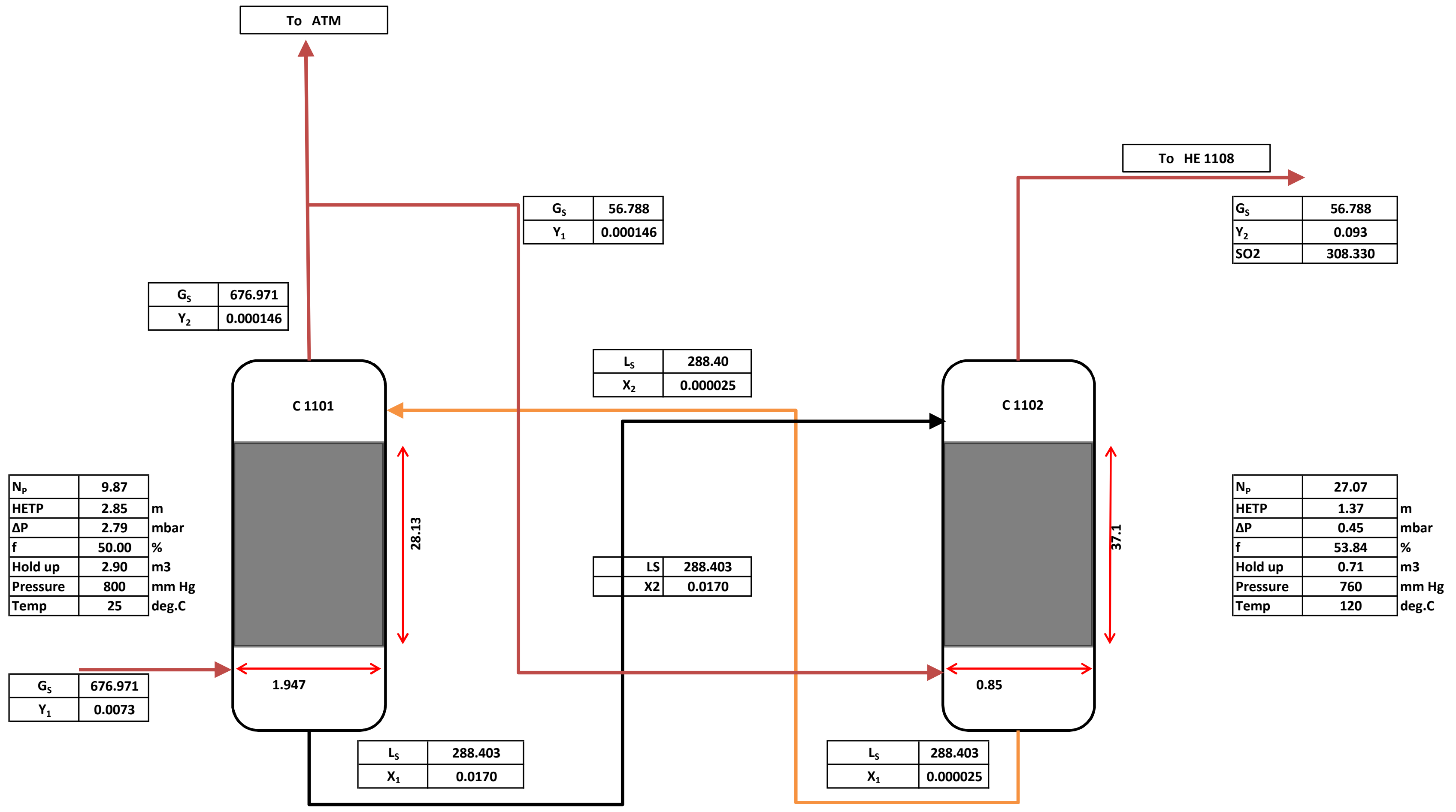

Absorber

Gas Phase

Mass flow rate	G	19420	kg/hr
Mol flow rate	G_S	676.9714	kg mol/hr
Avg. molecular weight		28.6866	kg/kg.mol
Operating pressure		800	mm of Hg
Operating temperature		25	deg.C
Density of the gas	ρ_g	1.2349	kg/m3
Wt of SO2 in gas inlet		315	kg/hr
Mol. Weight of SO2 in gas inlet		64	kg/kg.mol
No of moles of SO2 in gas inlet		4.921875	kg mol/hr
Mole fraction of SO2 in gas inlet		0.007270433	
Mole ratio of SO2 in gas inlet	**Y1**	**0.007323679**	
Absorption rate		98	%
No of moles of SO2 in gas outlet		0.0984375	
Mole fraction of SO2 in gas outlet		0.000145409	
Mole ratio of SO2 in gas outlet	**Y2**	**0.000146**	

