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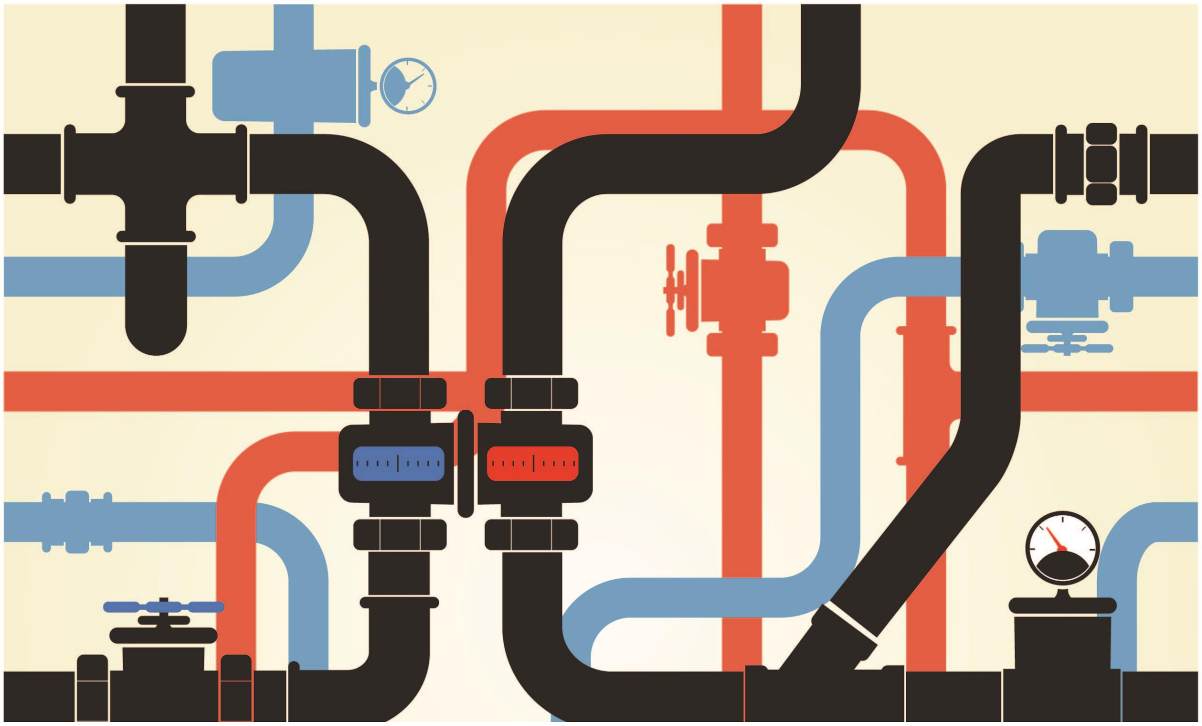

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Parallel Expander-Recompressor Controls& Piping Layouts.

Turboexpanders are key pieces of process equipment for the recovery of high-value condensates from natural gasses in modern NGL plants. This article discusses the association of turboexpanders with recompressors in parallel turbomachinery trains with their piping configuration and control challenges, especially as the tendency is that two or more such parallel trains are now becoming the standard design approach for large NGL plants.

Before the use of cryogenic turboexpanders to produce the required cooling of natural gasses in order to liquefy and then extract the high-value hydrocarbons, it was common to utilize the temperature drop produced by expanding natural gas pressure through a Joule-Thompson (JT) valve.
A conventional control valve may produce a pocket of very low internal pressures, which can raise gas internal velocity to unacceptable levels. In addition, this pocket of low internal gas pressure may produce a profile where the internal temperature values may rise beyond the lowest point, thus partially defeating the maximum temperature drop the valve is required to generate.

A purpose-designed J-T valve has a much smoother internal pressure (and therefore temperature) profile, usually achieved by employing a multi-stage trim. A purpose-designed JT valve is thus less likely to generate excessive noise and is usually more efficient in terms of producing a temperature drop than a conventional control valve.

