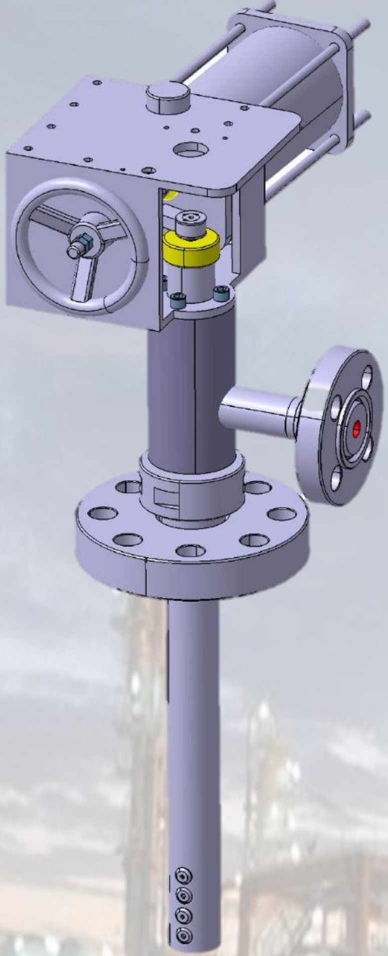


DESUPERHEATER

CONTROL VALVE

Type: 4HN

Series: 2H40.55-2N30.40

SURIN FIDAR

CONTROL TECHNOLOGY

Desuperheating

The process of cooling superheated steam by direct injection of water is called Desuperheating. This is typically done to meet the conditions required for downstream process(es) when the available steam happens to be at higher temperature and there is also a source for injecting spraywater into it. It is required in many industrial processes where the steam temperature, and/or quality, is critical for reliable and efficient operation of the system.

Such systems are common in power stations, refineries, pulp & paper industry and desalination plants, where a boiler producing superheated steam already exists.

There are four basic steps:

Injection of the correct amount of spraywater

Spray atomization (primary and secondary)

Spray penetration and pre-evaporation mixing

Evaporation and mixing

Injection of the correct amount of spraywater flow is the first and most fundamental requirement to correct operation of any desuperheating system. This requires careful, and correct, selection of the spraywater flow control element. This control element, which may be an external control valve, must be capable of providing good control over the entire range of spraywater flow required. Multi-stage pressure drop is necessary in cases of high pressure drop for long-term reliability.

The quantity of cooling water required is determined from heat balance and mass balance principles, which leads to:

$$Q_W = Qs \times \frac{(h1 - h2)}{h2 - hw}$$

Where:

Qw = Water quantity required in kg/hr
Qs = Steam flow in kg/hr
h1 = Enthalpy of inlet Steam in kJ/kg
h2= Enthalpy of outlet Steam in kJ/kg
hW =Enthalpy of spray

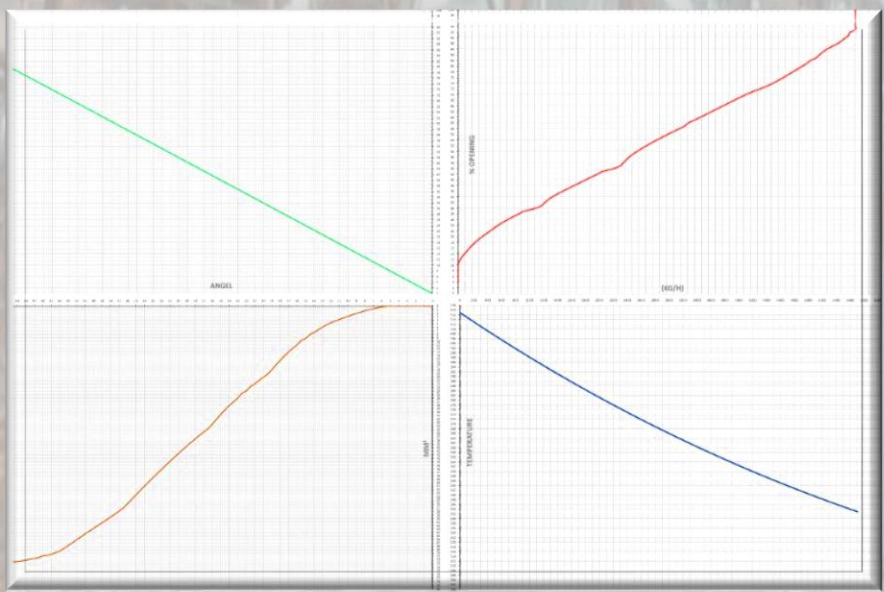


Fig. 1 Valve characteristic curve

Atomization

Atomization of the injected spraywater into droplets increases surfacearea for heat transfer with the surrounding steam.

