

## VisiMix TURBULENT. DISSOLVING OF SOLID PARTICLES

This example is devoted to the modeling of dissolution of solid particles suspended in liquid (liquid-solid mass transfer). VisiMix enables the user to calculate values of the dissolution time, concentration of solid and dissolved solids, mass transfer coefficient, etc. It also provides graphs illustrating the dynamics of main process characteristics. VisiMix dissolution option includes also calculations of the hydrodynamic and just suspension conditions to ensure the successful and efficient operation.

### **Problem description:**

Dissolution processes in liquid-solid systems always involve suspension. Therefore, for calculating dissolution processes, you will need both data normally needed for calculations of liquid-solid mixing (see Example 2 on determining Just Suspension Speed, JSS), and the data associated with the dissolution process proper. In this example, we will show how the equipment parameters (impeller tip diameter and the number of blades) affect the dissolution process.

### **Initial data**

The process takes place in a cylindrical fully baffled tank with an elliptical bottom.

#### **Tank:**

Inside tank diameter = 1400 mm;  
Total tank height = 2000 mm;  
Media level = 1600 mm;

#### **Baffle:**

There are 4 radial flat baffles attached at a distance of 30 mm from the tank wall.  
Width = 120 mm;  
Length = 1400 mm;  
Distance from bottom = 340 mm;  
Distance from the wall = 30 mm.

#### **Impeller:**

Downward pumping pitched paddle impeller  
2 blades inclined at 45°.  
Tip diameter = 600 mm;  
Blade width = 80 mm;  
Distance from bottom = 220 mm;  
Number of revolutions = 120 Rpm;  
Power of drive = 2000 W.

Outlet position has a height of 0 mm.

#### **Properties of the media:**

Newtonian liquid with the following average properties:  
Density = 1047 kg/m<sup>3</sup>;

Dynamic viscosity = 0.00119 Pa\*s.

Properties of solid and liquid phases:

Liquid phase:

Water

Density = 1000 kg/m<sup>3</sup>

Dynamic viscosity = 0.001 Pa\*s.

Solid phase:

Concentration = 90 kg/m<sup>3</sup> ;

Density = 2100 kg/m<sup>3</sup> ;

Average particle size = 350 microns;

Size of the largest particles = 900 microns;

Additional properties of the solution:

initial solute concentration - 0 kg/m<sup>3</sup>;

molecular diffusivity - 1.85e-10 m<sup>2</sup>/s;

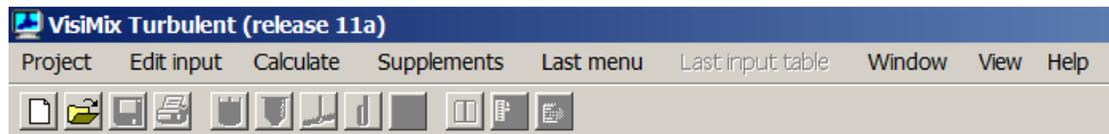
solid phase solubility - 107 kg/m<sup>3</sup>.

**The task is to calculate the dissolution time.**

**The Solution:**

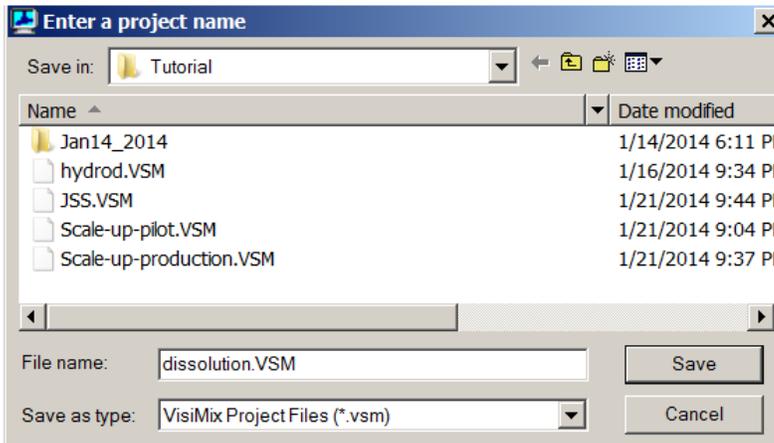
The dissolution time is calculated by the **Liquid-solid mass transfer** option of the **Calculate** option in the main menu. To obtain this value, you must start a new project file, select the equipment from the graphical menus, enter the initial data requested by the program, and then select **Dissolution time** in the **Liquid-solid mass transfer** option of the **Calculate**. Then you must enter other data if requested, and obtain the desired result. You may also calculate other important parameters (see “**Liquid-solid mass transfer**” option).

After installing **VisiMix**, the main menu shown in Figure 4-1 appears. Select **Project-New**.



