

CENTRIFUGAL COMPRESSOR CALCULATION SHEET

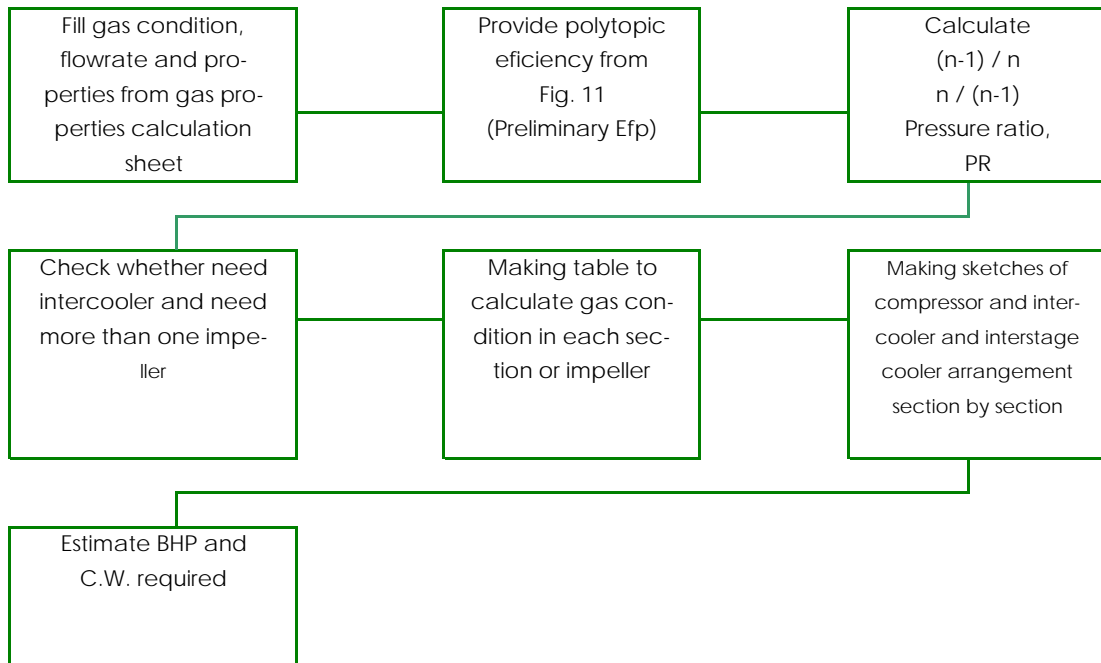
A. WITH CONSIDERING DETAIL OF IMPELLER

INPUT GIVEN CONDITION OR QUANTITY IN RED COLOR CELLS

WITH INTERCOOLER

INTEGRALLY GEARED CENTRIFUGAL COMPRESSOR

FLOW CHART



Gas properties, flowrate and conditions

(Sheet : 1 Of)

1	Gas name	Air				
	Item or symbol	Quantity	Unit	Item or symbol	Quantity	Unit
2	Suction pressure, ps	1.0132	bar A	Discharge pressure, pd	38.2	bar A
3	Suction temperature, ts	35	$^{\circ}\text{C}$			
4	Ts	308	$^{\circ}\text{K}$	P_{CR}	47.88	bar A
5	MW	28.4	kg/kgmol	T_{CR}	161.38	$^{\circ}\text{K}$
6	k_s	1.391		$P_R = P / P_{CR}$	0.02	
7	R_s	0.292	kJ/kg. $^{\circ}\text{K}$	$T_R = T / T_{CR}$	1.91	
8	DSs	1.125	kg/m ³	Z_s	1.00	
9	MCp	29.10	kJ/kgmol. $^{\circ}\text{K}$	C_{p_s}	1.04	kJ/kg
10	G	60840	kg/hr	G_{mol}	2560	kgmol/hr
11	Q_s	54150	m ³ /hr	Q_N	48000	Nm ³ /hr
12						

Compressor Calculation Sheet

Item	Symbol	Unit	Quantity	Note	
13					
14	<u>Check whether need intercooler</u>				
15	First Stage Volume flow	Qs	m3/hr	54150	
16	Preliminary Efficiency		0.787	Figure 11	
17	Total Pressure ratio (p _D / p _s)	PR	-		37.702
18	(n-1)/n = (k-1)/k.EF _p	(n-1) / n	-		0.3572
19	n/(n-1) = k.EF _p /(k-1)	n / (n-1)	-	2.800	
20	Max. temperature	t _{MAX}	°C	180	SeeChapter VI. For mechanical seal
21		T _{MAX}	°K	453	
22	PR _{STGMAX}	(p _D / p _s) _{MAX}	-	2.95	Equation (11)
23	Is PR < (p _D / p _s) _{MAX}		No	If No, need intercooler and use this sheet	
24					
25	<u>Check number of casing</u>				
26					
27	Total Hydrodynamic head	H _{TOTAL}	m	68272.7	Equation (7)
28	Total polytropic head	H _{pTOTAL}	m	86750.5	Equation (9)
29	Average tip speed	U _{avg}	m/s	310	As per appendix B.1. at MW
30	Max. tip speed (=0.9.a)	U _{max.}	m/s	319	where a=(1000.k.Z.R.T) ^{0.5}
31	Preliminary tip speed selected	U	m/s	310	
32	Preliminary head factor, Y			1.40	See appendix B.
33	Polytropic head / impeller at Y =1.05	H _{pi}	m	6857.3	Equation (14)
34	Preliminary est. of total no. of impeller	i _{TOTAL}		10	I = H _{pTOTAL} / H _{pi} in integer number
35					
36					
37					
38					
39					