Smaller droplet size is desirable because it means higher surface area of the spraywater and evaporate more easily.

The most significant parameter governing atomization is Weber number, defined as:

$$We = \frac{\rho U^2 d}{\sigma}$$

Where:

ρ = Density of steam in kg/m3

U = Relative velocity of Steam in m/s

d = Droplet diameter in m

σ = Surface tension of water in N/m

Droplets are stable when the Weber number is below the critical value which is generally in the range of 12 - 16.

Droplets with higher Weber number continue to break up until they reach a stable size.

Primary atomization depends on the spray nozzle design. In spray nozzles using pressure drop.

Secondary atomization (Fig. 2) is another mechanism for break-up of drops.

The energy of the surrounding flowing steam provides the force for droplet break-up in such cases.

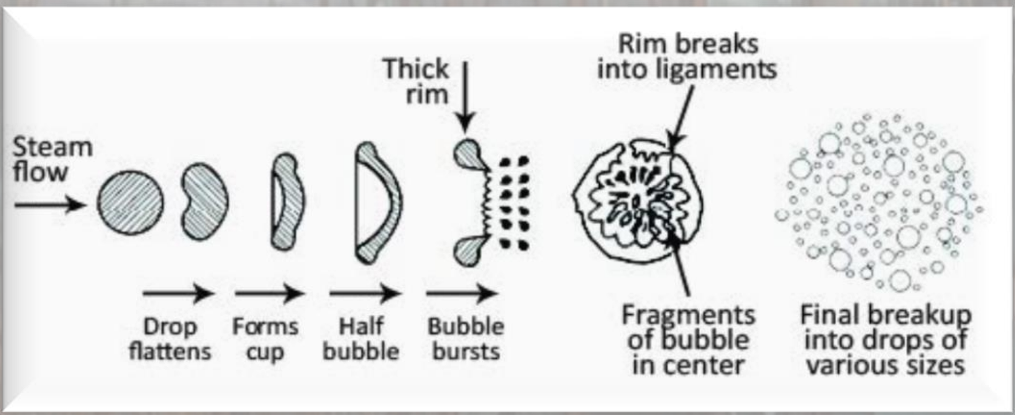


Fig. 2 Secondary breakup of water droplet by interaction with steam

Small droplets are beneficial in desuperheating because they evaporate faster and also stay suspended easily in the steam flow. So, good atomization is a very critical step in desuperheating SURIN FIDAR uses both primary and secondary atomization principles to achieve small droplet sizes, below 100 μm diameter as a general rule.

