GAZİ UNIVERSITY
ENGINEERING FACULTY
DEPARTMENT OF CHEMICAL ENGINEERING

KM451E
CHEMICAL ENGINEERING DESIGN I

ASSIGMENT I:
PIPELINE AND INTERMEDIATE TANK DESIGN

DELIVERED DATE : **23.10.2013**
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ANKARA 2013

ABSTRACT

In this design report the aim was transporting the product which is methanol, intermediate tank to main storage tanks. To product methanol we will use main components of synthesis gas which are carbon monoxide and hydrogen. It is planned to build the methanol plant with a capacity of 180 000 tons/year.

To carry out this aim we planted intermediate tank first and then we built pipe line between intermediate tank and main storage tanks. We built the system using about 300 m pipe length. The main storage tanks located at an altitude of 20 m from intermediate tanks. But there is an important point, Za-Zb will not 20m because of the main storage tanks height.

In this design, firstly we researched methanol properties and also is methanol corrosive matter. Then we decided to use carbon steel as pipe and tank material. By using carbon steel material we calculated optimum pipe diameter for pipeline system and also optimum h/D ratio for intermediate tank. To go on calculatins we roughly calculated the heights of main storage tanks.

Before calculations we decided to use 2 centrifuge pumps, 8 gate valves, 2 globe valves in bypass, 1 control valve to control flow rate, 2 check valves to make system safe, 3 filters for tanks, 7 tees, 13 90^o elbows and 2 45^o elbows and did calculations on this way.

To calculate optimum pipe diameter, we used all avaible standart pipe diameters on Excel program, and we calculated pump cost, pipe cost and total cost. By looking total costs we decided optimum pipe diameter as 3 ½ inch. And also we graphed diameter versus pump cost, pipe cost, total cost and optimum diameter shown as Figure 6. We found pump cost as 9703, pipeline cost as 6920 TL, and total cost as 16624 TL.

On intermediate tank calculations, optimum h/D ratio is found as 1,5 and wall thickness calculated about as 6 mm. Tank diameter is calculated about 6 m, and tank height calculated about 9 m by using %10 safety factor. To build intermediate tank we used carbon steel profiles which size are 1.5x6 m. But we decided to minimize wall thickness and also we decreased wall thickness every 1,5 m height.

Finally, after all calculations; total annual cost (pipeline and intermediate tanks) was found 33516 TL/yr.

In this design report we also gave detailed information about calculating optimum pipe diameter, all the specifications of the pipe, unions and valves, etc; type, capacity and required power of pumps, capacity, dimensions, wall thickness of the tank, material constraction, all the measuring an control devices, utilities, safety considirations, stand-by units, feasible service life and detailed preliminary cost estimination. And also we done market research in Turkey.

In addition to we used Chemcad program to verify calculations, and we found % 7,7 error on power of pumps. We have explained causion of this errors on part of result and discussion.

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1. INTRODUCTION

A factory is planned to build produce 180 000 ton/years methanol. For factory the pipeline will design, methanol will transport intermediate tank to storage tanks. The total used pipe length is 300 m. The intermediate tank is at an altitude of 20 m the main storage tanks. In this situation pipeline system will design between intermediate tank and main storage tank.

The main aim of this project is design a pipeline system between intermediate tank and main storage tank to transport product which is methanol produced from synthesis gas.

Methanol is small corrosive matter, for methanol corrosion rate is found 0.002 mm/year in carbon steel.**[1]** Any other physical and chemical properties of methanol is given on Appendix A1.

To choose material for transporting methanol and deciding tank etc. we look this specification. Designing pipeline system for methanol transporting; carbon steel pipe and carbon steel tank material is used.

There is detailed process flow chart:

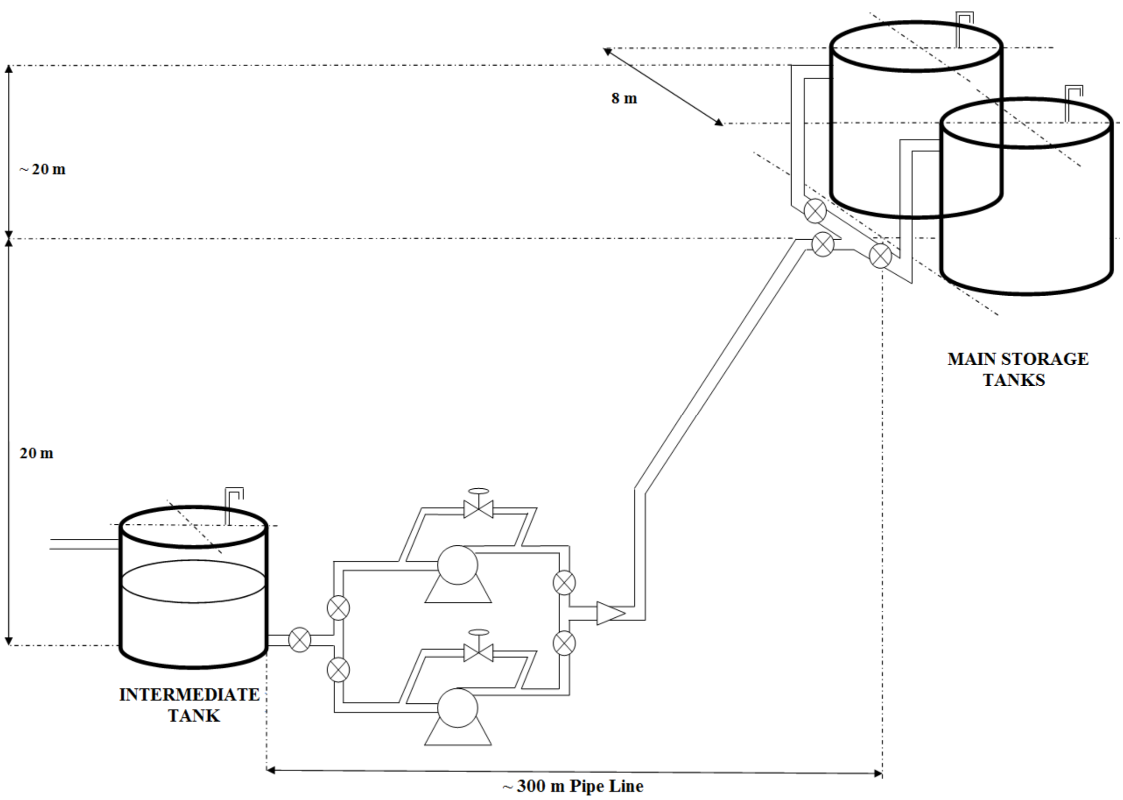

Figure 1. Flow Diagram

When looking flow diagram structure, the main equipments are intermediate tank, pumps and storage tanks are located. Calculations have done for intermediate tank, pumps and pipeline system.

1.1 Pipeline Design

The main idea of pipeline design is calculating optimum pipe diameter. This can calculate using two different way. One of them is using standart pipe diameters and calculating optimum diameter on Excel program by calculation of total cost. And selecting optimum diameter for piping system. The other one is using a simple formula. The formula is changing for flow type:

- For turbulent flow (Re > 2100) and $D_i \geq 0.0254\ m$,
  $D_{i_{opt}} = 0.363 * \dot{m}_{\vartheta}^{0.45} * \rho^{0.13}$..(1) **[2]**
- For viscous flow (Re < 2100) and $D_i \leq 0.0254\ m,$
  $D_{i_{opt}} = 0.133 * \dot{m}_{\vartheta}^{0.40} * \mu_f^{0.20}$..(2) **[2]**

where Di_{opt} is the optimum pipe diameter in m, $\dot{m}_{\vartheta}$ the volumetric flow rate in m^3/s , ρ the fluid density in kg/m^3 and μ_f the fluid viscosity in Pa.s **[2]**

This formulas can give ideas for design group. For pipeling design the important think is material selection. For methanol piping the stainless steel usable but carbon steel is also usable. Using carbon steel has more better than stainless steel for economy. Methanol is compatible with carbon steel and corrosivite is small on it.

1.1.1. Pumps

Pumps can be classified into two general types:

1. Dynamic pumps, such as centrifugal pumps.
2. Positive displacement pumps, such as reciprocating and diaphragm pumps.

The single-stage, horizontal, overhung, centrifugal pump is by far the most commonly used type in the chemical process industry. Other types are used where a high head or other special process considerations are specified. **[2]**

Pump selection is made on the flow rate and head required, together with other process considerations, such as corrosion or the pressure presence of solids in the fluid.

The chart shown in Figure 2. Can be used to determine the type of pump required for a particular head and flow rate.

