VALVE BODY STRESS CALCULATION INDUCED PIPING FORCE

The purpose of this calculation will be of reference in order to find any possible causes in valve body crack during its installation works after lined piping. As well, related design condition and thermal stress load was assumed considering working practice condition.

2 MaterialA106-B or C.S3 Max.Tensile stress 4218.42 kg/cm^2 4 Max. Temperature difference, ΔT 20 oC5 Thermal expansion coefficient, α 0.012 mm/M.oC6 Carbon steel elastic coefficient ,E12,100,000 kg/cm^278 Valve materialDuctile iron(450Mpa)9 Max.tensile stress, $\sigma 1$ 4500 kg/cm^210 Ductile iron elastic coefficient,E22,050,000 kg/cm^21112 Thermal expansion length,L1=L* α * ΔT 24 mm13 Clearance between two flange,C3 mm14 Max. expansion, λ 27 mm15 Elongation, $\varepsilon = \lambda/L$ 0.000271611718 Max. stress(at piping), $\sigma = E^{\varepsilon}$ 553.5 kg/cm^219 Flange section area for bolting area A, M20(6EA)18.85 cm^220 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ *A10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ 23,321.0 kg/cm^224 Comparing with stress ratio between σ 1, σ 274%	1 Applied piping length,L	100 m
4 Max. Temperature difference, ΔT 20 oC5 Thermal expansion coefficient, α 0.012 mm/M.oC6 Carbon steel elastic coefficient ,E12,100,000 kg/cm^278 Valve materialDuctile iron(450Mpa)9 Max.tensile stress, $\sigma 1$ 4500 kg/cm^210 Ductile iron elastic coefficient,E22,050,000 kg/cm^2111112 Thermal expansion length,L1=L* α * ΔT 24 mm13 Clearance between two flange,C3 mm14 Max. expansion, λ 27 mm15 Elongation, ε = λ/L 0.000271611718 Max. stress(at piping), σ =E* ε 553.5 kg/cm^219 Flange section area for bolting area A, M20(6EA)18.85 cm^220 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ *A10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ 23,321.0 kg/cm^2	2 Material	A106-B or C.S
5Thermal expansion coefficient, α 0.012 mm/M.oC6Carbon steel elastic coefficient ,E12,100,000 kg/cm^277Ductile iron(450Mpa)9Max.tensile stress, σ 14500 kg/cm^210Ductile iron elastic coefficient,E22,050,000 kg/cm^2111112Thermal expansion length,L1=L* α * Δ T24 mm13Clearance between two flange,C3 mm14Max. expansion, λ 27 mm15Elongation, $\varepsilon = \lambda/L$ 0.0002716111718Max. stress(at piping), σ =E* ε 553.5 kg/cm^219Flange section area for bolting area A, M20(6EA)18.85 cm^220Allowable stress force in Valve,F1= σ 1*A84,823 kg21Max. Stress in piping,F2= σ *A10,433 kg22Available sectional one bolt area in body flange3.1 cm^223Induced stress due to integral force, σ 23,321.0 kg/cm^2	3 Max.Tensile stress	4218.42 kg/cm^2
6 Carbon steel elastic coefficient ,E12,100,000 kg/cm^27Ductile iron(450Mpa)9 Max.tensile stress, σ 14500 kg/cm^210 Ductile iron elastic coefficient,E22,050,000 kg/cm^211Thermal expansion length,L1=L* α * Δ T24 mm13 Clearance between two flange,C3 mm14 Max. expansion, λ 27 mm15 Elongation, $\varepsilon = \lambda/L$ 0.00027161718 Max. stress(at piping), $\sigma = E^*\varepsilon$ 553.5 kg/cm^219 Flange section area for bolting area A, M20(6EA)18.85 cm^220 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ^* A10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ 23,321.0 kg/cm^2	4 Max. Temperature difference,∆T	20 oC
