VISIMIX LAMINAR. POWER, CIRCULATION AND MIXING TIME IN TANK WITH ANCHOR AGITATOR.

This example illustrates application of the program VisiMix Laminar for mathematical modeling of mixing of a viscous liquid in reactor with anchor agitator.

Reactor:
Tank with elliptical bottom
Internal diameter - 800 mm
Total height – 1050 mm

Mixing device:
Anchor agitator
Tip diameter – 700 mm
Height of blades – 800 mm
Width of blade – 55 mm.

Drive:
Rotation velocity - 45 rpm
Power – 4 kW.

Media:
Viscous liquid.
Volume – 400 l.
Density -1300 kg /cub.m.
Dynamic viscosity – 50000 cP.

Purpose of mixing: uniform mixing of viscous liquid.
Process regime: batch.

Step 1. Entering initial data.

1.1. Tank.

As the first step after starting a new project, the program provides a graphic menu for selection of the tank type. In our case a tank with elliptical bottom without jacket is selected (Fig.1), and the program provides input table with the list of necessary dimensions. The filled input table is shown in the Fig.2. If the **Volume of media** is entered, then the **Level of media** is defined by program.

Figure 1. Graphic menu for selecting of the tank design.

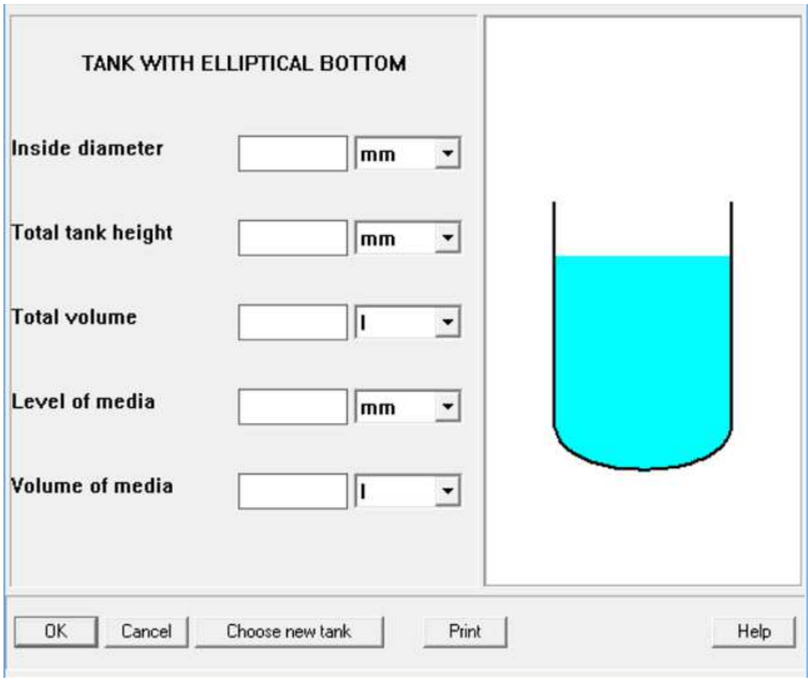


Figure 2.

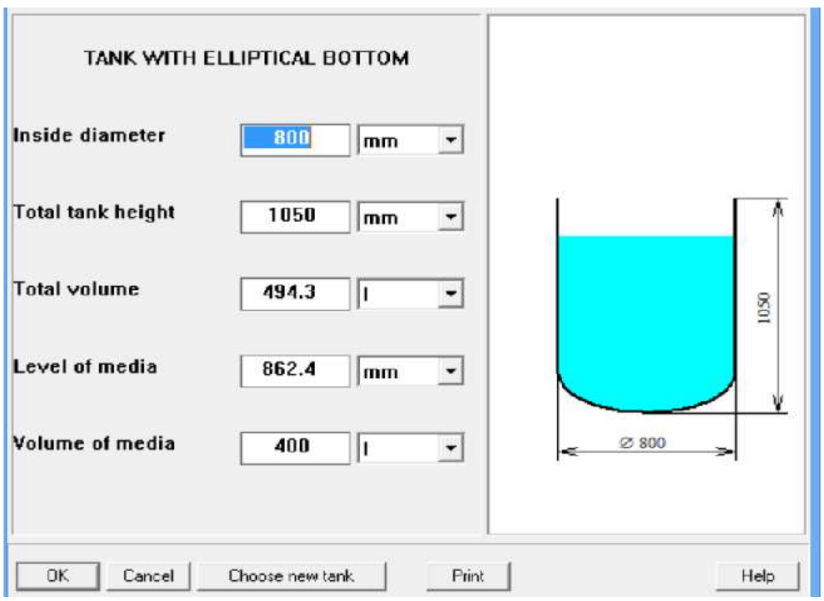


Figure 3. Entering dimensions of the tank.

