This example shows how to calculate main hydrodynamic characteristics and mixing parameters (the mixing time, circulation flow rate, etc.), and how to use VisiMix to improve the system design, in this case to decrease the mixing time and/or power consumption.

System Configuration

You have a tank with an elliptical bottom with a 3-stage Intermig impeller. The system has the following parameters:

Tank inside diameter	1200 mm
Tank height	3200 mm
Tip diameter of agitator	720 mm

There are 4 flat baffles inside the tank, with a width of 120 mm, length of 2700 mm, installed normally to the wall at a distance of 30 mm from the wall and 400 mm from the bottom.

The system is used for mixing a <u>Newtonian</u> media with the following characteristics:

Density	1130 kg/cub.m
Dynamic viscosity	3500 cP

The rest of the initial data is as shown in the input tables in Figures 3.3-3.7.

The Task

The task is to analyze the main mixing characteristics and mixing conditions. You must determine the mixing regime in your system, evaluate the axial circulation and mixing time, and check if you can improve the mixing and/or decrease the power consumption with the simplest technical means possible. Let us see how you can use VisiMix for the solution of this problem.

The Solution

The general sequence of operations is as follows: you must create a new project file for your case, select your equipment from the VisiMix graphical menus, enter the initial data for your mixing system requested by the program, and then select the parameters you want to calculate from the **Calculate** menu. After you have selected the desired parameter, the program may request additional data if required for the modeling, and after all the requested data is entered, you obtain the results in a table or graphical form.

In our case, the required parameters for calculations are listed in the submenus corresponding to the following options in the **Calculate** menu: **Power and forces**, **Flow characteristics** and **Blending, Uniformity of mixing.**

We will now follow the whole procedure step by step, showing you how to create a new project, enter initial data and finally obtain the desired result.
The first step in working with VisiMix is to create a project. Open VisiMix, and select **Project**, **New** in the main VisiMix menu. In the dialogue that appears, enter the project name in the **File name** box instead of the noname00.vsm (Figure1), and click OK.
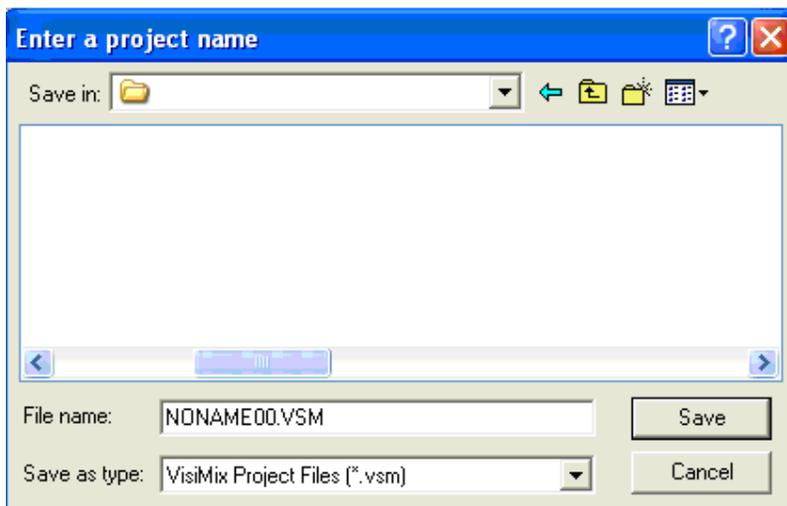
Figure 1. Entering a project name.

VisiMix **Tank types** graphical menu appears (Figure2). To choose the required tank type, click on the appropriate tank diagram. The tank you have selected (an unjacketed tank with an elliptical bottom) will appear in the **Current choice** window on the right (Figure2). Click **OK** to confirm your choice.