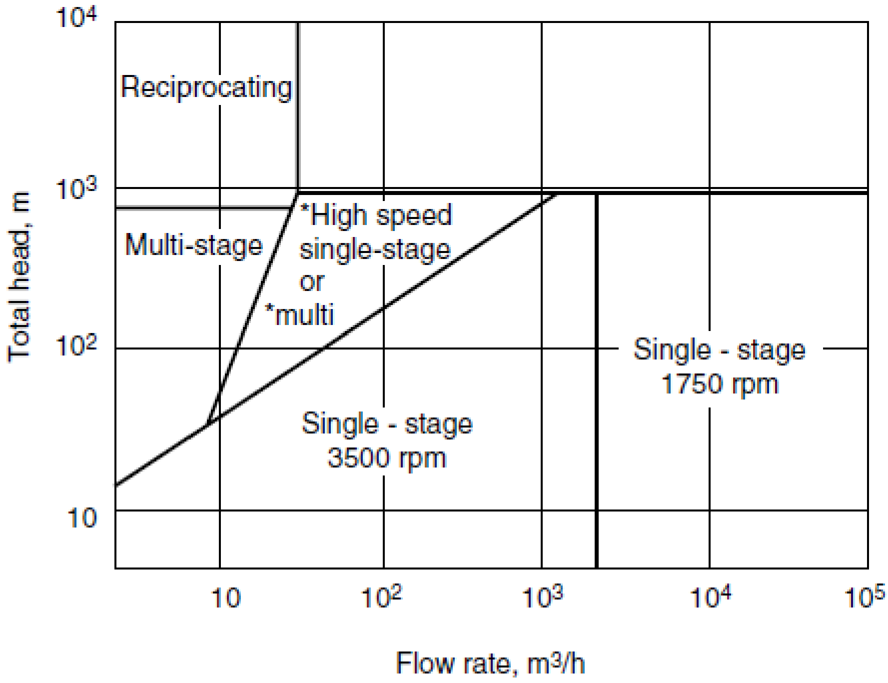

Figure 2. Centrifugal Pump Selection Guide **[2]**

Design of our pipeline we choose centrifugal pump because of these reasons. Centrifugal pumps are compatible with this pipeline design. We can calculate power of centrifugal pump using Bernoulli equation; **[3]**

$$\frac{P_a}{\rho} + \frac{g}{g_c} * z_a + a_a * \frac{v_a^2}{2g_c} + \eta W_p = \frac{P_b}{\rho} + \frac{g}{g_c} * z_b + a_b * \frac{v_b^2}{2g_c} + h_f \ldots\ldots\ldots\ldots\ldots(3)$$ **[3]**

where;

- P_a: pressure of point a in atm
- P_b: pressure of point b in atm,
- ρ :fluid density in kg/ m^3
- z_a: height from the ground to point a in m,
- z_b: height from the ground to point b in m,
- a_a: kinetic energy correction factor at point a,
- a_b: kinetic energy correction factor at point b,
- v_a: velocity of fluid in point a in m/s,
- v_b: velocity of fluid in point b in m/s

- η: efficiency of pump,
- W_p: theoretical power of pump in j/s.

1.1.2. Pressure Drop:

The pressure drop in a pipe, due a friction, is a function of the fluid flow-rate, fluid density and viscosity, pipe diameter, pipe surface roughness and the length of the pipe. **[2]**

It can be calculated using the following equation:

$$\Delta P_f = 8f\left(\frac{L}{di}\right)\left(\frac{\rho u^2}{2}\right)$$

where

- ΔP_f: Pressure drop, N/m^2
- f: friction factor,
- L: pipe length, m
- di: pipe inside diameter, m
- ρ: fluid density, kg/m^3
- u: fluid velocity, m/s.

In pipeline design system, we did not calculate pressure drop, because we calculated it on Chemcad Program by using trial and error method. We tried to make inlet pressure of main storage tank is 0,95 atm for Ankara.

1.1.3. Valves

The valves used for chemical process plant can be divided into two broad classes, depending on their primary function:

1. Shut-off valves (block valves), whose purpose is to close of the flow.
2. Control valves, both manual and automatic, used to regulate flow.

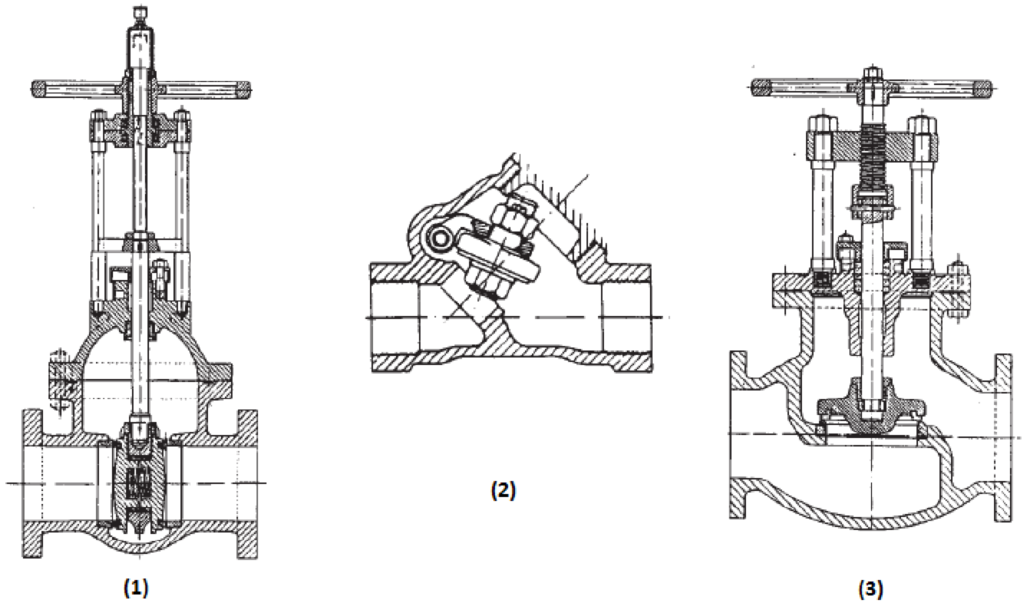

Figure 3. Some Valve Types Which are Used in Pipeline Design **[2]**

(1): Gate valve (slide valve)

(2): Check valve (non-return valve)

(3): Globe valve

We used gate valves to open or close fluid flow, check valves before main storage tanks for not returning fluid back and globe valves on bypass system to control the flow rate of methanol.

1.1.4. Valve Bypass:

The seating load of the larger parallel gate valves (except those with floating seats) can become so high at high fluid pressures that friction between the seatings can make it difficult to raise the disc from the closed position. Such valves are therefore frequently provided with a valved bypass line, which is used to relieve the seating load prior to opening the valve. There are no fast rules about when to employ a bypass, and the manufacturer's recommendation may be sought. Some standards of gate valves contain recommendations on the minimum size of the bypass. In the case of gases and vapors, such as steam, that condense in the cold downstream system, the pressurization of the downstream system can be considerably retarded. In this instance, the size of the bypass line should be larger than the minimum recommended size. **[4]**

1.1.5. Thickness

The pressure is more important paramater to select pipe wall thickness and also allowances for corrosion, erosion, and other mechanical allowances for pipe.

1.2. Tank

Intermediate tank is used temporary storage methanol on pipeline design. Residence time is chosen 8 hours for intermediate tank. So h/D is commonly bigger than 1 for intermediate tanks. When residence time increase volume of tank will increase. The wall thickness of intermediate tank have a connection with pressure of methanol. So selecting tank material is important.

In this design we selected carbon steel for tank material. Because it is cheaper than stainless steel and carbon steel have allowed corrosion rate in methanol.

The intermediate tanks are generally cylindirical. It can localized horizontal or vertical. But we prefer use it horizontal.

Spherical tanks generally use storage of gases. These tanks using the thin-steel construction of a vertical storage tanks are economically designed for pressures ranging.

2. METHOD OF CALCULATIONS

2.1. Intermediate Tank Calculation

- A tank material was selected which is compatible for methanol. Material selected as carbon steel (The properties of methanol are at Appendix A).
- Type of the tank was selected as cylindrical.
- The volume of the tank has been determined by using mass flow rate (%10 safety has been assumed).
- h/D optimization was done in order to determine the optimum size of the tank.
- Plate thickness were determined according to liquid pressure effecting on the tank wall.
- With the selected residence time (8 hours), calculating the thickness (at every 1,5 m) needed for the installation of tank for different aspect ratios; i.e, h/D ratios.

$$t = \frac{P_{gauge}(kPa).r_i(m)}{S(kPa).E_j - 0,6.P_{gauge}(kPa)} + Cc(m) \quad \text{.............(5)} \; \textbf{[5]}$$

$E_j = 0,85$ **[5]**

Corrosion factor = 0.002 mm/year **[1]**

- S =94,500 MPa (for carbon steel) **[5]**
- Number of plates necessary for production of the tank was found. Total cost of the tank was calculated by considering the cost of the plates.

$$\text{\# of profiles;} = \frac{A_T}{(1{,}5 * 6)m^2} = \frac{2 * \pi * r^2 + 2 * \pi * r * h}{(1{,}5 * 6)m^2} \quad \text{.....(6)}$$

- The optimum h/D ratio was determined which corresponds to the most suitable tank cost.

$$m(kg) = V.\rho \quad \text{..............................(7)}$$

- Cost is calculated:

$$\text{Cost} = \text{Unit Price of Profiles (TL/kg)} \times \text{Number of Profiles} \times \text{Density of Carbon Steel (kg/m}^3\text{) x Volume of Profile (m}^3\text{)}$$

2.1.1. Economic Calculation for Intermediate Tank

Direct Costs (DC)

1. Purchased Equipment Cost (PEC)
2. Installation Cost for Intermediate Tank= 0.4 x PEC
3. Instrument and Control Equipment Costs= 0.1 x PEC
4. Electrical Installed Cost= X

Indirect Costs(IC)

1. Engineering and Supervision= 0.15xPEC
2. Legal Expenses= X
3. Construction Expence= 0.15xFCI
4. Contingency= 0.05xFCI

Fixed Capital Investment= DC+IC

Fixed Cost (Service Life: 16 Years)

1. Depreciation= (1/16) x FCI
2. Local Taxes= 0.025 x FCI
3. Insurance= 0.005 x FCI
4. Rent= X
5. Financing= X

Operating Costs

1. Raw Materials= X
2. Operating Labor= X
3. Direct Supervisory= X
4. Utilities= X
5. Maintenance and Repairs= 0.02xFCI
6. Operating Supplies= X
7. Laboratory Charges= X
8. Patents and Royalities= X

Total Annual Cost for Intermediate Tank= Fixed Costs + Operating Costs

2.2. Pipeline Calculation

- The most suitable material was selected for transporting of methanol.
- Linear velocity and Reynolds number were defined as a function of diameter according to our mass flowrate.

$$\vartheta = \dot{m}/(\rho * A) \text{...}(8)$$

$$N_{Re} = \frac{D_i \vartheta \rho}{\mu} \text{...}(9)$$

- Since Reynolds number was greater than 2100 flow was determined to be turbulent. And the friction factor (f) was defined as a function of diameter.
- Pumps are used to transfer by increasing the pressure of the fluid and supplying the driving force necessary for flow. The most suitable pump is centrifugal pump for this pipe line.

$$x = \frac{k/D}{3.7} + \frac{5.74}{Re^{0.9}} \text{..}(10) \ \textbf{[3]}$$

$$f = \frac{0.33}{(\ln x)^{\wedge}2} \text{...}(11) \ \textbf{[3]}$$

$$h_f = \left[4f\frac{L}{D} + K_G + K_D + \sum K_B\right] x \left[\frac{v^2}{2g_c}\right] \text{......................}(12) \ \textbf{[3]}$$

- Kb values given in Appendix.

$$P = m * W_p \text{..}(13) \ \textbf{[3]}$$

- Calculate power of pump, W_p from Bernoulli Equation ;

$$\frac{P_a}{\rho} + \frac{g}{g_c} * z_a + a_a * \frac{v_a^2}{2g_c} + \eta W_p = \frac{P_b}{\rho} + \frac{g}{g_c} * z_b + a_b * \frac{v_b^2}{2g_c} + h_f \text{.........}(3) \ \textbf{[3]}$$

$$P = \frac{m}{\eta} * \left[\frac{g}{g_c} * (z_b - z_a) + \frac{v_b^2}{2g_c} + h_f\right] \ \textbf{[3]} \text{ .... (14)}$$

2.2.1. Total Cost for Pipeline

By using the assumptions, total cost of pipeline is calculated.

