## PROGRAM VISIMIX TURBULENT SV.

## Example 1.

### Contents.

- 1. Starting of a project and entering of basic initial data.
  - 1.1. Opening a Project.
  - 1.2. Entering dimensions of the tank.
  - 1.3. Entering baffles.
  - 1.4. Entering mixing device.
  - 1.5. Entering main characteristics of the jacket.
  - 1.6. Entering average properties of media.
- 2. Calculation of 'general' parameters of mixing.
  - 2.1 Parameters of Hydrodynamics.
  - 2.2. Shear rates and turbulence.
  - 2.3. Mixing time.
- 3. Mathematical modeling of a Batch Reactor.
  - 3.1. Entering initial data for modeling of a batch reactor.
  - 3.2. Results of mathematical modeling.
- 4. Liquid-solid mixing.
- 5. Heat Transfer. Modeling of temperature regime.

## Introduction.

The program VisiMix Turbulent performs modeling and technical calculations of mixing and mixing-dependent phenomena (among them - local turbulence, drop breaking and coalescence kinetics, solid-liquid and gas-liquid distribution and mass transfer, non-perfect chemical reactors, heat transfer and thermal regimes of reactors, vibrational stability of shafts, etc.) in low viscosity media, based on combination of theoretical solutions with experimental and practical results. Field of applications of the program – cylindrical tanks and impellers of practically all industrial types in practically unlimited range of volumes.

Program VisiMix Turbulent SV is developed for demonstration of all options and abilities of the program VisiMix Turbulent, but only with impellers of two standard types – propeller and disk (Rushton) turbine impellers.

The program is extremely user-friendly and accessible without any preliminary preparation. Destination of the current example - to facilitate the first steps of studying and application of the program.

# 1. Starting of a project and entering of basic initial data.

Subject of modeling: mixing reactor elliptical bottom and flat top. Internal diameter 1800 mm, total volume 5200 liter with 4 baffles. Width of baffles – 160 mm, length – 1700 mm. Volume of media – 4000 liters, density - 1050 kg/cub.m., viscosity 2 cP.

Tank material – stainless steel. Wall thickness – 6 mm. Inside diameter of jacket – 1870 mm Heat transfer area – 8.5 sq.m.

## 1.1. Opening a Project.

Application of VisiMix program starts with Opening of a Project for this reactor. Start VisiMix program. The main menu appears on the screen (Figure 1-1).

Project	Edit input	Calculate	Supplements	Last menu	Last input table	Window	View	Help
		1						

Figure 1-1. The main Menu bar.

Select Project in the Menu bar. Figure 1-2 appears.

Project	Edit input	Calculate	Supplements	Last menu	La	
New Open. Close					<b>b</b>	
Clone Projec	Clone Project comments					
Save Save /	As					
Repor	t			•		

Figure 1-2. The Project sub-Menu.

Select New in this sub-Menu. A dialogue box will appear.

Project	Edit input	Calculate	Supplements	Last menu	Last input table	1
Enter a	project nar	ne			?	×
Save in	r: 🔁 VisiM	ix Turbulent		• + •	] ┌️* ▥▾	
File nam	ie: Exar	nple SV-1			Save	
Save as	s type: VisiN	1ix Project Fil	es (*.vsm)	•	Cancel	

Figure 1-3. Dialogue box for opening of a new Project.

Print a name for the project in the File name window , for example, Example SV-1 (Figure 1-3) , and confirm this name using the Save button.

## 1.2. Entering dimensions of the tank.

After you click Save, the program provides a Tank selection screen (Figure 1-4). We select a tank with the type of bottom and heat transfer device corresponding to our initial data, in the current case - a tank with Conventional Jacket and Elliptic bottom. Click the corresponding picture, and it will be repeated in the Current choice window on the same screen.



Figure 1-4. Selecting the tank type.

Confirm your tank choice by selecting OK button, and the program will open the Input window corresponding to the selected tank type (Figure 1-5).

Print the Inside diameter and Total Volume of the selected tank accordingly to the data above. Print also Volume of media (4000 l) in the corresponding window. The Total tank height and the Level of media will be calculated by the program and entered automatically.



Figure 1-5. Entering the Tank dimensions.

After the table has been completed, click anywhere on the field of the window, and the tank diagram on the screen will change to reflect your input. To confirm the input, click OK.

#### 1.3. Entering baffles.

After you click OK, the Baffle types graphical menu appears (Figure 1-6). To choose the required variant, click on the appropriate baffle diagram. Select, for example, the Flat baffle-2. The selected type appears in the Current choice window on the right. Click OK to confirm your choice and enter sizes of the baffles in the next input table (Figure 1-7).

NOTE: Typical sizes of baffles are described in the Help section. Click Help button in the window, and the program will open the corresponding paragraph.



Figure 1-6. Defining the baffle type.