The **Tank** input table appears. Fill in the table in accordance with your tank characteristics (Figure3). The diagram in the screen will change to reflect your input.
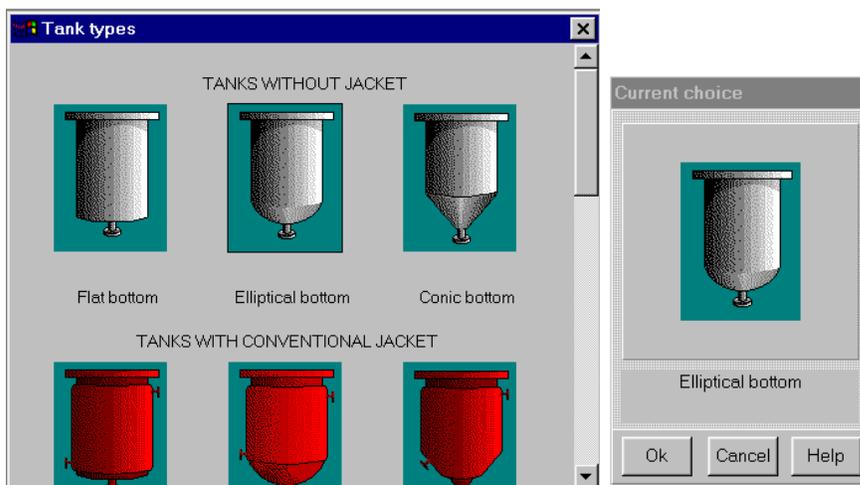
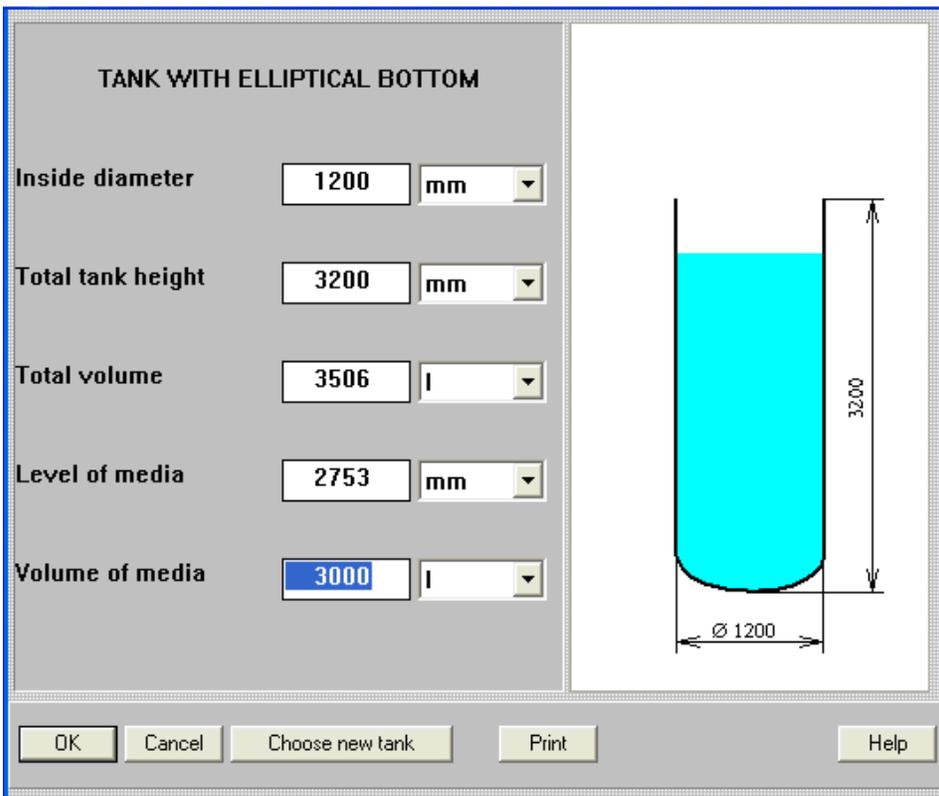**Figure 2. Selecting an unjacketed tank with an elliptical bottom.**

Figure 3. Entering the tank dimensions.

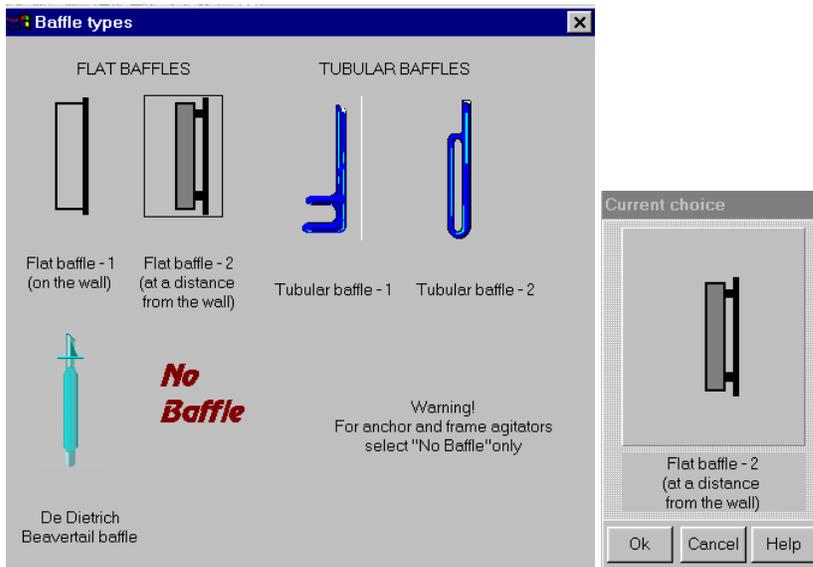Click OK, and Baffle types graphical menu appears (Figure4).

Figure4. Selecting the baffle type.