Liquid Phase

Solubility of SO2 in solvent @ 25deg.C		280	cm3/g.bar
		0.28	lit/g.bar
No of moles of SO2		0.0125	gmol/g.bar
Mol wt of solvent (solvent 1900)		230	kg/kg.mol
		230	g/g.mol
Density of Solvent (solvent 1900)	ρ_l	1004.25	kg/m3
		1.0043	g/cm3 (kg/lit)
		0.0124	g.mol/cm3.bar
Henry constant		80.34	cm3.bar / gmol
Operating pressure		800	mm of Hg
		1.0666	bar
Slope of the equilibrium line	**m**	0.3289	
At the equilibrium condition,			
Mole ratio of SO2 in solvent @ inlet	**X1**	0.0223	
Mole ratio of SO2 in solvent @ outlet	**X2**	0.0004	

Absorber Material Balance

LS (X1 - X2) = GS (Y1 - Y2)

Mole flow rate of liquid		222.6508	kg mol/hr
Mole fraction of SO2 in solvent		0.0218	
No of moles of SO2		4.8499	kg mol/hr
No of moles of solvent		217.8009	kg mol/hr
Mass flow rate of Gebosorb		50094.2115	kg/hr
Mass flow rate of SO2		310.3952	kg/hr
Total Mass flow rate		50404.6067	kg/hr
Average molecular weight		210.0000	kg/kg.mol
L/G ratio Minimum (in terms of moles)		0.3289	
L/G ratio considered		1.2	
		0.3947	
Mole flow rate of liquid reuired	L_S	**288.403**	kg mol/hr
Mass flow rate of liquid reuired	L	**60564.679**	kg/hr
At operating L/G			
No of moles of SO2 absorbed		4.8234	kg mol/hr
Mole fraction of SO2 in liquid outlet		0.0167	
Mole ratio of SO2 in liquid outlet	**X1**	**0.0170**	
No of moles of SO2 in liquid inlet		0.0072	
Mole fraction of SO2 in liquid inlet		0.000025	
Mole ratio of SO2 in liquid inlet	**X2**	**0.000025**	

Physical Properties

Gas Phase

Density	ρ_g	1.2349	kg/m3
Viscosity	μ_g	0.0167	cp
		0.0000167	Pa.s (N.S/m2)

Liquid Phase

Density	ρ_l	1004.25	kg/m3
Viscosity	μ_l	3.6175	cp
		0.0036175	Pa.s (N.S/m2)
Surface tension	σ_l	34	dyne/cm
		0.034	N/m (kg/s2)
Gravitional constant	g_c	9.82	m/s2

Column Diameter Calculation

Abscissa		**(L/G) X (ρ_g/ρ_l)^0.5**	
Abscissa		0.109363271	
By the G.P.D.C method			
At the flooding point,			
Ordinate (ref.col & rich Vol 6 Fig 11.44)	Є	3.25	

Packing Data

Type of the Packing		Pall Ring	
Size of the packing		2.0"	

Stripper

Solubility of SO2 in solvent @ 120 deg.C

P = aK + bK^2 + cK^3 + dK^4

P is in bar & X is in WT%			
Operating pressure of the system	**P**	760	mm of Hg
Operating temp of the system		120	deg.C
Assume, wt percent of solute	**K**	3.9	%
		1.004	bar
Consider,			
Weight of the solution		100	gram
Wt of Solute		3.9	gram
Wt of solvent		96.1	gram
Density of solvent		0.9125	g/cc
Volume of the solution		105.3151	cm3
Concentration of solute @ 1 bar		0.037	gram/cm3.bar
Henry constant		0.001	gram mol/cm3.bar
		1728.247	
Molecular weight of solvent		230	gram/gram mole
Slope of the equilibrium line	**m**	6.86	
Mole fraction of solute in liquid inlet	**x2**	0.0167	
By Henry's law,			
Mole fraction of solute in equilibrium	**y2**	0.1147	
Mole ratio of solute in gas outlet	**Y2**	0.1295	
Mole ratio of solute in gas inlet	**Y1**	0.000146	
Mole ratio of solute in liquid inlet	**X2**	0.01701	
Mole ratio of solute in liquid outlet	**X1**	0.00003	
Mass flow rate of liquid	**L**	60564.679	kg/hr
	LS	288.403	kgmol/hr

