

VisiMix TURBULENT. LIQUID - SOLID MIXING. DEFINING JSS (JUST SUSPENSION SPEED)

One of the most important requirements to liquid - solid mixing processes is prevention of sedimentation of solid particles on the tank bottom. Therefore, one of the main tasks of a designer is to provide Just Suspension Speed that is the minimum rotational velocity of the impeller at which there are no stagnant zones at the bottom. This example shows how to determine Just Suspension Speed in the case of mixing in a cylindrical fully baffled tank. The initial data for this example was borrowed from the paper of A. Mak, S. Yang and N. G. Ozcan-Taskin, *The Effect of Scale on the Suspension and Distribution of Solids in Stirred Vessels*. In the book: *Recent Progresses in Genie des Procédés, (MIXING - 97. Multiphase Systems)*, Vol.11, number 52 (1997), pp. 97 - 104.

Problem description:

A liquid - solid mixing process is carried out in a cylindrical, fully baffled tank with an elliptical bottom. The parameters of the mixing system are as follows:

Initial data

Tank:

Inside diameter = 1830 mm;
Total tank height = 2200 mm;
Level of media = 1830 mm;

Baffles:

4 radial flat baffles with the following parameters:
width = 183 mm;
length = 1743 mm;
distance from bottom = 457 mm.

Impeller:

A downward pumping pitched paddle impeller with
4 blades inclined at 45°; width of blade = 91.5 mm
Tip diameter = 915mm;
Distance from bottom = 457 mm.
Power of drive = 7500 W

Properties of the media:

Liquid phase: Water
Solid phase: Sand with density of about 2630 kg/m³.
The particle size range is 150 - 210 microns;
Concentration of the solid phase is 10 % .

Note: A combination of a 4-blade Impeller with 4 radial baffles in one reactor is generally not recommended, as it may in some cases lead to shaft vibrations. However, as you will see from the analysis of your present configuration, in this particular case no vibrations were observed.

The task is to evaluate Just Suspension Speed (JSS).

The Solution:

Just Suspension Speed (JSS) is the minimum rotational speed of the impeller that does not result in settling of solid particles on the tank bottom and ensures the absence of stagnant zones. Although VisiMix does not calculate JSS directly, it enables the user to determine this parameter in just a few minutes. When calculating any of the parameters in the **Liquid-Solid Mixing** option of the **Calculate** menu in cases when settling occurs, VisiMix issues a warning message informing the user of possible settling of solid particles. Therefore, to find this minimum value of rotational velocity, you must first enter any reasonable value of RPM, and start **Liquid-Solid** calculations. If there is a warning message on settling of particles, it means that your RPM value is lower than JSS. In this case, you will gradually increase RPM until the program stops issuing the message. If you do not get the warning message with the first RPM value you enter, it means that the RPM value is higher than JSS. You will then decrease RPM until the message appears. The first/last RPM value, which will not result in the warning message, will be the desired JSS value. Since VisiMix input is easy, and all calculations are instantly repeated after modifying any of the initial data, the entire calculation procedure proves to be short and simple.

You will now follow a regular VisiMix procedure, starting a new project, selecting the equipment from the VisiMix graphical menus, entering initial data, and then proceeding to calculations by selecting a parameter in the appropriate option in the **Calculate** menu. The program will request additional data required for modeling the selected parameter, and when all the requested data is entered, you will obtain the desired result as described above.

After installing **VisiMix**, the main menu shown in Figure 2-1 appears. Select **Project-New**.

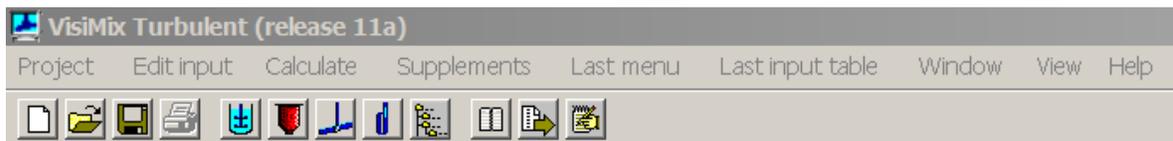


Figure 2-1. VisiMix main menu.

A dialogue shown in Figure 2-2 appears. Enter a name for the project, for example, **JSS.vsm**. You may create a special directory for your project, or choose an existing directory. In your case, the directory name is **tutorial**.

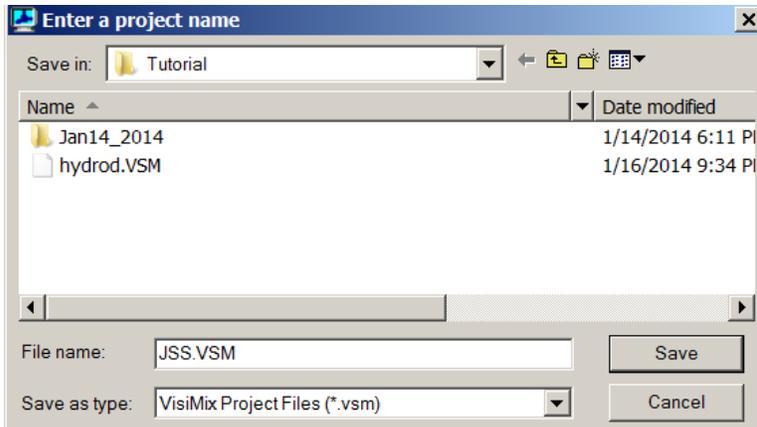


Figure 2-2. Starting a new project.