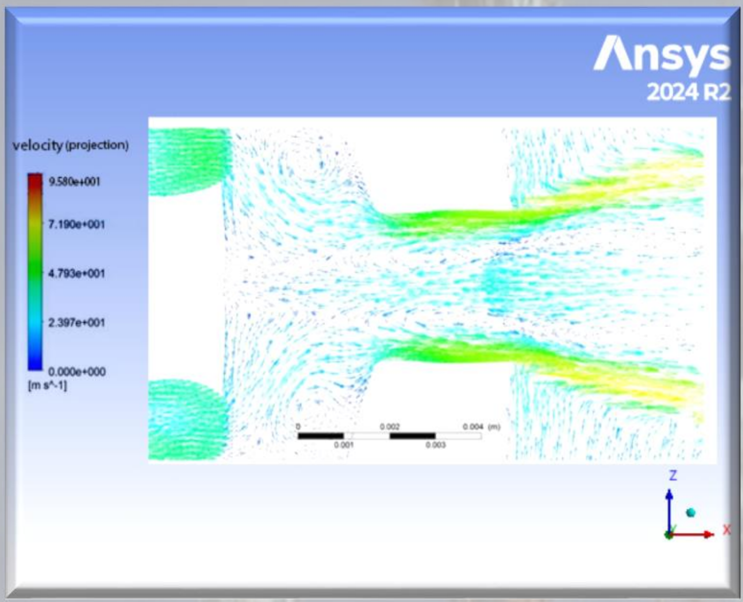


Fig. 3 Computational fluid dynamics analysis of spray distribution

Spray Penetration

Spraywater penetration into the surrounding steam depends primarily on the size of the initial jet, momentum ratio between steam flow and injected spraywater and downstream distance and the distance from spraywater injection.

Once the initial momentum of the injected spraywater is dissipated, the droplets mix with the surrounding steam and are carried further downstream suspended in the flow.

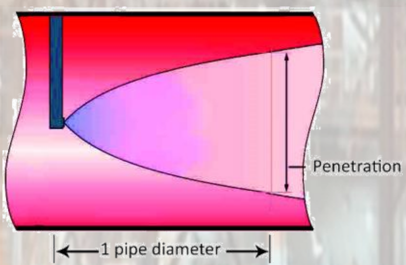


Fig. 4 Schematic for penetration of spray water in an inline flow of steam

$$h = f\left\{\left(\frac{q_l}{q_G}\right), d_j, x\right\}$$

Where:

h = spray penetration

q_l = momentum of spraywater jet

q_G = momentum of steam

d_j = jet diameter (or, spray sheet thickness)

X = distance from spray water injection

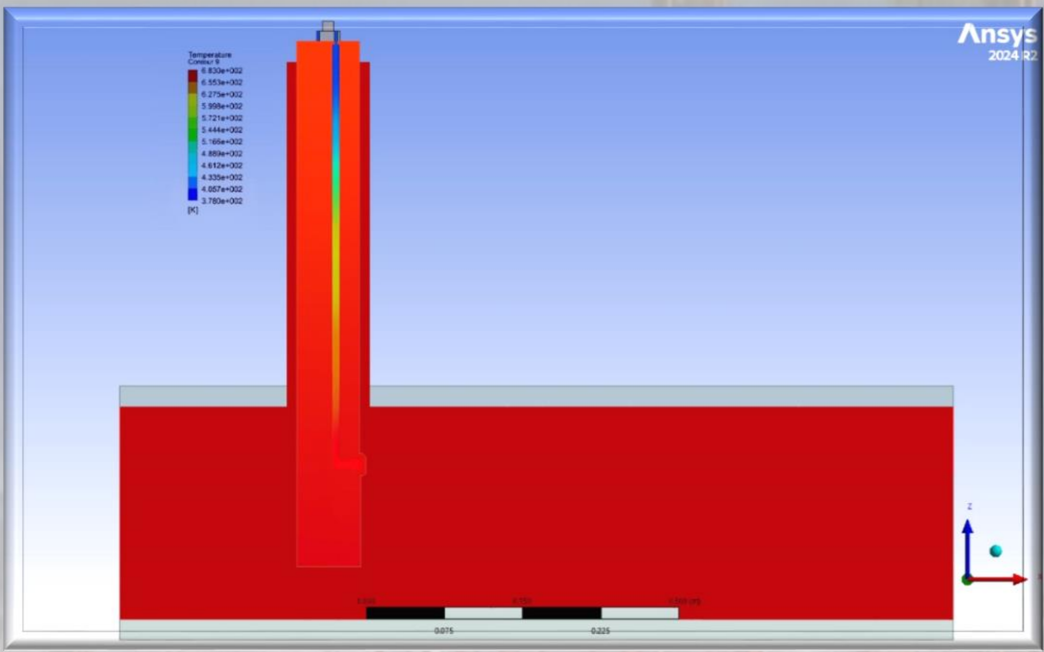


Fig. 5 thermodynamic analysis of temperature distribution through the valve (for flow 0-3 kg/min)