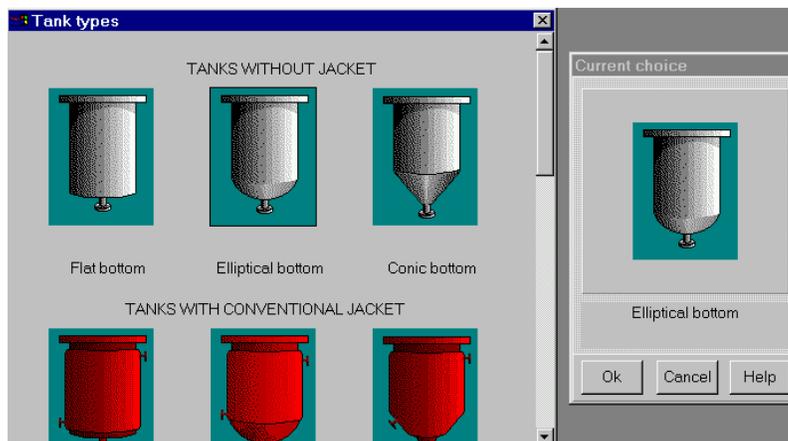
**Figure 4-1. VisiMix main menu.**

A dialogue shown in Figure 4-2 will appear. Enter a name for the project (here **dissolution.vsm** is entered as a name for this project). You may create a special directory for the project, or choose an existing directory. In this case, the directory name is **tutorial**.



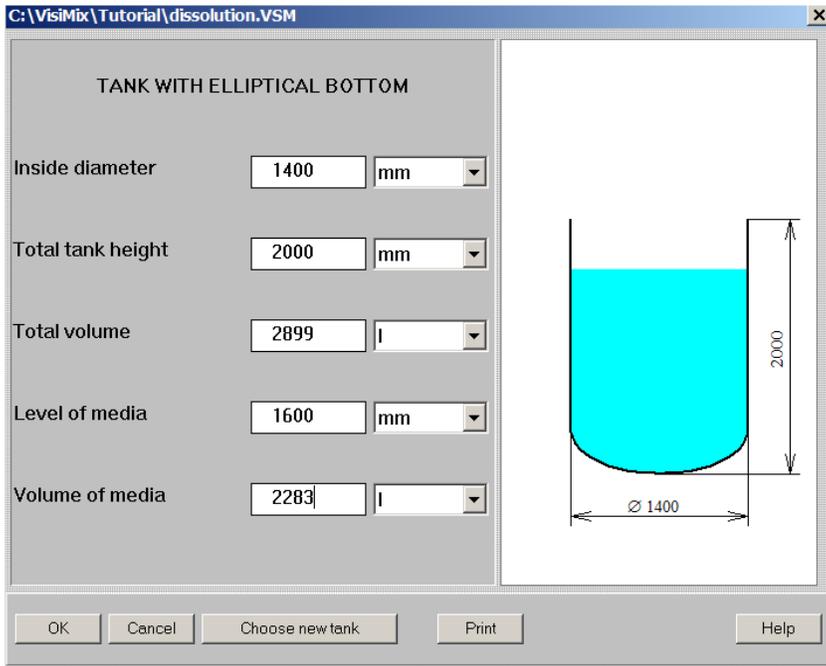
**Figure 4-2. Starting a new project.**

After you click **Save**, the **Tank types** menu with tanks differing by **bottom type** (flat, conic and elliptical) and **type of heat transfer device** (unjacketed tanks, and tanks with conventional, half-pipe coil and dimpled/embossed jacket) appears. Click on the diagram of your tank (unjacketed tank with elliptical bottom), and it will appear in the **Current choice** window on the right (Figure 4-3). Click **OK** to confirm your choice.



**Figure 4-3. VisiMix graphic tanks selection.**

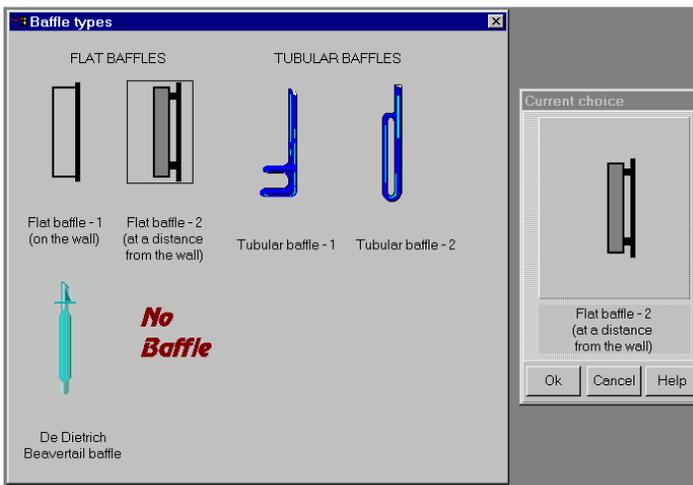
You will then be asked to enter all the required parameters for your tank in the TANK WITH ELLIPTICAL BOTTOM input table. Enter **Inside diameter**, **Total tank height**, and **Level of media**, and **Total volume** and **Volume of media** will be calculated by the program and entered automatically (Figure 4-4).