VisiMix Turbulent SV

### 1.4. Entering mixing device.

After you click OK, Impeller types menu appears (Figure 1-8). Unlike the commercial VisiMix version, the program VisiMix CV allows for two types of impellers only, and does not allow for 2or 3-stage mixing devices. In order to select one of the accessible types, for example – disc turbine, click on the appropriate picture. The agitator you have selected appears in the Current choice window on the right. Click OK to confirm the choice.



Figure 1-8. Defining the impeller type.

DISK						
Tip diameter	600	mm 💌				
Diameter of disk	450	mm 💌	Π			
Number of blades	6	]				
Pitch angle	90	deg 💌				
Width of blade	120	mm 💌				
Length of blade	150	mm 💌		2193		
Dist. from bottom	400	mm 💌				
Rotational speed	125	Rpm 💌		<u> </u>		
Motor power	7500	w	<del>≪</del> Ø 1800	->-		
Pumping direction down						
OK Cancel Choose new impeller Print Help						
Figure 1-9. Entering data on the mixing device.						

NOTE. To find standard or the most typical relations of selected impeller, use Help button in the lower part of this table.

After completing this table, click anywhere on the field of the window, and the impeller diagram on the screen will change to reflect your input. Click OK to confirm your input.

#### 1.5. Entering main characteristics of the jacket.

The program will provide you with the next input table. Enter characteristics of the jacket, for example – as shown in the Figure 1-10.

Use scrolling and select the Elliptical for Tank head type, the Yes for Jacket covers bottom and the 1 for Number of jacket sections.

TANK HEAT TRANSFER GENERAL DATA							ŀ	lelp
Tank head type Jacket covers bottom Number of jacket sections Lower section	Flat YES 1	V						
Distance from bottom		mm						<u> </u>
Height, Hlow	1600	Imm	┓		1			11
Heat transfer area for lower section If unknown, enter 0 *	8.5	sq.m		H low				663
Upper section								
Distance between two sections Height, Hup		mm		<u>*</u>				/ /
Heat transfer area for upper section		sq.m			<	Ø 1800		
If unknown, enter 0 * Connection of jackets								
* In this case heat trans	sfer area will b VisiMix	pe evaluated	i by	Сок		Cancel		Print

Figure 1-10. Main characteristics of the jacket.

NOTE: As you can see, the program allows also for tanks with 2-stage jackets.

### 1.6. Entering average properties of media.

After this table has been completed and confirmed with OK, you will be asked to fill AVERAGE PROPERTIES OF MEDIA input table (Figure 1-11).

	AVERAGE PROPERTIES OF MEDIA						
Type of media				Behavior of Non-Newtonian media is approximated with the functions:			
Average density Dynamic	2	kg/cub.r		$\tau = \tau_a + K * \gamma^n$			
viscosity Kinematic viscosity	1.905e-06	sq.m/s		$\boldsymbol{\mu} = \boldsymbol{\tau}_{o} * \boldsymbol{\gamma}^{\cdot 1} + \boldsymbol{K} * \boldsymbol{\gamma}^{n \cdot 1} ,$			
Constant K Exponent n		Pa*(sec)	n	where μ - dynamic viscosity, Pa*sec; Υ - shear rate, 1/sec; τ - shear stress, Pa; τ <sub>o</sub> -yield stress, Pa.			
Yield stress		N/sq.m					
ОК	Cano	cel	Print	Help			

Figure 1-11. Input table of average properties of media.

VisiMix Turbulent SV

Select Newtonian as the Type of media and enter the Density and Dynamic viscosity accordingly to the data presented above. The program will calculate Kinematic viscosity automatically accordingly to your input.

After these inputs are confirmed, a schematic drawing of the tank with mixing device will occur in the screen (Figure 1-12). It means that the data are complete enough for mathematical modeling of the basic hydrodynamic characteristics.



Figure 1-12.

# 2. Calculation of 'general' parameters of mixing.

This paragraph shows application of program VisiMix for general evaluation of mixing based on the most often used parameters:

Reynolds number mixing power circulation flow rate vortex depth turbulent dissipation shear rates mixing time

The list of the required mixing parameters is presented above. As it follows from the Table 1.1 of Help section (via Help>Contents>Selection and evaluating of mixing equipment), in order to get these results we have to perform three stages of mathematical modeling, each of them – corresponding to a section of Calculate menu (Table 1).

No	Parameter	Section of Calculate menu
1	Impeller Re number	Hydrodynamics
	Re number for flow	
2	Mixing power	
3	Circulation flow rate	
4	Turbulent dissipation	Turbulence
5	Shear rates	
6	Mixing time	Single phase mixing

#### Table 1. Stages of mathematical modeling.

## 2.1 Parameters of Hydrodynamics.

Let us start with hydrodynamic modeling. Click Calculate in the main menu bar and select Hydrodynamics (Figure 2-1) and select option GENERAL FLOW PATTERN (Approximate). Press Go in the right lower part of the arriving window and start visualization of flow pattern (Figure 2-2). For explanations – press F1.