Select your baffle (Flat baffle-2), and it will appear in the **Current choice** window on the right. After you click OK, the **Baffle** input table appears. Enter your baffle data as shown in Figure5.
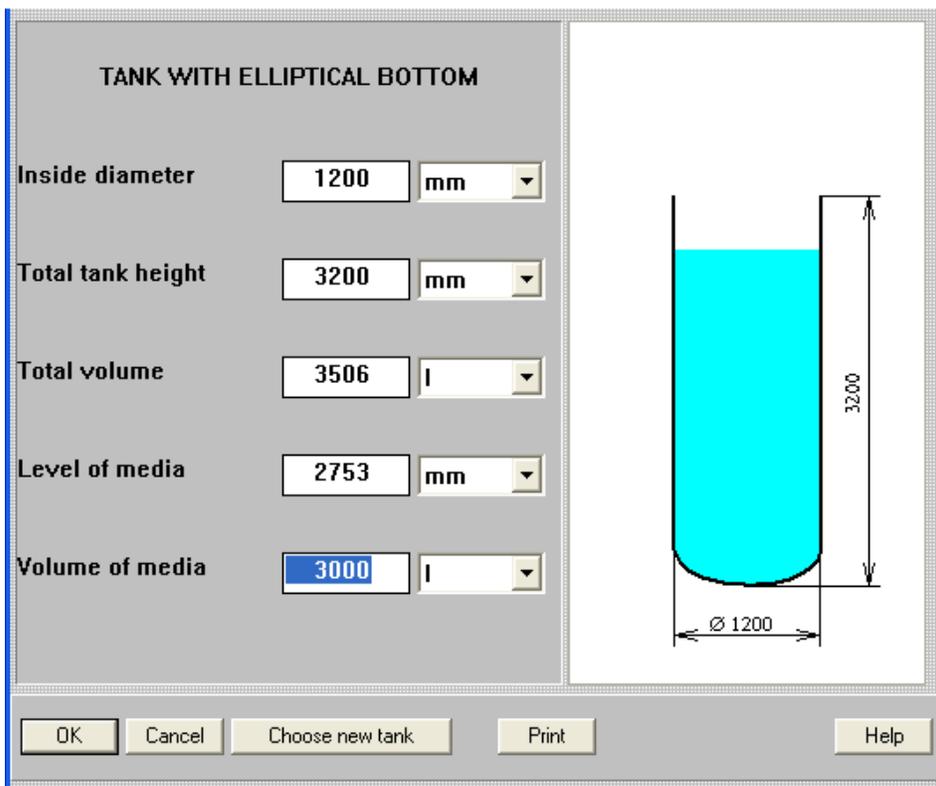
Figure 5. Entering the baffle data.

After you click OK, the **Agitator types** graphical menu appears (Figure6).
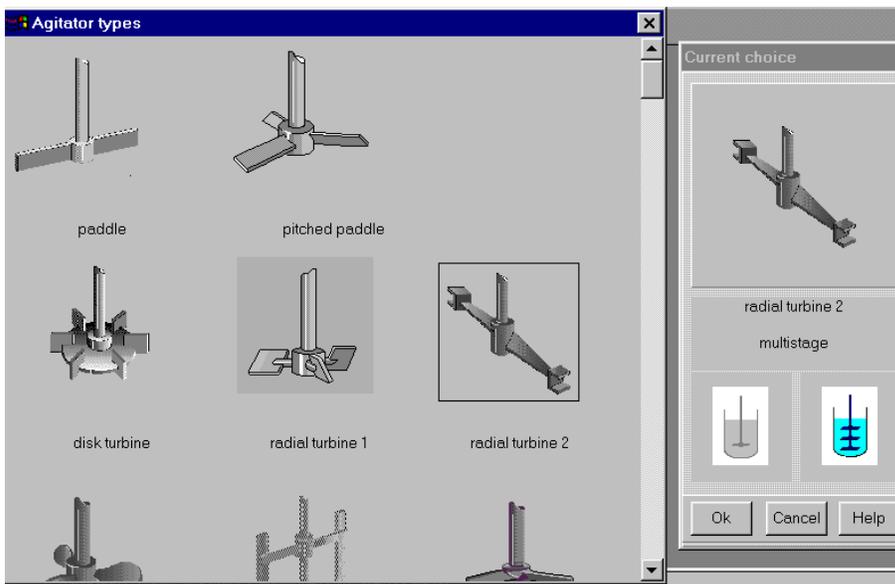

Figure6. Selecting Intermig impeller (radial turbine 2).

To choose the desired agitator type, click on the appropriate diagram. The agitator you have selected (**radial turbine 2**) will appear in the **Current choice** window on the right. In this window, you can also select **single**, or **multistage** mixing system by clicking on the appropriate icon. Your case corresponds to a multistage agitator. Select **multistage**, and click **OK** to confirm your choice.

Agitator input table appears. Before entering the agitator parameters, click on the **Help** button in this screen to get more detailed instructions for entering data for this particular agitator. Enter the agitator parameters as explained (Figure7) and click OK.

RADIAL TURBINE 2

Tip diameter	720	mm
Agitators number	3	
Dist. between stages	800	mm
Pitch angle, fi	26	deg
Width of blade, W	75	mm
Length of blade, L	105	mm
Dist. from bottom	350	mm
Number of revolutions	90	Rpm
Power of drive	4000	W

| OK | Cancel | Choose new agitator | Print | | Help |

Figure 7. Entering the agitator data.

The **Average properties of media** input table appears (Figure8).

DENSITY AND TYPE OF MEDIA

Average density   1130   kg/cub.m

TYPE OF MEDIA

◆ Newtonian

$$\tau = \mu * \gamma$$

◇ Power-law non-Newtonian

$$\tau = \tau_o + K * \gamma^n$$
$$\mu = \tau_o * \gamma^{-1} + K * \gamma^{n-1}$$

◇ Carreau non-Newtonian

$$\frac{\mu - \mu_{min}}{\mu_{max} - \mu_{min}} = \left[1 + (\lambda * \gamma)^2 \right]^{\frac{n-1}{2}}$$

| OK | Cancel | Print | | Help |

Figure 8. Entering average properties for the media.