Stripper Material Balance

GS(Y2-Y1) = LS(X2-X1)

Mol flow rate of gas		37.86	kgmol/hr
No of moles of SO2 in gas outlet		4.82	kgmol/hr
Weight of SO2 in gas outlet		308.33	kg/hr
L/G ratio Minimum (in terms of moles)		7.62	
L/G ratio considered		**1.5**	
		5.08	
Mole flow rate of gas reuired	**GS**	56.79	kgmol/hr
Mass flow rate of gas reuired	**G**	1628.69	kg/hr
At operating L/G			
No of moles of SO2 stripped		4.82	kgmol/hr
Mole fraction of SO2 in gas outlet		0.0848	
Mole ratio of SO2 in gas outlet	**Y2**	0.0927	

Physical Properties

Gas Phase

Density	ρ_g	0.889	kg/m3
Viscosity	μ_g	0.018	cp
		0.000018	Pa.s (N.S/m2)

Liquid Phase

Density	ρ_l	912.5	kg/m3
Viscosity	μ_l	0.6	cp
		0.0006	Pa.s (N.S/m2)
Surface tension	σ_l	25	dyne/cm
		0.025	N/m (kg/s2)
Gravitional constant	g_c	9.82	m/s2

Column Diameter Calculation

Abscissa		**(L/G) X (ρ_g/ρ_l)^0.5**	
Abscissa		1.160689785	
By the G.P.D.C method			
At the flooding point,			
Ordinate (ref.col & rich Vol 6 Fig 11.44)	Є	0.7	

Packing Data

Type of the Packing			Pall Rings	
Size of the packing			2"	
MOC of the packing			Plastic	
Packing dimension	dia		50	mm
	ht		50	mm
Packing Factor		**F**	25	ft2/ft3
		a	82	m2/m3
Hydraulic Diameter	**(4€)/(a)**	D_h	0.044878049	m
Void fraction		**€**	0.92	
Surface area			101.68	m2/m3

Equation for clculating ordinate 9Ref: Colusol & rich Vol 6 equ.11.118)