Pumping Cost

By using the equations below pumping cost is calculated.

Pumping Cost =Cost of pump x Number of pump

Piping Cost

By using the equations below piping cost is calculated.

Piping Cost= (Total Pipe Length) x (Cost of pipe)

Purchased Equipment Costs(PEC)

Purchased Equipment Cost = (Piping Cost) + (Pumping Cost) + Other equipments costs

2.2.2. Economic Calculation For Pipeline

Direct Costs (DC)

1. Purchased Equipment Cost (PEC)
2. Installation Cost for Pump and Pipeline= 0.4 x PEC
3. Instrument and Control Equipment Costs= 0.1 x PEC
4. Electrical Installed Cost= 0.1 x PEC

Indirect Costs (IC)

1. Engineering and Supervision= 0.15XPEC
2. Legal Expenses= X
3. Construction Expence= 0.15x FCI
4. Contingency= 0.05xFCI

Fixed Capital Investment= DC+IC

Fixed Cost (Service Life: 16 Years)

1. Depreciation= (1/16) x FCI
2. Local Taxes= 0.025 x FCI
3. Insurance= 0.005 x FCI
4. Rent= X
5. Financing= X

Operating Costs

1. Raw Materials= X
2. Operating Labor= %20 Capacity of .Labors
3. Direct Supervisory= X
4. Utilities= Electric Cost= (Working Hour) x(Electric Cost)x(Power)
5. Maintenance and Repairs= 0.02xFCI
6. Operating Supplies= X
7. Laboratory Charges= X
8. Patents and Royalities= X

Total Annual Cost for Pipeline= Fixed Costs + Operating Costs

2.3. Total Annual Cost for Process:

Total Annual Cost For Process = TAC Intermediate Tank + TAC Pipeline

3.SAMPLE CALCULATION

3.1. Sample Intermediate Tank Calculation

3.2. Optimum Diameter Sample Calculation

3.3. Economic Calculation for Intermediate Tank

3.4. Economic Calculation for Pipeline

4. RESULTS

After all calculations, for designed pipeline system;

- Optimum Pipe Diameter: 3 ½ Inch
- Centrifugal Pump Power: 4,04 kW
- Pump Electrical Cost: 9703 TL/yr
- PEC for Pipe System: 17688 TL
- Simply Calculation for Main Storage Tank Height: 20 m
- Optimum h/D Ratio for Intermediate Tank: 1,5
- Wall Thickness of Intermediate Tank: Average 6 mm
- Profile # of Intermediate Tank: 24,3
- Volume of Intermediate Tank: 251,7 m^3
- Heigth of Intermediate Tank: 8,97 m
- Diameter of Intermediate Tank: 5,98 m
- PEC for Intermediate Tank: 6038 TL
- Pump Power on Chemcad: 4,38 kW
- Pipe Diameter on Chemcad: 3 Inch
- Inlet Pressure of Pump on Chemcad: 0,95 bar
- Outlet Pressure of Pump on Chemcad: 5,1 bar
- Pressure of Inlet Main Storage Tank: 1,019 bar
- Total Annual Cost for Pipeline: 32051 TL/yr
- Total Annual Cost for Intermediate Tank: 1465 TL/yr
- Total Annual Cost: 33516 TL/yr

values founded.

5. DISCUSSION

In this report we have chosen carbon-steel pipe and profiles for our process because methanol is non-corrosive and carbon steel is cheaper than the other steels. Methanol corrosion rate is 0.002 mm/year on carbon steel and it can acceptable.

We designed a pipeline process for transporting methanol intermediate tank to main storage tank. After literature research we decided to use carbon steel pipe and tank material. When we calculated optimum diameter of pipe we found 3 ½ inch pipe diameter. After that we calculated pump power and pump electric cost. On Excel we found pump power as 4.04 kW but on Chemcad program we found it as 4,38 kW. When calculating error, there is 7,7 % error in our calculations. This error is looking good for first assigment, but source of this error may be calculation error. It can be fix working clearly.

For intermediate tank we selected residence time as 8 hours and 15 years service life. About wall thickness of tank, we found it 6 mm, but when we calculated cost of tank it was over 14000 TL. So we minimized the thickness of tank using 1,5 m height step by step. We used 1,5 x 6 m carbon steel profiles, so we calculated thickness as heigth: 1,5 m; 6,1 mm and height: 7,5 m; 4.2 mm showed in Appendix C Figure 4. After this minimazition of wall thickness we have seen that cost of tank decreased over 60%. And also we found volume of intermediate tank 251 m^3.

Another calculations was economic calculations for pipeline and intermediate tank. We found TAC for pipeline as 104051 TL/yr and TAC for intermediate tank as 1465 TL/yr. In this calculation we worked with 1 engineer, 1 chemist and 1 technician. This 3 workers are working all of the process. Final calculation we found TAC as 33516 TL/yr.

When look flowchart of pipe line process, Appendix C Figure 5 we decided to use 2 centrifuge pumps, 8 gate valves, 2 globe valves in bypass, 1 control valve to control flow rate, 2 check valves to make system safe, 3 filters for tanks, 7 tees, 13 90^o elbows and 2 45^o elbows and did calculations on this way.

The simply calculations for main storage tank we decided to use 2 main storage and and heigth of one of them average 20 m. This value is changed Za-Zb value so we did calculation using Za-Zb as 40 m.

6. CONCULUSION

After all calculations and discussion we decided that this Project usable for methanol production. We decided that located factor at İzmit/Kocaeli so we did calculation on this way. Total annual cost as 33516 TL/yr this Project will make profit.

7. SYMBOLS

A:	Area of the pipe, m^2
$\boldsymbol{a_a}$	Kinetic energy correction factor at point a
$\boldsymbol{a_b}$:	Kinetic energy correction factor at point b
$\boldsymbol{C_c}$:	Allowence for corrosion, m
$\boldsymbol{D_{i_{opt}}}$:	Optimum pipe diameter, m
$\boldsymbol{D_i}$:	Pipe diameter, m
$\boldsymbol{E_j}$:	Efficiency of joints expressed as a fraction
$\boldsymbol{g_c}$:	Gravitional convertion factor
$\mathbf{L}/\mathbf{D}$:	Rate of length-diameter of pipe
$\boldsymbol{h_{f_s}}$:	Friction loss (in head) of the pipe
$\boldsymbol{f}$:	Fanning frictional factor
$\mathbf{K_i}$:	Contraction, expansion, fitting loss coefficient, dimensionless
$\boldsymbol{P_a}$:	Pressure of point a, atm
$\boldsymbol{P_b}$:	Pressure of point b , atm
$\boldsymbol{N_{Re}}$:	Reynolds number
$\boldsymbol{N_{sc}}$:	Schedule number
$\boldsymbol{\dot{m}_{\vartheta}}$:	Volumetric flow rate ,m^3/s
$\boldsymbol{\rho}$:	Fluid density, kg/m^3
$\boldsymbol{\mu_f}$:	Fluid viscosity, Pa.s
$\boldsymbol{\eta}$:	Efficiency of pump
S:	Maximum allowable working stress, kPa
$\boldsymbol{\nu_a}$:	Velocity of fluid in point a, m/s
$\boldsymbol{\nu_b}$:	Velocity of fluid in point b, m/s.
$\langle\boldsymbol{\nu}\rangle$:	Mean average velocity fluid, m/s
$\boldsymbol{t}$:	Wall thickness, m
$\boldsymbol{W_p}$:	Theoretical power of pump, kW
$\boldsymbol{z_a}$:	Height from the ground to point a, m
$\boldsymbol{z_b}$:	Height from the ground to point b, m

8. REFERENCES

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9. APPENDIX

9.1 APPENDIX A. PROPERTIES OF METHANOL

Table 1. Phyical Properties of Methanol **[10]**

Property	Value
Boiling Point, (^{o}C)	64.70
Critical Temperature, (^{o}C)	239.43
Critical Pressure, (kPa)	8096
Critical Volume, (mL/mol)	118
Critical Value of Compressibility Factor	0.224
Heat of Formation (Liquid) at 25 ^{o}C, (kJ/mol)	-239.03
Free Energy of Formation (Liquid) at 25 ^{o}C, (kJ/mol)	-166.81
Heat Fusion, (J/g)	103
Heat of Vaporization at Boiling Point, (J/g)	1129
Heat of Combustion (Gross) at 25 ^{o}C, (J/g)	22,662
Flammable Limits in Air, Vol%	
Lower	6.0[c]
Upper	36 [c]
Autoignition Temperature, ^{o}C	464 [c]
Flash Point, Closed Cup, ^{o}C	11[c]
Surface Tension at 25 ^{o}C, mN/m(=dyn/cm)	22.1
Specific Heat of Vapor at 25 ^{o}C, (J/gK)	1.370
Specific Heat of Liquid at 25 ^{o}C, (J/gK)	2.553
Vapor Pressure at 25 ^{o}C, (kPa)	16.96
Solubility in Water	Miscible
Density at 25 ^{o}C, (g/mL)	0,7866
Refractive Index, (n_D^{20})	1.3284
Liquid Viscosity at 25 ^{o}C, mPa.s (=cP)	0.541
Dielectric Constant at 25 ^{o}C	32.7
Thermal Conductivity at 25 ^{o}C, (W/mK)	0.202