Select the **Newtonian** option and enter your media properties. Click OK, and
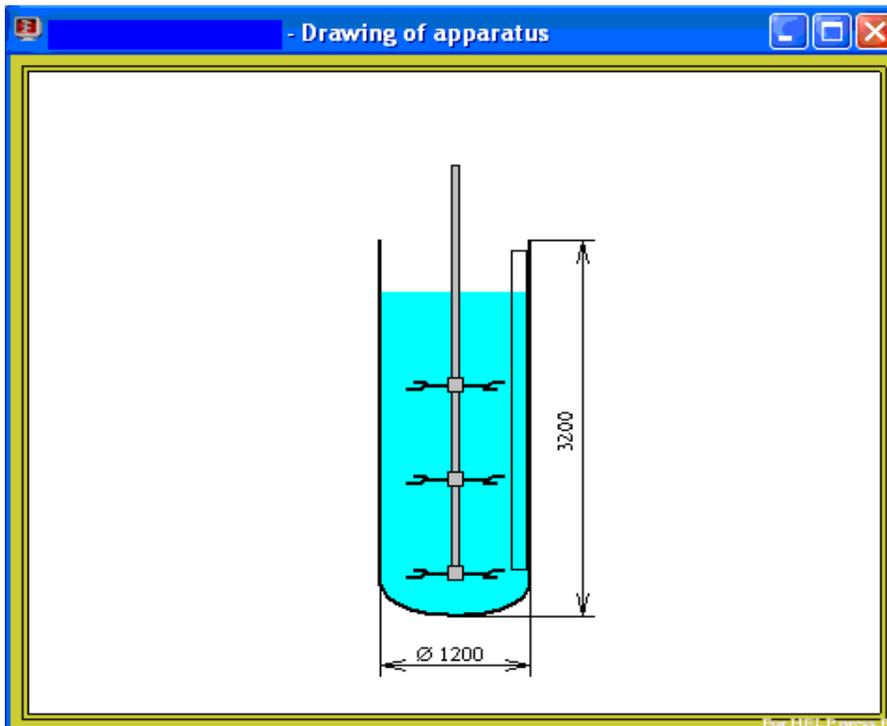a diagram of your tank appears, corresponding to the data you have entered (Figure9).

Figure 9. The diagram of your mixing system.

The appearance of the diagram of your system means that you have entered all the basic initial data for
your system. From now on, you will be asked to enter only the data required for solving your particular
problem, if any. You may now proceed to the calculations, closing the tank diagram window first.

All VisiMix calculation menus are contained in the **Calculate** option in the main menu.

The first parameter you would naturally want to calculate is the **Mixing power**. Select **Power and forces**
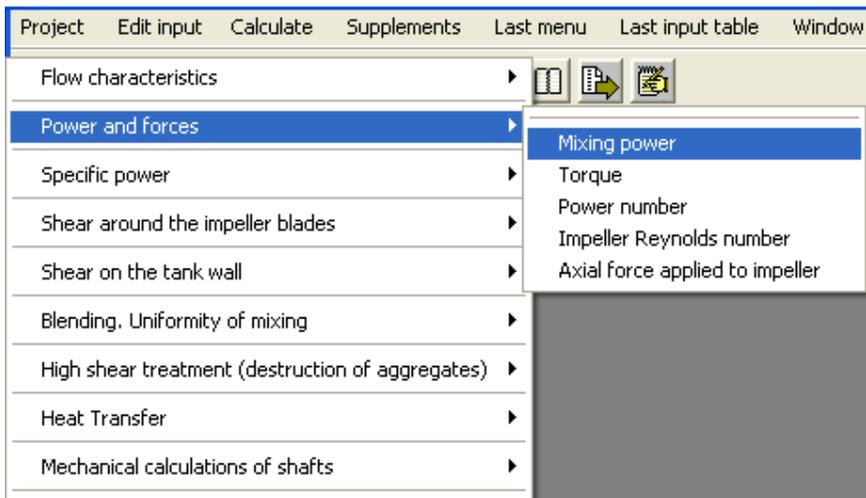in the **Calculate** and click on the **Mixing power** (Figure10).

Figure10. Calculating the mixing power.

The program starts the calculations, and almost immediately the appropriate output window appears (Figure11).

Figure11. The calculated value for the mixing power (3-stage Intermig).

You can now address other questions in the same menu, for instance, **Axial force applied to agitator** (this is, naturally, the force applied by the agitator to the fluid). The calculated value is shown in Figure12. It is a little greater than 13 kilograms.

Figure12. The calculated value for the Axial force applied to agitator (3-stage Intermig).

Now check the flow regime in your system. It is known that the mixing regime is normally characterized by the Reynolds number. VisiMix calculates three different Reynolds numbers:

- **Reynolds number for flow**

- **Re number for agitator blades**
- **Impeller Reynolds number**

The **Reynolds number for flow** calculated by VisiMix is based on the average flow velocity and characterizes the flow regime in the bulk of volume. The **Re number for agitator blades** is based on the velocity of the flow past the blade and the blade width, and characterizes the mixing conditions in the immediate vicinity of the blade. The **Impeller Reynolds number** is based on the agitator diameter and rotational velocity of the agitator and is given for reference purposes only. Until recently, this was the only **Re** number that was used by engineers, since the other two could not be calculated.