Project Edit input Calculate Supplement	s La	ast menu	Last input table	Window	View	Help
Hydrodynamics	•	HYDROD	YNAMICS, MAIN C	HARACTER:	ISTICS	
Turbulence	- <b>F</b>	GENERA	L FLOW PATTERN (	APPROXIM	ATE)	
Single-phase liquid mixing	•	Reynold: Impeller	s number for flow Reynolds number			
Continuous flow dynamics	•	CHARAC	TERISTICS OF TAN	IGENTIAL F	LOW	
Batch reaction /blending	►	RADIAL I Average	DISTRIBUTION OF value of tangentia	TANGENTI# I velocity	AL VELC	CITY
Semibatch reaction	•	Impeller	tip velocity	·		
Continuous flow reaction	►	Maximun Tangenti	n value of tangentia ial velocity near the	al velocity e wall		
Liquid-solid mixing	•	ENERGY	AND FORCES			
Liquid-liquid mixing	►	Mixing po Power nu	ower umber			
Gas dispersion and mass transfer	•	Torque				
Liquid-solid mass transfer	•	Force ap Force ap	plied to impeller bla plied to baffle	ide		
Heat Transfer. Continuous flow (CF)	•	CHARAC	TERISTICS OF CIR	CULATION	FLOW	
Heat Transfer. Batch (BH)	►	Circulatio Average	on flow rate circulation velocity			
Heat Transfer. Semibatch (SB)	►	VORTEX Vortex d	PARAMETERS epth			
Heat Transfer. Fixed temperature regime (FT	) 🔸	Vortex v	olume			
Mechanical calculations of shafts	•	Area of r	media surface			
Figure 2-1.						





The next step of calculations, accordingly to the Table 1 - Impeller Reynolds number in the same Hydrodynamics sub-menu. The corresponding calculation result arrives in the screen (Figure 2-3).

IMPELLER REYNOLDS	NUME	BER			
Parameter name	Units	Value			
Impeller Reynolds number		3.94e+05			
For HELP press F					

Figure 2-3.

Arrival of the first results means that the hydrodynamic stage of simulation is completed. In order to see the other results obtained on this stage, it is possible to use Last menu option in the main menu. So, the next step – click Last menu>Mixing power (Figure 2-4), and



Figure 2-4.

get the corresponding result in the arriving table (Figure 2-5).

MIXING POWER					
Parameter name	Units	Value			
Mixing power	w	3520			
For HELP press 1					

Figure 2-5.

In order to define Circulation flow rate, click Last menu>Characteristics of circulation flow. The result is obtained in a form of table (Figure 2-6).

CHARACTERISTICS OF CIRCULATION FLOW					
Parameter name	Units	Value			
Circulation flow rate	cub.m/s	0.859			
Average circulation velocity	m/s	0.337			
Mean period of circulation	s	4.66			
For HELP press F					

Figure 2-6.

### 2.2. Shear rates and turbulence.

The next step – evaluation of turbulent dissipation and shear rates in the tank. Click Calculate>Turbulence and select LOCAL VALUES OF ENERGY DISSIPATION (Figure 2-7). Before doing it, we recommend to close the accumulated windows (click Window>Close all in the main Menu bar).

Project Edit input Calculate Supplements	Last menu Last input table Window View Help
Hydrodynamics	
Turbulence	TURBULENCE, MAIN CHARACTERISTICS
Single-phase liquid mixing	DISSIPATION OF ENERGY AROUND THE IMPELLER
Continuous flow dynamics	LOCAL VALUES OF ENERGY DISSIPATION
	Energy dissipation - maximum value
Batch reaction (blending	Energy dissipation - average value
Semibatch reaction	Energy dissipation in the bulk volume Energy dissipation near haffles
Continuous flow reaction	VOLUMES OF ZONES WITH DIFFERENT TURBULENCE
Liquid-solid mixing	Volume of zone of maximum dissipation RESIDENCE TIME IN ZONES WITH DIFFERENT TURBULENCE
Liquid-liquid mixing	MICROSCALES OF TURBULENCE IN DIFFERENT ZONES
Gas dispersion and mass transfer	TURBULENT SHEAR RATES IN DIFFERENT ZONES Turbulent shear stress near the impeller blade
Liquid-solid mass transfer	LOCAL VALUES OF EFFECTIVE VISCOSITY
Heat Transfer, Continuous flow (CF)	•

Figure 2-7.

Results of modeling appear as a table (Figure 2-8).

LOCAL VALUES OF ENERGY DISSIPATION				
Parameter name	Units	Value		
Energy dissipation - maximum value	W/kg	243		
Energy dissipation - average value	W/kg	0.837		
Energy dissipation near baffles	W/kg	0.541		
Energy dissipation in the bulk volume	W/kg	0.237		

Figure 2-8.