**Figure 4-4. Entering tank data.**

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. Click **OK** to confirm your input.

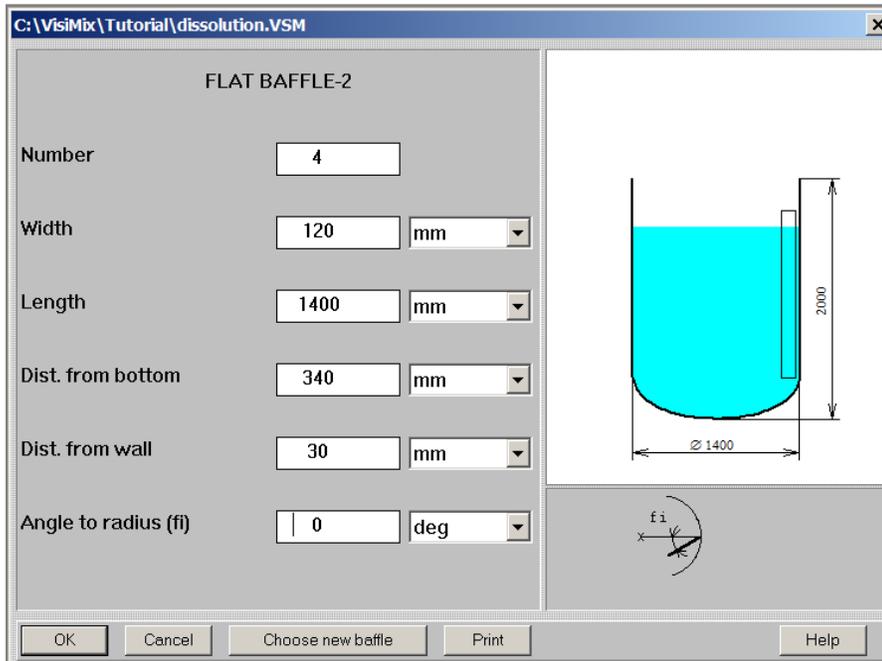
After you click **OK**, the **Baffle types** menu appears. Click on the diagram of your baffle type (Flat baffle-2), and it will appear in the **Current choice** window on the right (Figure 4-5). Click **OK** to confirm your choice.



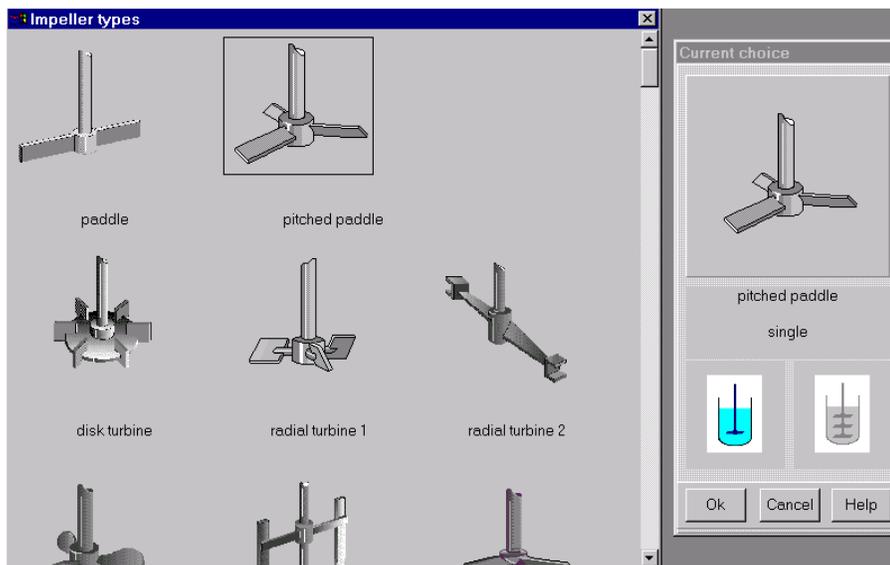
**Figure 4-5. VisiMix graphic baffle selection.**

Now enter the parameters of your baffle in the table that appears (Figure 4-6).

