Compressor on Total Recycle

S M Kumar
Process Design Consultant
Top Contributor

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Query
1. For which cases we may need compressor to be operated at total recycle mode?
2. What are the impacts of such an operation mode on design of equipment such as compressor and downstream cooler duty? or setting design temperature?
3. Any other advice or important design point for this case?

My response
1. All compressors may go thru this total reycle mode now and then, when you do not want to trip a compressor when the feed is interrupted or export line is impaired for a short time. You keep running the machine on total recycle until the operator fixes the issue
2. Flow during 'total recycle' is about 70% of design flow. I don't think it has any impact on design or compressor train or cooler. Some clients do ask the KOD liquid inflow should be checked for PARTIAL reycle - 30, 50, 70% recycle. During recycle the discharge gas is cooled and let down back to suction pressure. It may result in the recycled gas being cooler than feed gas and may condense additional liquids from the fresh feed. This may result in a liquid flow marginally higher than normal liquid inflow to suction KOD, at about 50-60% recycle. It is highly unlikely to affect KOD sizing but is a good check.
3. None

Comments

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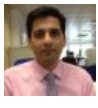

Saeid R. Mofrad
Principal Process Engineer at Petrofac (P.E.)
Top Contributor

Below is a query raised by one of the readers and Mr Kumar's response an request:

Query:
during recycle operation the inlet temperature to compressor and also outlet temperature may be higher. Also for some of the compressors the less the flow the less the efficiency and the more the outlet temperature. So equipment design may be affected

Response:
1. Recycling is at about 70% of design flow. So equipment capacity is not an issue.
2. Usually inlet temp is less after let down thru anti-surge recycle valve. JT cooling.
3. Recycling is done at the lowest possible speed, in variable speed machines like gas turbine or hydraulic coupled machines. So head developed is low and hence discharge temp will be low than normal 100% speed discharge temp
4. In fixed speed machines, head and discharge temperature may be more (as recycle happens close to surge point or higher than normal head); but in fixed speed machines suction is throttled to maintain volume flow and hence actual discharge speed many not be high. But it is worth checking discharge temp

Request:
Pls post your query to the group so that you get multiple responses. Going by a single person's biased view is not healthy.

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Mojtaba

Mojtaba Habibi
Process Engineer at Petroleum Engineering and Development Company (PEDEC)
Top Contributor

Dear Mr.Kumar,

1. About this part of your points:

"Recycling is at about 70% of design flow".
Could you please explain more about the basis for this value?

2. About this part of your points:

"Recycling is done at the lowest possible speed, in variable speed machines like gas turbine or hydraulic coupled machines. So head developed is low and hence discharge temp will be low than normal 100% speed discharge temp"

How about If client ask for fixed head for all of the conditions such as feed loss scenarions and reduced flow cases (turndown) for example export gas compressors?

3. How about this part of above mentioned query:

"For some of the compressors the less the flow the less the efficiency and the more the outlet temperature. So equipment design may be affected "

I remember for one of the previous projects the famous french consultant has considered reduced compressor efficiency due to reduced flow case and based on that has selected the design temperature of the compressor and downstream.

4. During basic design stage and at the absense of compressor vendor data how we should care about this case for process design of the equipment?

Many thanks for your time.

Best,
Mojtaba

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S M

S M Kumar
Process Design Consultant
Top Contributor

Dear Mojtaba: I pass this to others to respond to you. Kumar

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Stuart

Stuart Williamson
Dynamic Simulation Consultant at CB&I

Dear Mojtaba
Some thoughts on this chain of comments:
1. When in total recycle, the compressor will be operating on its surge control line which is typically 10% to the right of the surge limit line. The 70% figure is just a rough estimate if you have no other data, and will vary from machine to machine. If you have a compressor curve for a machine from a similar application then you could estimate the reduction in flow from that. The one I was looking at this week was nearer 90% from the design point to the surge control line. If for example it is a fixed speed machine then you need to remember that when started up, often the recycle valve is fully open until the normal design speed is reached and only then is it ramped closed to the surge control line. Hence the machine could be running at greater than 100% in full recycle for a period (when the anti-surge valve is 10% open).
2. There can be cases where the full recycle case is the design case for the cooler. If the normal suction temperature is low (e.g. in a refrigeration machine) then often when the recycle valve opens, the suction temperature rises and so does the discharge which places a larger duty on the cooler. Similarly for machines with suction coolers, sometimes the normal suction duty is low and increases to a higher value only when the compressor goes into recycle.
3. Compressors can operate in recycle at start-up, shutdown, when "unloaded" by operations (for some reason), on loss of suction flow, or discharge flow, and sometimes this may not necessarily coincide with a speed reduction down to minimum governor speed (especially if suction or discharge pressures are being controlled).
4. In some fixed speed machines, the suction throttle valve is outside of the recycle loop, hence the head and discharge temperature can rise in such circumstances.
5, With compressors in full recycle, if liquids are knocked out in the suction scrubber then sometimes the gas can "lean" out resulting in lower molecular weight gas in the loop and a "shift" in the surge control line. This can result in difficulties meeting a desired discharge pressure especially if the suction temperature also rises as this increases the machine polytropic head. Compressors in recycle don't naturally load balance either, which is why many compressor

