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Latent Heat of Vaporization via Hysys flash calculations

Vagif Gafarov
Senior Process Engineer at Jacobs

Dear All,

can you please confirm that this approach is correct to determine the LHV in each 5% mass vapor flash!?

I define the inlet stream, which represents the mixture of vapor and liquid in a separator by setting up the mass flows kg/h as per kg's of mass of vapor and liquid, which I have at, high high liquid level.

I set the pressure at the relieving pressure. The resulting stream is zero vapor fraction. I then put the vapor fraction to "0" and find the relieving temperature. I connect the heater to obtain 5% vaporization based on the inlet stream conds. Then I subtract $[(M_{vap} \times C_{pvap} \times dT) + (M_{liq} \times C_{pliq} \times dT)]$ from the heater duty. The result is divided by the vapor mass flow to obtain the latent heat of vaporization !?

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Fahad Al-Sadoon
Process Engineer at Petrofac Engineering Ltd

Fahad

Hi There,

Remember that C_p is a function of temperature and you might not get the most accurate result if you take a constant one. However, I think it would be easier to do the following

- * Assume 100 kg/h, set your pressure at relieving pressure and vapor fraction to "0", as you have mentioned earlier.
- * Record the mass heat of vaporization from properties tab in Hysys stream option.
- * Use a heater to vaporize this stream and use an adjuster that will vary heat duty to produce 5 kg/h of vapor.
- * Use a separator to separate the vapor and liquid. Record the mass latent heat of vaporization of the liquid stream.
- * Repeat the steps above to complete the successive flashing of 5% of mass. Check which steps gives you the lowest value for latent heat of vaporization and use it for subsequent calculation steps.

You can make the procedure much simple if you assume that 5% mass vapor fraction is equal to 5% volume vapor fraction, this way you could just simple set the outlet of heater as 0.05.

Hope this helps

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Jeremy Goldbloom
Oil & Energy Professional

I agree. This is the recommended way to do the flare load calculations as in API-520/21 where a

Jeremy

latent heat value is needed. A fire will distill off vapor from the initial inventory effectively step by step. So you should model a series of heat added flashes passing the liquid product forward (but not the vapor) from each flash. This models a fire driving off the lightest fractions first. Evaluate the relief load for each successive flash to obtain the largest required relief area for your PSV.

This routine is however not the correct way to calculate latent heat for many heat exchanger rating programs which also need a sensible heat portion to be evaluated. You did not say what you are doing with the number.

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ASHOK

ASHOK KUMAR

Process Engineer at MODEC International INC

Hello there,

The Cp of liquid and vapor is an important factor while calculating the latent heat.

In $M C_p dT$, C_p is for bulk temperature.

If you take the C_p at the relieving condition the latent heat will be lesser than the C_p at 5% vaporized liquid.

It is better to take the bulk mean C_p value.

Regards

Ashok

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Frank

Frank Petz

research at Consultant

As suggested by other members it depends if composition (W) should be constant (i.e. you are vaporizing some fluid in a closed vessel) or variable (i.e. you separate the vapor so that composition becomes that of remaining liquid),

in both cases you can easily calculate initial and final mass and enthalpy for gas and liquid fractions, from these you should be able to obtain the latent heat,

I have another software (PRODE PROPERTIES) and I do not know the details with HYSYS but the procedures should be equivalent.

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ASHOK

ASHOK KUMAR

Process Engineer at MODEC International INC

Hello Mr Frank

The difference in enthalpy of the mixture at its dew point and bubble point is reported as the Latent heat of the mixture by HYSYS.

That's why we have to calculate the latent heat manually.

Also, I read a technical paper, which said to calculate the latent heat by sum of the individual components latent heat multiplied by the mole fraction and the molecular weight of the individual component whole divided by the average molecular weight (apologies, I couldn't write in equation form), provided free water is ignored.

The above method also works fine.

