Chemwork

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Outlet temperature of PSV/BDV

Hooman Tabaraei
Specialist Process Engineer (MIChemE, CEng)

Hi,
Does anyone have experience on estimation outlet temperature of PSV (particularly in case of high pressure drop through PSV in non-fire case like blocked outlet)? some references recommends Isentropic and some prefers Adiabatic process. Isentropic method will result in lower outlet temperature compared to adiabatic. some reference recommends combination of both mentioned methods, i.e, down to 50% pressure drop, isentropic is used and the remained by adiabatic method.

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Appreciate for sharing your expereince,

Hooman

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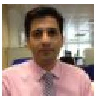

Saeid R. Mofrad
Principal Process Engineer at Petrofac (P.E.)
Top Contributor

I'd like to separate BDV from PSV. Pressure reduction in depressuring facility is through orifice rather than blowdown valve. Temperature drop across orifice is enthalpy constant process. Pressure reduction in PSV is a combination of isentropic and isenthalpic processes but it is hard to precisely specify each one's contribution. If we assume that the inlet section of PSV (from inlet flange to disc seating area) is frictionless, fast, adiabatic and reversible, it can be ideally considered ISENTROPIC. The second part of PSV where flow direction changes and fluid internal energy is converted into noise is not reversible (ISENTHALPIC process).
If we assume that chocking phenomena (reduction of pressure to critical pressure, i.e about 50% of upstream pressure) exactly takes place in first section, the method recommended by Hooman is perfect. In line with this understanding, there is an option in new version of Flarenet for user to specify the overall isentropic efficiency of relief valve (default value is 50%). First 50% isentropic & second 50% isenthalpic seems to be OK, isn't it?
How can I simulate a valve with 50% isentropic efficiency in Hysys?

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Sathappan Kathiresan (AMIChemE)
SENIOR PROCESS ENGINEER at FOSTER WHEELER SINGAPORE

Sathappan

Probably you can try with a expander, where you can predict the outlet temperature with specifying isentropic efficiency, because one needs it to estimate a power. It may be a work around solution for it.

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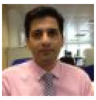

Saeid R. Mofrad
Principal Process Engineer at Petrofac (P.E.)
Top Contributor

I tired to compare the result of following four methods for a hydrocarbon mixture (mainly C1) when pressure drops from 70bar and 40 C to 5bar. The following temperature were obtained at PSV

outlet:
1) 100% DP isenthalpic : 3 degree C
2) 100% DP isentropic : - 72.8 degree C
3) 50% DP isentropic + 50% DP isenthalpic : -31.5 degree C
4) 100% DP with 50% isentropic efficiency (turbo expander) : -54.6degree C

The results are very different but i like third method. Does anybody have test data?

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Hooman

Hooman Tabaraei
Specialist Process Engineer (MIChemE, CEng)

In Aspen Flarenet selecting the option to compensate for the change in kinetic energy from inlet to outlet gives results closer to the complex model values,i.e; an isentropic flash from inlet pressure to sonic velocity & pressure at the Vena Cava , ie a nozzle and then an isenthalpic flash from the VC to the valve outlet.
The optional isentropic method in Flarenet gives ridiculously low exit temps and should not be used as it could give incorrect metallurgy selection. However some references prefer to estimate PSV outlet temperatue based on ONLY isentropic!

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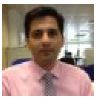

Saeid R. Mofrad
Principal Process Engineer at Petrofac (P.E.)
Top Contributor

I checked a wide range of compositions in Flarenet and found that "selecting the option to compensate for the change in kinetic energy from inlet to outlet" as recommended above does not give the same result as third method (50% DP isentropic + 50% DP isenthalpic). In view of this, it seems the only way to get correct temperature at the outlet of PSV in Flarenet is to use following procedure:

1) Using Hysys to get PSV outlet temperature when 50% of DP is isentropic and 50% of DP is isenthalpic
2) Using Hysys to get isentropic efficiency (for 100% DP) by setting turbo expander outlet temperature at temperature obtained from step 1
3) Using isentropic efficiency from step 2 in Flarenet (Version 7.1 and above - Methods Tap, Energy Balance options)

It should be noted that this procedure should be done for each PSV's scenario as isentropic efficiency may change by composition and relieving temperature of relieved gas (set pressure is constant for different scenarios of each PSV).

Regards
Saeid

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Hooman

Hooman Tabaraei
Specialist Process Engineer (MIChemE, CEng)

Thanks Saeid for your explains. Could you please address me how can I specify isentropic efficiency in Flarenet Ver.7.2.
Another point - When system contains liquid hydrocarbon, by increasing heat flux generated relief rate (kg/hr) will be increased but valve Cv (usgpm) at a specific heat flux onwards will be deducted however peak flow rate apart from reduction in valve CV will being increased. I've come across to this situation when we had to select JET fire scenario instead of pool fire for PSV sizing (in JET fire we had to select 200KW/m2 as a heat flux that would be significantly greater than considered heat flux in pool fire). Does anyone have come across to this situation and if yes, what were your concerns?