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 or dimpled/embossed jacket) appears. To choose the required tank type, click on the appropriate tank diagram. The tank you have selected (unjacketed tank with elliptical bottom in your example) appears in the **Current choice** window on the right (Figure 2-3). Click **OK** to confirm your choice.

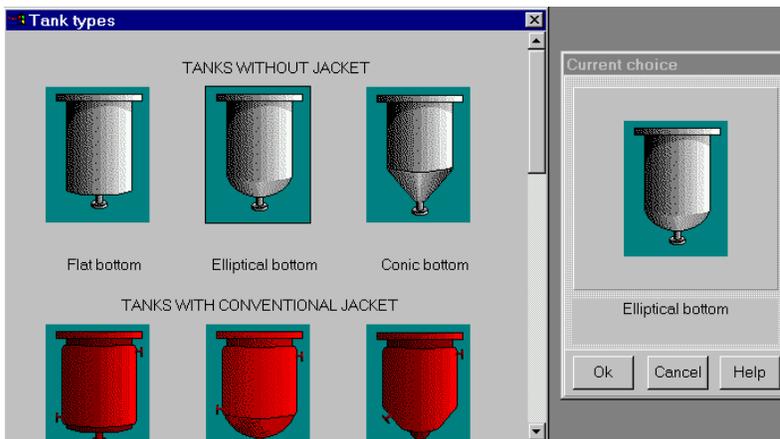


Figure 2-3. VisiMix graphic tanks selection.

The next step is to enter the initial data for your project. Now, you do not need to choose the initial data that must be entered. The program will request all the data it needs by asking you to complete the appropriate input tables. At this stage, you will be asked to enter all the required tank parameters. After you have selected the tank, **TANK WITH ELLIPTICAL BOTTOM** input table appears. Supply the internal dimensions of the selected elliptical-bottomed tank. Enter **Inside diameter**, **Total tank height** and **Volume of media**, and **Total volume** and **Level of media** will be calculated by the program and entered automatically. After the table has been completed (Figure 2-4), click anywhere on the field of the window, and the elliptical-bottomed tank diagram on the screen will change to reflect your input. Click **OK** to confirm your input.

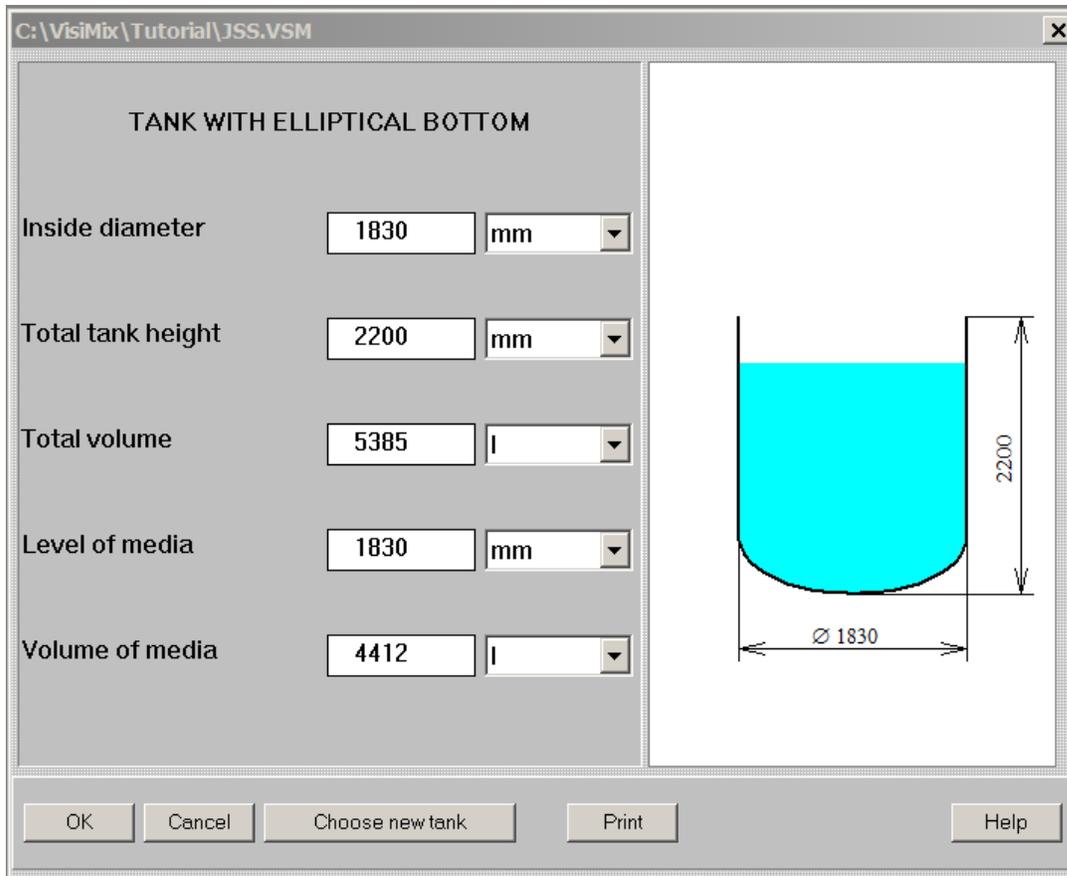


Figure 2- 4. Entering tank data.

After you click **OK**, the **Baffle types** menu appears. To choose the required variant, click on the appropriate baffle diagram. The one you have selected (Flat baffle-1) will appear in the **Current choice** window on the right (Figure 2-5). Click **OK** to confirm your choice.