Table 2. Methanol Specifications (At 20 ^oC) **[10]**

Parameter	Grade A	Grade AA	ASTM D1152
Purity, wt%	99.85	99.85	99.85
Specific Gravity	0.7928	0.7928	0.7920-0.7930
Distillation Range, ^oC	1.0 (incl. 64.6+-0.1)	1.0 (incl. 64.6+-0.1)	1.0 (incl. 64.6+-0.1)
Color (Pt-Co, max)	5	5	5
Odor	Characteristic, Nonresidual	Characteristic, Nonresidual	Characteristic, Nonresidual
Carbonizable Impurities (Color, Pt-Co, max)	30	30	50
Apperance	Clear, No Sediment	Clear, No Sediment	-
Nonvolatile Content, mg/100 mL, max	1	1	5
Permanganate Time, min	30	30	50
Acetone+Aldehydes, wt%, max	0.003	0.003	-
Acetone, wt%, max	-	0.002	0.003
Ethanol, wt%, max	-	0.001	-
Acidity, wt%, max	0.003	0.003	0.003
Water, wt%, max	0.15	0.10	0.10
Water Miscibility	No Turbidity	No Turbidity	No Turbidity

9.2. APPENDIX B. MARKET RESEARCHING, COST LIST

Table 3. Table of Used Equipments and Equipments' Cost **[8]**

Equipment	#	Cost (TL)	Total Cost (TL)
Intermediate Tank (Carbon Steel) H=8,97m D=5,98m	1	6038	6038
Centrifuge Pumps 5 kW 7,5 HP	2	2028	4056
300m 3 1/2" SCH40 Pipeline (Carbon Style)	1	6921	6921
Gate Valve GTK-16	8	250	2000
Globe Valve (304 Stainless Steel) GV-16	2	260	520
Control Valve Stevi 12.440-P	1	3040	3040
Check Valve (Stainless Steel) CLV-50	2	220	440
Filter (304 Stainless Steel) PTY-20	3	155	465
Tee	7	13	91
90 Elbow	13	9	117
45 Elbow	2	9	18

Table 4. Profile's Sizes **[9]**

E DEMİR	**Levha sac ağırlıkları - St 37 sac - St 52 sac - St 52-3 sac**			
	Dkp sac, Levha sac, Hrp sac ve plaka sac ebatları ölçüleri ağırlıkları			
Demir sac kalınlıkları mm	**Leva sac ölçüsü 1000*2000**	**Leva sac ölçüsü 1200*2400**	**Leva sac ölçüsü 1250*2500**	**Leva sac ölçüsü 1500*6000**
0.40 mm	6.4 kg	9.2 kg	10.0 kg	
0.50 mm	8.0 kg	11.5 kg	12.5 kg	
0.60 mm	9.6 kg	13.8 kg	15.0 kg	
0.70 mm	11.2 kg	16.1 kg	17.5 kg	
0.80 mm	12.8 kg	18.4 kg	20.0 kg	
0.90 mm	14.4 kg	20.7 kg	22.5 kg	
1.00 mm	16.0 kg	23.0 kg	25.0 kg	
1.20 mm	19.2 kg	27.6 kg	30.0 kg	
1.50 mm	24.0 kg	34.5 kg	37.5 kg	
2.00 mm	32.0 kg	46.0 kg	50.0 kg	
2.50 mm	40.0 kg	57.6 kg	62.5 kg	
3.00 mm	48.0 kg	69.1 kg	75.0 kg	216.0 kg
3.50 mm	56.0 kg	80.6 kg	87.5 kg	252.0 kg
4.00 mm	64.0 kg	92.2 kg	100.0 kg	288.0 kg
5.00 mm	80.0 kg	115.2 kg	125.0 kg	360.0 kg
6.00 mm	96.0 kg	138.2 kg	150.0 kg	432.0 kg
7.00 mm	112.0 kg	161.2 kg	175.0 kg	504.0 kg
8.00 mm	128.0 kg	184.3 kg	200.0 kg	576.0 kg
9.00 mm	144.0 kg	207.0 kg	225.0 kg	648.0 kg
10.00 mm	160.0 kg	230.0 kg	250.0 kg	720.0 kg
12.00 mm	192.0 kg	276.0 kg	300.0 kg	864.0 kg
13.00 mm	208.0 kg	299.0 kg	325.0 kg	936.0 kg
14.00 mm	224.0 kg	322.0 kg	350.0 kg	1008.0 kg
15.00 mm	240.0 kg	345.0 kg	375.0 kg	1080.0 kg
16.00 mm	256.0 kg	368.0 kg	400.0 kg	1152.0 kg
18.00 mm	288.0 kg	414.0 kg	450.0 kg	1296.0 kg
20.00 mm	320.0 kg	460.0 kg	500.0 kg	1440.0 kg
25.00 mm	400.0 kg	576.0 kg	625.0 kg	1800.0 kg
30.00 mm	480.0 kg	691.0 kg	750.0 kg	2160.0 kg
35.00 mm	560.0 kg	806.0 kg	875.0 kg	2520.0 kg
40.00 mm	640.0 kg	921.0 kg	1000.0 kg	2880.0 kg
50.00 mm	800.0 kg	1152.0 kg	1250.0 kg	3600.0 kg
60.00 mm	960.0 kg	1382.0 kg	1500.0 kg	4320.0 kg
70.00 mm	1120.0 kg	1612.0 kg	1750.0 kg	5040.0 kg
80.00 mm	1280.0 kg	1843.0 kg	2000.0 kg	5760.0 kg
90.00 mm	1440.0 kg	2073.0 kg	2250.0 kg	6480.0 kg
100.00 mm	1600.0 kg	2304.0 kg	2500.0 kg	7200.0 kg

Table 5. Profile's Cost **[9]**

LME DEMİR						Tel: 0216 621 30 15
ST 37 Levha Sac Fiyatları Günlük Fiyatlardır. Lütfen Teyid Ediniz.						Fax:0216 621 30 16
						www.lme.com.tr
ST 52 Levha Sac Fiyatları için lütfen fiyat sorunuz.						info@lme.com.tr
Malzeme Tipi Metal Demir Saç	**Hadde Şekli**	**Kalite**	**En Genişliği**	**Boy Genişliği**	**Malzeme Kalınlığı**	**TON FİYATI**
LEVHA SAC PAKET	SICAK	DD11	1250	3000	2,00 MM	625 $ / TON
LEVHA SAC ST 52 PAKET	SICAK	S355MC	1250	2500	3,00 MM	685 $ / TON
LEVHA SAC	SICAK	S235JR+AR	1500	6000	3,00 MM	645 $ / TON
LEVHA SAC	SICAK	S355JR+AR	1250	6000	4,70 MM	685 $ / TON
LEVHA SAC	SICAK	S355JR+AR	1500	6000	5,00 MM	685 $ / TON
LEVHA SAC	SICAK	S235JR+AR	1500	6000	5,00 MM	625 $ / TON
LEVHA SAC	SICAK	S355JR+AR	1500	6000	6,00 MM	685 $ / TON
LEVHA SAC	SICAK	S235JR+AR	2500	8000	6,00 MM	685 $ / TON
LEVHA SAC	SICAK	S235JR	1500	6000	7,00 MM	$ / TON
LEVHA SAC	SICAK	S355JR+AR	1500	6000	8,00 MM	685 $ / TON
LEVHA SAC	SICAK	S355JR+AR	2000	8000	9,00 MM	685 $ / TON
LEVHA SAC	SICAK	S235JR+AR	2000	8000	10,00 MM	665 $ / TON
LEVHA SAC	SICAK	S235JR+N	2000	6000	12,00 MM	630 $ / TON
LEVHA SAC	SICAK	S355JR+AR	2000	10000	12,00 MM	630 $ / TON
LEVHA SAC	SICAK	S235JR+AR	2500	8000	14,00 MM	610 $ / TON
LEVHA SAC	SICAK	S355JR+N	2000	8000	15,00 MM	710 $ / TON
LEVHA SAC	SICAK	S275JR+AR	2500	12000	15,00 MM	675 $ / TON
LEVHA SAC	SICAK	S355JO+N	2870	6740	17,00 MM	630 $ / TON
LEVHA SAC	SICAK	S355JO+N	2850	6740	17,00 MM	630 $ / TON
LEVHA SAC	SICAK	S355JR+AR	2000	6000	20,00 MM	710 $ / TON
LEVHA SAC	SICAK	S355JR+AR	2500	12200	20,00 MM	710 $ / TON
LEVHA SAC	SICAK	S355J2+N	2500	12200	22,00 MM	670 $ / TON
LEVHA SAC	SICAK	S235JR+AR	2000	8000	24,00 MM	670 $ / TON
LEVHA SAC	SICAK	S355JR+AR	2500	12200	24,00 MM	670 $ / TON
LEVHA SAC	SICAK	S355J2+N	2000	6000	25,00 MM	710 $ / TON
LEVHA SAC	SICAK	S355JR+AR	2000	12000	26,00 MM	690 $ / TON
LEVHA SAC	SICAK	S235JR+N	1500	12000	30,00 MM	670 $ / TON
LEVHA SAC	SICAK	S355J2+N	2500	12000	30,00 MM	710 $ / TON
LEVHA SAC	SICAK	S355J2+N	1500	12000	35,00 MM	710 $ / TON
LEVHA SAC	SICAK	S355JR+N	1500	12000	40,00 MM	710 $ / TON
LEVHA SAC	SICAK	S235JR+AR	1500	6000	40,00 MM	690 $ / TON
LEVHA SAC	SICAK	S355J2+N	1500	12000	50,00 MM	720 $ / TON
LEVHA SAC	SICAK	S355	2500	10000	50,00 MM	720 $ / TON
LEVHA SAC	SICAK	S275JR+AR	2500	7700	80,00 MM	700 $ / TON
LEVHA SAC	SICAK	S355	2000	4900	105,00 MM	740 $ / TON
LEVHA SAC	SICAK	S355	2100	4900	105,00 MM	740 $ / TON