To calculate the Reynolds numbers, select **Flow characteristics** in the **Calculate** and click on the appropriate parameters (Figure13).
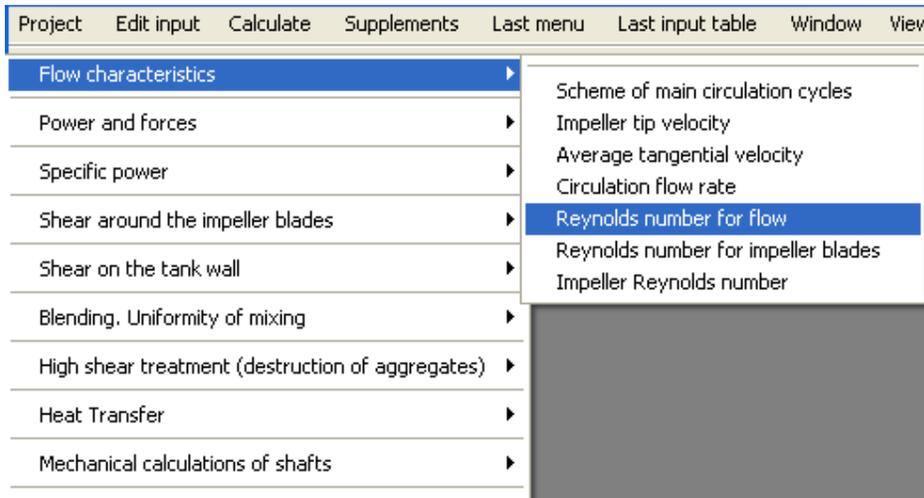

Figure13. Calculating the Reynolds number.
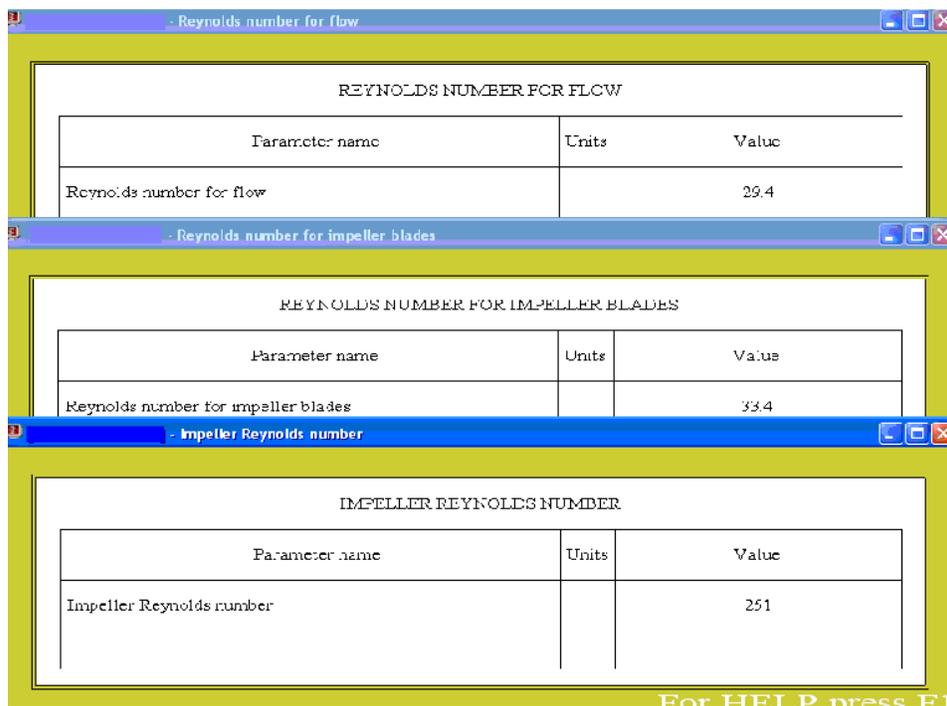
The appropriate output windows are shown in Figure14.

Figure14. The calculated values for the three Reynolds numbers.

You can see that both in the bulk of volume, and near the blades the flow regime is strictly laminar (the **Re number** is about 30). The **Impeller Reynolds number** is about 10 times greater. Therefore, if you had this parameter only at our disposal, you may have supposed that you are close to the transitional flow regime.

For a laminar flow regime, one of the most important characteristics of mixing is the **Circulation flow rate**. Let us calculate this parameter which is accessed through the **Flow characteristics** option (Figure13), and also the **Mean circulation time** accessed through the **Blending. Uniformity of mixing** option (Figure15).
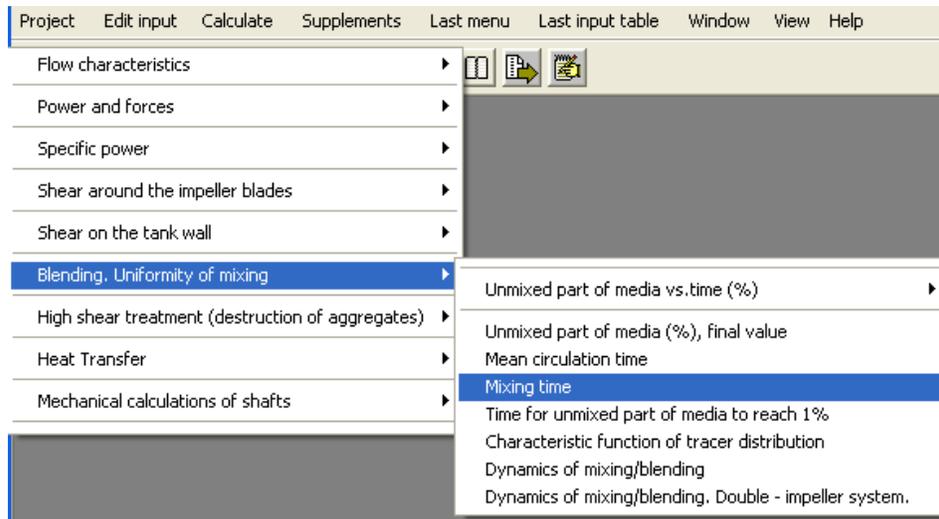

Figure15. Calculating the Mean circulation time.