Enter the parameters of the selected baffle in the input table that appears (Figure 2-6).

Now select your impeller in the **Impeller types** menu that appears (Figure 2-7), clicking on the appropriate impeller diagram. The pitched-paddle impeller you have selected will appear in the **Current choice** window on the right. In this window, **single** or **multistage** mixing system is also selected (your case corresponds to the **single** option). Click **OK** to confirm your choice.

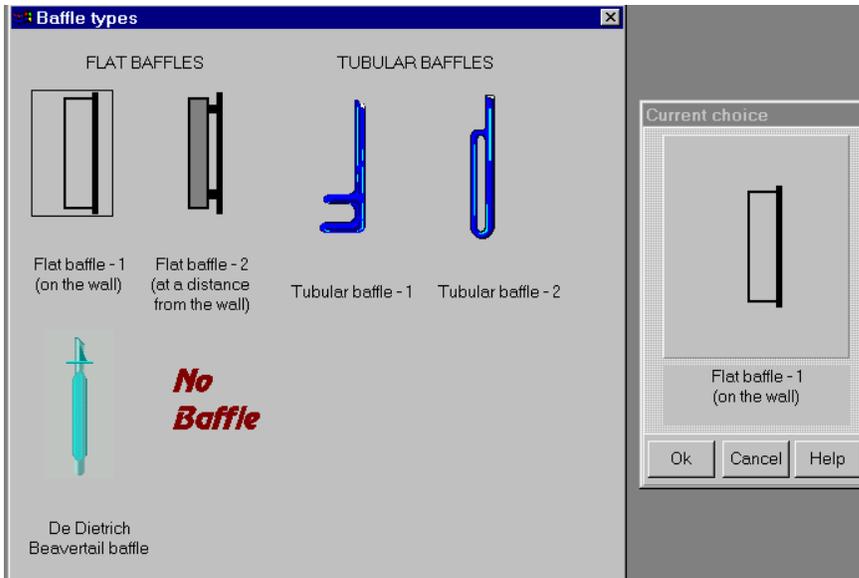


Figure 2-5. VisiMix graphic baffle selection.

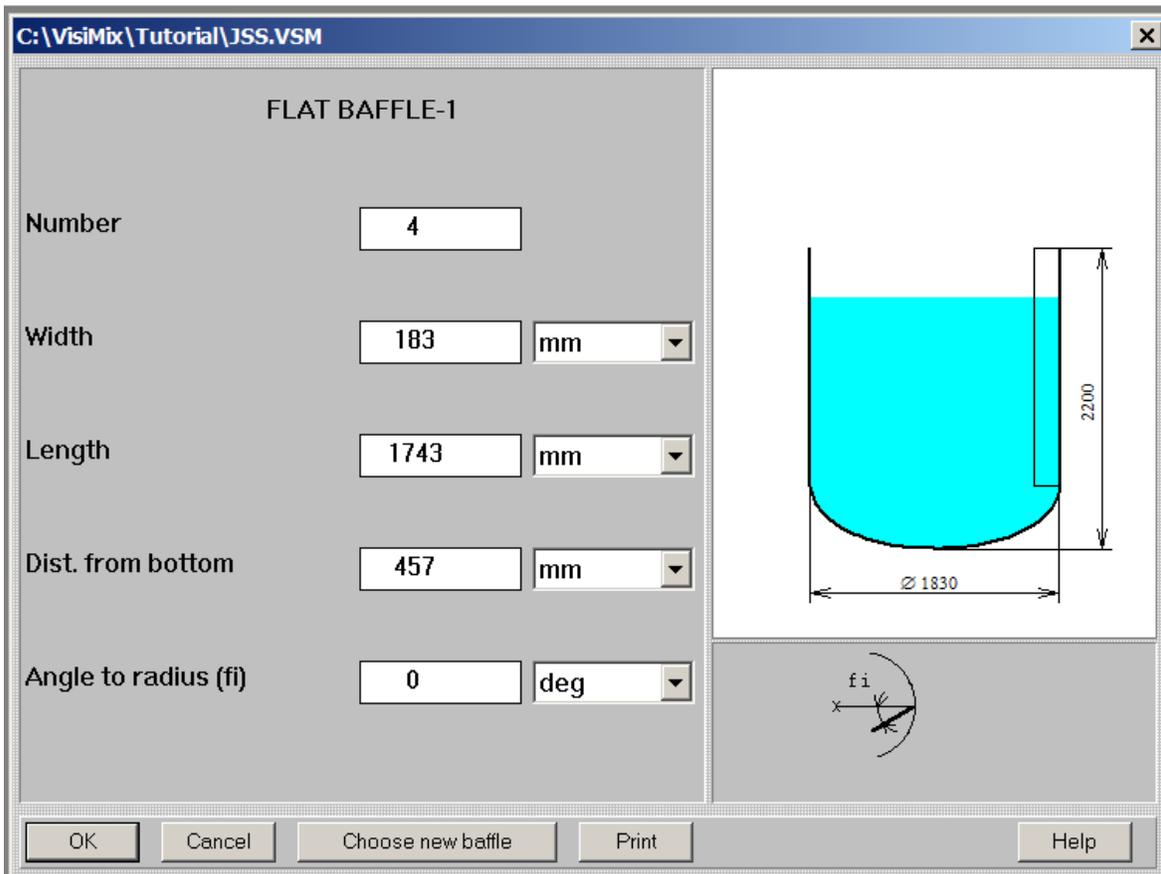


Figure 2-6. Entering baffle data.