Thanks

Regards

Ashok

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Frank

Frank Petz

research at Consultant

you can calculate gas enthalpy for pure components as

$H_{gi} = H_{li} + H_{vi}$ where H_{vi} is the latent heat

for a mixture

$$H_g = \sum(W_i \cdot H_{g,i})$$

where W_i is the weight (mass) fraction
the same procedure for liquids.

once you know the enthalpy of vapor and liquid phases you can calculate latent heat at specified condition (i.e. vaporizing a limited amount of liquid with specified T, P, W),

unfortunately as said I cannot comment on HYSYS,
I have a different software (PRODE PROPERTIES with Excel 64) in my computer,
PRODE allows to calculate the above values where a phase (vapor, liquid, solid) is present,
then I can calculate latent heat ($H_{\text{vapor}} - H_{\text{liquid}}$)
and heat of fusion ($H_{\text{liquid}} - H_{\text{solid}}$)

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Saeid Rahimi Mofrad
Senior Specialty Process Engineer at Fluor

Ashok,

The definition of Latent Heat has been always "The difference in enthalpy of the mixture at its dew point and bubble point is reported as the Latent heat of the mixture by HYSYS." this is not what Hysys has invented.

About formula you have mentioned, what is the definition of latent heat in your formula? where latent heats of individual components are coming from? Hysys? if yes, so what is the point of using this formula which ignores the interaction effect of different components in the mixture on the physical properties of the mixture?

Furthermore, if you correctly use Hysys (or any other software) you don't need to calculate the latent heat manually.

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Frank Petz
research at Consultant

Frank

I would suppose the discussion is about wide boiling mixtures,
the definition of latent heat as "difference in enthalpy of the mixture at its dew point and bubble point" does provide a good indication for a pure fluid (isothermal process) and (very) narrow boiling mixtures (with similar properties),
but for wide boiling mixtures (as those in refineries etc.) the heat required to vaporize a small, constant, fraction dW_{weight} of liquid may show (large) differences moving from bubble point to dew point (although, as you state, the amount required to vaporize all liquid can be calculated as difference in enthalpy of the mixture at its dew point and bubble point".
Since the process has not been specified it is difficult to propose a solution,
perhaps it's for PSV sizing but could be also for a different purpose,
anyway there are several methods (for example solving a flash operation) to calculate those values.

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ASHOK KUMAR
Process Engineer at MODEC International INC

ASHOK

Mr Saied

The latent heat estimated by hysys is the difference between the enthalpy at its bubble point and dew point. Which is 100% liquid vaporization. Off course it is the definition of latent heat.

In real scenario as the fire progress the liquid latent heat varies from time to time. The lighter components vaporize first and results in the change in latent heat of the liquid .

The latent heat estimated by hysys is much higher than the latent heat estimated by the above method, since the above method estimates the latent heat to vaporizes 5% mass of liquid from its boiling point .

I meant this.

I never meant anything about hysys invention.

Regarding the formula , I read it in a technical paper.

The formula can be used for rough estimation of latent heat when simulator is not available. I

missed to mention this.

Regards
Ashok

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Jeremy

Jeremy Goldbloom
Oil & Energy Professional

The stepwise method that I recommended, was the one used by a major UK oil company, where I worked about 10 years ago. It corresponds to the comment by Ashok, where the boil off proceeds with time and with relief removal of vapor. As we have mentioned, the ultimate use of the value is important. Is it for sizing a PSV for the fire case or what?

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Frank

Frank Petz
research at Consultant

Mr. Ashok,
you can (see your above post) "calculate the latent heat by sum of the individual components latent heat multiplied by the mole fraction and the molecular weight of the individual component whole divided by the average molecular weight"

by dividing individual molar fractions * mole weight by average molar weight you convert molar fractions to weight fractions (see my above post)

by the way you can estimate enthalpy of vaporization (or latent heat) of individual components from their vapor pressure correlation via Clausius-Clapeyron formulation, you need simply to differentiate vapor pressure correlation, this method can be very accurate (for example if you differentiate a 6 parameters vapor pressure correlation) for pure fluids, however for mixtures it doesn't take in account (as noted by Saeid) the interactions between different components, simulators calculate instead a departure from ideal conditions, accuracy depending from the thermodynamic package selected.