Now select your pitched paddle impeller in the **Impeller types** menu that appears by clicking on the appropriate diagram. It will appear in the **Current choice** window on the right (Figure 4-7). In this window, select also **single** for your single-stage system. Click **OK** to confirm your choice.

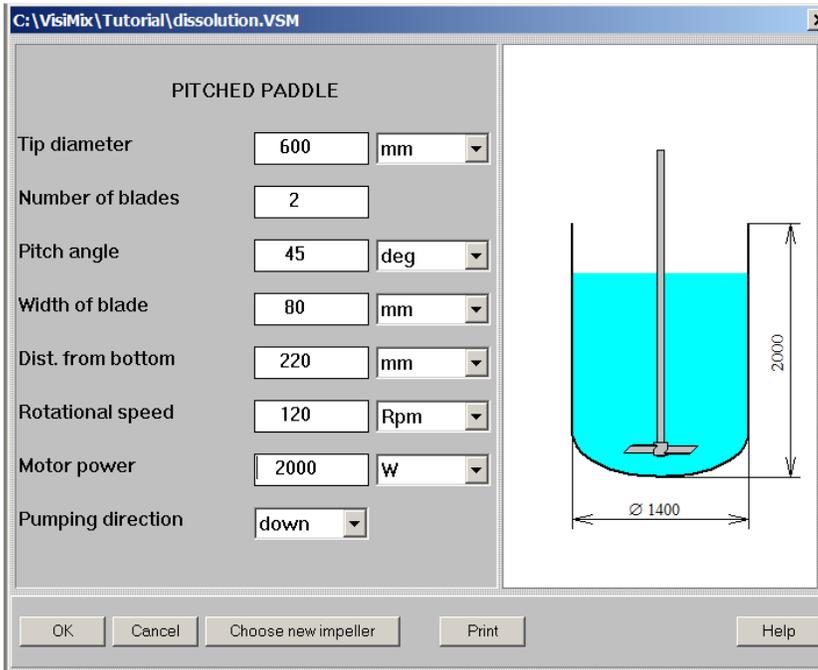


**Figure 4-6. Entering baffle data.**



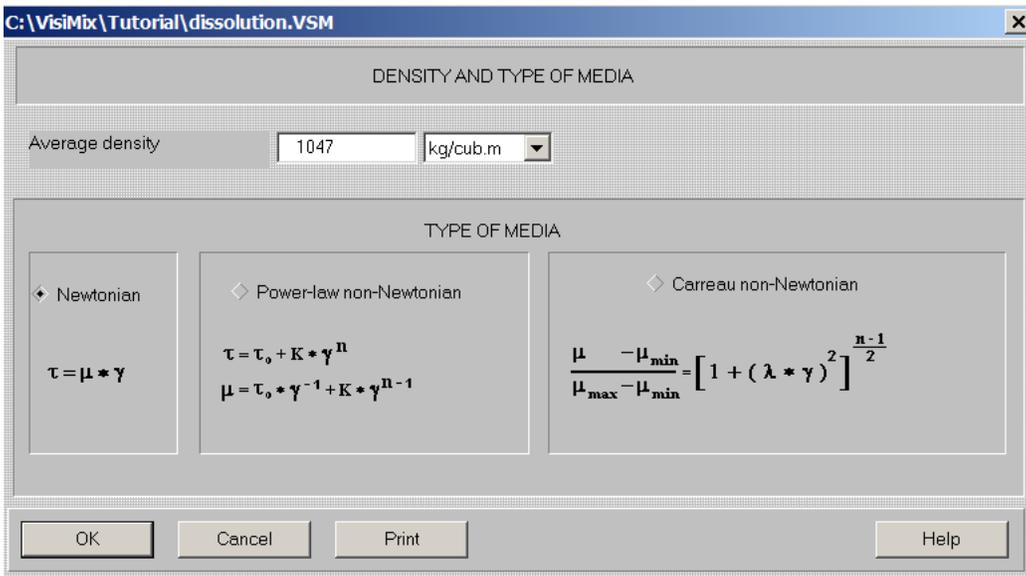
**Figure 4-7. VisiMix graphic impeller selection.**

Now you will be asked to fill PITCHED PADDLE input table (Figure 4-8).