7Note8 Valve materialDuctile iron(450Mpa)9 Max.tensile stress, $\sigma 1$ 4500 kg/cm^210 Ductile iron elastic coefficient,E22,050,000 kg/cm^2111212 Thermal expansion length,L1=L* α * Δ T24 mm13 Clearance between two flange,C3 mm14 Max. expansion, λ 27 mm15 Elongation, $\varepsilon = \lambda/L$ 0.00027161718 Max. stress(at piping), $\sigma = E^{\varepsilon}$ 553.5 kg/cm^219 Flange section area for bolting area A, M20(6EA)18.85 cm^220 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ *A10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ 23,321.0 kg/cm^2	5 Thermal expansion coefficient, α	0.012 mm/M.oC
8 Valve materialDuctile iron(450Mpa)9 Max.tensile stress, $\sigma1$ 4500 kg/cm^210 Ductile iron elastic coefficient,E22,050,000 kg/cm^2111212 Thermal expansion length,L1=L* α * Δ T24 mm13 Clearance between two flange,C3 mm14 Max. expansion, λ 27 mm15 Elongation, ε = λ /L0.00027161718 Max. stress(at piping), σ =E* ε 553.5 kg/cm^219 Flange section area for bolting area A, M20(6EA)18.85 cm^220 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ *A10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ 23,321.0 kg/cm^2	6 Carbon steel elastic coefficient ,E1	2,100,000 kg/cm^2
9 Max.tensile stress, $\sigma1$ 4500 kg/cm^210 Ductile iron elastic coefficient,E22,050,000 kg/cm^21112 Thermal expansion length,L1=L* α * Δ T24 mm13 Clearance between two flange,C3 mm14 Max. expansion, λ 27 mm15 Elongation, $\varepsilon=\lambda/L$ 0.00027161718 Max. stress(at piping), $\sigma=E^*\varepsilon$ 553.5 kg/cm^2219 Flange section area for bolting area A, M20(6EA)18.85 cm^2220 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ^*A 10,433 kg22 Available sectional one bolt area in body flange3.1 cm^2223 Induced stress due to integral force, $\sigma2$ 3,321.0 kg/cm^22	7	
10Ductile iron elastic coefficient,E2 $2,050,000 \text{ kg/cm}^2$ 1112Thermal expansion length,L1=L* α * Δ T24 mm13Clearance between two flange,C3 mm14Max. expansion, λ 27 mm15Elongation, $\varepsilon = \lambda/L$ 0.00027 1617181718Max. stress(at piping), $\sigma = E^{\varepsilon}$ 19Flange section area for bolting area A, M20(6EA)18.85 cm^220Allowable stress force in Valve,F1= σ 1*A84,823 kg21Max. Stress in piping,F2= σ *A10,433 kg22Available sectional one bolt area in body flange3.1 cm^223Induced stress due to integral force, σ 23,321.0 kg/cm^2	8 Valve material	Ductile iron(450Mpa)
1112 Thermal expansion length,L1=L* α * Δ T24 mm13 Clearance between two flange,C3 mm14 Max. expansion, λ 27 mm15 Elongation, $\varepsilon = \lambda/L$ 0.00027160.000271718 Max. stress(at piping), $\sigma = E^{\varepsilon}$ 553.5 kg/cm^219 Flange section area for bolting area A, M20(6EA)18.85 cm^220 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ^* A10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ 23,321.0 kg/cm^2	9 Max.tensile stress, σ1	4500 kg/cm^2
12 Thermal expansion length,L1=L* α * Δ T24 mm13 Clearance between two flange,C3 mm14 Max. expansion, λ 27 mm15 Elongation, $\varepsilon = \lambda/L$ 0.0002716-17-18 Max. stress(at piping), $\sigma = E^{\varepsilon}\varepsilon$ 553.5 kg/cm^219 Flange section area for bolting area A, M20(6EA)18.85 cm^220 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ *A10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ 23,321.0 kg/cm^2	10 Ductile iron elastic coefficient,E2	2,050,000 kg/cm^2
13 Clearance between two flange,C3 mm14 Max. expansion, λ 27 mm15 Elongation, $\varepsilon = \lambda/L$ 0.00027161718 Max. stress(at piping), $\sigma = E^{\varepsilon}$ 553.5 kg/cm^219 Flange section area for bolting area A, M20(6EA)18.85 cm^220 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ^* A10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ 23,321.0 kg/cm^2	11	