The energy dissipation achieves the maximum value in vortices formed behind the impeller blades, and is decreasing with the distance from the impeller. Result of modeling of turbulence decrease is obtained as a graph via Last menu>DISSIPATION OF ENERGY AROUND THE IMPELLER (Figure 2-9).



Figure 2-9.

To obtain data on shear rates in different zones of the tank (Figure 2-10), click Last menu>TURBULENT SHEAR RATES IN DIFFERENT ZONES.

- LOCAL VALUES OF ENERGY DISSIPATION 5_1] - TURBULENT SHEAR RATES IN DIFFERENT ZONES			
TURBULENT SHEAR RATES IN	DIFFE	RENT ZONES	
Parameter name	Units	Value	
Turbulent shear rate near the impeller blade	1/s	2020	
Turbulent shear rate near the baffle	1/s	219	
Turbulent shear rate in the bulk volume	1/s	219	
			📘
		For H	IELP press F1



In order to get additional information on the parameters presented in this table, click F1, and you will open the corresponding paragraph of Help section.

#### 2.3. Mixing time.

Accordingly to the Table 1, the next step is evaluation of mixing time – duration of mixing necessary for a more or less uniform distribution of dissolved tracer in the tank volume. In order to perform the evaluation, let us go to Calculate>Single phase mixing and select MAIN CHARACTERISTICS (Figure 2-11).



Figure 2-11.

As it can be seen in the resulting output table (Figure 2-12) the program performs simulation of macro-scale and micro-scale turbulent transport of tracer and provides two constituents of mixing duration. The 'total' mixing time is estimated as a sum of the Macromixing time and Characteristic time of micromixing. To get more information on the physical meaning of these parameters, click F1, and the program will open the corresponding paragraph of the Help section.

SINGLE-PHASE MIXING. MAIN CHARACTERISTICS				
	Parameter name	Units	Value	
	Macromixing time	s	21.8	
	Mean period of circulation	s	4.66	
	Characteristic time of micromixing	s	5.41	

Figure 2-12.

# 3. Mathematical modeling of a Batch Reactor.

One of the most efficient applications of VisiMix program – mathematical modeling and analysis of influence of mixing on efficiency of batch reactors.

Subject of the current example - application of the mixing tank for a batch organic synthesis process that includes two parallel homogeneous reactions. The main product is obtained as a result of a 2nd order reaction between reactant A and B as A + B > C.

The specific reaction rate is estimated as  $0.12 \, 1/(\text{mol.s})$ . Along with the main product, some quantity of a by-product is formed as a result of the parallel reaction:

B+B>D with specific reaction rate 0.004 1/(mol.s).

Before start of the process the reactor is filled with solution of reactant A (concentration is 0.8 g-mol/l) and catalist. The equimolecular quantity of the reactant B is added instantly on the surface of liquid, on some distance – about 300 mm – from the tank wall.

### 3.1. Entering initial data for modeling of a batch reactor.

For mathematical modeling of the reactor let us use the Menu option Batch reaction/blending (Figure 3-1) and select Batch reactor. General pattern.

Project Edit input Calculate Supplements	Last menu Last input table Window View Help
Hydrodynamics Turbulence	
Single-phase liquid mixing	
Continuous flow dynamics	•
Batch reaction /blending	Batch blending. General pattern
Semibatch reaction	Max. local concentration, batch blending
Continuous flow reaction	Min. local concentration, batch blending
Liquid-solid mixing	Max. difference in local concentrations, batch blending Local concentration in chosen point, batch blending
Liquid-liquid mixing	Batch reactor. General pattern
Gas dispersion and mass transfer	Average concentration of reactant A, batch reactor
Liquid-solid mass transfer	Max. local concentration of reactant A, batch reactor
Heat Transfer. Continuous flow (CF)	Min. local concentration or reactant A, batch reactor Max. difference in reactant A concentrations, batch reactor
Heat Transfer. Batch (BH)	Reactant A, concentration in chosen point, batch reactor     Degree of reactant A conversion, batch reactor

Figure 3-1,

As a response, the program starts providing requests for additional initial data.

SINGLE- PHASE BLENDING AND REACTORS. HOMOGENEOUS CHEMICAL REACTION				
MAIN REACTION A + B = C Reactant A is charged initially into the tank	SIDE REACTION Side reaction is assumed to be slow compared to the main reaction			
Specific reaction rate for BLENDING - enter 0 (zero) for FAST reaction - enter F	Reaction type B + C = D B + C = D B + B = D Specific reaction rate			
OK Cancel Print	Help			

Figure 3-2.

Enter the data on chemical kinetics into the table provided by the program, i.e.: - scroll the Reaction type box in the window shown in the Figure 3-2 and select B+B reaction - enter values of the specific reaction rate, as shown in the Figure 3-3, and confirm the input with OK.