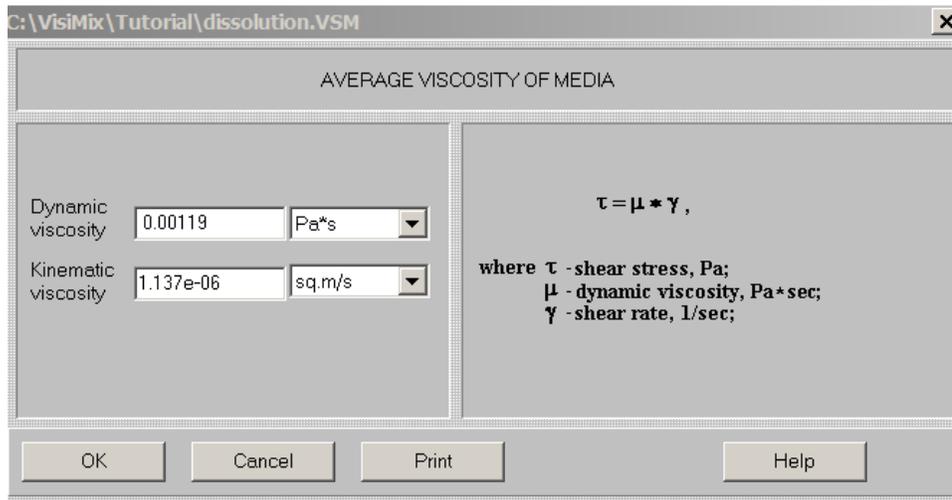


**Figure 4-8. Entering impeller data (basic variant).**

Enter your data and click **OK** to confirm your choice. After this table has been completed, you will be asked to specify average properties of the media: at first to fill **DENSITY AND TYPE OF THE MEDIA** table (Figure 4- 9a) and then **AVERAGE VISCOSITY OF THE MEDIA** table (Figure 4- 9b).

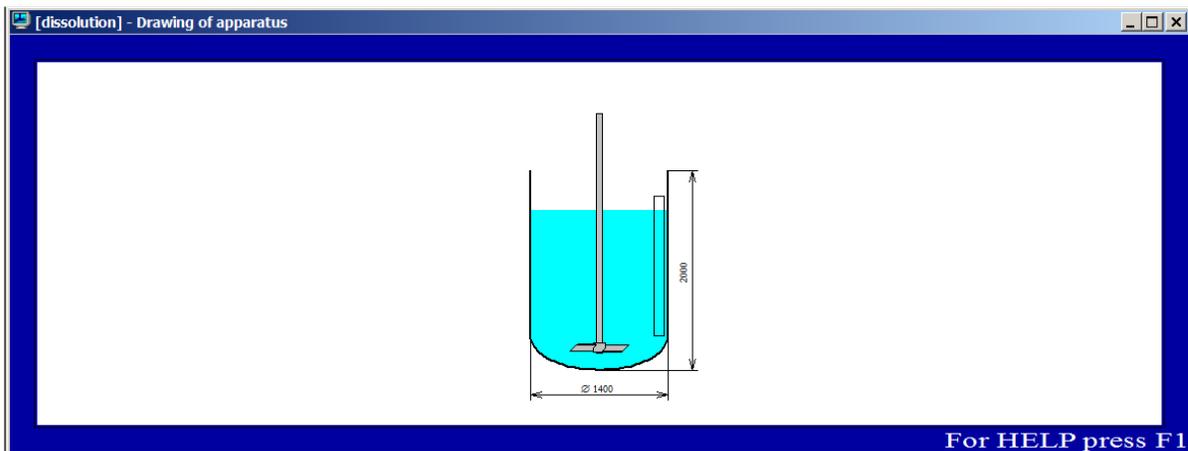


**Figure 4-9a. Entering density and type of media.**



**Figure 4-9b. Entering average viscosity of media.**

Now you have completed entering basic initial data, and the tank diagram corresponding to the data you have entered appears (Figure 4-10).



**Figure 4-10. The diagram of your mixing system.**

We recommend closing this window before proceeding to calculations.

Now you may proceed to calculations. Select **Liquid-solid mass transfer** in the **Calculate** option and then click on the desired parameter, **Time of complete dissolution**. Additional data is required for calculating this parameter, and you will therefore be asked to complete the table PROPERTIES OF SOLID AND LIQUID PHASES (Figure 4-11). This set of data is normally required for calculating liquid-solid mixing (suspensions).

As mentioned above, more data is required for calculating dissolution processes. You will now be asked to complete the second relevant input table, DISSOLUTION OF SOLID PARTICLES. In your case, **Molecular diffusivity** is known (see **Initial data** above), and you'll enter its value in the appropriate box in this table (Figure 4-12). In cases, when **Molecular diffusivity** is unknown, you should enter "0" (Figure 4-13), and select your solvent from the list of solvents in the right part of the table. Then enter **Molecular weight of solvent**, **Molecular weight of dissolved solids** and **Temperature**, and VisiMix will evaluate molecular diffusivity.

C:\VisiMix\Tutorial\dissolution.VSM

PROPERTIES OF SOLID AND LIQUID PHASES.