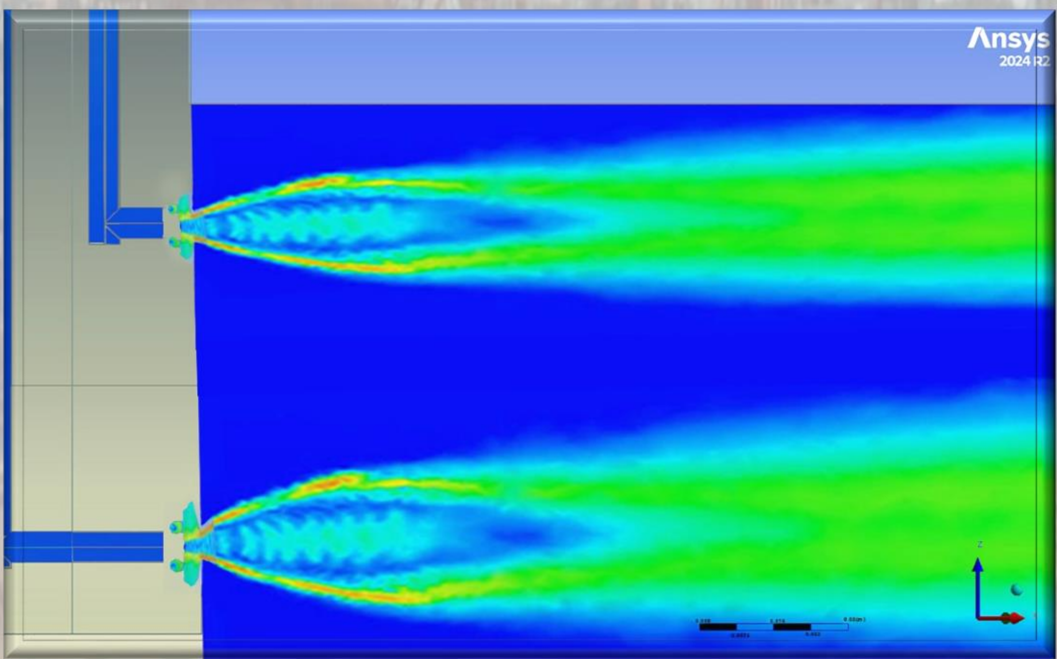


Fig. 6 Computational fluid dynamics analysis (nozzle sprays with 3 & 4 mm diameter)

Evaporation and Mixing

Evaporation of the suspended droplets progresses with heat transfer from the superheated steam.

The time for complete evaporation of the injected spraywater depends on many factors; the most important among these factors are droplet size, the desired degree of superheat in the outlet steam, amount of spraywater (as % of steam) and local heat transfer coefficient. Uniform steam temperature downstream is achieved eventually, after all the spraywater is converted into steam and through turbulent mixing that occurs in the steam pipe.

The description above gives a simple overview of the physics. However, many design details need to be considered for each step to work correctly.

Injection of correct amount of spray water flow requires a reliable spraywater flow control across the entire operating range.

Multi-stage pressure letdown design is required where the pressure drop across the flow control element is high.

Spray nozzle selection, type and quantity, play a direct role in achieving fine atomization and correct spray penetration.

Further, optimumdivision of the available pressure drop between the spraywater valve and the spray nozzles is an important part of the sizing process.