Thanks
Hooman

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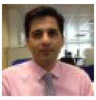

Saeid R. Mofrad
Principal Process Engineer at Petrofac (P.E.)
Top Contributor

Dear Hooman,

In Flarenet version 7.2 for PSV for example, go to "Methods Tap", "Energy Balance Options" where you can specify isentropic efficiency.

for question about jet fire depressuring, I suggest opening new discussion with a proper name.

Regards
Saeid

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S M

S M Kumar
Process Design Consultant
Top Contributor

Caution: This aspect is missed by process engineers. The PSV or PCV body can conduct cold upstream, thereby reducing the temperature of the high pressure fluid and hence may result in downstream temperature lower than predicted by process calcs/ commercial software. All programs predict unreliable values; Imperial college, UK's Blowdown model claims a 0.5C accuracy in prediction based on field verification. In critical services, better to have a run by them, rather than take things for granted

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Bahareh Mahdavian likes this

Mojtaba

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

Dear S M Kumar,

As per your experience, how much is the effect of this coldness transfer through PSV/PCV body on upstream temperature?

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S M

S M Kumar
Process Design Consultant
Top Contributor

Mojtaba: It is a question of time - how long you operate in and how cold it is d/s. I don't have any old reports to look at and respond to you.

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Mojtaba

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

If this is PSV then from set pressure downto blowdown pressure may not take a long time.If this BDV then it will take maximum 15 minutes (unless it is manual depressuring or finger type slug catcher)So maybe only the BDV case should be studied more.Let me know.

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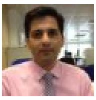

Saeid R. Mofrad
Principal Process Engineer at Petrofac (P.E.)
Top Contributor

With respect to the deviation of HYSYS depressuring results from test data, accuracy of BLOWDOWN software and the way the gap betwen the results of these software can be reduced, I have done some case studies which can be referred in the following reports:

- Validation of Hysys Depressuring Utility
- Set Depressuring Model Dimensions to Get More Accurate Results

If you ensure that Hysys prediction on temperature downstream of valve is acceptable, the conduction of temperature to valve body and valve upstream piping can be estimated using the heat transfer model and method introduced in:

- Is 600mm Sufficient to Keep BDV Functional?

Based on my observation during preparation of above mentioned note, I would say even if temperature downstream of valve is -100°C, it will reach -28°C within maxumium 1 to 2 meters (back temperature propagation to the piping upstream of valve). This is because coldness is conducted via thickness of pipe (small area) whereas it is lost via internal surface (in contact with high speed gas flowing inside the pipe) and external surface (to ambient air).

According to this, most probably PSV and PCV body reaches downstream temperature. But the coldness transfer will be limited to couple of meters of piping upstream of PSV/PCV.
For BDV, 600 mm will prevent upstream piping from reaching very low temperature if the source of cold temperature is pressure drop across BDV (orifice).

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Obumneme

Obumneme Uyaemesi

Process / Flow Assurance Engineer

A major pressure drop will take place at restriction orifice (RO), downstream of the blowdown valve (BDV) during blowdown. Joule Thompson (JT) effect results to fluid temperature drops to below subzero downstream of the restriction orifice. The coldness will travel back upstream of the restriction orifice and probably reach the blowdown valve causing the upstream blowdown valve body temperature to drop below subzero as well. Moisture from the atmosphere will freeze at the blowdown valve body and potentially cause the stem to stick at a position and this may potentially lead to backflow. A good engineering practice stipulates that a minimum distance of 600mm will be maintained between a blowdown valve and a restriction orifice to avoid coldness travelling down to the BDV.

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Roberto

Roberto Paron

Software consultant & contractor at Prode

"Does anyone have experience on estimation outlet temperature of PSV (particularly in case of high pressure drop through PSV in non-fire case like blocked outlet)? some references recommends Isentropic and some prefers Adiabatic process. Isentropic method will result in lower outlet temperature compared to adiabatic. some reference recommends combination of both mentioned methods, i.e, down to 50% pressure drop, isentropic is used and the remained by adiabatic method."

I would suggest to model the PSV as isentropic nozzle, for usual VLE you can go with HEM, what you need is a suitable thermodynamic model to calculate H,S,V nowadays many applications permit to calculate these properties,
a simple Excel procedure to model the isentropic nozzle is available in this sofware "http://www.prode.com/docs/pppman.pdf"

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