Table 6. Pipe’s Cost **[6]**

ASİL ÇELİK HAMMADDESİNDEN ÜRETİLEN % 100 TÜRK MALI DİKİŞSİZ ÇELİK ÇEKME						
ST 52 Malzeme						
DIŞ	***ET KALINLIĞI (mm)***					
Ø 63,5	**10**			-		
Ø 70	**10**			-		
Ø 73	**10**			-		
Ø 76	**10**	**12**				
Ø 83	**10**	**14**		-		
Ø 88,9	**10**	**12**	14			
Ø 95	**15**	**17,5**				***1,70 TL/KG***
Ø 101,6	**10**					
Ø 108	8	**16**				
Ø 114,3	**8**	**16**	**20**			
Ø 121,0	**20**					
Ø 127	**10**					
Ø 139,7	**10**	**11**	14			
Ø 146	**20**					
ST 37 Malzeme						
DIŞ	***ET KALINLIĞI (mm)***					
Ø 60,3	**3,2**	**4**	**5,5**			
Ø 76,1	**4**	**5**		-		***1,80 TL/KG***
Ø 88,9	**5,5**			-		
Ø 114,3	**6**	**8,5**				
Ø 139,7	**6,3**			-		
NOT :	***4140 KALİTE VE ÖZEL ALAŞIM BORU TEKLİFLERİNİZ DEĞERLENDİRİLİR.***					
					SARDOĞAN END. VE	
					MEHMET SARDOĞAN	

9.3. APPENDIX C. PIPELINE AND TANK CALCULATIONS

Table 7. Calculations for Optimum h/D Ratio, Thickness and Cost of Intermediate Tank

h/D	m (kg/s)	ρ (kg/m3)	Q (m^3/hr)	Residence Time (hr)	Safety Factor	Tank Volume (m^3)	D (m)
0,1	6,25	786,6	28,60412	8	0,1	251,7162471	14,74621
0,2	6,25	786,6	28,60412	8	0,1	251,7162471	11,70408
0,3	6,25	786,6	28,60412	8	0,1	251,7162471	10,22445
0,4	6,25	786,6	28,60412	8	0,1	251,7162471	9,289533
0,5	6,25	786,6	28,60412	8	0,1	251,7162471	8,623638
0,6	6,25	786,6	28,60412	8	0,1	251,7162471	8,115154
0,7	6,25	786,6	28,60412	8	0,1	251,7162471	7,708701
0,8	6,25	786,6	28,60412	8	0,1	251,7162471	7,373107
0,9	6,25	786,6	28,60412	8	0,1	251,7162471	7,08924
1	6,25	786,6	28,60412	8	0,1	251,7162471	6,844586
1,1	6,25	786,6	28,60412	8	0,1	251,7162471	6,630551
1,2	6,25	786,6	28,60412	8	0,1	251,7162471	6,441002
1,3	6,25	786,6	28,60412	8	0,1	251,7162471	6,271423
1,4	6,25	786,6	28,60412	8	0,1	251,7162471	6,1184
1,5	**6,25**	**786,6**	**28,60412**	**8**	**0,1**	**251,7162471**	**5,979297**
1,6	6,25	786,6	28,60412	8	0,1	251,7162471	5,852039
1,7	6,25	786,6	28,60412	8	0,1	251,7162471	5,734967
1,8	6,25	786,6	28,60412	8	0,1	251,7162471	5,626734
1,9	6,25	786,6	28,60412	8	0,1	251,7162471	5,526235
2	6,25	786,6	28,60412	8	0,1	251,7162471	5,432552

h_{tank}	H_{MeOH}	P_{max} (MPa)	Tank Area (m^2)	Wall Thickness (mm)	# of Profiles	Cost of Profiles
1,474621	1,340565	0,111669531	409,6773555	10,256528	45,51971	44875,9408
2,340816	2,128014	0,117745919	301,0939889	8,5840958	33,45489	27603,7379
3,067336	2,788487	0,122842491	262,6031066	7,8238106	29,17812	21942,6684
3,715813	3,378012	0,127391584	243,8708494	7,3718824	27,09676	19200,3674
4,311819	3,919836	0,131572591	233,5128079	7,068245	25,94587	17627,6149
4,869093	4,426448	0,135481888	227,4656875	6,8492644	25,27397	16639,1478
5,39609	4,905537	0,1391788	223,9098823	6,6838905	24,87888	15983,5719
5,898486	5,36226	0,142703123	221,9085676	6,5549192	24,65651	15535,0503
6,380316	5,800287	0,146083185	220,9312103	6,4519479	24,54791	15223,6635
6,844586	6,222351	0,149340058	220,6557766	6,3682704	24,51731	15007,4896
7,293606	6,630551	0,152489954	220,8761896	6,2993459	24,5418	14859,8906
7,729203	7,026548	0,15554568	221,4549878	6,2419778	24,60611	14763,1468
8,15285	7,411681	0,158517581	222,2973639	6,1938436	24,69971	14705,0262
8,56576	7,787054	0,161414163	223,3361128	6,1532114	24,81512	14676,8225
8,968945	**8,153587**	**0,164242526**	**224,5224979**	**6,1187606**	**24,94694**	**14672,1777**
9,363262	8,512057	0,167008676	225,8204917	6,0894651	25,09117	14686,3456
9,749443	8,86313	0,169717751	227,2030248	6,0645147	25,24478	14715,7165
10,12812	9,207382	0,17237419	228,6494749	6,0432604	25,4055	14757,4992
10,49985	9,545315	0,174981859	230,1439433	6,0251758	25,57155	14809,5045
10,8651	9,877367	0,177544154	231,6740481	6,0098293	25,74156	14869,9935

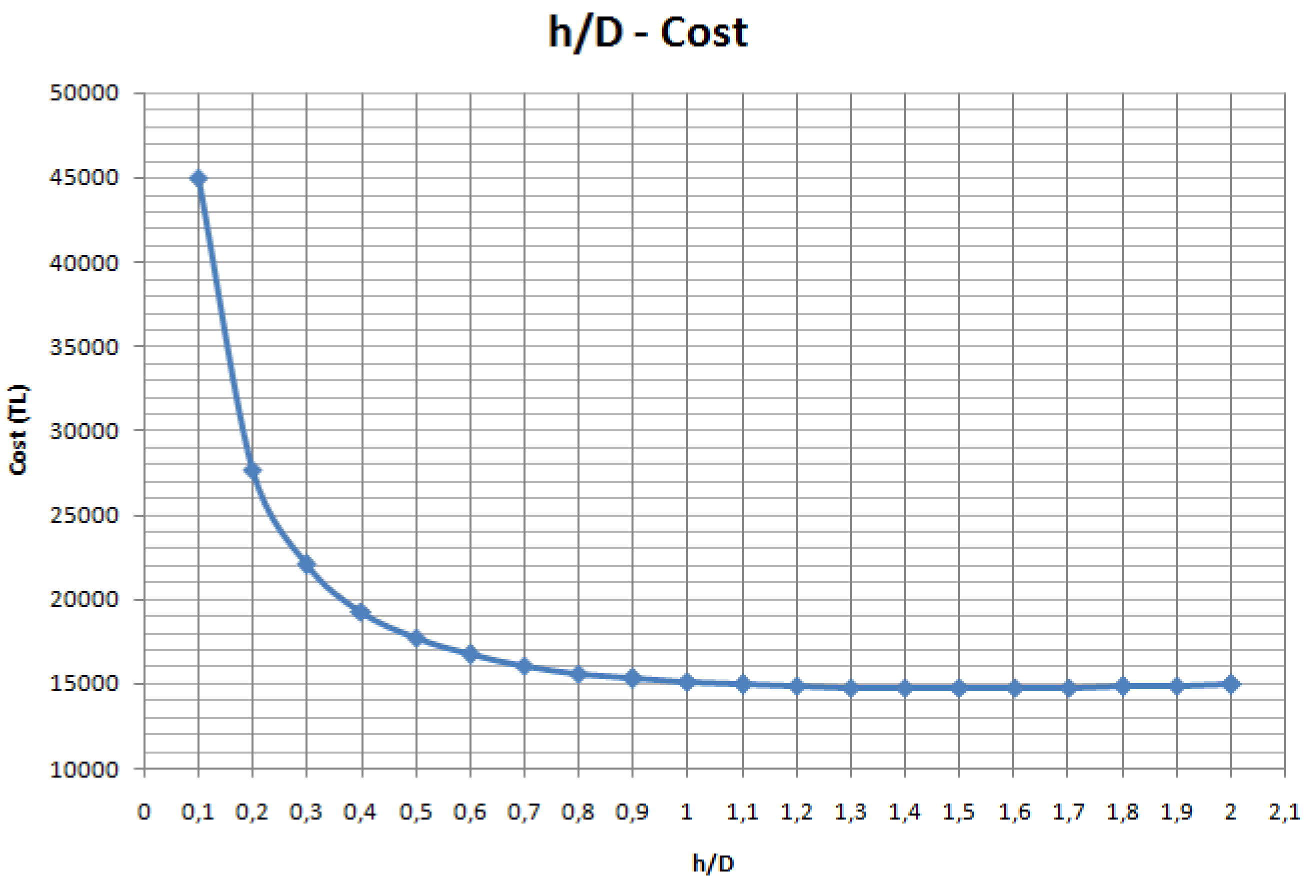

Figure 3. Graph For Optimum h/D Ratio Calculations

Table 8. Calculations for Minimizing Wall Thickness of Intermediate Tank

h/D	m (kg/s)	ρ (kg/m3)	Q (m^3/hr)	Residence Time (hr)	Safety Factor	Tank Volume (m^3)	D (m)
1,5	6,25	786,6	28,60411899	8	0,1	251,7162471	5,979297
1,5	6,25	786,6	28,60411899	8	0,1	251,7162471	5,979297
1,5	6,25	786,6	28,60411899	8	0,1	251,7162471	5,979297
1,5	6,25	786,6	28,60411899	8	0,1	251,7162471	5,979297
1,5	6,25	786,6	28,60411899	8	0,1	251,7162471	5,979297
1,5	6,25	786,6	28,60411899	8	0,1	251,7162471	5,979297