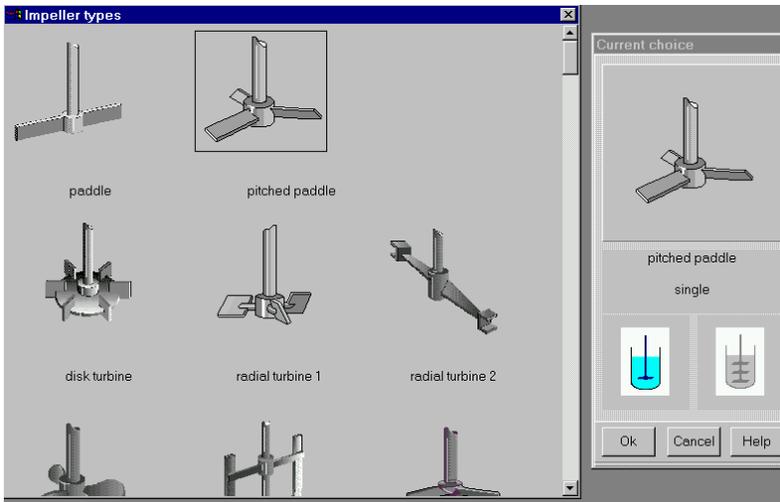


Figure 2-7. VisiMix graphic impeller selection.

You will now be asked to enter the impeller data in the PITCHED PADDLE input table (Figure 2-8).

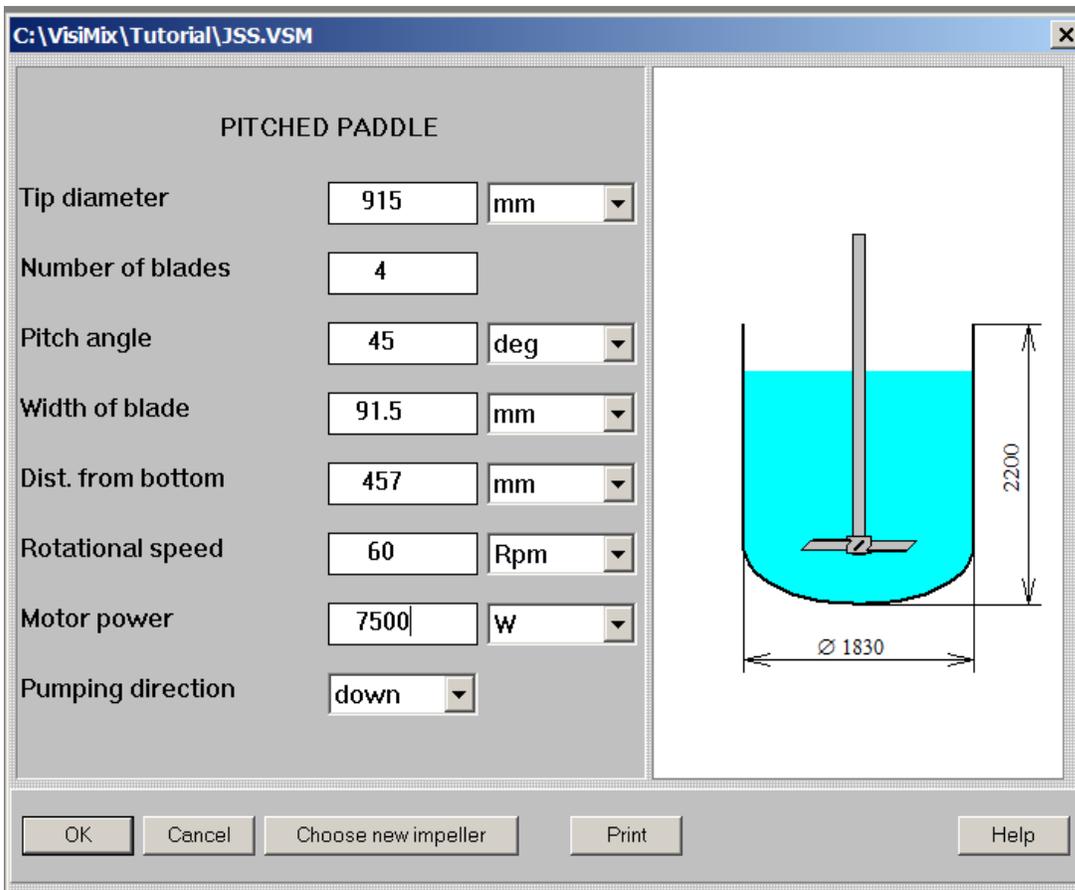


Figure 2-8. Entering impeller data

Enter tip diameter, number of blades, pitch angle, distance from bottom and power of drive according to your initial data. As for the rotational speed, you must start with any reasonable

RPM value as described above. Let us, for instance, enter **60** RPM and click **OK** to confirm the input.

After this table has been completed, you will be asked to fill DENSITY AND TYPE OF MEDIA table (Figure 2-9a) and then AVERAGE VISCOSITY OF MEDIA table (Figure 2-9b). In your example, the media in the tank is ordinary water.