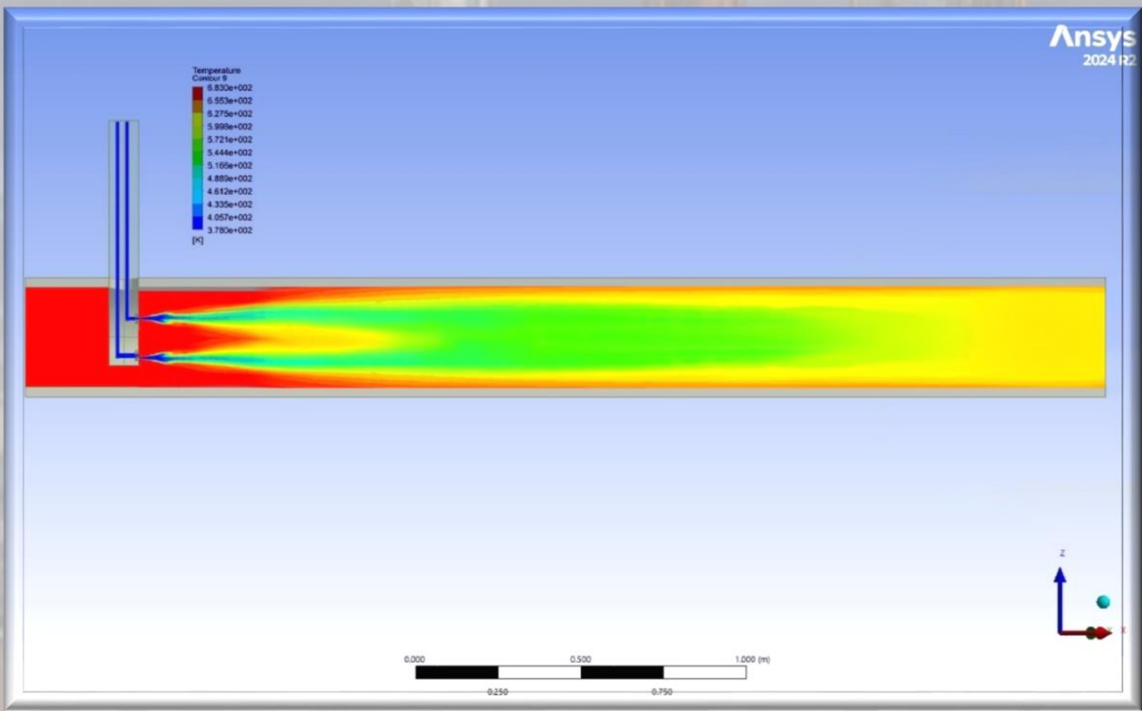
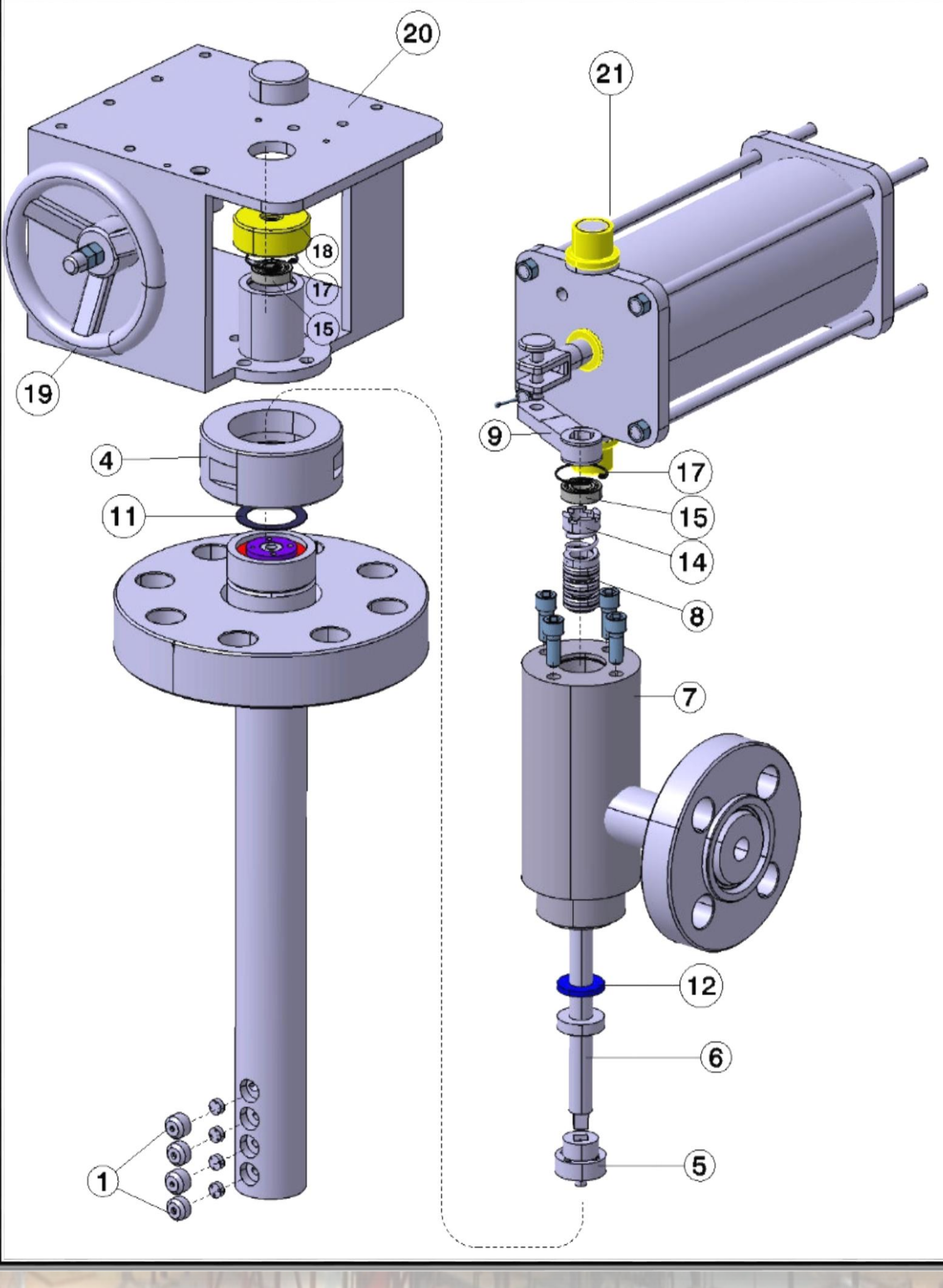