1.2. Baffles.
The program provides a visual menu for selection of baffles. In our case the **'NO BAFFLE'** option has to be selected (Fig.4).

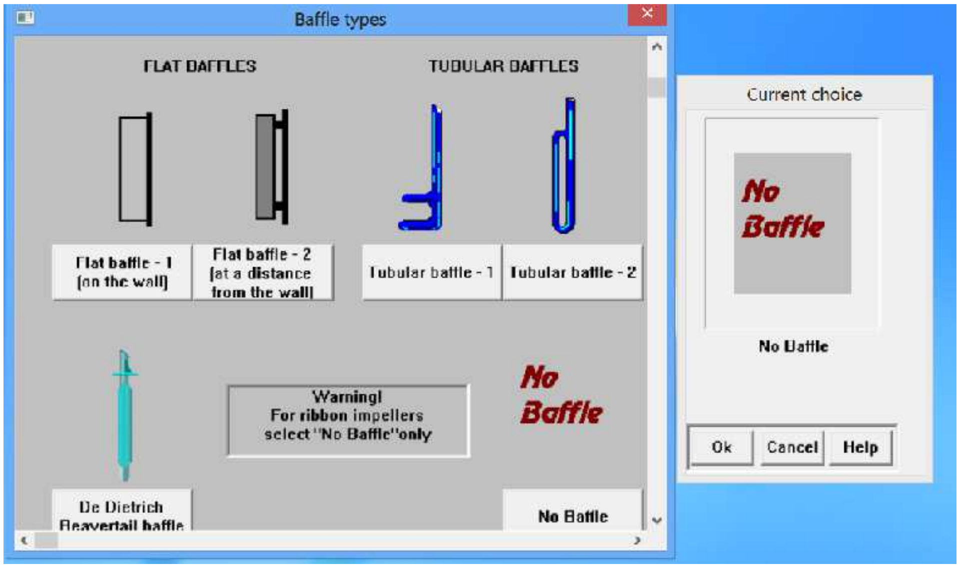


Figure 4.

1.3. Impeller.

The next step – selection of the anchor impeller in a graphic menu provided by the program (Fig.5) and entering of the impeller and drive data into the arriving table (Fig.6).

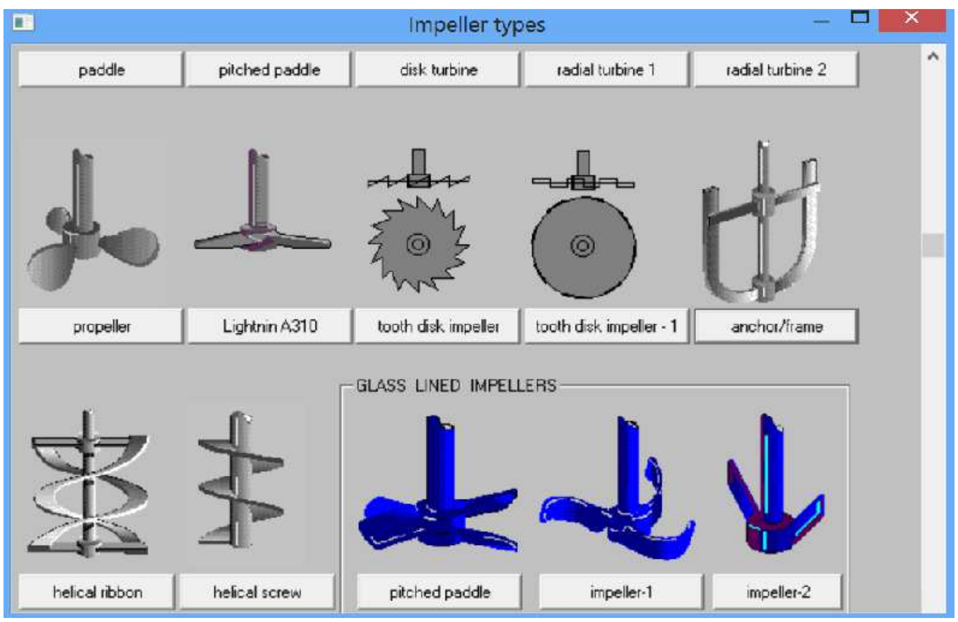


Figure 5. Graphic menu for selection of impeller (fragment).

