A1) The result of the simulation with N=1, γ0=0.05 is as below.

----------------------------------------------------------------

[Input Parameter]

number of reactor : N = 1

initial concentration of monomer : γ0 = 0.050

temperature of coolant : T2 = -15.000[°C]

----------------------------------------------------------------

[Constances]

product flow rate : Gp = 63.000[ton/day]

total conversion rate : ζ = 0.600

residence time of one reactor : τ = 18000.000[s]

mixture density : ρ = 850.000[kg/m^3]

reactor aspect rate : α = 1.300

polymerization heat : ⊿H = 72.800[kJ/mol]

mixture temperature : T1 = 50.000[°C]

thermal conductivity of toluene : λ = 0.128[W/K\*m]

specific heat of toluene : Cp = 1.680[J/K\*g]

molecular weight of toluene : M = 54.000[g/mol]

monomer length : ML = 50

reaction rate const : K = 0.000[1/s]

----------------------------------------------------------------

[Reactors Overview]

feed rate : F = 0.029[m^3/hour]

volume : V = 514.706[m^3]

diameter : D = 7.959[m]

height : H = 10.346[m]

side area : S = 258.689[m^2]

----------------------------------------------------------------

[Reactor 1]

concentration of Butadien of out : C\_1 = 0.020

product heat of polymerization : Qp = 983024.691[W]

viscosity : μ\_1 = 0.616[Pa\*s]

Nusselt number : Nu = 3635.013

Prandtl number : Pr = 8086.036

Reynolds number : Re = 6893.441

Power number : Np = 1.229

revolution number : n\_1 = 0.316[rps]

power consumption : P\_1 = 32745.985[W]

----------------------------------------------------------------

[Total]

total power consumption : P = 32745.985[W]

----------------------------------------------------------------

So, the size of the reactor and the total power consumption are as below.

Size of the reactor:

Volume : **514.706[m^3]**

Diameter:  **7.959[m]**

Height : **10.346[m]**

Total power consumption:

**32745.985[W]**

A2) The result of the simulation with N=3, γ0=0.04 is as below.

----------------------------------------------------------------

[Input Parameter]

number of reactor : N = 3

initial concentration of monomer : γ0 = 0.040

temperature of coolant : T2 = -15.000[°C]

----------------------------------------------------------------

[Constances]

product flow rate : Gp = 63.000[ton/day]

total conversion rate : ζ = 0.600

residence time of one reactor : τ = 4286.506[s]

mixture density : ρ = 850.000[kg/m^3]

reactor aspect rate : α = 1.300

polymerization heat : ⊿H = 72.800[kJ/mol]

mixture temperature : T1 = 50.000[°C]

thermal conductivity of toluene : λ = 0.128[W/K\*m]

specific heat of toluene : Cp = 1.680[J/K\*g]

molecular weight of toluene : M = 54.000[g/mol]

monomer length : ML = 50

reaction rate const : K = 0.000[1/s]

----------------------------------------------------------------

[Reactors Overview]

feed rate : F = 0.036[m^3/s]

volume : V = 153.215[m^3]

diameter : D = 5.314[m]

height : H = 6.908[m]

side area : S = 115.329[m^2]

----------------------------------------------------------------

[Reactor 1]

concentration of Butadien of out : C\_1 = 0.029

product heat of polymerization : Qp = 431209.843[W]

viscosity : μ\_1 = 0.064[Pa\*s]

Nusselt number : Nu = 2388.085

Prandtl number : Pr = 835.304

Reynolds number : Re = 11420.827

Power number : Np = 1.067

revolution number : n\_1 = 0.121[rps]

power consumption : P\_1 = 213.450[W]

----------------------------------------------------------------

[Reactor 2]

concentration of Butadien of out : C\_2 = 0.022

product heat of polymerization : Qp = 317718.129[W]

viscosity : μ\_2 = 0.253[Pa\*s]

Nusselt number : Nu = 1759.556

Prandtl number : Pr = 3320.648

Reynolds number : Re = 3622.750

Power number : Np = 1.472

revolution number : n\_2 = 0.153[rps]

power consumption : P\_2 = 590.307[W]

----------------------------------------------------------------

[Reactor 3]

concentration of Butadien of out : C\_3 = 0.016

product heat of polymerization : Qp = 234096.719[W]

viscosity : μ\_3 = 0.499[Pa\*s]

Nusselt number : Nu = 1296.452

Prandtl number : Pr = 6554.413

Reynolds number : Re = 1630.846

Power number : Np = 1.840

revolution number : n\_3 = 0.136[rps]

power consumption : P\_3 = 517.832[W]

----------------------------------------------------------------

[Total]

total power consumption : P = 1321.589[W]

----------------------------------------------------------------

So, the size of the reactor and the total power consumption are as below

Size of the reactor:

Volume : **153.215[m^3]**

Diameter:  **5.314[m]**

Height : **6.908[m]**

Total power consumption:

**1321.589 [W]**

A3)Table 1 and figure 1, 2 represent the relation between the number of reactors, monomer concentration in the feed of the reactor train, and the total power consumption.

|  | | **Γ0 : Monomer concentration in the feed of the reactor train** | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **0.01** | **0.02** | **0.03** | **0.04** | **0.05** | **0.06** | **0.07** | **0.08** | **0.09** | **0.10** |
| **N : Number of reactors** | **1** | 541.1 | 2469.4 | 6923.9 | 15903.3 | 32746.0 | 62923.0 | 115277.2 | 203945.6 | 351320.6 | 592594.1 |
| **2** | 105.2 | 480.2 | 1346.4 | 3092.4 | 6367.5 | 12235.5 | 22415.9 | 39657.6 | 68315.0 | 115231.1 |
| **3** | 45.0 | 205.2 | 575.4 | 1321.6 | 2721.2 | 5229.0 | 9579.7 | 16948.2 | 29195.4 | 49245.6 |
| **4** | 26.2 | 119.5 | 335.0 | 769.4 | 1584.2 | 3044.1 | 5576.8 | 9866.4 | 16996.0 | 28668.2 |
| **5** | 17.6 | 80.5 | 225.7 | 518.4 | 1067.3 | 2051.0 | 3757.4 | 6647.5 | 11451.2 | 19315.4 |

*Table 1: The total power consumption[w] of each numbers of reactors and each monomer concentrations in the feed of the reactor train.*

*Figure 1: The relation between the total power consumption and the monomer concentration in the feed of the reactor train.*

*Figure 2: The relation between the total power consumption and the number of reactors.*

These results show that increasing the number of reactors is very effective to save the power consumption. With increasing the monomer concentration of the feed, the power consumption is increasing exponentially. Therefore, these results show that using larger reactor and lower concentration mixture is better. However, as larger reactors, as much cost of circulation of the coolant, so we must also consider of that cost.

Program

* Each constant parameters are written with **#define** syntax, and if need, converted unit order in other constant for readability and editability.
* **showUsage** method shows usage of this program.
* When 3 parameter were passed for this program, it calculates total power consumption and show. If parameter is invalid format, only the usage is shown.