Fig. 7 Thermodynamic analysis of temperature distribution inside the tube



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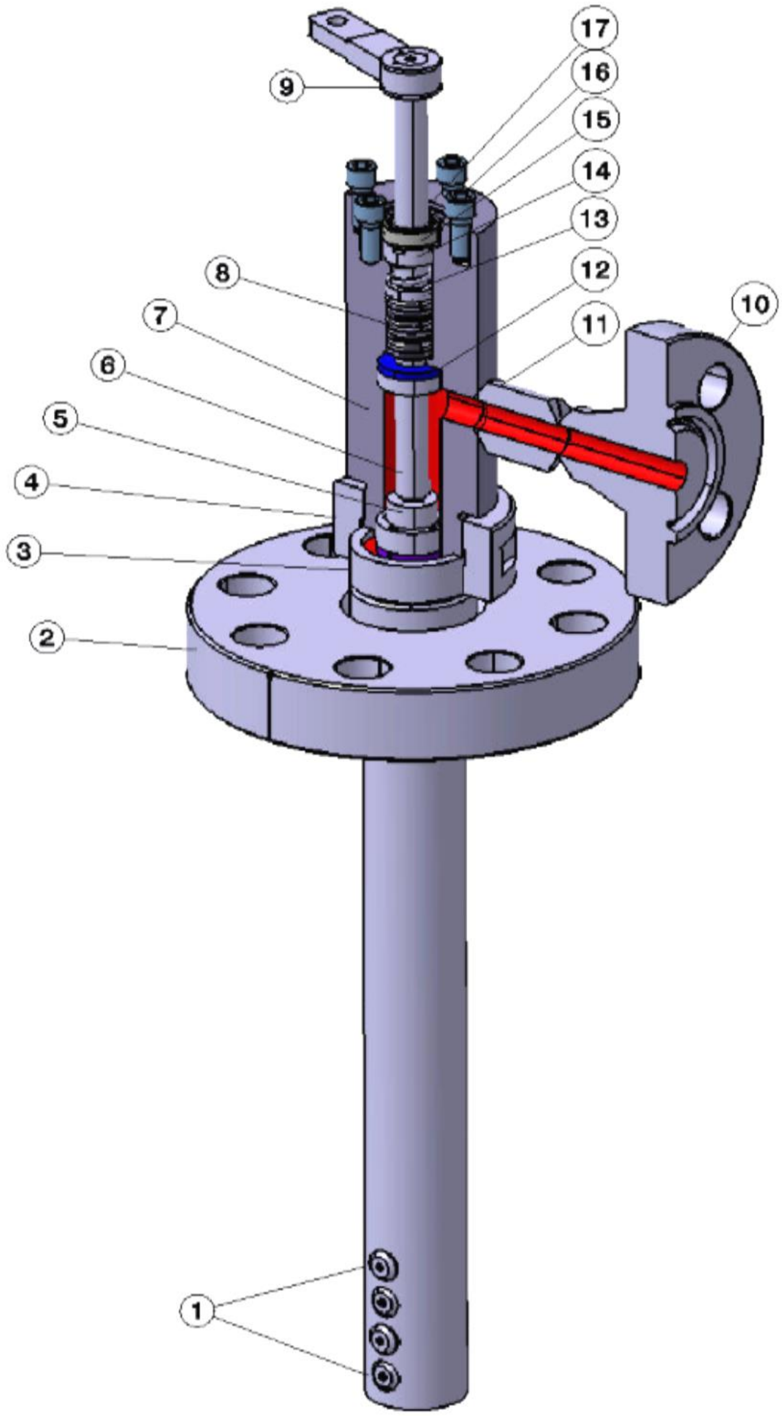
Item No.	Description	Materials	QTY.
1	Nozzel Assembly	Stellite 6	8
2	Flang 3"1500#	DIN1.7711 40CrMoV4-6	1
3	Seat	DIN1.7711 40CrMoV4-6 + Stellite 6	1
4	L-R Nut	DIN1.7711 40CrMoV4-6	1
5	Plug	SST 420 + CUSN 7	1
6	Stem	SST 304	1
7	Body	DIN1.7711 40CrMoV4-6 + SST 309	1
8	Seal Assembly	PTFE GCS847 +SST304	6
9	Lever	DIN1.7711 40CrMoV4-6	1
10	Flang 1 1/2"1500#	DIN1.7711 40CrMoV4-6	1
11	Pipe	ASTM A335 P22	1
12	Trust ring	PTFE GCS847	1
13	Spring	SST304	1
14	Spring Nut	SST304	1