Note : 1. Integrally gear centrifugal compressor is usually use 3 dimension unshrouded impellers

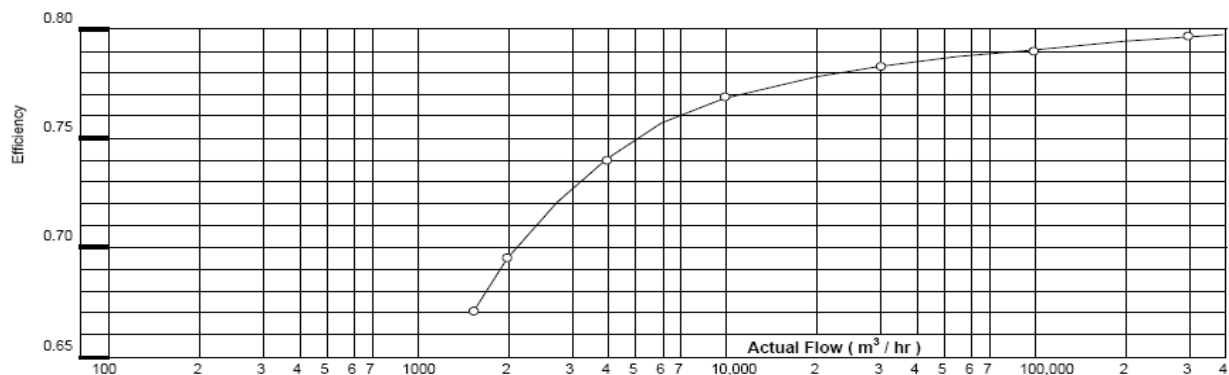
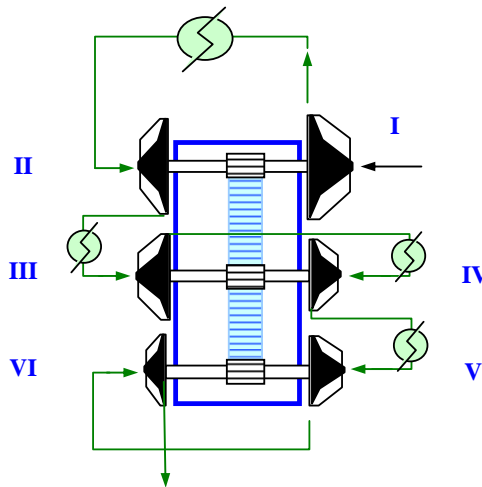
Compressor Calculation Sheet (Cont.)

(Sheet : 2 Of)