control schemes (for parallel trains of compressors) include load sharing / balancing schemes.

All the above issues are often investigated using dynamic simulation (of compression systems), to ensure that the equipment design, controls, and instrumentation are adequate and safe for transient operation.

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S M

S M Kumar
Process Design Consultant
Top Contributor

Thanks Stuart

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Mojtaba

Mojtaba Habibi
Process Engineer at Petroleum Engineering and Development Company (PEDEC)
Top Contributor

Dear Stuart,

How about items 3 and 4 of my previous post?

3. How about this part of above mentioned query:

"For some of the compressors the less the flow the less the efficiency and the more the outlet temperature. So equipment design may be affected "

I remember for one of the previous projects the famous french consultant has considered reduced compressor efficiency due to reduced flow case and based on that has selected the design temperature of the compressor and downstream.

4. During basic design stage and at the absense of compressor vendor data how we should care about this case for process design of the equipment?

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Sonia

Sonia Rai
Technical Recruitment Coordinator at Stepstone Deutschland AG

What is the typical dP/dL (pressure drop per unit length) used for designing the kick-back lines of natural gas compressors?

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S M

S M Kumar
Process Design Consultant
Top Contributor

Sonia: Here you are letting down pressure drop; so you can go as high as noisy velocity (about 60 m/s at prevailing pressure or compressor discharge pressure). Hence this is a smallest possible size piping. Make this line as long as possible so that the recycle valve is as close to suction line as possible.) Read more in para 6.3.2 of NORSOK standard P-001
http://www.standard.no/pagefiles/1134/p-001e5.pdf

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Sonia

Sonia Rai
Technical Recruitment Coordinator at Stepstone Deutschland AG

Dear Mr. S M Kumar,

Thanks for giving useful advice on setting design standard for sizing KB lines. Can you please share some more information about selection of operating conditions for sizing KB lines. In my previous design company we used to follow the practice of using the expected performance curves to evaluate the surge conditions. As you must have seen that a surge line is clearly shown in these curves from which we can get the maximum flow rate and the maximum pressure at surge conditions (to be used in sizing of KB line). Normally the performance curves are given at three or four different speeds (hence providing three or four different surge conditions), and the dP/dL (or calculated velocity) at the different surge conditions varies a lot, causing confusion some times (to myself only) as to which one has to be used for getting an optimum line size. Therefore, I hereby wish to seek your valuable thoughts on this perspective.

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S M

S M Kumar
Process Design Consultant
Top Contributor

Dear Sonia:

I will let Stuart Williamson give you the correct response. Yes, Surge line flows reduces with speed. Surge flow is usually 70% of design flow at 100% speed. Stuart mentioned it can be as high as 90%. Usual practice or rather the practice I know is to size the recycle line and recycle valve for 100% that is normal flow with upstream pressure at control line (dashed line right of surge line)at 100% speed

Kumar

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S M

S M Kumar
Process Design Consultant
Top Contributor

Dear Sonia: The recycle valve is AND should be sized by the compressor vendor. Use his flow and pressure parameters to size the line.

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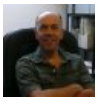

Stuart

Stuart Williamson
Dynamic Simulation Consultant at CB&I

Sonia
As per Mr Kumar's comment, the anti-surge valve is often sized by the vendor as it is within his responsibility / scope of supply. Typically it will be sized based on the surge (control) line and the stonewall flow lines at maximum and minimum speeds, such that an acceptable operating range is established based on the valve size selected. The approach varies from vendor to vendor, and there are also sizing methods employed by anti-surge system vendors (such as CCC) where the Cv of the anti-surge valve lies within an acceptable range. The sizing criteria must also cater for varying molecular weight gases (where the surge line will move with different molecular weight gases at the same suction conditions).
I'm not an expert on pipework sizing, but I'd be surprised if the highest speed (and hence maximum flow condition) doesn't end up being the determining factor (with the highest velocity).

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