15	Deep GROOVE BALL BEARING	6004 2RS	2
16	Socket head screw	SST304	4
17	Internal Retaining Ring	DIN 472 SST304	2



Standard Iso 2768-1					
Tolerance Class	0.5to3	3to6	6to30	30to120	120to400
f	±0.05	±0.05	±0.1	±0.15	±0.2
m	±0.1	±0.1	±0.2	±0.3	±0.5

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ITEM	Qty	Part Name	Material	Hardness	Mass	DWG NO.	REV

Client	Name	Date
Drawn	M.MIRZAEI	1403/03/03
Checked	M.MIRZAEI	1403/03/03
Approved	N.REZAEI	1403/03/03

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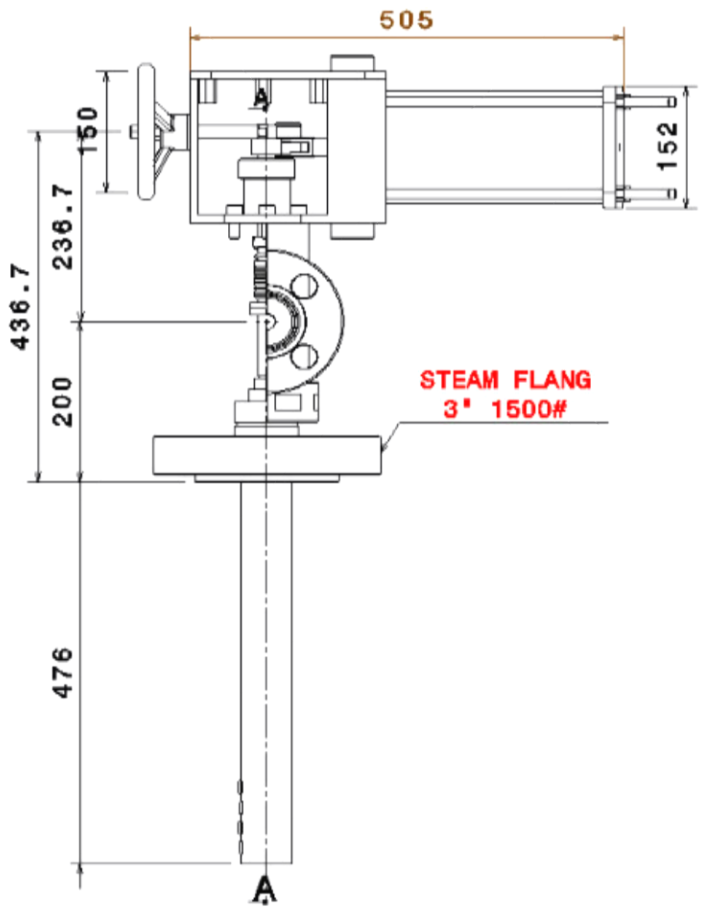
Scale: 1:3
Size: A4
Unit:mm & kg
Tolerance: Iso 2768-1f Iso 2768-1H