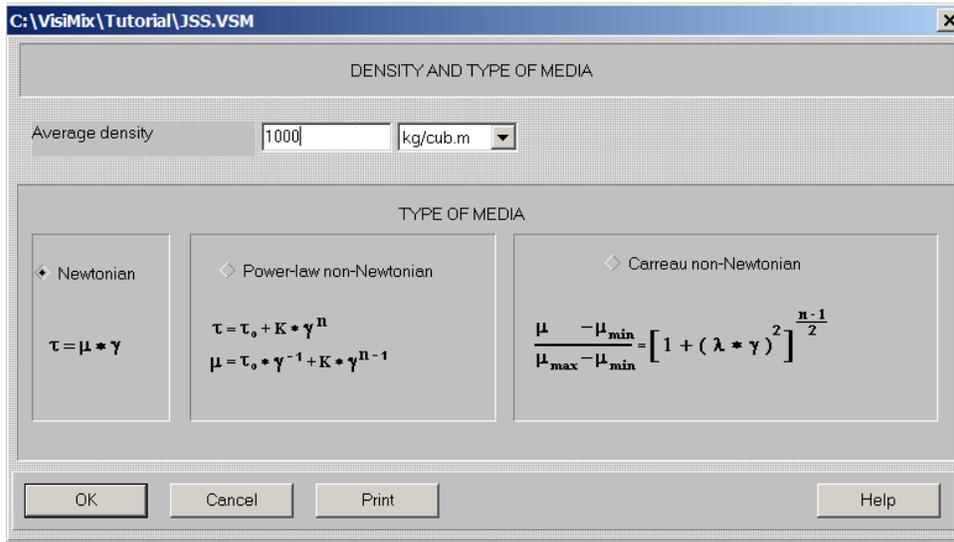


Figure 2-9a. Entering average density and type of media.

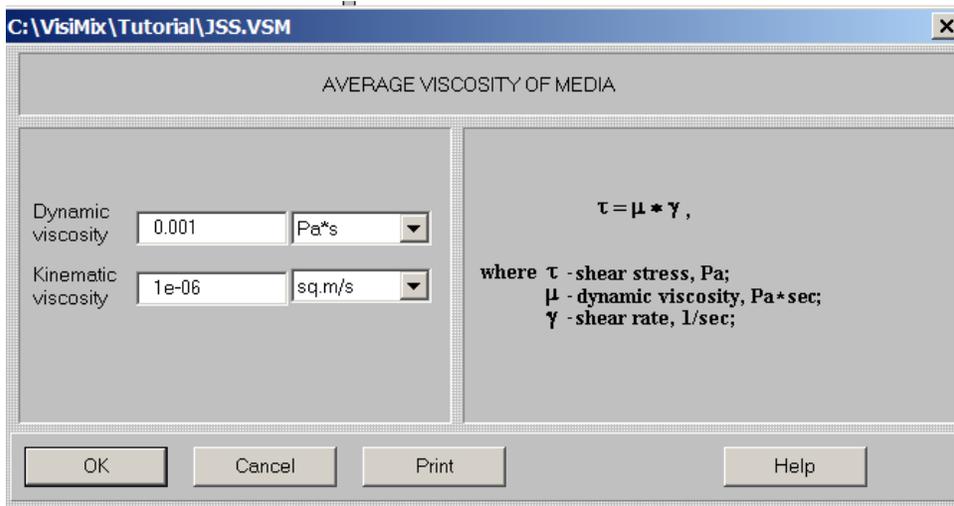


Figure 2-9b. Entering average viscosity of media.

After average properties of media has been entered, the tank diagram appears, which corresponds to your input (Figure 2-10).

We recommend closing this window before proceeding to calculations.

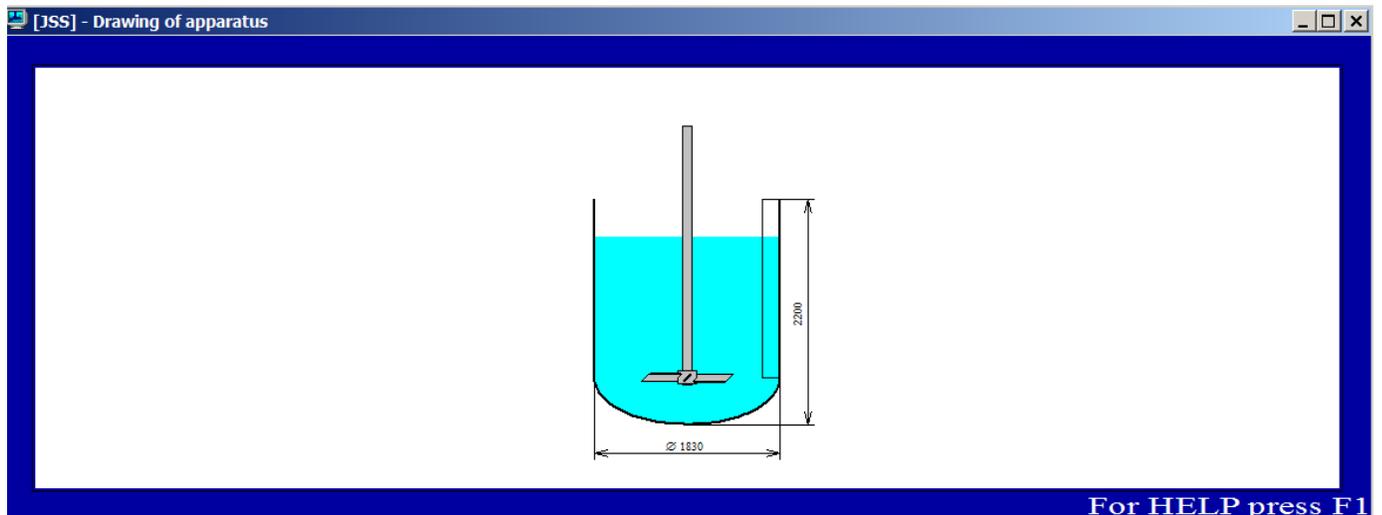


Figure 2-10. The diagram of your mixing system.