The appropriate output windows are shown in Figure16.

Figure16. Circulation flow rate and Mean circulation time (3-stage Intermig).

You see that the **Circulation flow rate** is about 100 l/s, and the **Mean circulation time** is very small, about 8 s. This means that the circulation in your system is quite intensive and satisfactory. Note another parameter in the **Circulation flow rate** table: **Index of uniformity of flow distribution in the tank volume**. What does this parameter mean?

Click on **Help** – **Contents** - **Output parameters** – **Flow characteristics** - **Circulation flow rate**. You will find that " The degree of non-uniformity of the circulation is described by **Index of uniformity of flow distribution in the tank volume**. The higher this index is, the higher the uniformity of the flow distribution, and the smaller the "short circuited" part of the flow. Higher values of the **Index** correspond to better mixing. Values lower than 0.2 are a sign of poor mixing, when almost all circulation is short-circuited in a small area near the agitator." This is illustrated by the **Scheme of main circulation cycles**, which is another parameter in the **Flow characteristics** option. This scheme is shown in Figure17.
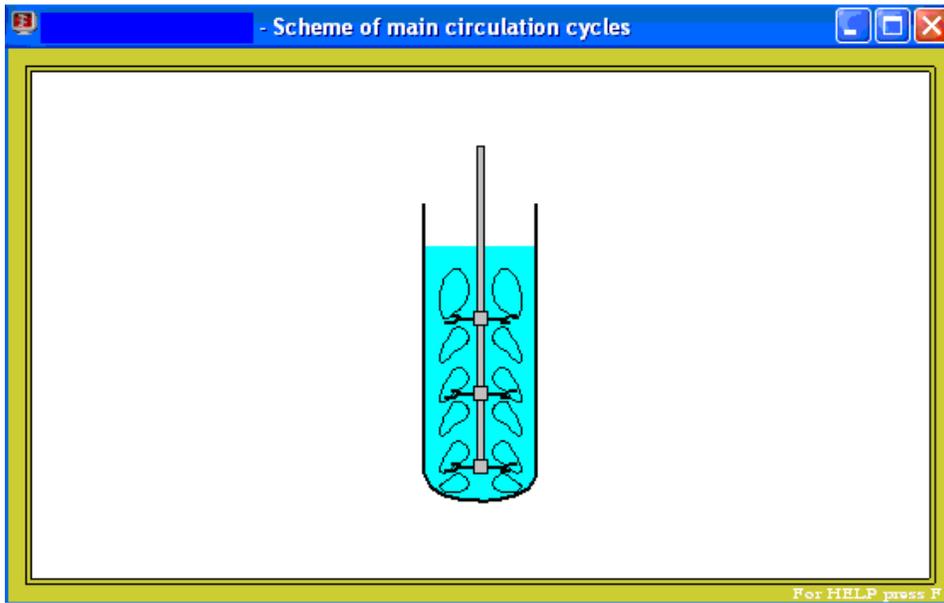
Figure17. The scheme of main circulation cycles (3-stage Intermig).

You can see that in your case the entire volume of the tank is involved in the circulation. However, this is not always the case, and it depends on the apparatus design. For example, let us try to replace your agitator by another one without changing any other parameters.

Click on **Edit, Agitator**, and then on **Choose new agitator** button at the bottom of the input table that appears. **Agitator types** screen will appear (Figure6). Select the **single** option in the **Current choice** window, and click OK. The **Agitator** input table appears (Figure18).

Click OK, and the **Scheme of main circulation cycles** will change accordingly (Figure19).

