Setting MDMT Based on Hysys Depressuring Results

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Introduction

Depressuring of a process system after being maintained in isolated and pressurized condition for a long time (which is called cold depressuring) is the basis for determining Minimum Design Metal Temperature, MDMT. As system pressure reduces during depressuring, the temperature of system contents (gas or/and liquid) decreases which causes a differential temperature between process system and surrounding. Depending on system and surrounding heat transfer features, a momentary heat flux from surrounding to system is established which results in different temperature profile for:

- Gas
- Liquid
- Vessel's metal in contact with gas
- Vessel's metal in contact with liquid

The purpose of this note is to specify which one of above temperatures shall be used as process system's design temperature. The recommendations of this note are based on data presented in note "Validation of Hysys depressuring utility".

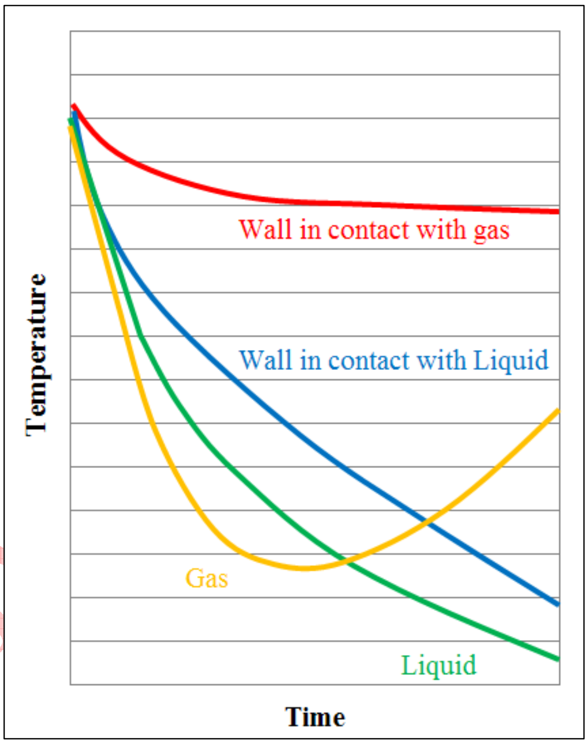

Figure 1 – Typical trend of system temperatures

Depressuring Facts

Before discussing about minimum design metal temperature, going through below paragraph which outlines some facts about depressuring process may be helpful.

1. Those parts of the system which are closer to depressuring valve will reach lower temperature.
2. Those parts of the system which have lower thickness will reach lower temperature. Pipes are usually thinner than vessel's head and vessel's head thinner than vessel's shell.
3. Temperature of vessel's metal in contact with liquid is usually 2 to 5°C higher than liquid temperature.
4. Temperature of vessel's metal in contact with gas is usually 10 to 50°C higher than gas temperature.
5. Piping upstream of depressuring valve reaches gas temperature because of high gas velocity and low piping thickness.
6. Temperature of gas drops much faster than liquid temperature because of lower heat capacity (Cp) of the gas.
7. Temperature of gas substantially drops to very low temperatures at initial stage of depressuring and just before being heated up by wall and taking ascending course.
8. Temperature of liquid is always descending during depressuring but not as steep as gas in initial depressuring stages. All above observations have been depicted in Figure 1.
9. In many cases, gas and liquid temperatures approach to the same temperature as depressuring continues for a long time.
10. An accurate definition of system dimensions and dimension related parameters as discussed in technical note "Setting Hysys Depressuring Input to Get More Accurate Results" is crucial because it affects system heat content and heat transfer features.
11. An accurate definition of system thermodynamic and heat transfer parameters as discussed in technical note "Effect of Different Parameters on Depressuring Calculation Results" is also vital as it will change depressuring rate and fluid/metal temperature as main objectives of this study.

MDMT

Table 1 specifies how to use Hysys depressuring calculation result for MDMT. As mentioned above, pipe upstream of BDV reaches gas temperature. Therefore selecting the design temperature and material of this line shall be always done based on temperature of gas not metal in contact with gas (which is usually much higher than gas temperature).

For vessel, since nozzle is connected to pipe upstream of BDV therefore pipe temperature will be conducted to the vessel (basically part of vessel which is closer to depressuring nozzle and pipe, for example top head of vertical vessel) through thermal conduction. In other word, part of vessel also can reach pipe (gas) temperature. Keep in mind that although Hysys reports single temperature for entire gas node, there will be always a temperature profile along the pipe from BDV to vessel nozzle and across the vessel. In view of this, vessel should also be designed for gas temperature unless suitable thermal sleeve or any other type thermal barrier is inserted between vessel nozzle and the pipe flange so that vessel can be treated as separate node. In this case, since gas inside the vessel is almost stagnant, then the vessel body (metal) temperature will be function of heat transfer rate to surrounding which is well predicted by Hysys. Therefore min metal temperature reported by Hysys can be used as MDMT.

Table 1- MDMT of different systems (Note 1)

System Description	MDMT for Pipe upstream of BDV	MDMT for Vessel
Gas filled	Min. gas temperature	• "Min. gas temperature" if there is no thermal sleeve between BDV inlet pipe and vessel otherwise • "Min. metal temperature in contact with gas" if there is thermal sleeve
Gas filled with condensation	Min. gas temperature	• "Min. gas temperature" if there is no thermal sleeve between BDV inlet pipe and vessel • "Min. metal temperature in contact with liquid" if there is thermal sleeve (Note 2)
Two phase	Min. gas temperature	• "Min. gas temperature" if there is no thermal sleeve between BDV inlet pipe and vessel • "Min. metal temperature in contact with liquid" if there is thermal sleeve (Note 2)

Note

1) Appropriate margin (if needed) can be considered for setting MDMT based on above temperatures.

2) Some people have used liquid temperature because draining of remaining liquid inside the vessel after depressuring may not be possible immediately due to operation or design constraints.

Conclusion

From mechanical design point of view, MDMT can be coincident with design pressure if system re-pressurization is allowed or envisaged when it is at MDMT. If it is not possible or practical to design the system for MDMT and design pressure, preparing a procedure for system safe re-pressurization, like re-pressurization in stages with a warm gas supply to avoid exceeding the allowable stress of the vessel is recommended (subject to Client approval).
The second scenario is that system re-pressurization when system is at MDMT is not credible so MDMT will be coincident with design pressure.

From metallurgy point of view, MDMT is basis of material selection. Very low temperatures which are usually observed after depressuring high pressure and/or low temperature systems may call for exotic material such as stainless steel. Following remedies (subject to the approval of the principal) may be examined to keep the project cost within budget:

- Providing thermal sleeve between BDV inlet pipe and vessel nozzle
- Providing a temperature trip to inhibit system depressurization if initial temperature is less than required value to prevent system from reaching extremely low temperatures

Moreover, using absolute minimum temperature as specified in Table 1 for setting MDMT is not 100% correct as it can also result in expensive materials. This is important because in reality system will experience minimum temperature at a pressure much lower than system design pressure (see Figure 1). So it is worth to undertake further engineering effort if it helps to reasonably select suitable material and avoid extra material costs. In view of this, it is recommended preparing the profile of depressuring temperature versus pressure and consult with material/mechanical specialist to select a suitable material as per method described in note "Material Selection for Low Temperature Applications".

Contact

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