Advanced Expander Process Controls

A Petrotech, Inc. White Paper

Petrotech, Inc.

EXPERIENCE • CAPABILITY • EXECUTION

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Company Overview

Petrotech Incorporated (Petrotech), headquartered in New Orleans, Louisiana has been providing advanced turbomachinery and process control systems for more than 40 years. With facilities in Houston, Texas and Suffolk, United Kingdom, Petrotech provides a full range of products and services for rotating machinery control and instrumentation. Our products include integrated control systems for gas and steam turbines, generators, compressors, pumps and the associated ancillary equipment. We also provide sophisticated process control solutions around the rotating machinery that complement or replace DCS based plant controls. Our turnkey services include engineering design (software and hardware), control panel manufacturing, site I&E services, commissioning and startup.

Within the energy sector, Petrotech has installed control system solutions for oil & gas, petrochemical and power generation plants. We help our customers increase reliability, improve efficiency and reduce downtime. Over our 40 years, we have developed a library of mature control products and applications for centrifugal and reciprocating compressors anti-surge and process control, as well as gas, hydro and steam turbines. These applications have logged millions of hours controlling, optimizing and protecting the operation of a variety of rotating machinery.

Regardless of where in the energy chain Petrotech operates, our approach remains the same. To deliver superior customer satisfaction, that builds upon our reputation as a leader in rotating machinery controls.

Abstract

Expander systems are found in natural gas separation processes where a raw natural gas steam is separated into products such as pipeline-quality natural gas and natural gas liquids (NGLs). An Expander system in one of these facilities provides work as a byproduct of the expansion process used to cool a raw natural gas stream. The separation process requires the expansion of the incoming stream to cool the raw natural gas enough to enable the separation and distillation of heavier constituents such as ethane, propane, butane and pentane into NGLs. Following the extraction of the NGLs, the compressor attached to the expander driver compresses the remaining methane/ethane (termed pipeline quality natural gas) mixture up to a sales gas or export pipeline pressure.

An expander is a centrifugal or axial flow turbine through which a high pressure gas is expanded to produce work. The produced work drives a centrifugal compressor that is part of the process downstream of the expander/expansion process. Expansion of the high pressure gas through an expander approximates an isentropic process. In an isentropic process the expansion is considered reversible, meaning that the process gas is in thermodynamic equilibrium at all times. An expander approximates this scenario, thus the gas does positive work during the expansion, and its temperature decreases. This temperature decrease facilitates the separation and distillation of NGLs as previously described.

Expander systems also include a bypass valve around the expander. The bypass valve, called a Joule Thompson Throttling Valve (JTV), provides the ability to continue operation of the surrounding process equipment during periods when the expander is at full capacity, in manual mode for maintenance or other process reasons, or is not operational.

Expansion across the JTV is different than the expansion across an expander. As described above, the expander expansion is adiabatic and reversible (not isentropic). The JTV expansion approximates an irreversible adiabatic process. During this process the gas does zero work (as opposed to positive work in the expander) and absorbs no heat, so the internal energy is conserved. If an ideal gas is expanded in this manner, the temperature would remain constant. However, in the case of a real gas, the temperature may either increase or decrease, depending on the initial temperature and pressure. In the case of the process gases used in natural gas liquid extraction, the temperature of the process gas

decreases as it expands across the JTV. However, the temperature drop induced by JTV expansion is not as large as the temperature drop induced the expansion across the expander. Therefore, for maximum efficiency, it is desirable to maintain the JTV in its closed position to produce the greatest possible temperature drop across the expander/JTV system.