SINGLE- PHASE BLENDING AND REACTORS. HOMOGENEOUS CHEMICAL REACTION				
MAIN REACTION A + B = C Reactant A is charged initially into the tank	SIDE REACTION Side reaction is assumed to be slow compared to the main reaction			
	Reaction type B + B = D			
Specific reaction rate 0.12 I/(mol*sec)  for BLENDING - enter 0 (zero) for FAST reaction - enter F	Specific reaction rate 0.004 (/(mol*sec)			
OK Cancel Print	Help			

Figure 3-3.

The next input table provided by the program serves for entering of initial concentrations of the reactants. The filled table is shown in the Figure 3-4.

SINGLE- PHASE BLENDING AND REACTORS. INITIAL CONCENTRATIONS (LOADS) OF REACTANTS (BATCH & SEMIBATCH)			
Init. concentration of reactant A	0.8	mol/liter	
Relation of loads - B[mol]/A[mol]	1		
OK Cancel	Print	Help	

Figure 3-4.

After the input is confirmed, position of inlet of reactant B must be entered. Accordingly to the data above, enter radius 600 mm. For height from bottom it is possible to enter any value higher then the tank height - the program will automatically put the inlet point on liquid surface (Figure 3-5).

SINGLE- PHASE BLENDING AND REACTORS. INLET (BATCH AND SEMIBATCH)  Position of inlet of reactant B  radius  600 mm  inlet	
OK Cancel Print	Help

Figure 3-5.

In order to complete the input, the program provides a table for entering position of sensor. You can enter the real position (Figure 3-6) or any other point in the tank. The program will provide concentrations of reactants in this point.

SINGLE- PHASE BLENDING AND REACTORS. SENSOR	
Sensor position O radius 800 mm V height from bottom 1/1500 mm V	© 1200
OK Cancel Print	Help

Figure 3-6.

### 3.2. Results of mathematical modeling.

Now, after all the requested data are entered, the program performs simulation of the reaction process with regard to geometry of the reactor, flow velocities and macro-scale turbulence. Accordingly to our request (Figure 3-1), the first output window presents visualization of reactants distribution in the reactor as function of time (Figure 3-7). To start the visualization, click Start.



Figure 3-7.

The program provides also quantitative results of modeling. In order to evaluate selectivity of the reaction, click Last menu > Average concentration of product and Last menu > Average concentration of product.









Results of modeling arrive as a graphs (Figures 3-8 and 3-9).

NOTE. The corresponding tables are presented in the Report (via Project>Report>Batch reaction/blending).

As follows from the results, there is a problem of selectivity. For amore exact definition of the problem click Last menu > By-product quantity. As follows from the arriving graph (Figure 3-10), formation of about 200 mol of by-product in this reactor is expected.



(Figure 3-10)

The program allows to define if this level of selectivity is defined by the reaction kinetics only or it can be improved by some change of mixing conditions. In order to do it, we will check dependence of the by-product formation on rotational velocity of impeller in our tank. Click on the Impeller icon in the upper bar (Figure 3-11).

Project	Edit input	Calculate	Supplements	Last menu	Last input table	Window	View	Help
		🛃 👅	í 🚣 🧴 🦹					
			Impeller					

Figure 3-11.

In the arriving Impeller input table increase Rotational speed to from 125 to 250 rpm (Figure 3-12).



Figure 3-12.

In this case program provides a warning message (Figure 3-13).

Mixing pow	er is too high for your drive.	

Figure 3-13.



Figure 3-14.

In our case it does not matter, so click OK. The graph in the Figure 3-10 will change automatically accordingly to the new conditions. It shows the final by-product quantity about 145 mol (Figure 3.14). It means that in our case selectivity can be improved by selection of better mixing conditions.

VisiMix allows also to check another possibility – selection of a better position of reactant B inlet. First of all, return to rotational velocity 125 rpm – using Impeller icon or Last input table option of the main menu. Then go to Edit input in the main menu bar and select Properties & regime > Single phase blending and reaction > Input position. In the arriving input table change height from bottom from 1722 mm to 450 mm (Figure 3-15).



Figures 3-15.





Accordingly to the automatically updated output graph, the change of inlet position allows to decrease by-product formation by pproximately 25% (compare graphs in Figures 3-10 and 3-16).

## 4. Liquid-solid mixing.

Mixing of suspensions is one of the most usual applications of mixing equipment. Usually the mixing tank must satisfy two main requirements – pick-up from bottom (complete suspending) of the solid phase, and relatively uniform distribution of solid phase in the volume.

Subject of this example – mathematical modeling and defining parameters of liquid-solid mixing for suspension that contains solid particles with mean size 85 micrometers (up to 130 micrometers) with density 2630 kg/cub.m. Mass concentration of solid – 100 kg per cub.m.