To proceed to calculations, select **Liquid - Solid Mixing** in the **Calculate** option and select any parameter for modeling, for instance **Axial distribution of solid phase**. You will be asked to enter additional data required for calculating this parameter in the table PROPERTIES OF SOLID AND LIQUID PHASES shown in Figure 2-11.

C:\VisiMix\Tutorial\JSS.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	18.41	kg/cub.m
Density of solid phase	2630	kg/cub.m
Average particle size	180	micron
Size of largest particles *	210	micron
Position of outlet-height	0	mm

OK Cancel Print Help

* significant fraction - 5% of solid phase

Figure 2-11. Properties of solid and liquid phases.

After this table is completed, VisiMix starts calculations. Since the properties of your media changed due to the presence of the solid phase, VisiMix suggests that you adjust your input. A warning message appears (Figure 2- 12) informing you that the calculated density and viscosity values differ from those you have previously entered in AVERAGE PROPERTIES OF MEDIA input table. If you consider the change insignificant, you can click **OK** and proceed with calculations without changing your data. To adjust the input, click on **Cancel**.

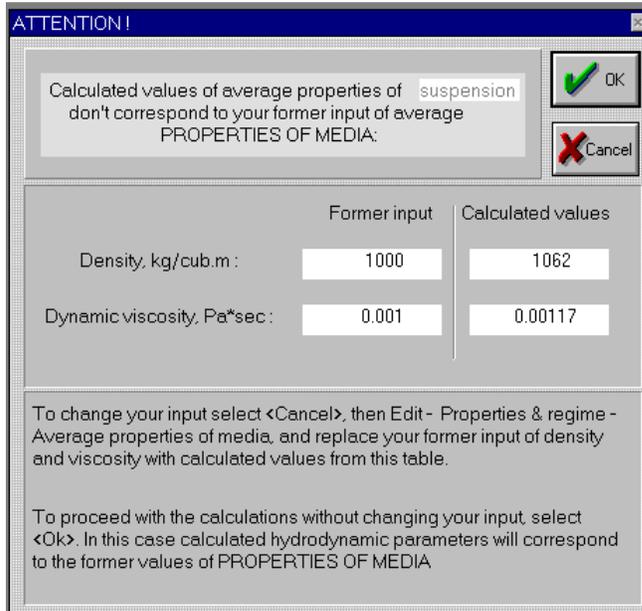


Figure 2-12. The message warning of the difference between calculated data and former input.

Let's replace previously entered data with the calculated data. Click on **Cancel**, and a message shown in Figure 2-13 will appear, reminding you to change your input and select again the desired parameter for calculations from the **Calculate** option.

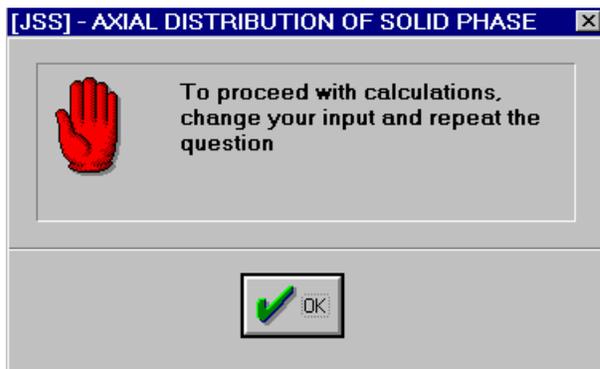


Figure 2-13. The message recommending to change the input

Click **OK**, then select **Edit input, Properties & Regime, Average properties of media** and **Density and types of media** and **Parameters of rheology**. Correct the data in the tables according to the recommendations in Figure 2-12 (Figures 2-14a and 2-14b).

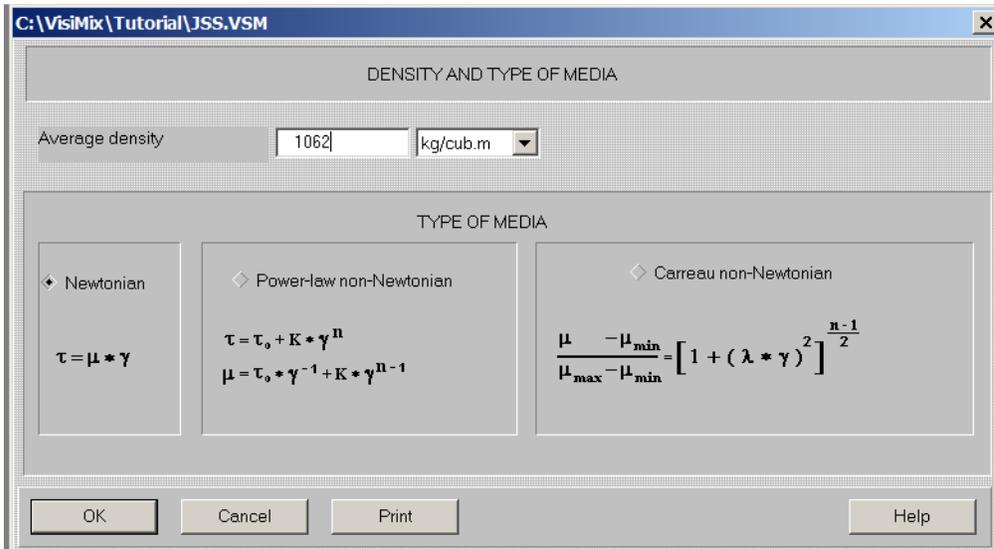


Figure 2-14a. Entering adjusted density and types of media.