You can see that in this case, the circulation is distributed less uniformly in the tank volume. If you select again **Circulation flow rate** in the **Flow characteristics**, you will see that this index decreased (Figure20). It is now 0.463 as compared to 0.720 for a multistage system.
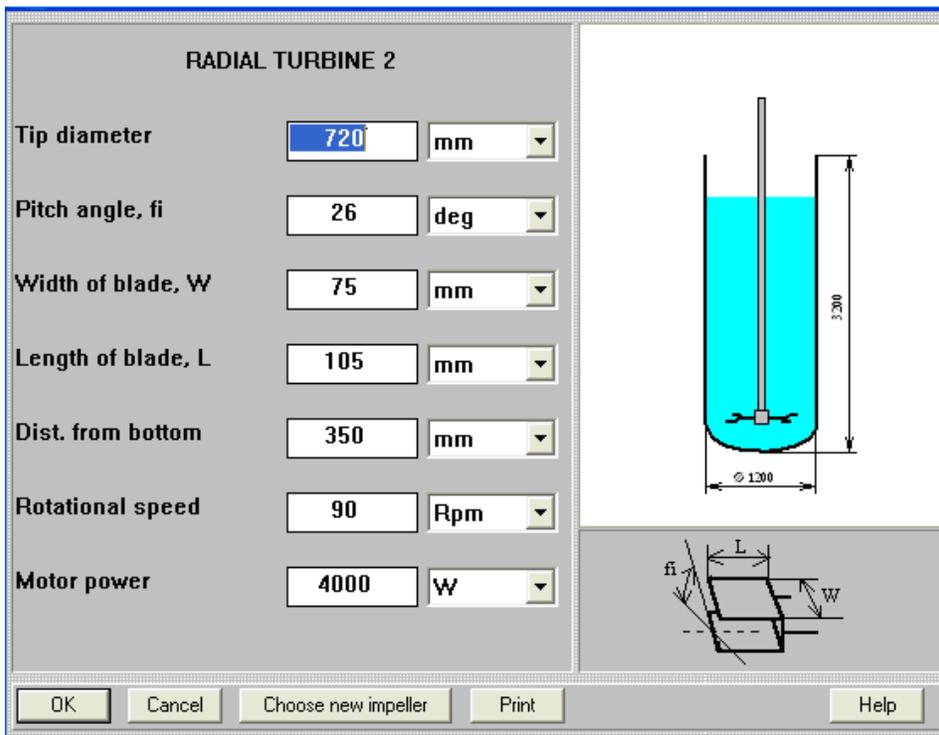
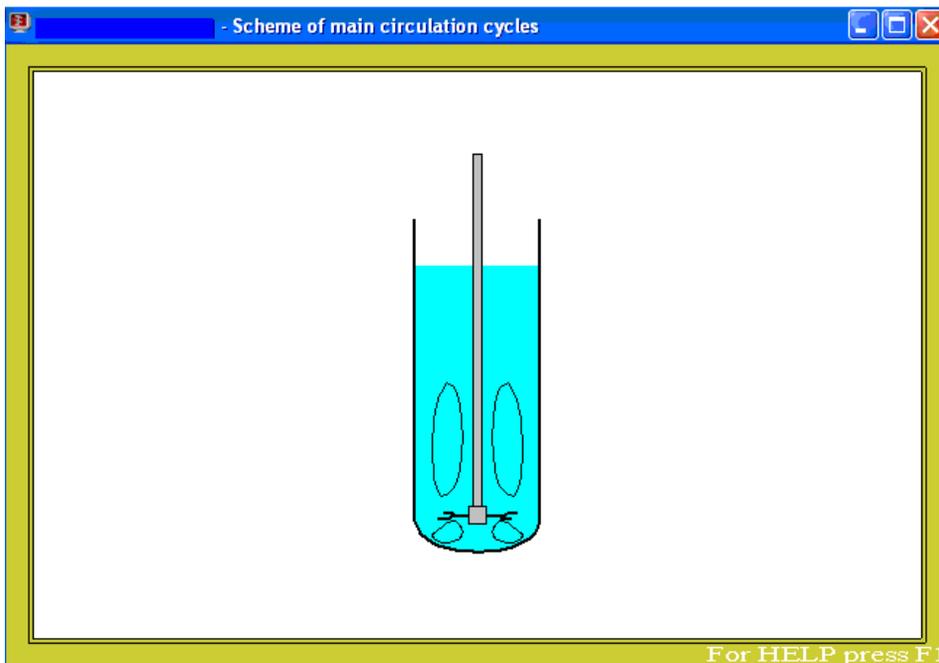**Figure18. Single-stage Intermig impeller.**

Figure19. The scheme of main circulation cycles for a single-stage system.

Now let us come back to our basic multistage configuration. To do it, select **Edit**, **Agitator**, and change the number of agitator stages from 1 to 3. You will have to
enter the distance between the agitator stages again, since the program did not store this information.

CIRCULATION FLOW RATE

Parameter name	Units	Value
Circulation flow rate	cub.m/s	0.0828
Index of uniformity of flow distribution in the tank volume		0.463

**Figure20. Circulation flow rate and Index of uniformity for a single-stage system.**

Now let us address the main question of interest to us, which is the **Mixing time**. Select the **Mixing time** in the **Blending. Uniformity of mixing** option (Figure15).

Additional data is needed to calculate the mixing time. VisiMix invokes an appropriate input table (Figure21), and you are requested to enter the inlet zone location since the mixing time naturally depends on the point where the admixture is added. In this table, you are also asked to indicate the sensor position in the tank.
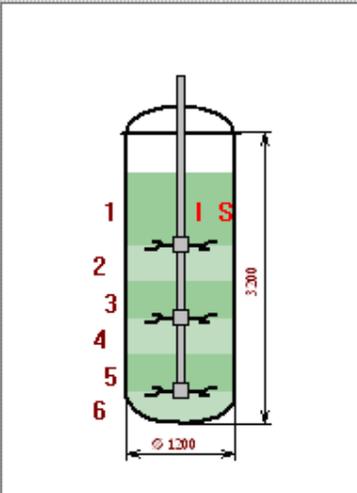
Figure21. Entering the location of the inlet and sensor zones (3-stage Intermig).

Click OK, and in a few seconds the appropriate output window appears (Figure22).

Figure22. The calculated values for the mixing time (3-stage Intermig).

In this table you see three different values of the mixing time, depending on the degree of uniformity achieved. Note that for any desired uniformity, the mixing time is 20-30 min. At the same time, you have previously obtained a much smaller value, 8 s for the **Mean circulation time**. This means you need about 150 cycles to mix your media.