Table 8. Continious

h_{tank}	H_{MeOH}	P_{max} (MPa)	Tank Area (m^2)	Wall Thickness (mm)	# of Profiles	Cost of Profiles
8,968945	8,072051	0,16361335	224,5224979	6,095314341	3	585,8816145
8,968945	7,5	0,159199095	224,5224979	5,93082014	3	570,0704319
8,968945	6	0,147624276	224,5224979	5,499518208	3	528,6136901
8,968945	4,5	0,136049457	224,5224979	5,068253584	3	487,1605345
8,968945	3	0,124474638	224,5224979	4,637026265	3	445,7109646
8,968945	1,5	0,112899819	224,5224979	4,205836246	3	404,2649799

Table 8. Continious

Calculations for Base of Intermediate Tank				
Base Area	**One Profile Area**	**# of Profiles**	**Wall Thickness**	**Cost of Base Profiles**
28,071914	9	3,119101556	6,095314341	1827,424255
Calculations for Roof of Intermediate Tank				
Roof Area	**One Profile Area**	**# of Profiles**	**Wall Thickness**	**Cost of Base Profiles**
28,071914	9	3,119101556	4,205836246	1188,21495

Table 8. Continious

Total # of Profile	Total Material Cost of Intermediate Tank (TL)
24,23820311	6037,34142

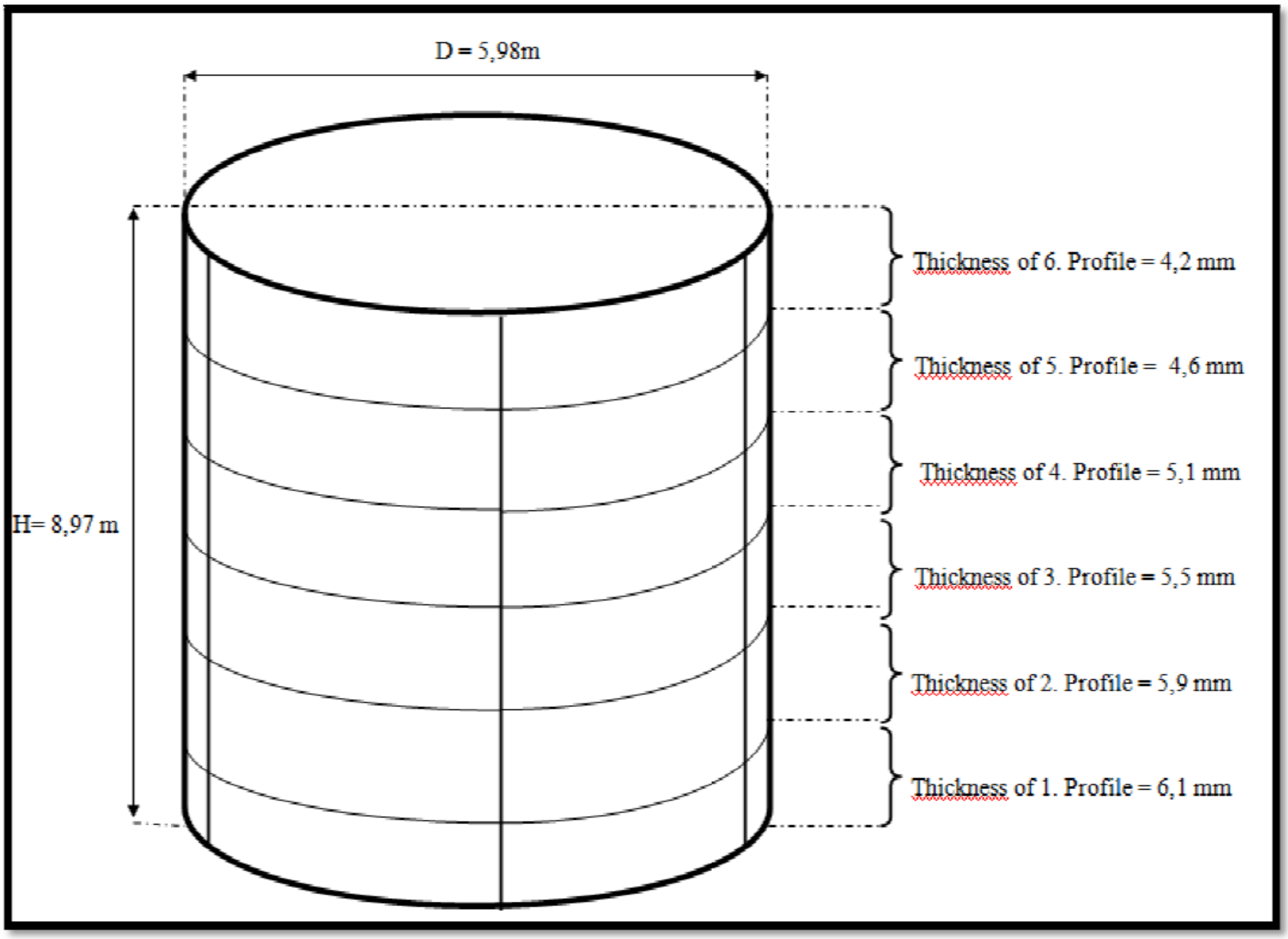

Figure 4. Minimizing Intermediate Tank Wall Thickness

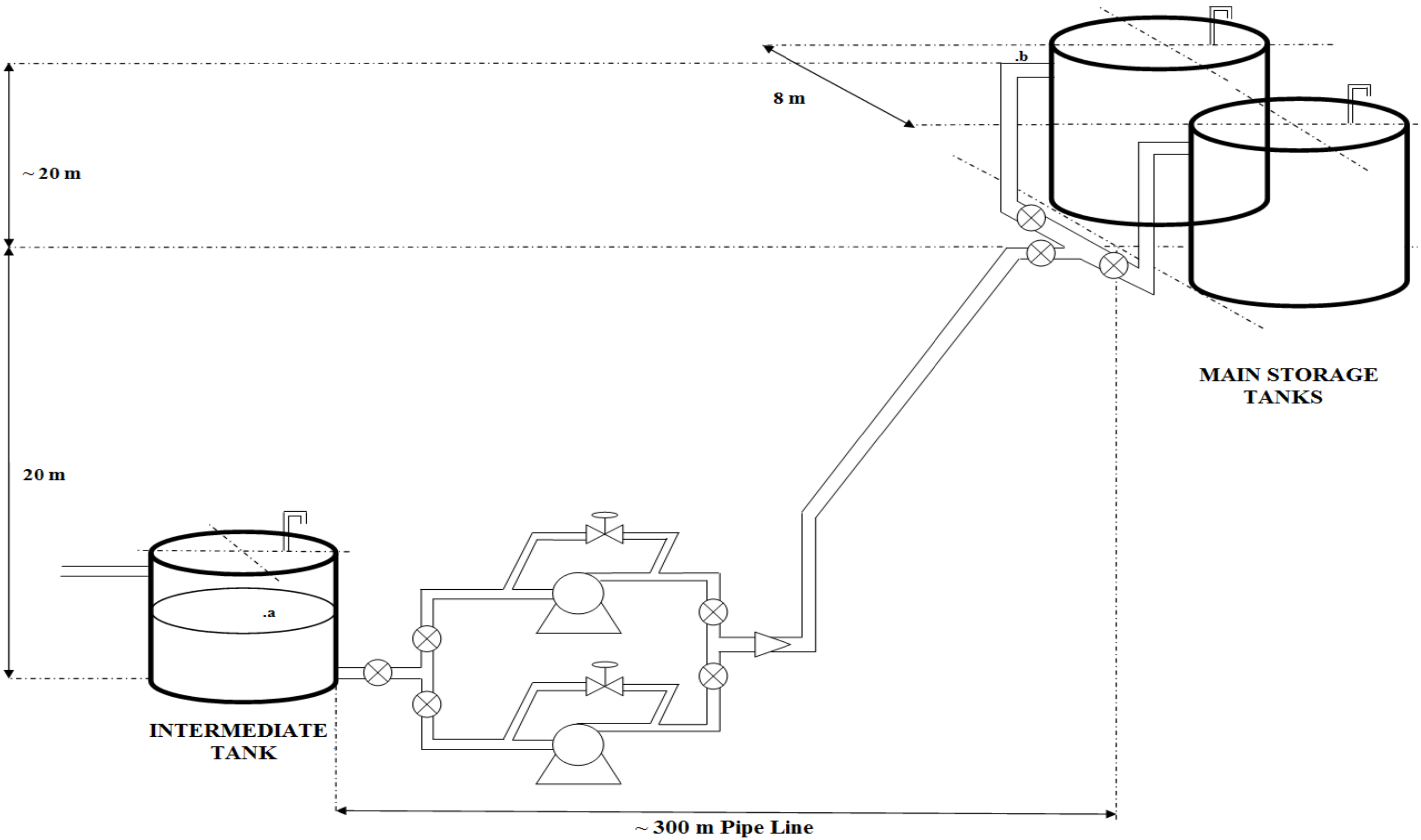

Figure 5. Detailed Flow Chart for Process

Table 9. Equipment List Which are Used in Berneoulli Equation and Their Kb Values **[3]**