If you wish to estimate the average heat of vaporization on each 5% fraction you need to specify if "composition (W) should be constant (i.e. you are vaporizing some fluid in a closed vessel) or variable (i.e. you separate the vapor so that composition becomes that of remaining liquid)" see my above post.

Depending from above there are different procedures applicable,

since the application has not been specified I include some examples.

If you wish to simulate a vessel protected by a PSV you can estimate the initial conditions (when PSV opens) see:

<http://prodesoftwareapplications.blogspot.it/>

or the whole process (i.e. including discharge),

if you wish to size / rate a PSV there are models as HEM / HNE etc. which can be solved directly (i.e. without to define a simplified model as Omega procedure) etc.

with a simulator you can create procedures for solving these cases

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Saeid Rahimi Mofrad
Senior Specialty Process Engineer at Fluor

Dear Ashok,

I appreciate your contribution but I was trying not to create any confusion for readers.

If you have accepted to use sequential flashing method to calculate the fire relief load (as it was raised in the original question), you will have this chance to obtain the latent heat of lighter components' from the software as you have already made an stream representing the lighter components.

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Sridhar Pokala Shanmugam
Lead Process Engineer at Siemens Pte Ltd

Sridhar

On this same topic, I am doing a fire case for one particular liquid composition. When I tried to do 5% vaporization, hysys pop-up shows as 'stream temperature is not available at this condition'. Hence I vaporized the liquid to vapor fraction of 1 to get relief properties. But hysys unable to show the mass heat of vaporization and it shows empty. In this case, how to get the LHV value?

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Shaun Nateghi
Senior Process Engineer, CPEng MIEAust, RPEQ, NPER

Shaun

Sridhar,

It could be because you are running close to the stream critical point above which VLE calculation is not available/valid. If super-critical, you'll need to switch to the relevant method for the calculation rather than classic sequential flash and latent heat.

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Frank Petz
research at Consultant

Frank

there could be different reasons why the software is unable to find a solution, for some mixtures as for example H2 or C1 + H2O (or a heavy component) convergence is difficult and numerical errors are expected due to the very different fugacities, in those cases perhaps you may try a isothermal flash, as first step you can plot a phase envelope and see where your initial point is located, if the initial point is within VLE area then you should be able to solve (at constant pressure) from bubble point to dew point and calculate the latent heat of the mixture with the specified composition.

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Shaun Nateghi
Senior Process Engineer, CPEng MIEAust, RPEQ, NPER

Shaun

Further to the previous post about near critical cases, this is copied from API-521, 2008, Sec 5.15.3.2:

"If no accurate latent heat value is available for these hydrocarbons near the critical point, a minimum value of 115 kJ/kg (50 Btu/lb) is sometimes acceptable as an approximation."

It gives rise to high fire relief rates though.

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Frank Petz
research at Consultant

Frank

"It gives rise to high fire relief rates though"

I agree,

I think those values should be adopted only when the software is unable to find a solution and/or the phase envelope shows that initial point is near the boundary of VLE area and a little contribute of heat will move to dense or vapor phases.

With many mixtures there is a critical point located on left side of VLE area and the heat contribute will move to VLE area where the latent heat has a value > 0 (at critical point latent heat = 0, of course the same for dense or vapor areas)

so, in my opinion, it is important in above mentioned cases, calculate the phase envelope.

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Abbas Eisa
Foreman @ visbreaking plant at petroenergy-ep

Abbas

dear i need clear answer

what is equation that hysys use to calculate latent heat

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Saeid Rahimi Mofrad
Senior Specialty Process Engineer at Fluor

Abbas,

For a given composition and pressure, Hysys reports the difference between the enthalpy of stream at dew and bubble points as the latent heat.

Saeid

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