Why is this value so high? It is natural to assume that the transport (diffusion) of admixtures is impeded between the circulation zones (see Figures 1-17 and 1-21). If this is the case, the mixing may be considerably improved if you decrease the number of circulation zones in the tank. Let us try to replace the 3-stage turbine with an identical 2-stage turbine without changing any other parameters.

Figure23. Entering a 2-stage Intermig impeller.

Select **Edit**, **Agitator**, and replace 3 with 2 in the **Agitators number** box. For this configuration, we suggest that you also change the distance between the stages from 800 to 1200, and the distance from bottom from 350 to 600, as shown in Figure23.

Click OK, and the **Blending** input table appears again (Figure24), with a new distribution of the zones. Since we do not need to change anything in this table, click OK, and the program will recalculate the mixing time.
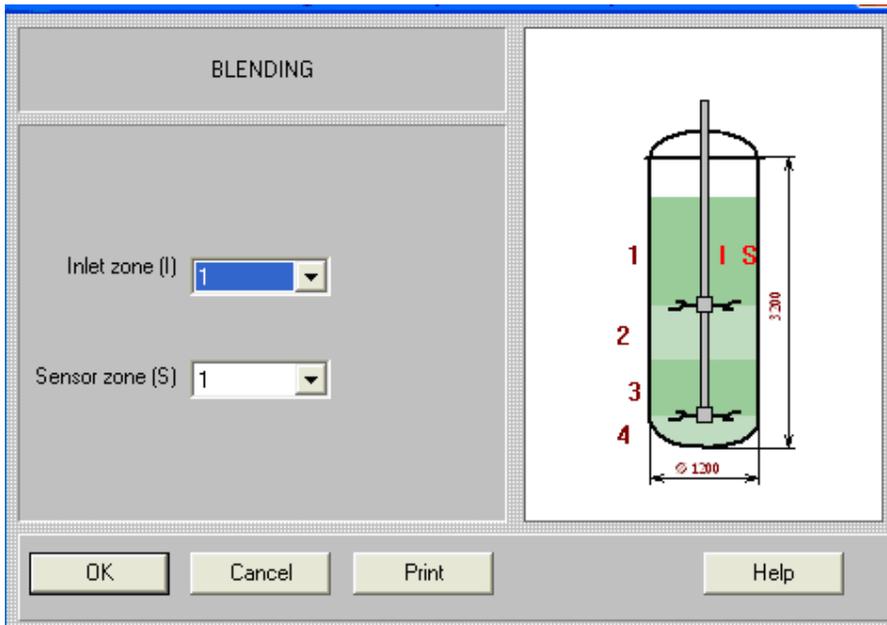

Figure24. Entering the location of the inlet and sensor zones for a 2-stage Intermig.

The calculated results are shown in Figure25. You can see that the mixing time has considerably decreased. This means that changing the number of agitator stages from three to two has had a favorable effect on your process.

Figure25. The calculated values for the mixing time (2-stage Intermig).

However, you will now see that the decrease in the mixing time was not the only beneficial effect of this modification. Since there are now two stages only, we may assume that the mixing power has also decreased. Let us check the mixing power through the **Power and forces** option. The calculated value is shown in Figure26.

MIXING POWER

Parameter name	Units	Value
Mixing power	W	803

For HELP press F1

Figure26. The calculated value for the Mixing power (2-stage Intermig).

You can see that compared to the **Mixing power** value obtained for a 3-stage impeller (1160 W, Figure11), the mixing power has decreased considerably.

The conclusion:

VisiMix has thus shown that considerable process improvement can be achieved by quite simple means, without going into major expenditures.

However, you can also use VisiMix for checking a lot of additional process parameters, for example, you can see how the concentration in the sensor zone changes as a function of time. To do it, select **Characteristic function of tracer distribution** in the **Blending. Uniformity of mixing** option in the **Calculat**. Or, for example, you can find out what is the relative part of the media that has not passed through the agitator zone a certain number of times, by selecting **Dynamics of mixing/blending** in the same menu.

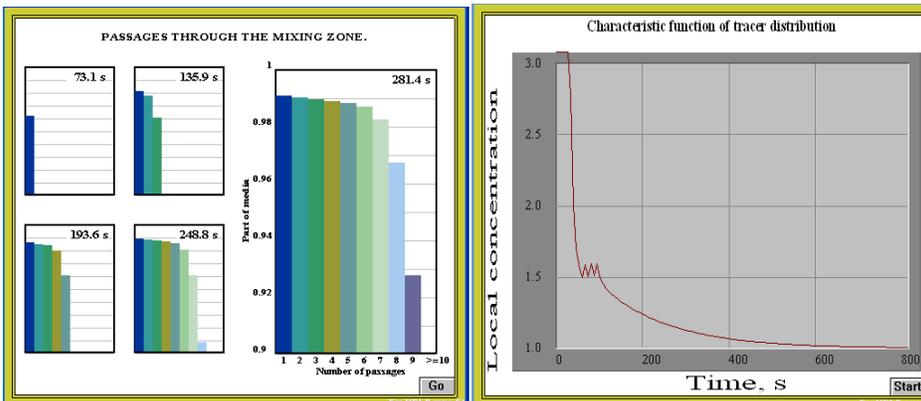Both output tables are shown in Figure27.

Figure27. Characteristic function of tracer distribution and Dynamics of mixing/blending (2-stage Intermig).