To start calculations, go to Liquid - Solid Mixing in the Calculate option of the main menu and select any parameter for modeling, for instance Complete/incomplete suspending (via Calculate> Liquid - Solid Mixing, Figure 4-1).

Project Edit input Calculate Supplements	; Last menu Last input table Window View Help
Hydrodynamics	
Turbulence	•
Single-phase liquid mixing	•
Continuous flow dynamics	•
Batch reaction /blending	•
Semibatch reaction	•
Continuous flow reaction	•
Liquid-solid mixing	LIQUID-SOLID MIXING. MAIN CHARACTERISTICS
Liquid-liquid mixing	Complete/incomplete suspension
Gas dispersion and mass transfer	AXIAL DISTRIBUTION OF SOLID PHASE RADIAL DISTRIBUTION OF SOLID PHASE
Liquid-solid mass transfer	Relative residence time of solid phase
Heat Transfer. Continuous flow (CF)	COLLISIONS OF PARTICLES     Maximum local concentration of solid phase
Heat Transfer. Batch (BH)	Minimum local concentration of solid phase
Heat Transfer. Semibatch (SB)	Average concentration of solid phase in continuous flow     Maximum degree of non-uniformity - axial, %
Heat Transfer. Fixed temperature regime (FT	Maximum degree of non-uniformity - radial, %
Figure 4-1.	

As a response, the program returns a table for entering necessary additional data –PROPERTIES OF SOLID AND LIQUID PHASES, as shown in Figure 4-2.

PROPERTIES OF SOLID AND LIQUID PHASES.					
Density of liquid phase	1000	kg/cub.m 💌			
Dyn. viscosity of cont.phase	1	сР			
Concentration of solid phase	100	kg/cub.m 💌			
Density of solid phase	2630	kg/cub.m 💌			
Average particle size	85	micron			
Size of largest particles	× 130	micron			
Position of outlet-height	0	mm			
OK Cano	el Prin	t Help			

Figure 4-2.

After this table is completed, VisiMix starts calculations with defining average density and viscosity of the suspension. Since the average properties calculated by VisiMix are not identical to our previous input (see Figure 1-11), VisiMix suggests to adjust the input. A warning message appears (Figure 4-3) informing that the calculated density and viscosity values differ from those that have been entered in AVERAGE PROPERTIES OF MEDIA input table (Figure 1-11).

Calculated values of average properties of suspension don't correspond to your former input of average PROPERTIES OF MEDIA:						
	Former input	Calculated values				
Density, kg/cub.m :	1050	1062				
Dynamic viscosity, Pa*sec :	0.002 0.00117					
To change your input select <cancel>, then Edit - Properties &amp; regime - Average properties of media, and replace your former input of density and viscosity with calculated values from this table.</cancel>						
To proceed with the calculations without changing your input, select <ok>. In this case calculated hydrodynamic parameters will correspond to the former values of PROPERTIES OF MEDIA</ok>						



As we consider that in our case the difference is not significant, we can click OK and proceed with calculations without changing the data. In response to OK, the program performs the calculations using the results of hydrodynamic modeling obtained before, and provides the message that confirms complete suspending of the solid particles (Figure 4-4).

NOTE: If we select Cancel in the previous dialog and enter new values of average properties, the mathematical modeling of hydrodynamics and turbulence is repeated automatically.

	Complete suspension is expected
İ	

Figure 4-4.

Results of modeling of axial and radial distribution of solid particles can be presented in a graphic form or as final values. Click Last menu and select Axial distribution of solid phase (Figure 4-5) and get a graph as shown in the Figure 4-6.

Jt	Calculate Supplements Last menu Last input table
-	LIQUID SOLID MIVING MAIN CHARACTERISTICS
	Complete/incomplete suspension
	AXIAL DISTRIBUTION OF SOLID PHASE
	RADIAL DISTRIBUTION OF SOLID PHASE
	Relative residence time of solid phase
	COLLISIONS OF PARTICLES
	Maximum local concentration of solid phase
	Minimum local concentration of solid phase
	Average concentration of solid phase in continuous flow
	Maximum degree of non-uniformity - axial, %
	Maximum degree of non-uniformity - radial, %

Figure 4-5



Figure 4-6.

The other way – click Last menu>Maximum degree of non-uniformity – axial and get the table as in Figure 4-7.

MAXIMUM DEGREE OF NON-UNIFORMITY - AXIAL, %				
Parameter name	Units	Value		
Maximum degree of non-uniformity - axia	l, %	6.65		

Figure 4-7.

Results of modeling of radial distribution of suspension are obtained in the same way (Figures 4-8 and 4-9).



Figure 4-8.