	Item	1'st impeller	2'nd impeller	3'rd impeller	4'th impeller	5'th impeller	6'th impeller	7'th impeller		
1										
2	Compressor discharge press.	38.20	38.20	38.20	38.20	38.20	38.20	38.20		
3	Max. discharge temp., tdmax (C)	180	180	180	180	180	180	180		
4	0.9 x Sound velocity, 0.9 a (m/s)	318.7	321.6	321.6	321.6	321.1	320.8	#VALUE!		
5	Tip speed as per appendix B.1	310	310	310	310	310	310	310		
6	Select tip speed, U (m/s)	310	315	315	315	280	280	280		
7	Estimate flow coef., CQ	0.10	0.10	0.10	0.10	0.10	0.10	0.10		
8	Estimated diameter, D (mm)	785.9	799.0	410.9	411.1	223.9	224.0	129.9		
9	Max. speed, Nmax (RPM)	7533	7533	14641	14641	23888	23888	41153		
10	Rated speed, Nrated (RPM)	7533	7533	14641	14641	23888	23888	41153		
11	Estimated head coef., Y	1.40	1.40	1.40	1.40	1.40	1.40	1.40		
12	Head per impeller, Hi (m)	6857	7080	7080	7080	5594	5594	5594		
13	Pol. Eff., EFp at CQ=0.09 (fig.14)	0.780	0.780	0.780	0.780	0.780	0.780	0.805		
14	Correction factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
15	Efficiency, EFp	0.780	0.780	0.780	0.780	0.780	0.780	0.805		
16	ps (barA)	1.0132	1.912	3.692	7.175	13.993	24.084	41.579		
17	Ts (K)	308.0	318.0	318.0	318.0	318.0	318.0	-		
18	pcr (barA)	47.88	47.88	47.88	47.88	47.88	47.88	47.88		
19	Tcr (K)	161.38	161.38	161.38	161.38	161.38	161.38	161.38		
20	PR ED	0.0212	0.040	0.077	0.150	0.292	0.503	0.868		
21	T RED	1.9085	1.971	1.971	1.971	1.971	1.971	#VALUE!		
22	Zs	1	1	1	1	0.997	0.995	1		
23	MW	28.40	28.97	28.97	28.97	28.97	28.97	28.97		
24	R	0.29	0.29	0.29	0.29	0.29	0.29	0.29		
25	MCp	29.10	29.158	29.158	29.158	29.158	29.158	29.158		
26	ks	1.39	1.399	1.399	1.399	1.399	1.399	1.399		
27	(n-1)/n	0.360	0.366	0.366	0.366	0.366	0.366	0.354		
28	n/(n-1)	2.775	2.736	2.736	2.736	2.736	2.736	2.823		
29	Discharge pres. pd , equation 7.	1.962	3.742	7.225	14.043	24.134	41.579	#VALUE!		
30	Pressure ratio, PR	1.936	1.957	1.957	1.957	1.725	1.726	#VALUE!		
31	Is compression continued ?	Continue	Continue	Continue	Continue	Continue	Stop	#VALUE!		
32	Td	390.8	406.5	406.5	406.5	388.1	388.3	#VALUE!		
33	Discharge temp., td (C)	117.8	133.5	133.5	133.5	115.1	115.3	#VALUE!		
34	G	60840.0	60840.0	60840.0	60840.0	60840.0	60840.0	60840.0		
35	DSs	1.125	2.054	4.045	7.862	15.333	26.390	37.316		
36	Qs (m3/hr)	54150.0	29625.1	15040.0	7738.2	3968.0	2305.4	1337.0		
37	Discharge density, DSd	1.715	3.208	6.194	12.038	21.667	37.316	#VALUE!		
38	Discharge flow , Qd (m3/hr)	35480.2	18967.6	9822.7	5053.9	2807.9	1630.4	#VALUE!		
39	Is between impeler need in-	Yes	Yes	Yes	Yes	Yes	No	#VALUE!		
40	tercooler ?									
41	Intercooler press. Drop (bar)	0.050	0.050	0.050	0.050	0.050	0.050	0.050		
42	Gas temp. outlet intercooler (C)	45	45	45	45	45	45	45		
43	Density outlet intercooler (kg/m3)	2.054	4.045	7.862	15.333	26.390	45.506	#VALUE!		
44	Vol. flow outlet intercooler (m3/h)	29625.1	15040.0	7738.2	3968.0	2305.4	1337.0	#VALUE!		
45	GHP (kW)	1457.5	1504.9	1504.9	1504.9	1189.1	1189.1	0.0		
46	MCp of discharge gas	29.600	29.380	29.380	29.380	29.340	29.530	0.000		
47	Cp of discharge gas	1.042	1.014	1.014	1.014	1.013	1.019	0.000		
48	C.W. required per-impeller, ton/hr	111	131	131	131	104	0	#VALUE!		
49	Mech. losses factor : RL	1.675	0.756	0.400	0.150	0.130	0.070			
50	RD	2.100	1.800	1.000	0.600	0.530	0.250			
51	Mech. Losses (kW), brgs.	95.1	42.9	85.7	32.2	74.2	39.945			
52	Mech. Seal	158.2	135.6	146.4	87.8	126.6	59.7			
53	Total BHP	9434.759								

- Note :** 1. If any cell contain "**#VALUE!**" in a column, this column shall be neglected because compression has finished
2. C.W. for aftercooler to be calculated separately
3. **Trial and error** is required in line no. 6 of sheet no. 2 in the range of values in line 4 and 5 untill discharge pressure is equal or little higher than specified pressure
4. There are hidden supporting column : Column F, H, J, L, N, P, R of this original sheet. Don't delete. Those columns are containing calculation that assumed without intercooler
5. In addition to note 3, white letter in red cell is input with adjusment if necessary.