Density of liquid phase: 1000 kg/cub.m

Dyn. viscosity of cont.phase: 0.001 Pa\*s

Concentration of solid phase: 90 kg/cub.m

Density of solid phase: 2100 kg/cub.m

Average particle size: 350 micron

Size of largest particles \*: 900 micron

Position of outlet-height: 0 mm

OK Cancel Print Help

\* significant fraction - 5% of solid phase

Figure 4-11. Properties of solid and liquid phases.

C:\VisiMix\Tutorial\dissolution.VSM

DISSOLUTION OF SOLID PARTICLES

Initial concentration of dissolved solids: 0 kg/cub.m Solvent: [dropdown]

Molecular diffusivity: 1.85e-10 sq.m/s Molecular weight of solvent: [input]

If unknown, enter 0\*

Solubility of solid: 107 kg/cub.m Molecular weight of dissolved solids: [input]

Duration of the batch: 30 min Temperature: [input] °C

\* In this case molecular diffusivity will be evaluated by VisiMix. Enter YOUR data in the right part of the table.

OK Cancel Print Help

Figure 4-12. Entering data for calculating the dissolution when molecular diffusivity is known.

C:\VisiMix\Tutorial\dissolution.VSM

DISSOLUTION OF SOLID PARTICLES

Initial concentration of dissolved solids: 0 kg/cub.m Solvent: water

Molecular diffusivity: 0 sq.m/s Molecular weight of solvent: 18

If unknown, enter 0 \*

Solubility of solid: 107 kg/cub.m Molecular weight of dissolved solids: 58.5

Duration of the batch: 30 min Temperature: 20 °C

\* In this case molecular diffusivity will be evaluated by VisiMix. Enter YOUR data in the right part of the table.

OK Cancel Print Help

Figure 4-13. Entering data for calculating the dissolution when molecular diffusivity is unknown.

After entering your data in the table in Figure 4-12, you will see a warning message shown in Figure 4-14. It informs you that in your available tank, you may not achieve complete suspension of solid particles.

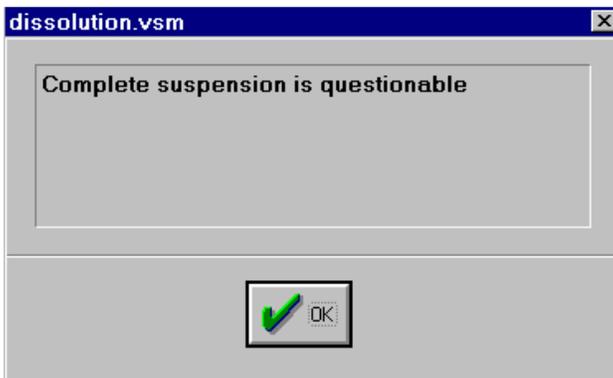


Figure 4-14. The message warning of possible settling of the solid phase.

Click **OK**, and the table **Time of complete dissolution** (Figure 4-15) will appear, containing the results of the calculation.

[dissolution] - Time of complete dissolution

TIME OF COMPLETE DISSOLUTION

Parameter name	Units	Value
Estimated dissolution time	s	1350
Dissolution time for largest particles	s	9290

For HELP press F1

Figure 4-15. Time of complete dissolution (basic variant).

You may now obtain additional information on your dissolution process. Click on **Last menu** option in the main menu, and check other parameters of **Liquid-solid mass transfer** option. Some of them are presented below in Figs 4-16 – 4-18.

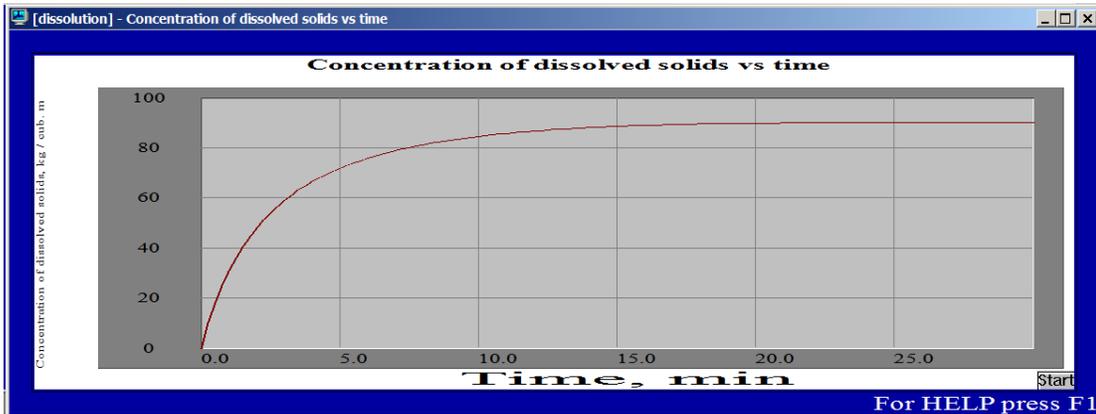


Figure 4-16. Concentration of dissolved solids vs. time (basic variant).