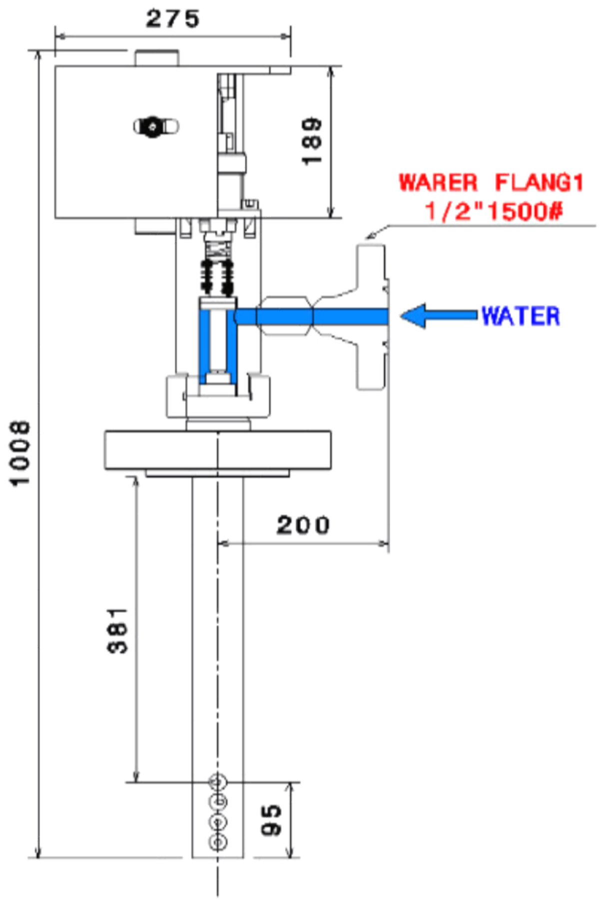
Sheet: 1of1
Project No. 14030424

Object DESUPERHEATER VALVE
Desoription VALVE ASSEMDLY

Ord.No. 00000
P/N. 000000
MOAC NO. ----------
TAG No. X-103



Left view
Scale: 1:6



Section view A-A
Scale: 1:6

Standard Iso 2768-1					
Tolerance Class	0.5to3	3to6	6to30	30to120	120to400
f	±0.05	±0.05	±0.1	±0.15	±0.2
m	±0.1	±0.1	±0.2	±0.3	±0.5

1	1	-	***	****	****	SFJJ/00/01	00
ITEM	Qty	Part Name	Material	Hardness	Mass	DWG NO.	REV

	Client		
		Name	Date
	Drawn	M.MIRZAEI	1403/03/03
Scale: 1:6	Checked	M.MIRZAEI	1403/03/03
Size: A4	Approved	N.REZAEI	1403/03/03
Unit:mm & kg	Sheet: 1of1	Object DESUPERHEATER VALVE	Ord.No. 00000
Tolerance:			P/N. 000000
Iso 2768-1f Iso 2768-1H	Project No. 14030424	Description Section view	MOC NO. ----------
			TAG No. X-103

Surin Fidar