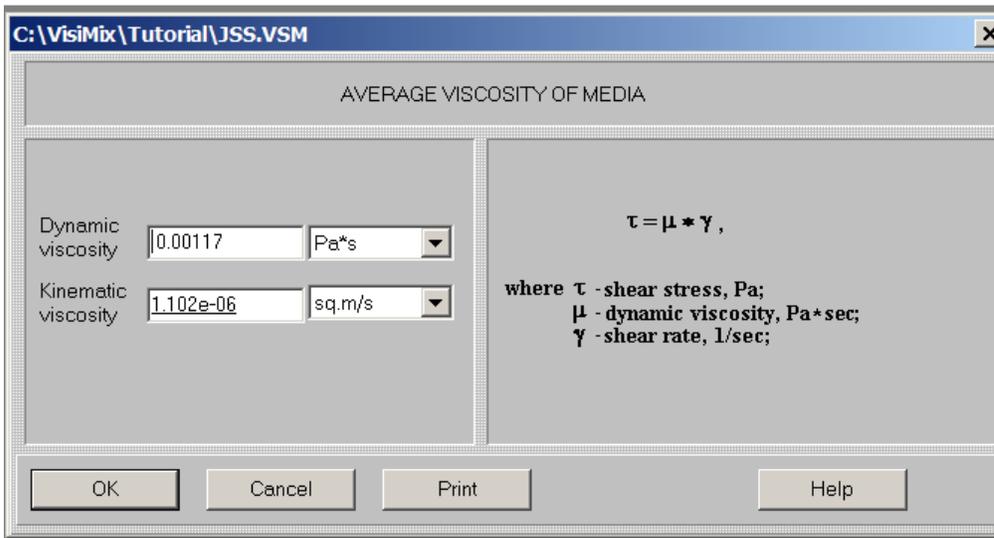


Figure 2-14b. Entering adjusted parameters of rheology (average viscosity of media).

After you click **OK**, select **Last menu** in the main menu and click again on **Axial distribution of solid phase**. A message shown in Figure 2-15 appears.

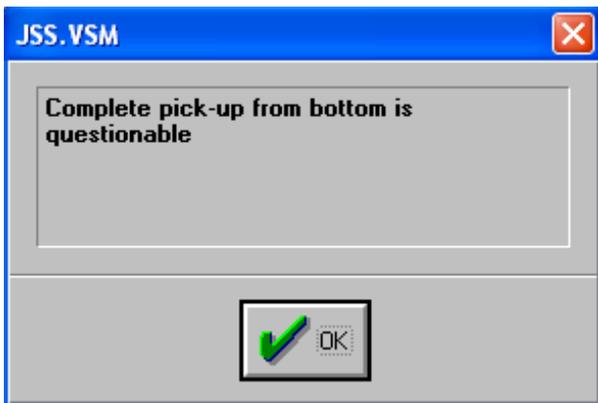
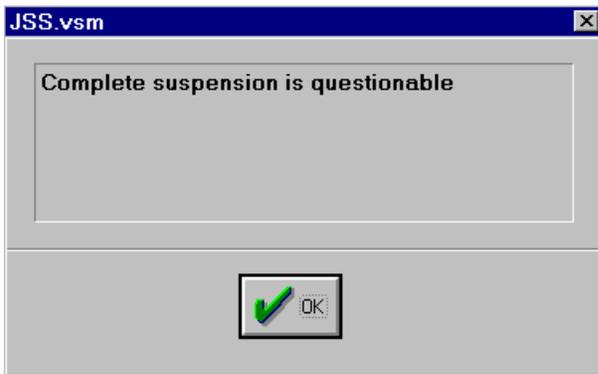


Figure 2-15. The message warning of possible settling of solid phase.

This means that the RPM value you have entered (60 RPM) is lower than JSS. After you click **OK**, the graph of axial distribution of solid phase appears (Figure 2-16).

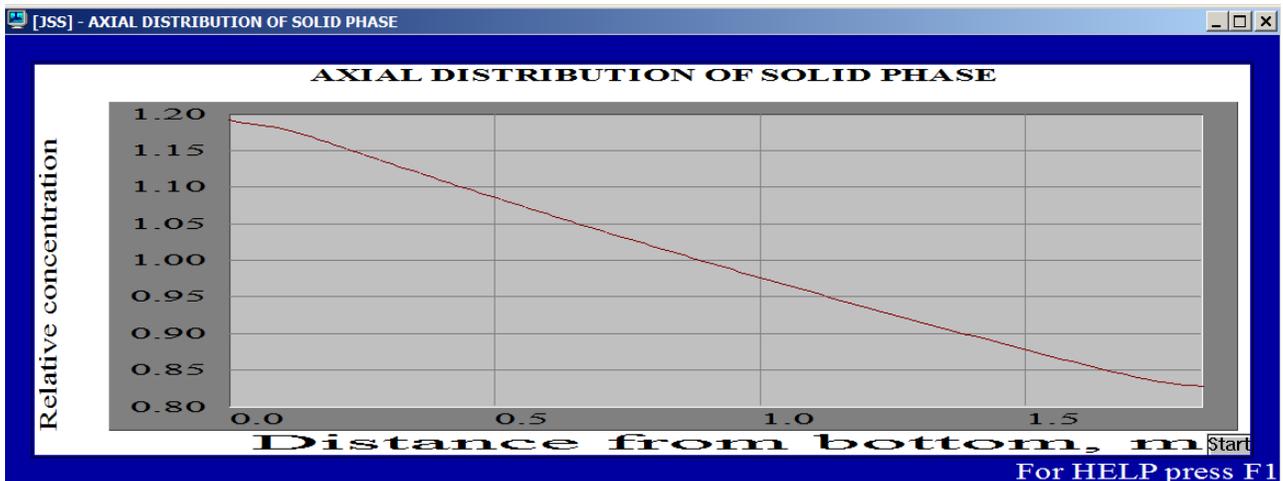


Figure 2-16. Axial distribution of solid phase (60 RPM).