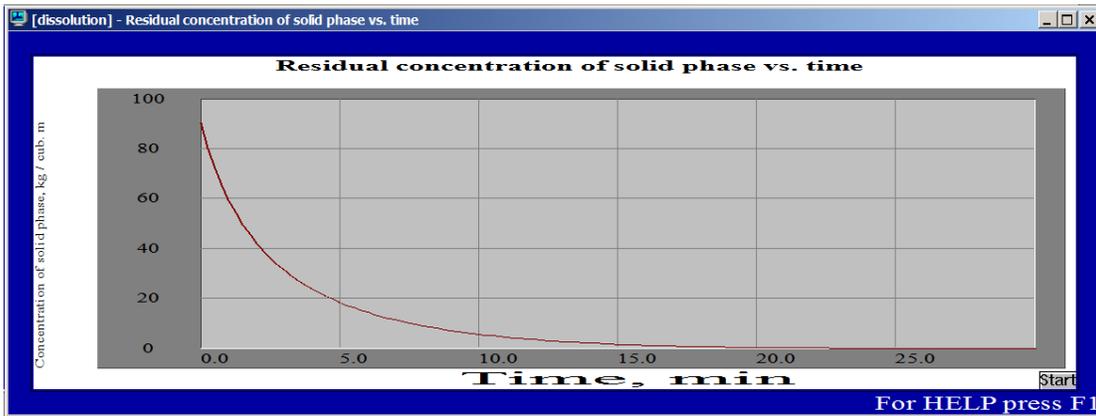


Figure 4-17. Concentration of solid phase vs. time (basic variant).

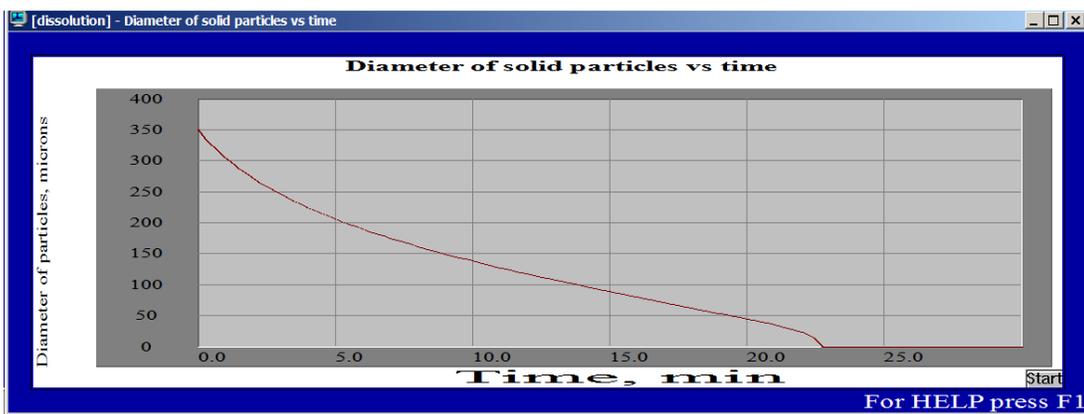
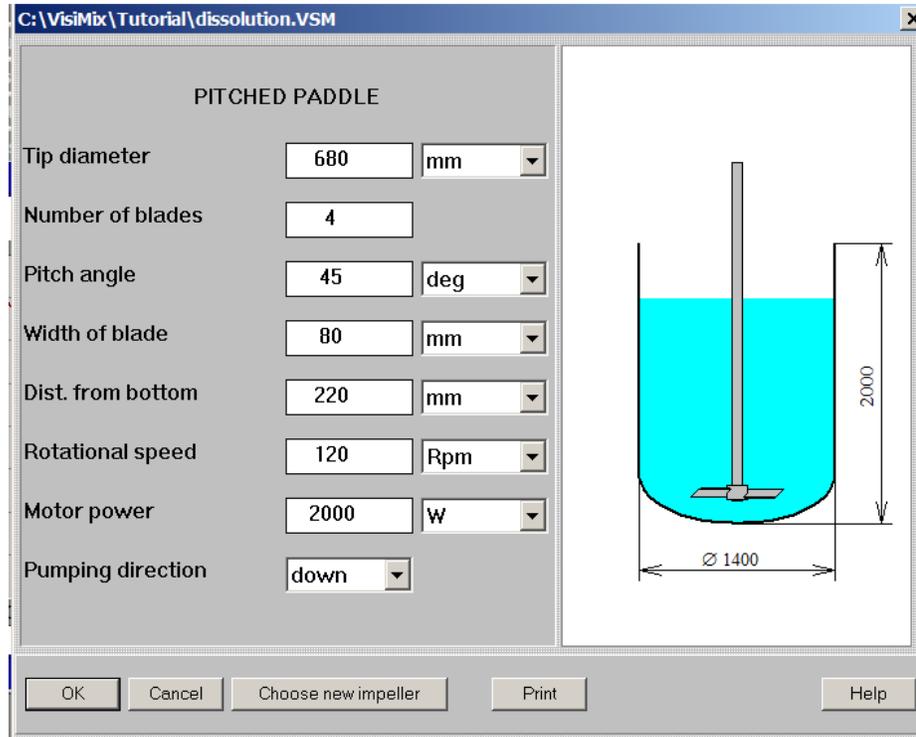