Efficiency: Turboexpanders and JT valves

The expansion of gas in a JT valve proceeds along an isenthalpic path (i.e. along a line of more or less constant enthalpy) when using a Pressure-Enthalpy chart. For the same pressure drop, however, a turboexpander would allow the gas to expand following an isentropic path (i.e. along a line of more or less constant entropy), thus producing a higher temperature drop than a JT valve, as may be seen in Fig. 1.

In addition, the use of a turbo-expander allows the plant designer to recover most of the shaft power generated by the expander in an associated recompressor. This produces significant energy savings in the requirement to compress the processed gas back up to discharge battery limit specified values, as opposed to the use of a J-T valve, which generates no recoverable power.

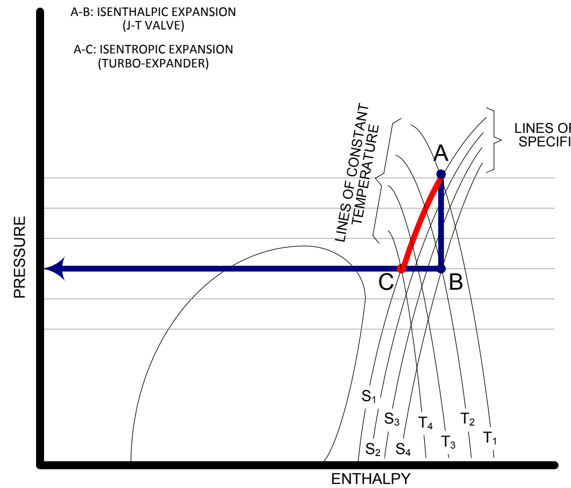

Fig. 1 – A turboexpander produces lower temperatures than a JT Valve

Finally, as a more efficient isentropic gas expansion path is followed, a turboexpander can produce lower exit temperatures than a JT valve, which increases condensate recovery and plant profitability.

Single turboexpander recompressor piping layout

In a single train application, the piping layout should look like what is illustrated in Fig. 2.

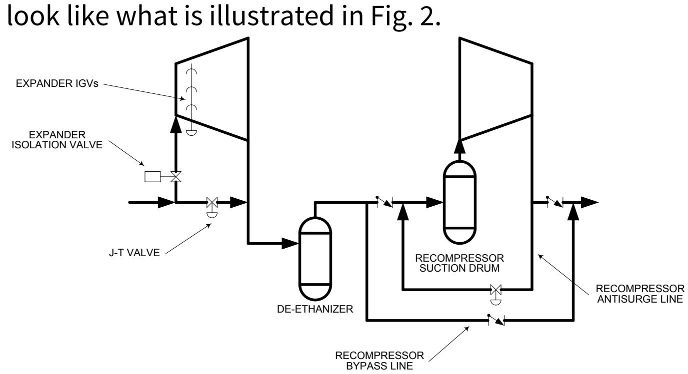

Fig. 2 - Typical single train piping layout

The gas-condensate mixed phase stream exiting the turboexpander is typically sent directly to the deethanizer tower, and the export gas (typically from the top of the deethanizer tower) is partially compressed in the associated recompressor before being sent to the export trains. This partial recompression provides significant savings in the energy that would otherwise be expended in the export compressors.

Parallel turboexpander recompressor piping layout problems

As NGL plant design capacity increases, it becomes necessary to design two (or even three) parallel expander recompressor trains. It is often the case that process designers, in an effort to save on expensive process equipment, sometimes design such parallel trains with one common JT valve. This leads to the following layout shown in Fig. 3.