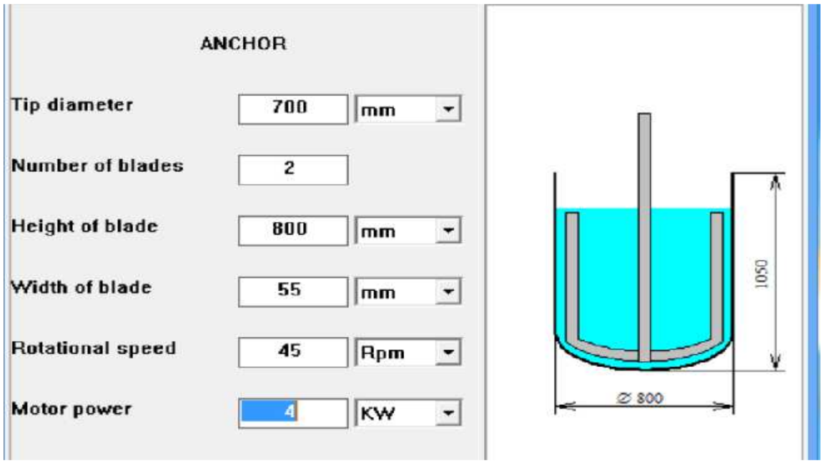


Figure 6. Entering data for impeller and drive.

1.4. Average properties of media.

After input of design data is completed, the program provides tables for entering of average properties of media. For our case, the density is entered, and the media is defined as Newtonian (Fig.7). The table for entering of viscosity is provided by the program (Fig.8). Note, that if the **Dynamic viscosity** is entered, **the Kinematic viscosity** is defined by the program.

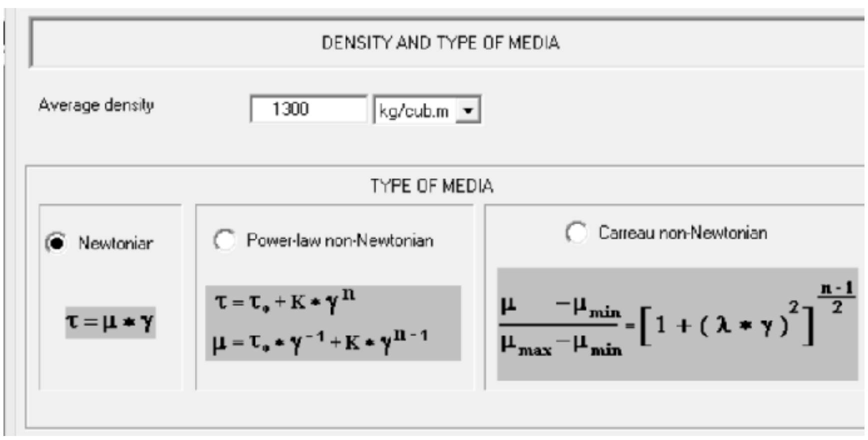


Figure 7. Entering density and type (rheological model) of liquid media.

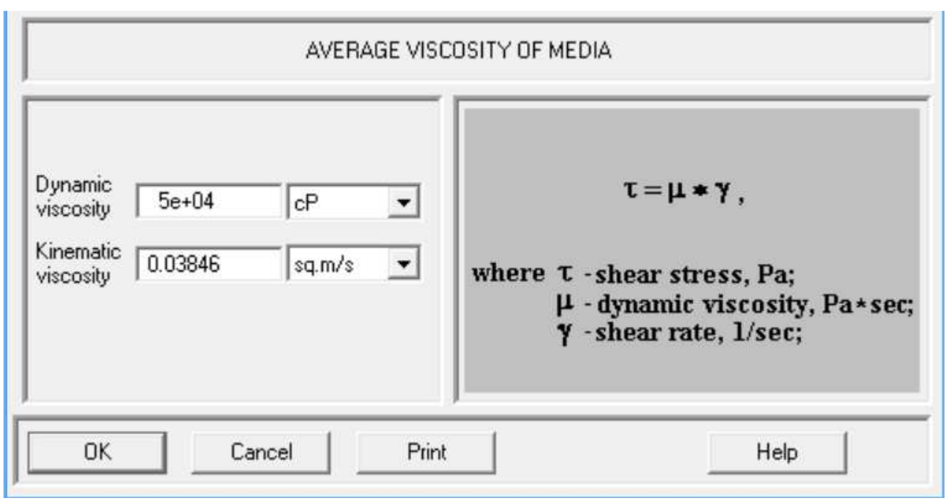


Figure 8. Entering viscosity of liquid.