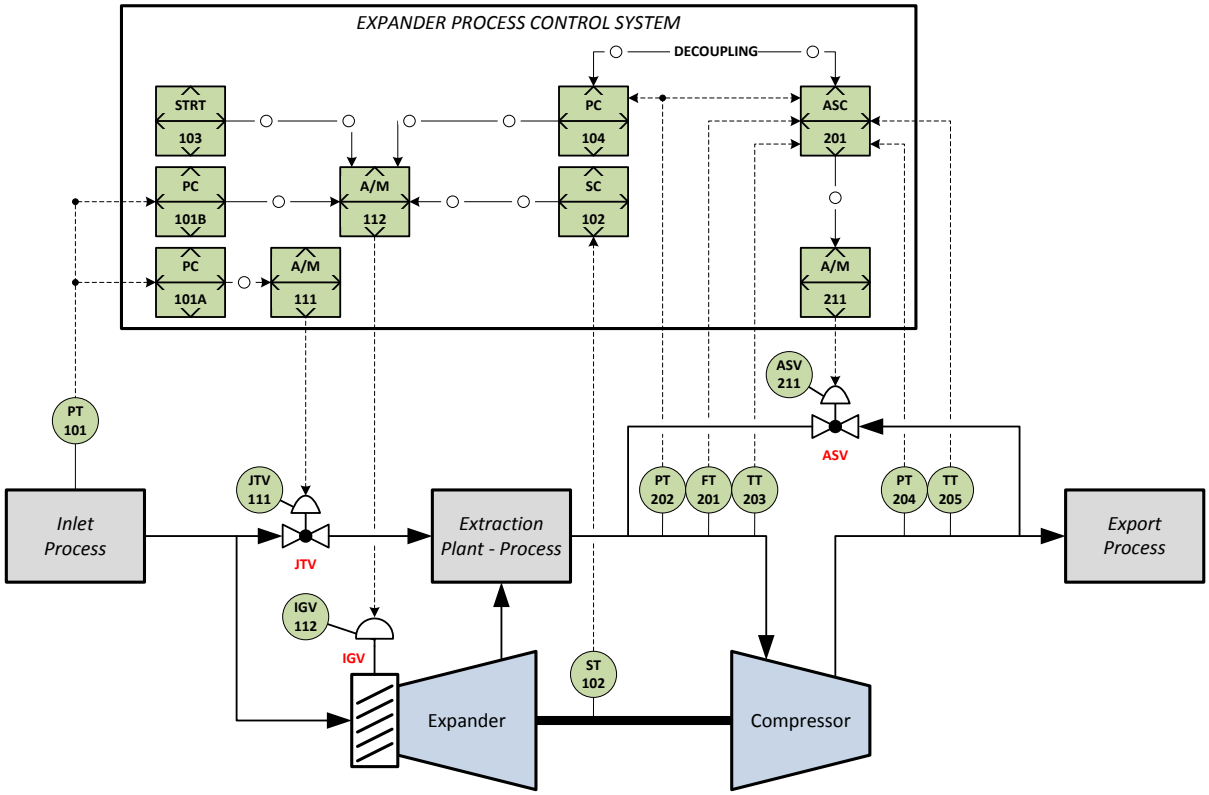

Figure 1 – Simplified Expander System Schematic

Control System Overview

The expander control system depicted in Figure 1 shows the full complement of control elements available for optimum expander and process control. Not every control element is essential for successful operation. However, by using all the available elements, the expander can regulate throughput to accommodate process disturbances across the entire facility.

- PC-101A – (Optional) Joule Thompson Valve (JTV) Expander Inlet Pressure Controller. On rising expander inlet pressure, PC-101 opens the JTV to maintain the pressure setpoint. PC-101 is always active regardless of the expander online status. When the expander trips offline and can no longer swallow process gas flow, PC-101 will actuate the JTV position in order to maintain the pressure setpoint.
- A/M-111 – (Optional) JTV Auto-Manual Station. Enables manual mode operation of the JTV. Manual mode operation allows the operator to manually position the JTV at a specific position and ignore the automatic response of PC-101A.
- PC-101B – (Optional) Inlet Guide Vane (IGV) Expander Inlet Pressure Controller. On rising expander inlet pressure, PC-101 opens the IGV, thus increasing the expander speed to maintain the pressure setpoint.
- SC-102 – (Required) Expander Maximum Speed Controller. SC-106 provides a maximum speed backstop and closes the IGV, thus limiting the expander speed to maintain the maximum speed setpoint.
- STRT-103 – (Required) Start Sequence Speed Controller. STRT-103 governs the IGV position

during run up or until another controller begins to govern. Ultimately STRT-103 ramps up to 102% to out of the way once normal operations begin.

- PC-104 – (Optional) Compressor Suction Pressure Controller. On falling compressor suction pressure, PC-104 closes the IGV, thus decreasing the expander speed to maintain the pressure setpoint. Additional instances of compressor control (compressor discharge pressure, compressor flow etc.) can be made available if site requirements dictate.
- A/M-112 – (Required) IGV Auto-Manual Station. Enables manual mode operation of the IGV. A/M-112 also includes the IGV Low Signal Selector. Selects the lowest output from PC-101B, SC-102 STRT-103, and PC-104 to govern the IGV position which regulates the expander speed to maintain the expander operation within safe conditions and match the process conditions. Manual mode operation allows the operator to manually position the IGV at a specific position and ignore the automatic response of PC-101B, STRT-103, and PC-104. For overspeed safety protection, SC-102 always overrides the manual mode operations.
- ASC-201 – (Required) Anti-Surge Controller. ASC-201 provides minimum flow protection to protect the compressor from surge conditions. In response to near surge conditions, ASC-201 will open the Anti-Surge Valve (ASV) to maintain sufficient flow through the compressor. Decoupling communications between ASC-201 and PC-104 are provided to prevent undesirable process interaction when ASC-201 is responding to near surge conditions as well.
- A/M-211 – (Required) ASV Auto-Manual Station. Enables manual mode operation of the ASV. The ASC always operates in "safe-manual" to provide anti-surge protection. Safe-Manual allows the operator to set the ASV to a specific position. However, if ASC-201 detects near surge conditions the automatic output will govern the ASV position to prevent surge.
- Setpoint Management – With the exception of STRT-103 and ASC-201, the Expander Setpoint Management logic (not shown) manages the control element setpoints. Setpoint logic passes the HMI entered values through a ramping function to prevent stepping thus providing smooth operation when setpoint changes are necessary. Setpoints for STRT-103 and ASC-201 are managed automatically through calibration settings specific to the expander and compressor operating requirements.

Other Applications

The expander control system described in this paper is not limited to the NGL separation applications. Petrotech has the expertise to deploy controls on expanders found in other applications such as refrigeration, and fluidized catalytic cracker (FCCU) applications.

Regardless of the application the Petrotech's expander process controls philosophy provides a scalable solution that can be adapted to our client's specific process requirements. If expander inlet pressure control is the process objective our controls enable the expander speed to regulate the inlet pressure thus allowing the expander to be operated at the fastest possible speed for the process conditions which in turns insures the maximum temperature drop across the expander. More temperature drop enhances the process to maximize the production of NGLs.

If compressor suction or discharge pressure control is the process objective, the expander speed is automatically regulated to maintain the process setpoint with little or no operator intervention. In addition to tight accurate control of the key process parameters, our integrated system also provides the opportunity to customize decoupling strategies when compressor process flowrates require anti-surge valve recycling.