MAXIMUM DEGREE OF NON-UNIFORMITY - RADIAL, %					
Parameter name	Units	Value			
Maximum degree of non-uniformity - radial, %		0.696			



VisiMix Turbulent SV

As it is possible to see in the sub-menu Liquid-solid mixing, the program provides also calculation of some additional parameters that are useful for analysis of continuous flow reactors (Relative residence time of solid) or crystallization (Figure 4-10).

COLLISIONS OF PARTICLES				
Parameter name	Units	Value		
Maximum energy of collisions	J	1.96e-11		
Energy of collisions in the bulk volume	J	1.93e-13		
Frequency of collisions of maximum energy	1/s	0.0254		
Characteristic time between two strong collisions	s	39.4		

Figure 4-10.

# 5. Heat Transfer. Modeling of temperature regime.

Subject of this paragraph – demonstration of VisiMix application for mathematical modeling of heat transfer of mixing tanks. The program provides simulation of heating cooling regimes for complicated cases, including batch or continuous flow chemical reactors with temperature dependent heat release. However, in this example we are applying the program for a simple case of batch cooling the tank with water.

Let us assume that initial temperature of media in our tank is 80 deg. C, and we need to reduce it to 40 deg or less within 4 hours. Accordingly to this task, we open the menu option Calculate, select Heat transfer.Batch > Liquid agent and start with request for Media temperature (Figure 5-1).



As in the previous example, the program starts providing tables for some additional initial data. First arrives a table defining the main process parameters – presence of chemical reaction and limits of temperature (Figure 5-2).

HEAT TRANSFER. CHEMICAL REACTION DATA AND TEMPERATURE LIMITS					
Will you enter reaction kinetics?	YES		Reaction velocity constant K is described by Arrhenius equation :		
Arrhenius constant	0	I/(mol*sec) 🔽	K = A exp( - E / RT) ,		
Energy of activation	0	J/mol 💌	where		
Lower limit of temperature		°C 🔽	E is energy of activation , B = 8.314 L/ (mol*K) =		
Upper limit of temperature		°C 🔽	= 1.986 Btu / (lb*mol) / *F is universal gas constant.		
Heat effect of reaction	0	J/mol 💌	T is absolute temperature .		
ОК	Cancel	Print	Help		

Figure 5-2.

Assuming the simple case of cooling of a water solution in tank with water in jacket, we select No for reaction kinetics and enter limits for temperature of media –from 10 to 90 degrees C, as shown in the Figure 5-3.

HEAT TRANSFER. CHEMICAL REACTION DATA AND TEMPERATURE LIMITS					
Will you enter reaction kinetics? Arrhenius constant	NO	I/(mol*sec) ▼	Reaction velocity constant K is described by Arrhenius equation : K = A evp(-F / BT)		
Energy of activation		J/mol 💌	where A is Arrhenius constant		
Lower limit of temperature	10	°C 🔽	E is energy of activation , R = 8.314 J / (mol*K) =		
Upper limit of temperature	90	°C 🔽	= 1.986 Btu / (Ib*mol) / *F is universal gas constant , T is absolute temperature		
Heat effect of reaction	]	J/mol			
ОК	Cancel	Print	Help		

Figure 5-3.

The next requests of the program - additional information on the tank itself. (Figure 5-4). Use the scroll box for selection the tank material. The program will enter the heat conductivity and other properties of the material automatically using a built-in database.

The thermal resistance of fouling depends on the heat transfer agent. You can select the appropriate value using the table Thermal resistance of fouling for various media that is present

in the Help section. You need only to click the Help button in the lower part of this window (Figure 5-4).

Wall thickness and mass of tank are usually present in the technical data provided by manufacturer. If tank mass is unknown, enter 0, and the program will perform approximate evaluation.

TANK SHELL CHARACTERISTICS				
Material Stainless steel (generalized)				
Wall thickness	6 mm			
Thermal resistance of fouling	0.00023 (m²*K)/W			
Tank mass (without drive) If unknown, enter 0 *	0 kg 💌			
OK Cano	cel Print Help			
* In this case tank mass will be	evaluated by VisiMix			

Figure 5-4.

The next table provided by the program – specific characteristics of jacket. In our case a tank with simple jacket is used (Figure , and you have to enter the Width and Wall thickness of the jacket (Figure 5-5).

NOTE. The program provides options for more complicated modern designs – jackets with agitation nozzles or spiral channeling. These options are selected by scrolling, the typical characteristics of the heat enhancing devices are presented in the Help (see button in the lower part of the window).

		Lower section			
Heat-transfer enhancing	absent 💌	Width, W	50	mm 💌	
Jevice	absent agitation nozzles	Wall thickness, t	6	mm 💌	1 L
l	spiral baffle	Number of inlets			
Diameter of <b>[</b> nozzle	mm	Number of nozzles			
		Upper section			
		Width, W		mm 🔽	->-<
Spiral channel <b>[</b> height	mm	Wall thickness, t		mm 🔽	
Leakage, %		Number of inlets			
		Number of nozzles			

Figure 5-5.