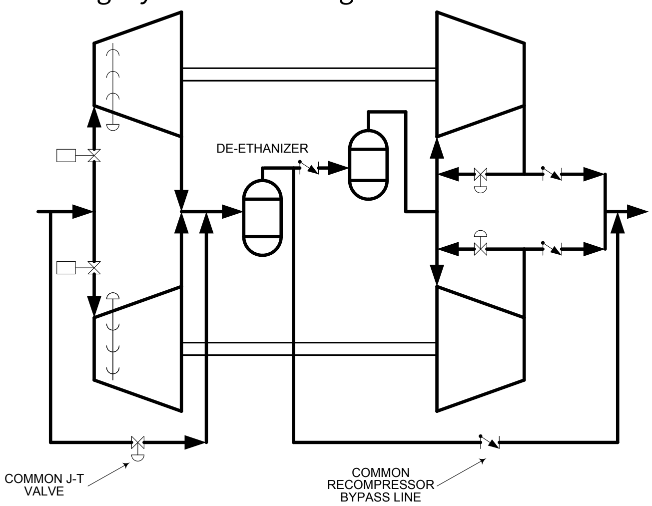

Fig. 3 – Common EPC design layout for parallel expander recompressor trains

Consider a typical design with each train rated to handle a maximum of 66% of the design plant flow. During normal operations each train with the design plant load split equitably between them would be handling approx. 76% of its own maximum capacity. The following occurs if one of the two trains trip for any reason, and the remaining train continues to operate:

- Since it is typical to set up the performance control to keep the common suction pressure at a designated set point, when one train trips the remaining running train would tend to run at maximum capacity.
- The common JT valve should open to handle the flow that exceeds the capacity of the remaining running train.
- Because the remaining recompressor still produces a positive pressure rise, the check valve in the common recompressor bypass line will remain closed.
- As may be seen in Fig. 4, there will be more flow entering the demethanizer than the remaining recompressor pulls out of it, therefore the demethanizer pressure will start to rise.
- The rising demethanizer pressure equates to a lower differential pressure (than the design value) across the remaining turboexpander and JT valve, therefore less efficient liquid extraction occurs.
- Assuming that the reason for tripping the second train is resolved and the second train is started up again, recycled gas from its antisurge valve will not flow into the suction of the recompressor being started up. This piping path presents a higher resistance than the alternative path of the already-running recompressor. Therefore, the recompressor being started up will surge incessantly until it reaches a high enough speed that its discharge pressure rises to a value that forces open its discharge check valve and forward flow is established. This could take a significant amount of time.

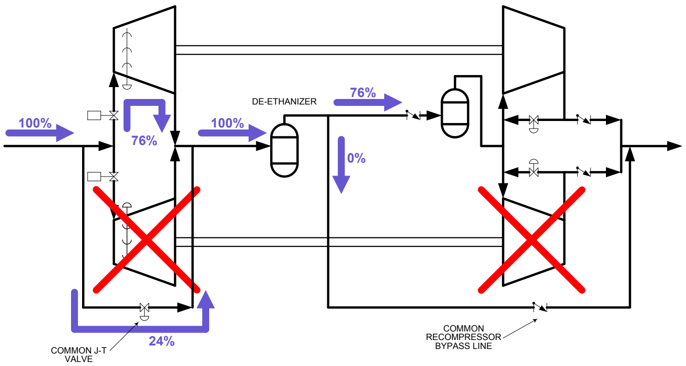

Fig. 4 – Problems with the common EPC design layout for parallel expander recompressor trains

Parallel turboexpander: suggested recompressor piping solutions

In order to avoid the problems with starting up and operating the parallel trains with the typical piping layout, it is recommended that a completely symmetrical piping arrangement be designed (Figure 5).

Key features include:

- Installing a separate and dedicated JT valve for each train.
- Installing a separate and dedicated recompressor bypass line with the associated check-valve.
- Installing a separate and dedicated condensate collector (often called the low temperature separator) at the discharge of each turboexpander. The condensates produced by each expander or JT valve can then be routed to the deethanizer, while the vapor stream of each train can be directed to the Recompressor (if the turboexpander is running) or the JT valve for each train, (if the turboexpander is not running).