Є = (13.1 X G'^2 X F X (μ_l/ρ_l)^0.1) / $(\rho_g$ X $(\rho_l-\rho_g))$

By rearranging the equation

Flexera
CONSULTING

MOC of the packing			Plastic	
Packing dimension	dia		50	mm
	ht		50	mm
Packing Factor		**F**	25	ft2/ft3
		a	82	m2/m3
Hydraulic Diameter	**(4€)/(a)**	**D_h**	0.044878049	m
Void fraction		**€**	0.92	
Surface area			101.68	m2/m3
Equation for clculating ordinate 9Ref: Colusol & rich Vol 6 equ.11.118)				
	Є = (13.1 X G'^2 X F X (μ_l/ρ_l)^0.1) / (ρ_g X (ρ_l-ρ_g))			
By rearranging the equation				
	G' = ((Є X ρg X (ρl - ρg)) / (13.1 X F X (μ_l/ρ_l)^0.1))^0.5			
Gas superficial velocity @ flooding		**G'**	3.622819634	kg/s.m2
Flooding rate considered		**f**	50	%
Gas superficial velocity @ operating		**G' oper.**	1.811	kg/s.m2
Tower cross sectional area		**A_T**	2.978	m2
Tower diameter		**D_T**	**1.947**	**m**
Ordinate value for the G' operating		**Є**	0.8125	
From the fig 11.44 (cou & rich)				
Pressure drop			25	mm water / m
No of thertical stage Calculation				
Absorption factor	**(L_S / (m.G_S)**	**A**	1.295316154	
		1/A	0.7720	
		1 - (1/A)	0.22799	
No of theoretical stages		**N_P**	**9.8658**	
HETP Calculation				
Liquid superficial velocity		**L_V**	0.0056	m3/m2.sec
Gas superficial velocity		**W_O**	1.4668	m3/m2.sec
	(4$L_V\rho_l$)/(aμ_l)	**R_{eL}**	76.1771	
	(L_V^2.a)/(g_c)	**F_{rL}**	0.0003	
	(L_V^2.ρ_l)/(σ_l.a)	**W_{eL}**	0.0114	
Effective surface area				
	1.5.a.(a.D_h)^-0.5.R_{eL}^-0.2.W_{el}^0.75.F_{re}^-0.45	**a_e**	38.3133	m2/m3
Diffusivity of solute in liquid phase		**D_L**	0.000000001	m2/s
Diffusivity of solute in gas phase		**D_G**	0.000012543	m2/s
Diffusivity of solute in liquid phase calculation				
(Ref: Wilke Chang equation)				
	D^0_{AB} = (1.173 X 10^(-13) X (Φ.M)^0.5 X T) / (μ X Va^0.6)			
Molar volume of SO2 (ref: cou & rich vol6)		**Va**	0.0448	m3/kgmol
Association factor of solvent		**Φ**	1	
Diffusivity		**D^0_{AB}**	9.44502E-10	m2/s
Liquid side mass transfer co efficient		**K_L**	**5.64565E-05**	m/s
	KL = 0.0051.(g_c.μ_l/ρ_l)^(1/3).((L.ρ_l)/(a_e.μ_l))^(2/3).((D_L.ρ_l)/(μ_l))^(1/2).(a.d_p)^0.4			
	μ_g/(ρ_g.D_G)	**S_{CG}**	1.0781	
Gas side mass transfer co efficient		**K_G**	**0.0502**	m/s
	KG = 5.23.D_G.(a.((ρ_g.W_o)/(a.μ_g))^0.7.(S_{CG})^(1/3).(a.d_p)^(-2)			
	(L_V/(K_L.a_e)	**H_L**	2.601	m
	(W_o/(K_G.a_e)	**H_G**	0.762	m
Height Equivalent Theoretical Plate		**H_{OG}**	**2.85**	m
Total packing height		**Z**	**28.13**	m
Pressure Drop Calculation				
	Re_G = w_0*d_h* ρ_g / μ_g*€	**R_{eG}**	5291.105	
	((37/$Re_{G)}$ +(0.113/(ReG^$^{0.1}$)))*(h_p/D_h)^$^{-0.51}$*€^$^{-3.42}$	**Ψ**	0.0691	
	2Ψ $w_0^2\rho_g$ / d_h.€^2	**ΔP_O/H**	6.5948	Pa
	3.17*(R_{eL})^(-0.098)*(F_{rL})^(0.37)*€^(-2.47)	**A_O**	0.1208	
		ΔA	0.0065	
	ΔA =3.48*10^(-4) *((W_O/€)^2/(gd_h))^(1.69)(L_V^2a/g)^(0.087) (L_V.ρ_l /$\rho_g W_0$)^(0.483).(h_p/D_h)^(-1.17).€^(-3.04)			
		A	0.13	
	ΔP/H = (ΔP_0/H)/(1-A)^3	**ΔP/H**	9.92	Pa
		ΔP	**279.11**	**Pa**
Total pressure drop across packing			**2.79**	**mbar**
			28.46	mm water
Liquid Hold up				
Ref: Fluid Dynamics of packed Columns equ: 4.20 & 4.21				
	h_L = (3/8)^(1/3)*a^(2/3)*(v_L*L_V)^(1/3) - (4.20)	**h_L**	**0.0347**	
Kinematic viscosity		**v_L**	0.0000036	m2/s
	h_L = 2.2 * (F_{rL}/R_{eL})^(1/3)	**h_L**	0.0333	
Packing volume			83.77	m3
Liquid hold up required		**h_L**	**2.9032**	m3
Column height required for hold up			0.97	m