From this graph, you see that at 60 RPM the non-uniformity is about 20%. You can also check this value directly, selecting **Last menu, Maximum degree of non-uniformity, axial (%)**.

Let us now increase RPM to find the required minimum value for the rotational speed, which does not result in settling of particles on the bottom. Click impeller quick access button in the upper screen bar, or **Edit input, Impeller** and enter, for instance, 85 RPM in the impeller input table. The program will repeat the calculations, and you will obtain the result similar to that shown in Figure 2-16, without a warning message (Figure 2-17). The absence of the warning means that now JSS is lower than the entered RPM value. The axial distribution of the solid phase is now more uniform, the non-uniformity being about 13%.

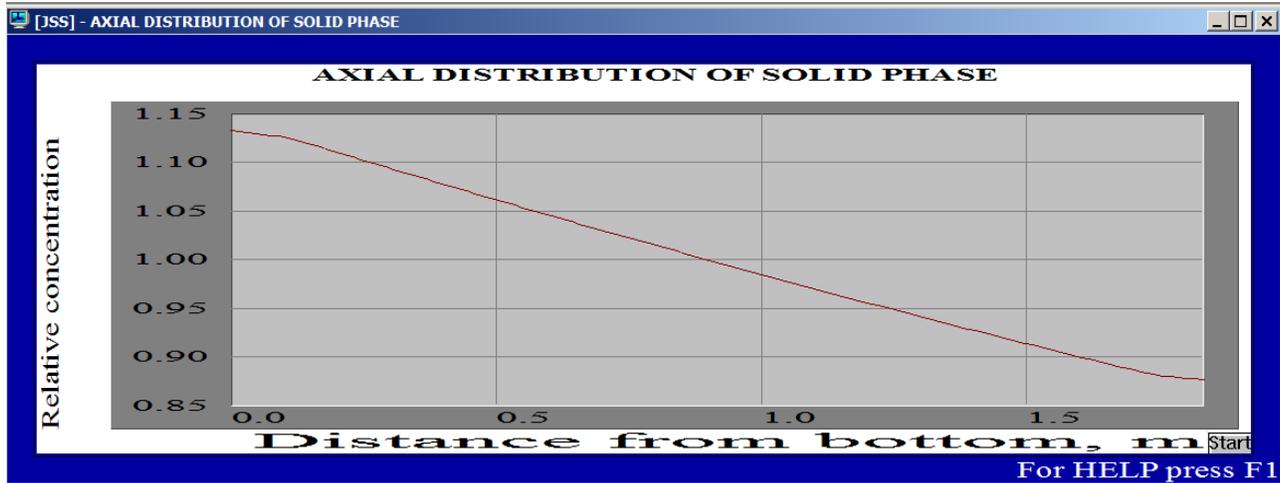


Figure 2-17. Axial distribution of solid phase (85 Rpm).

Changing RPM values again, you find that at 65 RPM, the warning message still appears, while at 66 RPM the graph of **Axial distribution of solid phase** appears without the warning message.

The required **JSS** value is thus **66 RPM**, and the corresponding value of axial non-uniformity is 18.7%. (Figure 2-18).

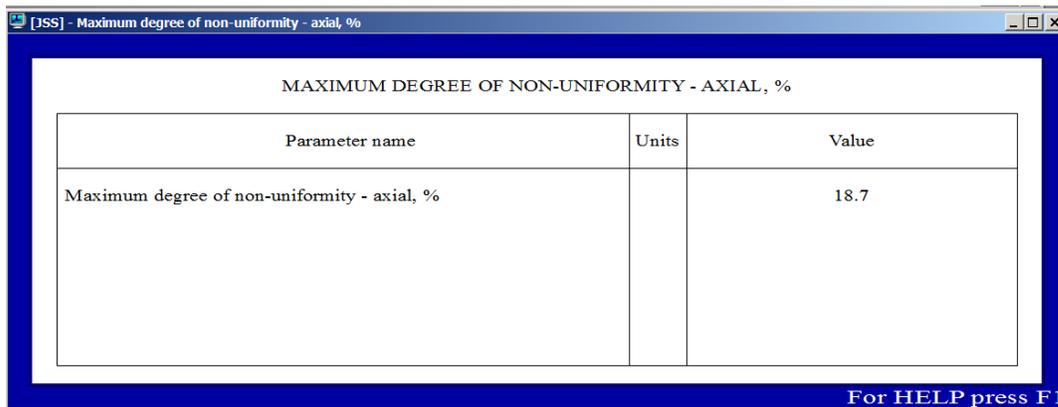


Figure 2-18. Non-uniformity of axial distribution of solid phase (66 Rpm).

At **81 RPM**, the axial non-uniformity is 15.1%.