Figure 4-18. Diameter of solid particles vs. time (basic variant).

Since VisiMix alerted you to the possible settling of solid phase, you must now try to improve the mixing to ensure complete suspension. Let us check if changing some impeller parameters will help. Click on the impeller button in the upper screen bar, or **Edit input, Impeller** in the

main VisiMix menu, and the table with the impeller parameters you have previously entered appears.

Change **Tip diameter** from 600 mm to 680 mm, and **Number of blades** from 2 to 4 (Figure 4-19).

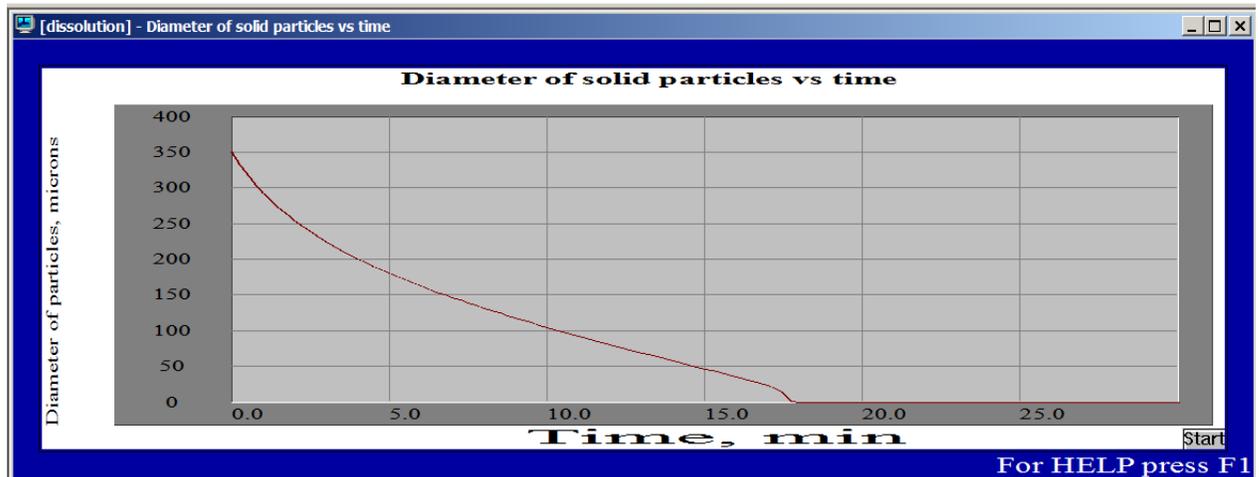


**Figure 4-19. Entering impeller data (alternative variant).**

After you click **OK**, VisiMix will repeat all calculations for the modified project, and show new results (Figs 4-20 – 4-21). This time there will be no warning message preceding the appearance of the tables of results.

TIME OF COMPLETE DISSOLUTION		
Parameter name	Units	Value
Estimated dissolution time	s	1050
Dissolution time for largest particles	s	7030

**Figure 4-20. Time of complete dissolution (alternative variant).**



**Figure 4-21 Diameter of solid particles vs. time (alternative variant).**

It means that in the alternative variant, there is no settling of the solid phase. Comparing the results of the basic and alternative projects (Figs 4-15 and 4-20, and Figs 4-18 and 4-21), you see that the dissolution time calculated for particles of average diameter decreased from 1350 s for the basic variant to 1050 s for the alternative project (a 22.0 % decrease). At the same time, the dissolution time for the largest particles decreased from 9290 s for the basic variant to 7030 s for the alternative variant (a 24 % decrease).

You have thus improved your design to ensure complete suspension, and calculated the dissolution time in your tank. The change in the impeller parameters (tip diameter and number of blades) proved to be favorable to your process.