EQUIPMENTS	#	Kb	Total Kb
Gate Valve	6	0,2	54,4
Globe Valve	1	12,5	
Control Valve	1	4,5	
Tee	5	1,5	
Check Valve	2	4,5	
90 Elbow	9	2,1	
45 Elbow	2	0,4	

Table 10. Calculation of Optimum Pipe Diameter on Excel Program

Pipe Size SCH40	D in (m)	v (m/s)	N_{RE}	X	f	h_f	Z_b-Z_a	η	P (W)	Pumping Cost (TL/yr)	Piping Cost (TL)	Total Cost
1 1/4	0,03505207	8,238138288	422196,3	0,000402	0,005398	8117,174	40	0,75	71,1959	170870,1572	1723,8	172594
1 1/2	0,040894082	6,052509664	361882,5	0,000359	0,005246	3815,79	40	0,75	35,22089	84530,13744	2065,5	86595,64
2	0,052501905	3,672030628	281872,7	0,000307	0,005043	1143,855	40	0,75	12,85831	30859,9339	2774,4	33634,33
2 1/2	0,062712725	2,573623859	235978,5	0,000281	0,004935	492,8688	40	0,75	7,404838	17771,61115	4396,2	22167,81
3	0,077927356	1,666773304	189905,8	0,00026	0,004845	179,2002	40	0,75	4,774911	11459,78524	5757,9	17217,69
3 1/2	**0,09011938**	**1,246292634**	**164213,9**	**0,000253**	**0,004812**	**92,01241**	**40**	**0,75**	**4,043242**	**9703,780725**	**6920,7**	**16624,48**
4	0,102260605	0,967920533	144717,1	0,000251	0,004802	51,87748	40	0,75	3,706216	8894,918291	8195,7	17090,62
5	0,128194056	0,615914802	115441	0,000256	0,004824	18,88383	40	0,75	3,428946	8229,47017	11107,8	19337,27
6	0,154051308	0,426506484	96064,45	0,000268	0,00488	8,405608	40	0,75	3,340805	8017,931242	14412,6	22430,53
8	0,202717805	0,24630466	73002,24	0,000302	0,005023	2,552032	40	0,75	3,29152	7899,647295	21690,3	29589,95
10	0,254508509	0,156261434	58146,79	0,000344	0,00519	0,962902	40	0,75	3,278126	7867,50221	30753	38620,5

