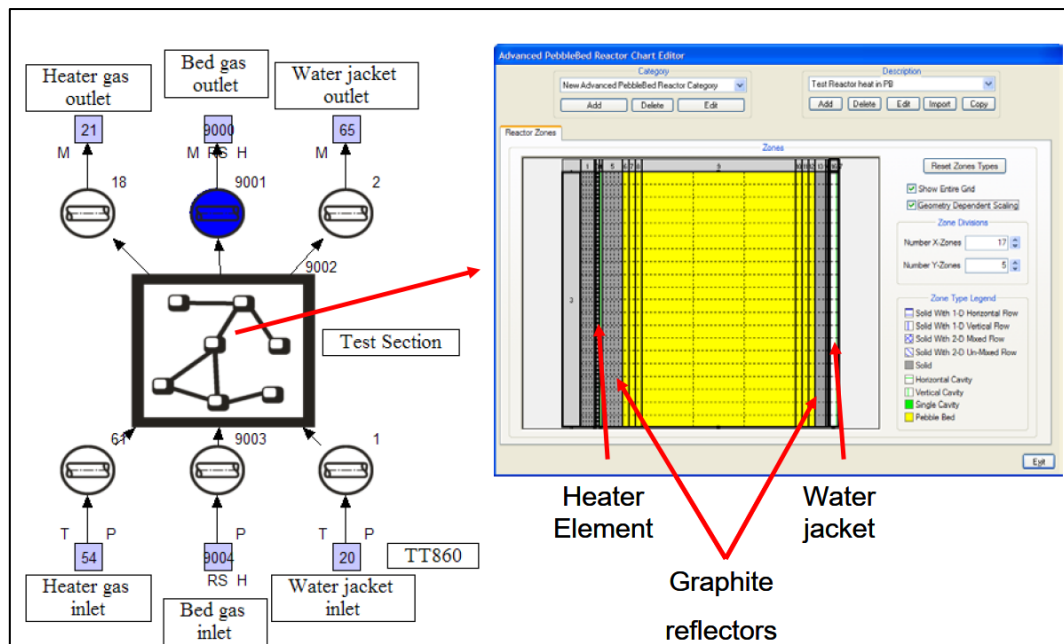


Figure 6: Heater element, pebble bed and water jacket Flownex model in the test section

This separate model can, with the help of the shared variables in LabVIEW, be linked to the other separate detailed models on the same or different computers or processors. A typical section of the LabVIEW programming to enable communication between LabVIEW and Flownex inputs and outputs are shown in Figure 7.

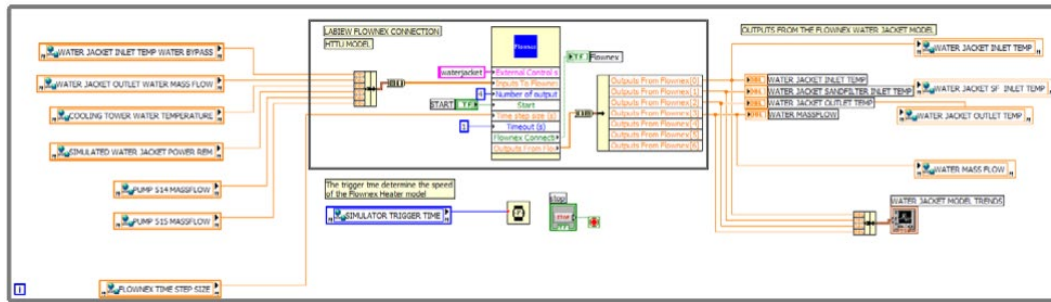


Figure 7: Typical LabVIEW programming to link inputs and outputs to and from LabVIEW and Flownex

The combined simulation power, speed and accuracy are then integrated and displayed on the LabVIEW SCADA and control interface as shown in Figure 8. The figure illustrates the behavior of the test section model of the heater, pebble bed and waterjacket during transient events specified by the user on the LabVIEW interface. The display for the different interlocks and the fault or bridge indications are also shown in Figure 8.

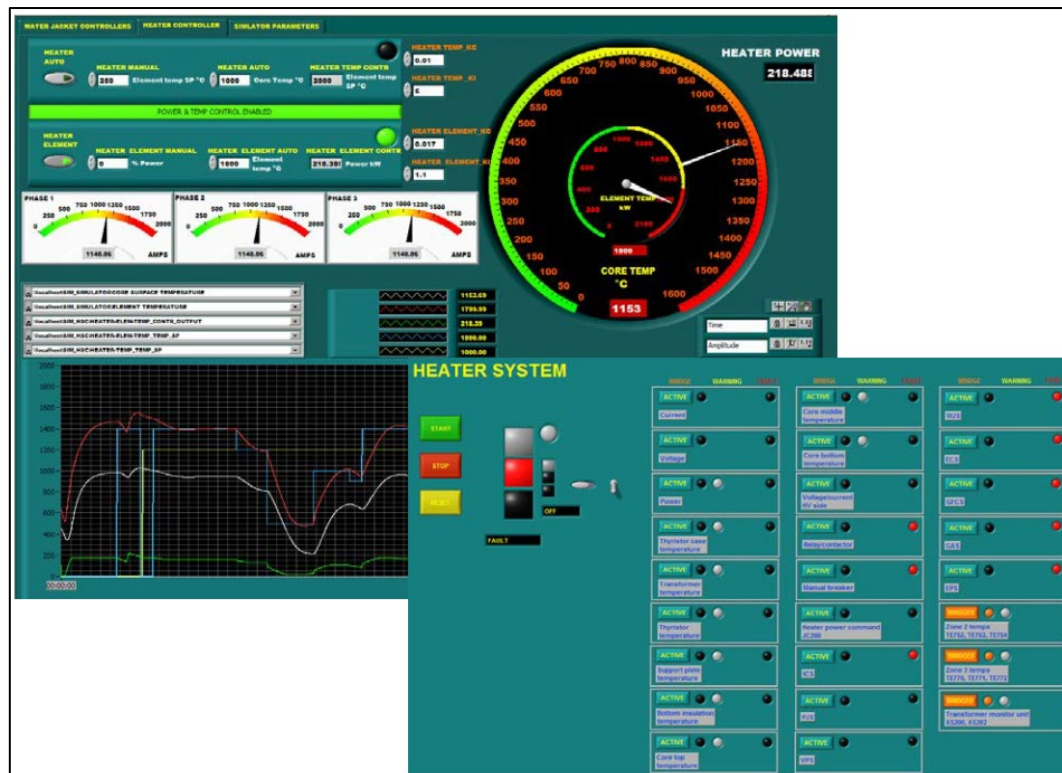


Figure 8: LabVIEW - Flownex engineering simulator interface for the heater, pebble bed and water jacket in the test section during simulation

CONCLUSIONS

The LabVIEW-Flownex engineering simulator enabled the controllers to have already been designed by the time the plant commissioning starts. There are also sufficient operators trained before the commissioning even commence. Thus, to summarize the advantages and capabilities of the LabVIEW-Flownex simulator:

- The Flownex models can provide accurate results at faster than real time speed.
- The simulation speed can be adjusted by increasing the computer load or by adjusting the accuracy during simulation.
- Simulation speed can be increased by either using a faster computer or by splitting up the models on different computers.
- The simulator setup/connection to Flownex is very easy to use.
- The simulator setup file is small - approximately 36 Kbytes.