Sketch



Copy of fig. 11. Preliminary efficiency estimation used for line no. 16 sheet no. 1

Gas or Vapor Name	Hydrocarbon Refer. Symbols	Chemical formula	MW (kg/kgmol)	k at 15.5 °C	Critical condition		MCp (kJ/kgmol.°K)		
					P _{CR} (bar A)	T _{CR} (°K)	at 0 °C	at 100 °C	at 197 °C
Acetylene	C ₂ =	C ₂ H ₂	26.04	1.24	62.4	309.4	42.16	48.16	53.17
Air (dry)		N ₂ +O ₂	28.97	1.4	37.7	132.8	29.05	29.32	-
Ammonia		NH ₃	17.03	1.31	112.8	406.1	34.65	37.93	-
Argon		Ar	39.94	1.66	48.6	151.1	20.79	20.79	20.79
Benzene		C ₆ H ₆	78.11	1.12	49.2	562.8	74.18	103.52	-
Iso-Butane	iC ₄	C ₄ H ₁₀	58.12	1.1	36.5	408.3	89.75	116.89	141.88
n-Butane	nC ₄	C ₄ H ₁₀	58.12	1.09	38	425.6	93.03	117.92	141.04
Iso-Butylene	iC ₄ _	C ₄ H ₈	56.1	1.1	40	418.3	83.36	104.96	124.87
Butylene	nC ₄ _	C ₄ H ₈	56.1	1.11	40.2	420	83.4	105.06	-
Carbon Dioxide		CO ₂	44.01	1.3	74	304.4	36.04	40.08	43.7
Carbon Monoxide		CO	28.01	1.4	35.2	134.4	29.1	29.31	29.63
Chlorine		Cl ₂	70.91	1.36	77.2	417.2	35.29	35.53	35.9
Coke Oven Gas ¹⁾		-	10.71	1.35	28.1	109.4	31.95	34.21	-
n-Decane	nC ₁₀	C ₁₀ H ₂₂	142.28	1.03	22.1	619.4	218.35	280.41	-
Ethane	C ₂	C ₂ H ₆	30.07	1.19	48.8	305.6	49.49	62.14	74.37
Ethyl Alcohol		C ₂ H ₅ OH	46.07	1.13	63.9	516.7	69.92	81.97	-
Ethyl chloride		C ₂ H ₄ Cl	64.52	1.19	52.7	460.6	59.61	70.16	-
Ethylene	C ₂ _	C ₂ H ₄	28.05	1.24	51.2	283.3	40.9	51.11	60.55
Flue Gas ¹⁾		-	30	1.38	38.8	146.7	30.17	30.98	-
Helium		He	4	1.66	2.3	5	20.79	20.79	20.79
n-Heptane	nC ₇	C ₇ H ₁₆	100.2	1.05	27.4	540.6	161.2	202.74	239.8
n-Hexane	nC ₆	C ₆ H ₁₄	86.17	1.06	30.3	508.3	138.09	174.27	206.88
Hydrogen		H ₂	2.02	1.41	13	33.3	28.67	29.03	29.25
Hydrogen Sulfide	C ₁	H ₂ S	34.08	1.32	90	373.9	33.71	35.07	36.88
Methane		CH ₄	16.04	1.31	46.4	191.1	34.5	40.13	44.64
Methyl Alcohol		CH ₃ OH	32.04	1.2	79.8	513.3	42.67	55.32	-
Methyl Chloride		CH ₃ Cl	50.49	1.2	66.7	416.7	45.6	49.82	-
Natural Gas ¹⁾		-	18.82	1.27	46.5	210.6	34.66	39.54	-
Nitrogen		N ₂	28.02	1.4	33.9	126.7	29.1	29.31	29.46
n-Nonane	nC ₉	C ₉ H ₂₀	128.25	1.04	23.8	596.1	197.07	253.1	-
Iso-Pentane	iC ₅	C ₅ H ₁₂	72.15	1.08	33.3	461.1	112.09	145.56	-
n-Pentane	nC ₅	C ₅ H ₁₂	72.15	1.07	33.7	470.6	115.21	145.94	173.96
Pentylene	C ₅ _	C ₅ H ₁₀	70.13	1.08	40.4	474.4	102.11	130.37	-
n-Octane	nC ₈	C ₈ H ₁₈	114.22	1.05	25	569.4	176.17	226.17	-
Oxygen		O ₂	32	1.4	50.3	154.4	29.17	29.92	30.78
Propane	C ₃	C ₃ H ₈	44.09	1.13	42.5	370	68.34	88.68	107.71
Propylene	C ₃ _	C ₃ H ₆	42.08	1.15	46.1	365.6	60.16	75.7	90.54
Blast Furnace Gas ¹⁾		-	29.6	1.39	-	-	29.97	30.64	-
Cat Cracker Gas ¹⁾		-	28.83	1.2	46.5	286.1	46.16	57.31	-
Sulphur Dioxide		SO ₂	64.06	1.24	78.7	430.6	38.05	40	45.7
Water Vapor		H ₂ O	18.02	1.33	221.2	647.8	33.31	34.07	34.9

Note : For MCp, use linier interpolation to determine MCp at other temperature.