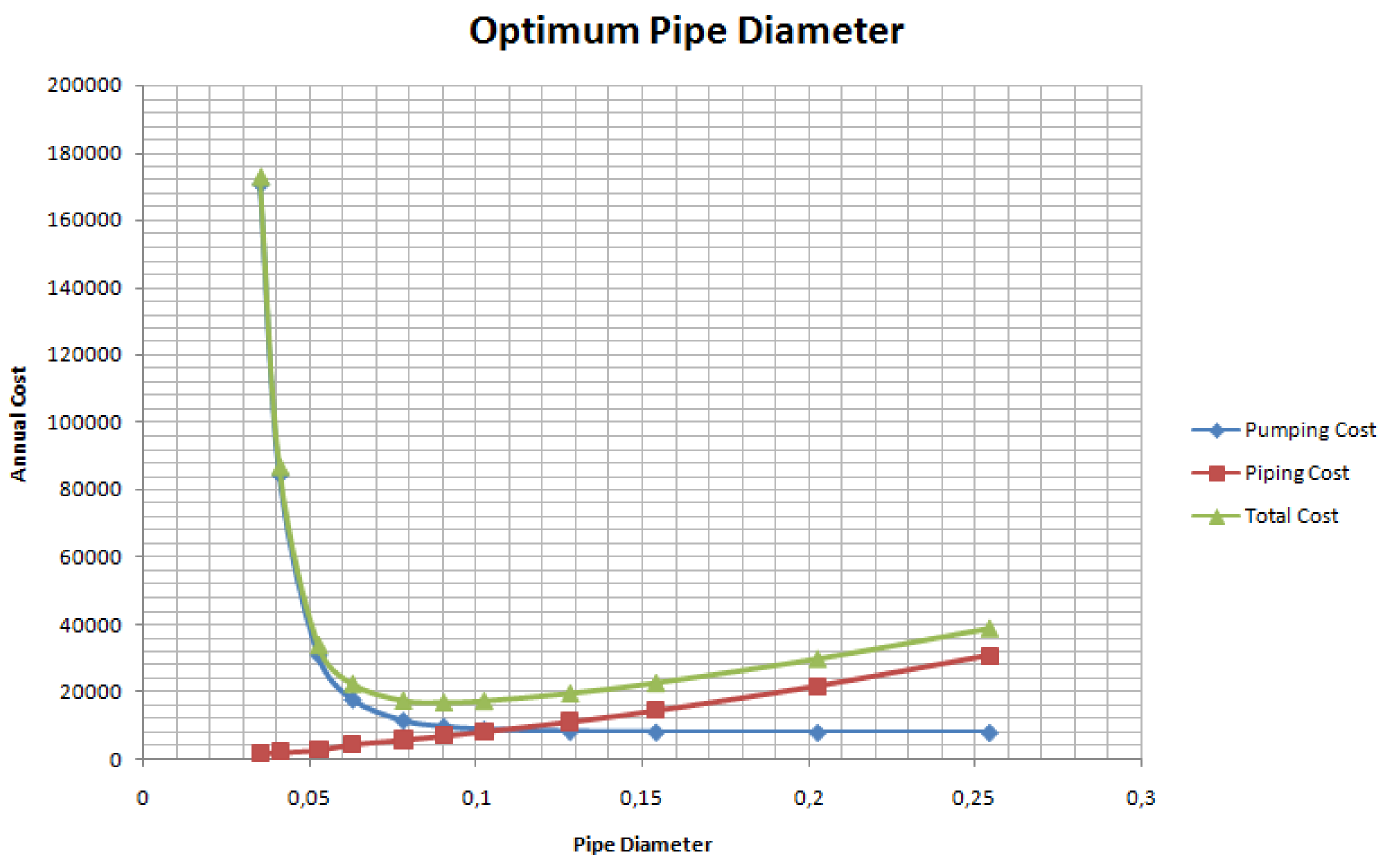

Figure 6. Annual Cost Versus Pipe Diameter Graph

9.4. APPENDIX D CHEMCAD CALCULATIONS

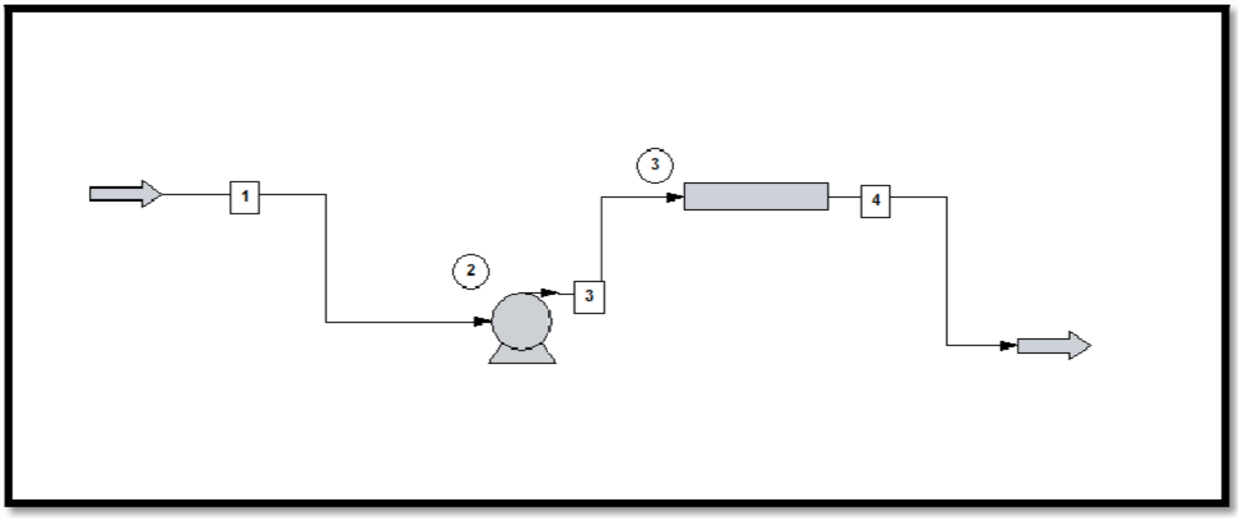

Figure 7. Simply Chemcad Flow Chart

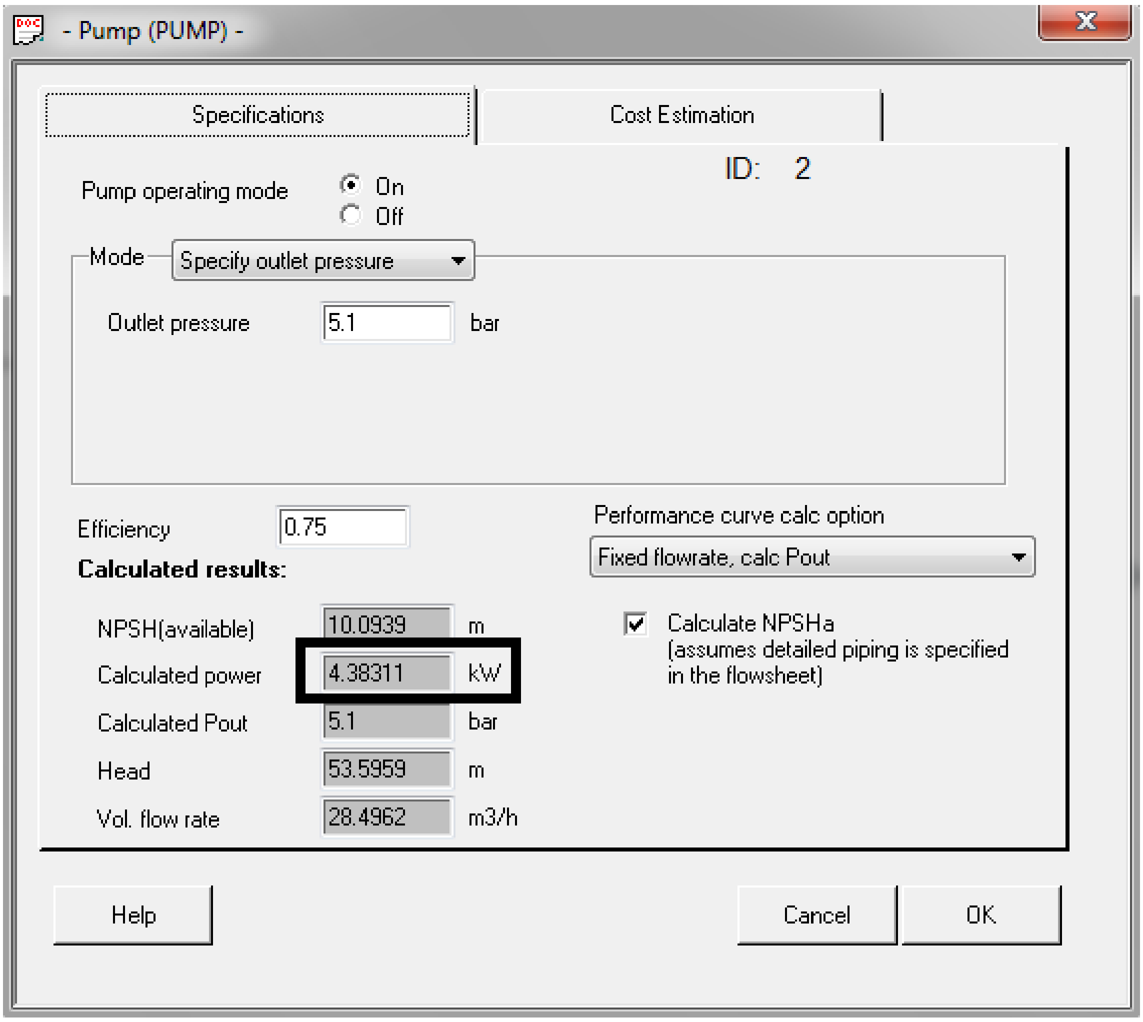

Figure 8. Calculated Pump Power on Chemcad

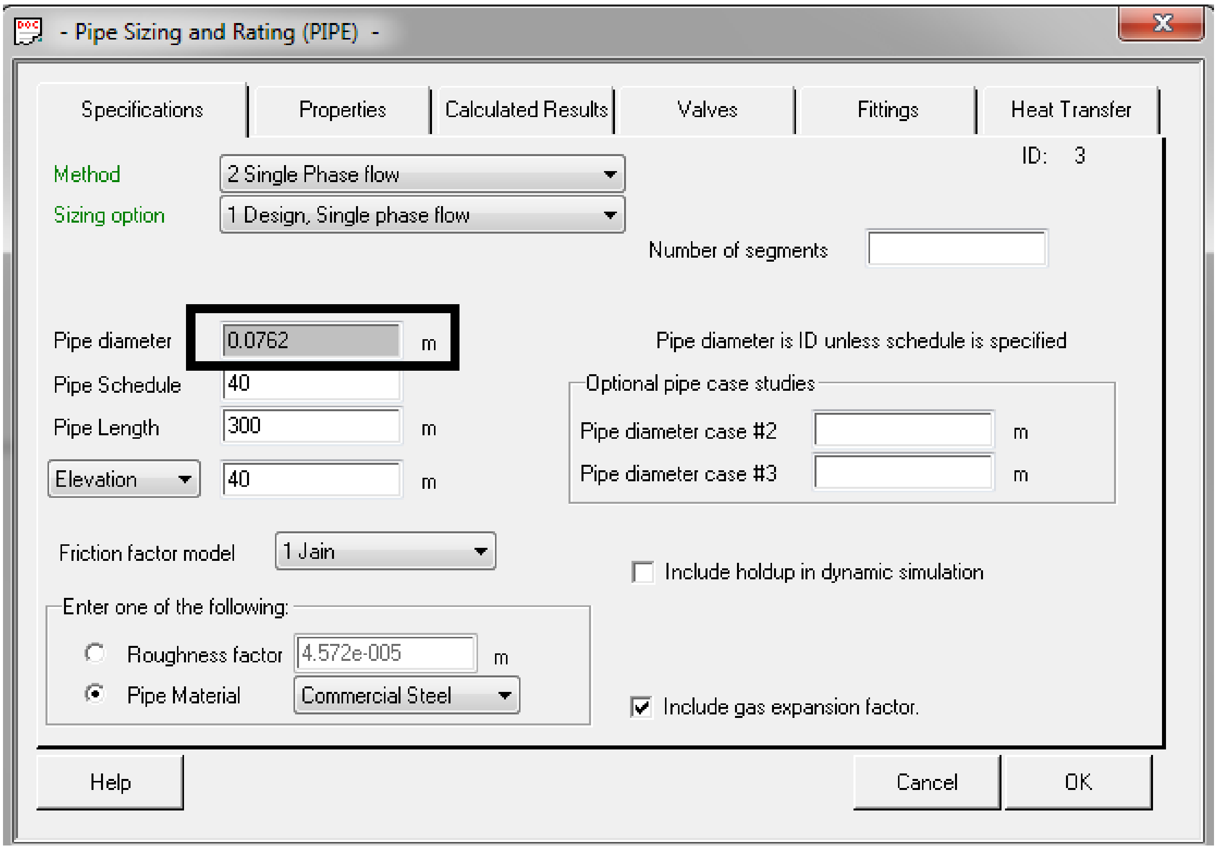

Figure 9. Calculated Pipe Diameter on Chemcad

Table 11. Chemcad Results

CHEMCAD 6.1.

Job Name: Methanol Pipeline Design Group G Date: 21/10/2013 Time: 22:00:23

Stream No.	1	3	4
Stream Name			
Temp C	25.0000*	25.2767	25.2767
Pres bar	0.9500*	5.1000	1.0197
Enth kW	-46610.	-46605.	-46605.
Vapor mole fraction	0.00000	0.00000	0.00000
Total kmol/s	0.1951	0.1951	0.1951
Total kg/s	6.2500	6.2500	6.2500
Total std L m3/h	28.1040	28.1040	28.1040
Total std V m3/h	15738.94	15738.94	15738.94
Flowrates in kg/s			
Methanol	6.2500	6.2500	6.2500

9.5. APPANDEX E. ECONOMIC CALCULATIONS

Table 12. Economic Calculations for Pipeline

ECONOMIC CALCULATIONS FOR PIPELINE	
Direct Costs(DC)	
1. Purchased Equipment Cost(PEC)	17668
2. Installation Cost for Pump and Pipeline= 0.4 x PEC	7067,2
3. Instrument and Control Equipment Costs= 0.1 x PEC	1766,8
4. Electrical Installed Cost = 0.1 x PEC	1766,8
	28268,8
Indirect Costs(IC)	
1. Engineering and Supervision= 0.15XPEC	2650,2
2. Legal Expenses= X	
3. Construction Expence=0.15x FCI	5797,31
4. Contingency=0.05xFCI	1932,44
Fixed Capital Investment=DC+IC	38648,8
Fixed Cost	
1. DepreciatioN= (1/16) x FCI	2415,55
2. Local Taxes=0.025 x FCI	966,219
3. Insurance=0.005 x FCI	193,244
4. Rent=X	
5. Financing=X	
	3575,01
Operating Costs	
1. Raw Materials=X	
2. Operating Labor= %20 Capacity of Labors	18000
3. Direct Supervisory=X	
4. Utilities=Electric Cost=(Working Hour) x(Electric Cost)x(Power)	9703
5. Maintenance and Repairs=0.02xFCI	772,975
6. Operating Supplies=X	
7. Laboratory Charges=X	
8. Patents and Royalities=X	
Total Annual Cost For Pipeline= Fixed Costs + Operating Costs	32051

Table 13. Economic Calculations for Intermediate Tank

ECONOMIC CALCULATIONS INTERMEDIATE TANK	
Direct Costs(DC)	
1. Purchased Equipment Cost(PEC)	6038
2. Installation Cost for Intermediate Tank = 0.4 x PEC	2415,2
3. Instrument and Control Equipment Costs = 0.1 x PEC	603,8
4. Electrical Installed Cost X	
	9057
Indirect Costs(IC)	
1. Engineering and Supervision= 0.15XPEC	1358,55
2. Legal Expenses= X	
3. Construction Expence=0.15x FCI	1952,91
4. Contingency=0.05xFCI	650,97
Fixed Capital Investment=DC+IC	13019,4
Fixed Cost	
1. DepreciatioN= (1/16) x FCI	813,713
2. Local Taxes=0.025 x FCI	325,485
3. Insurance=0.005 x FCI	65,097
4. Rent=X	
5. Financing=X	
	1204,29
Operating Costs	
1. Raw Materials=X	
2. Operating Labor= X	
3. Direct Supervisory=X	
4. Utilities= X	
5. Maintenance and Repairs=0.02xFCI	260,388
6. Operating Supplies=X	
7. Laboratory Charges=X	
8. Patents and Royalities=X	
	260,388
Total Annual Cost For Intermediate Tank= Fixed Costs + Operating Costs	1464,68

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