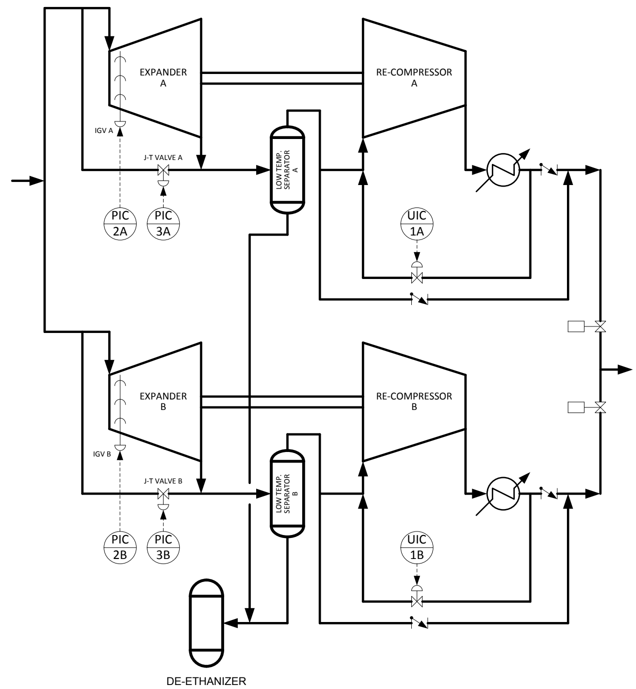

Fig. 5 – Suggested parallel expander recompressor trains piping layout

With the suggested piping layout, the same upset that was depicted in Fig. 4 would be handled as follows:

- It is advisable to allow the remaining running turboexpander train to handle the maximum possible load, since the expander is more efficient than the JT valve in terms of producing condensate, hence its turboexpander IGVs are ramped to open fully.
- The JT valve of the tripped train is opened to keep the common suction header pressure at the desired set point value.
- Gas from the low temperature separator of the running train is routed to the running recompressor.
- Gas from the low temperature separator of the tripped train is routed to the recompressor bypass line.
- The discharge pressure of the single running recompressor is still at the design value, and the Wobbe index of this gas stream is still as per requirements, therefore it may continue to be directly routed to the export facilities.

- On the other hand, the end pressure of the tripped train will be significantly lower than the discharge pressure of the other train, and so the two streams cannot be mixed. The gas produced by the train with the tripped turboexpander will probably be of unacceptable Wobbe Index values, as well as being of too little pressure, therefore it may be necessary to route it to a reinjection header, instead of the export header.
- Because of the different terminal pressures of each running train, it may be necessary to segregate the two trains from each (Figure 6)..

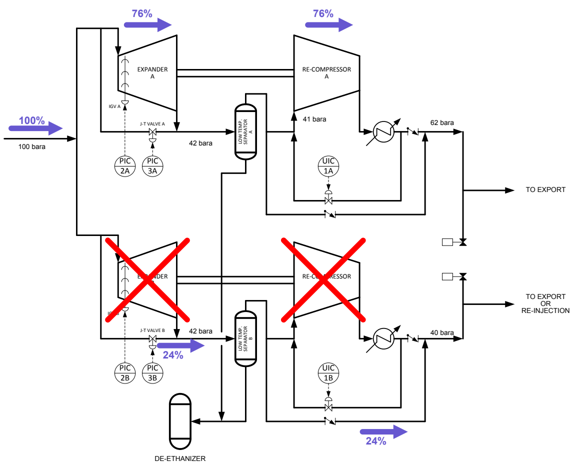

Fig. 6 – Segregated train piping with one train tripped

Conclusion

While the typical piping layout of parallel turbo-expander trains that include one common JT valve offer plant constructors some cost-saving benefits, operational flexibility is greatly compromised, and this could significantly impact the end-users profitability and operational costs for the lifetime of the plant.

The symmetrical piping layouts, recommended in this article should address these concerns and allow for greater operational flexibility of plants using parallel turbo-expander trains to recover condensates from natural gas.

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Medhat Zaghloul is CCC's Regional Technology Manager for the Europe, Middle East and Africa Regions with Compressor Controls Corporation (CCC), based in the Abu Dhabi Office. Medhat joined CCC in 1993 and has over 38 years of experience in the oil and gas industry with 15 years specific to the instrumentation and controls for the petrochemical industry. He is responsible for the development of technical solutions and control applications and providing technical guidance and support. Mr. Zaghloul holds a B.Sc. in Electrical Engineering from the Cairo Institute of Technology in Egypt (now Helwan University).