	G' = ((Є X ρg X (ρl - ρg)) / (13.1 X F X (μ_l/ρ_l)^0.1))^0.5			
Gas superficial velocity @ flooding		**G'**	1.481	kg/s.m2
Flooding rate considered		**f**	60	%
Gas superficial velocity @ operating		**G' oper.**	0.8884	kg/s.m2
Tower cross sectional area			0.5092	m2
Tower diameter		**D_T**	0.8052	m
			0.85	**m**
Tower cross sectional area		**A_T**	0.5675	m2
		G' oper.	0.7973	kg/s.m2
		f	53.8445	%
Ordinate value for the G' operating		**Є**	0.2029	
No of thertical stage Calculation				
Absorption factor	**(L_S / (m.G_S)**	**A**	0.7407	
		1-A	0.2593	
No of theoretical stages		**N_P**	**27.0651**	
HETP Calculation				
Liquid superficial velocity		**L_V**	0.0325	m3/m2.sec
Gas superficial velocity		**W_O**	0.2282	m3/m2.sec
	(4$L_V\rho_l$)/(aμ_l)	**R_{eL}**	2410.3720	
	(L_V^2.a)/(g_c)	**F_{rL}**	0.0088	
	(L_V^2.ρ_l)/(σ_l.a)	**W_{eL}**	0.4699	
Effective surface area				
	1.5.a.(a.D_h)^-0.5.R_{eL}^-0.2.W_{el}^0.75.F_{re}^-0.45	**a_e**	237.1697	m2/m3
Diffusivity of solute in liquid phase		**D_L**	0.000000008	m2/s
Diffusivity of solute in gas phase		**D_G**	0.000012543	m2/s
Diffusivity of solute in liquid phase calculation				
(Ref: Wilke Chang equation)				
	D^0_{AB} = (1.173 X 10^(-13) X (Φ.M)^0.5 X T) / (μ X Va^0.6)			
Molar volume of SO2 (ref: cou & rich vol6)		**Va**	0.0448	m3/kgmol
Association factor of solvent		**Φ**	1	
Diffusivity		**D^0_{AB}**	7.50994E-09	m2/s
Liquid side mass transfer co efficient		**K_L**	**0.000627**	**m/s**
	KL = 0.0051.(g_c.μ_l/ρ_l)^(1/3).((L.ρ_l)/(a_e.μ_l))^(2/3).((D_L.ρ_l)/(μ_l))^(1/2).(a.d_p)^0.4			
	μ_g/(ρ_g.D_G)	**S_{CG}**	1.6143	
Gas side mass transfer co efficient		**K_G**	**0.0118**	**m/s**
	KG = 5.23.D_G.(a.((ρ_g.W_o)/(a.μ_g))^0.7.(S_{CG})^(1/3).(a.d_p)^(-2)			
	(L_V/(K_L.a_e)	**H_L**	0.2184	m
	(W_o/(K_G.a_e)	**H_G**	0.1682	m
Height Equivalent Theoretical Plate		**H_{OG}**	1.3715	m
Total packing height		**Z**	**37.1191**	**m**
Pressure Drop Calculation				
	Re_G = w_0*d_h* ρ_g / μ_g*€	**R_{eG}**	549.8448	
	((37/$Re_{G)}$ +(0.113/(ReG^$^{0.1}$)))*(h_p/D_h)^$^{-0.51}$*€^$^{-3.42}$	**Ψ**	0.1604	
	2Ψ $w_0^2\rho_g$ / d_h.€^2	**ΔP_O/H**	0.3910	Pa
	3.17*(R_{eL})^(-0.098)*(F_{rL})^(0.37)*€^(-2.47)	**A_O**	0.3153	
		ΔA	0.0001	
	ΔA =3.48*10^(-4) *((W_O/€)^2/(gd_h))^(1.69)(L_V^2a/g)^(0.087) (L_V.ρ_l /$\rho_g W_0$)^(0.483).(h_p/D_h)^(-1.17).€^(-3.04)			
		A	0.3155	
	ΔP/H = (ΔP_0/H)/(1-A)^3	**ΔP/H**	1.2189	Pa
		ΔP	**45.2449**	**Pa**
Total pressure drop across packing			**0.4524**	**mbar**
			4.6137	mm water
Liquid Hold up				
Ref: Fluid Dynamics of packed Columns equ: 4.20 & 4.21				
	h_L = (3/8)^(1/3)*a^(2/3)*(v_L*L_V)^(1/3) - (4.20)	**h_L**	0.0378	
Kinematic viscosity		**v_L**	0.0000	m2/s
	h_L = 2.2 * (F_{rL}/R_{eL})^(1/3)	**h_L**	0.0339	
Packing volume			21.0632	m3
Liquid hold up required		**h_L**	**0.7139**	**m3**
Column height required for hold up			1.26	m