After all the design data are entered, the program will provide a table for selecting a heating / cooling agent (Figure 5-6).

Names of the heating / cooling agents are shown in scrolling box . Temperature limits of application and physical properties of the selected agent occur in the lower part of this input table.

HEATING / COOLING LIQUID AGENT IN JACKET.						
Heating/cooling agent	Water	•				
Inlet temperature	20 °C 💌	•				
Flow rate of heat transfer agent in lower jacket	3 cub.m/h 💌	-				
Flow rate of heat transfer agent in upper jacket	cub.m/s					
OK Cancel	Print Help					
Operating temperature range: 5 - 204°C [41 - 400°F] Properties of the agent density1000 kg/m³ [62.4 lbm/ft³] specific heat4190 J/(kg*K) [1.01 Btu/(lbm*°F)] thermal conductivity0.603 W/m*K [0.348 (Btu*ft)/(h*ft <sup>&amp;</sup> **F)] dynamic viscosity at 100°C(212°F)0.000284 Pa*sec [0.284 cP]						



The next two input tables are related to the media in the tank - physical properties (Figure 5-7) and initial temperature (Figure 5-8). It is enough to define physical properties of the media at one temperature, and the program will use build-in correlations for properties dependent on temperature.

NOTE. If you have a problem with defining the physical properties, please click the Help button in the lower part of this input window. It is possible that you will find some useful information in one of the VisiMix databases.

HEAT TRANSFER PROPERTIES OF THE MEDIA					
Media	Water solution	•			
	PARAMETER			TEMPER	RATURE
Average density	1050	kg/cub.m	•	20	°C 💌
Dynamic viscosity	2	сР	•	20	°C 💌
Specific heat	4000	J/(kg*K)	•	20	°C 💌
Heat conductivity	0.6	W/(m*K)	•	20	°C 💌
ОК	Cancel	Print			Help

Figure 5-7.

BATCH PROCESS. H	IEAT TRANSFE	R SPECIFIC DATA.
Initial temperature in the tank	80'	°C 💌
Initial concentration of reactant A in the tank.		mol/liter
Initial concentration of reactant B in the tank	<b></b>	mol/liter
Simulation time	4	h 💌
OK Canc	el Print	Help

Figure 5-8.

This input table is the last one. After it is filled, the program performs simulation and provides the output table corresponding to the initial request, in our case – Media temperature (Figure 5-9).



Figure 5-9.

Accordingly to this graph, at the conditions corresponding to our inputs the outlined time -4 hours- is not enough to achieve the necessary level of temperature (lower then 40 deg.). The program allows to find an acceptable way to achieve the required results.



Figure 5-10.







Figure 5-12.

Addressing the Last menu option, we can find that heat transfer rate in our case is limited due to low value of film heat transfer coefficient in the jacket (compare Last menu >Overall heat-transfer coefficient, lower jacket, Figure 5-10, and Last menu > Outside film coefficient, lower jacket, Figure 5-11) and relatively high temperature of cooling water in the jacket (Last menu > Outlet temperature of liquid agent in lower jacket, Figure 5-12). So, the easiest way to increase the heat transfer rate is to increase flow rate of the cooling water. In order to check this option, click icon Initial data explorer in the upper bar (Figure 5-13), select the necessary input parameter via Properties & regime > Heat transfer >Heating / cooling liquid agent > Flow rate of heat transfer agent in lower jacket and click Edit button (Figure 5-13).



Figure 5-13.

The program provides the input table for Heating / cooling liquid agent, shown in the Figure 5-6. Enter a higher value of water flow rate and click OK, and the program will provide the corrected graph of Media temperature. Accordingly to data of Figures 5-14 and 5-15, in order to achieve the required cooling rate, at least double flow rate of water is necessary.

HEATING / COOLING LIQUID AGENT IN JACKET.						
Heating/cooling agent	Water					
Inlet temperature	20 °C 💌					
Flow rate of heat transfer agent in lower jacket	6 cub.m/h 💌					
Flow rate of heat transfer agent in upper jacket	cub.m/s					
OK Cancel	Print Help					

Figure 5-14.





If increase of flow of cooling water is in-desirable, the problem can be solved by cooling with chilled water, for example – with initial temperature 10 deg. In order to check the new conditions, use the option Last input table of the main menu and change the data in the arriving table (Figure 5-16).

HEATING / COOLING LIQUID AGENT IN JACKET.						
Heating/cooling agent	Water	•				
Inlet temperature	10	°C 💌				
Flow rate of heat transfer agent in lower jacket	3	cub.m/h				
Flow rate of heat transfer agent in upper jacket		cub.m/s				
OK Cancel	Print	Help				

Figure 5-16.



Figure 5-17.

Accordingly to the results presented in the Figure 5-17, this cooling regime also is satisfactory.