14 Max. expansion, λ 27 mm15 Elongation, $\varepsilon = \lambda/L$ 0.0002716171718 Max. stress(at piping), $\sigma = E^{\varepsilon}\varepsilon$ 553.5 kg/cm^219 Flange section area for bolting area A, M20(6EA)18.85 cm^220 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ^*A 10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ^2 3,321.0 kg/cm^2	12 Thermal expansion length,L1=L* α * Δ T	24 mm
15 Elongation, $\varepsilon = \lambda/L$ 0.0002716171718 Max. stress(at piping), $\sigma = E^*\varepsilon$ 553.5 kg/cm^219 Flange section area for bolting area A, M20(6EA)18.85 cm^220 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ^*A 10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ^2 3,321.0 kg/cm^2	13 Clearance between two flange,C	3 mm
161718 Max. stress(at piping), $\sigma = E^* \varepsilon$ 553.5 kg/cm^219 Flange section area for bolting area A, M20(6EA)18.85 cm^220 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ^* A10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ^2 3,321.0 kg/cm^2	14 Max. expansion, λ	27 mm
1718 Max. stress(at piping), $\sigma = E^* \epsilon$ 553.5 kg/cm^219 Flange section area for bolting area A, M20(6EA)18.85 cm^220 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ^* A10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ 23,321.0 kg/cm^2	15 Elongation, ε= λ/L	0.00027
18 Max. stress(at piping), $\sigma = E^* \epsilon$ 553.5 kg/cm^219 Flange section area for bolting area A, M20(6EA)18.85 cm^220 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ^* A10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ^2 3,321.0 kg/cm^2	16	
19 Flange section area for bolting area A, M20(6EA)18.85cm^220 Allowable stress force in Valve,F1= σ 1*A84,823kg21 Max. Stress in piping,F2= σ *A10,433kg22 Available sectional one bolt area in body flange3.1cm^223 Induced stress due to integral force, σ 23,321.0kg/cm^2	17	
20 Allowable stress force in Valve,F1= σ 1*A84,823 kg21 Max. Stress in piping,F2= σ *A10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ 23,321.0 kg/cm^2	18 Max. stress(at piping), σ=E*ε	553.5 kg/cm^2
21 Max. Stress in piping,F2= σ^*A 10,433 kg22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ^2 3,321.0 kg/cm^2	19 Flange section area for bolting area A, M20(6EA)	18.85 cm^2
22 Available sectional one bolt area in body flange3.1 cm^223 Induced stress due to integral force, σ23,321.0 kg/cm^2	20 Allowable stress force in Valve,F1=σ1*A	84,823 kg
23 Induced stress due to integral force, σ^2 3,321.0 kg/cm^2	21 Max. Stress in piping,F2=σ*A	10,433 kg
	22 Available sectional one bolt area in body flange	3.1 cm^2
24 Comparing with stress ratio between $\sigma 1$, $\sigma 2$ 74%	23 Induced stress due to integral force, $\sigma 2$	3,321.0 kg/cm^2
	24 Comparing with stress ratio between σ 1, σ 2	74%

As shown on stress calculation comparing between piping and valve material, Induced thermal stress force is nearly close to assumed maximum tensile stress for ductile iron valve.

Also, this force may be enough able to cause embrittlement crack considering ductile iron's less tough value in mechanical properties and its characteries.

Prepared By Ryu-ChangMyong/ Professional Engineer in Mechanical