<u>Step 2. Hydrodynamical modeling. Circulation Power.</u>

After the main initial data are entered, simulation can be started.
In order to evaluate general flow conditions in the tank, we start hydrodynamic simulation with pressing one of the **Calculate> Flow characteristics** menu options, for example **Calculate>Flow characteristics> Reynolds number for flow** (Fig.9).

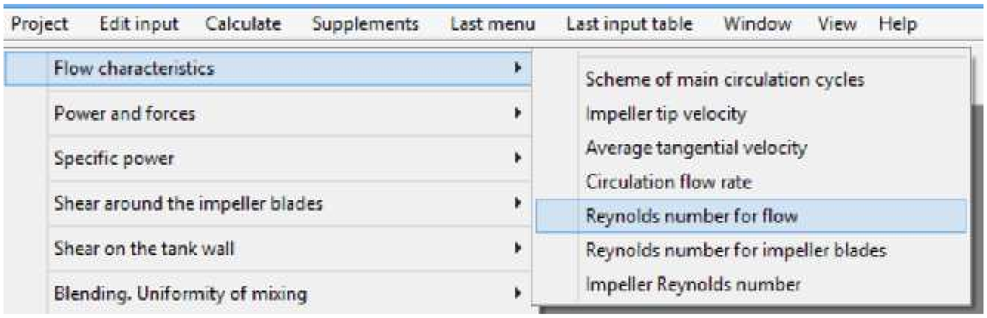
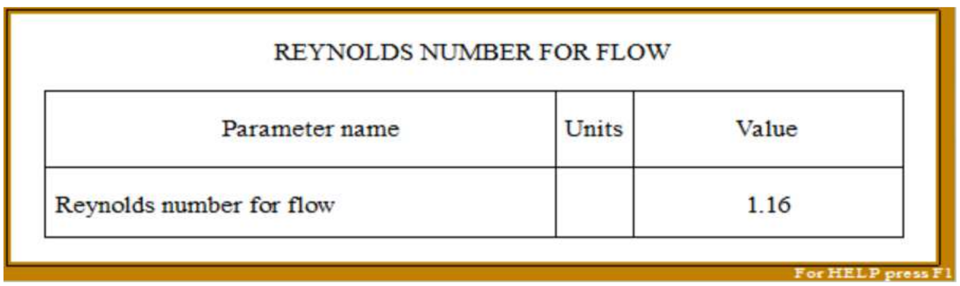


Figure 9. Menu options for hydrodynamic simulation.

Answer to our request based on the results of modeling is shown in the Fig.10. For additional information, we press also **Last menu> Scheme of main circulation cycles** and **Last menu>Circulation flow rate.**


REYNOLDS NUMBER FOR FLOW

Parameter name	Units	Value
Reynolds number for flow		1.16

For HELP press F1

Figure 10. Simulation results. Re number value based on calculated flow velocity.

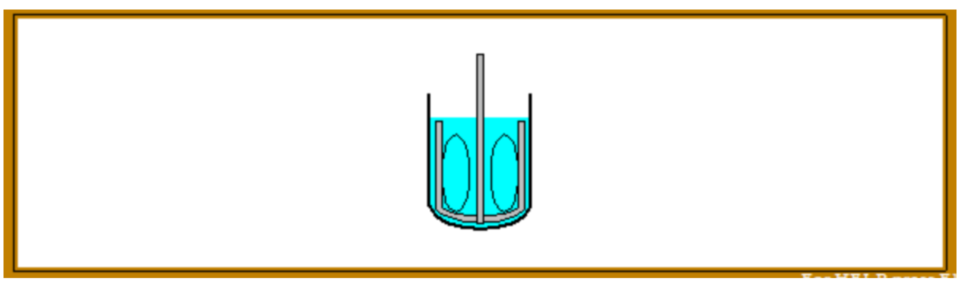
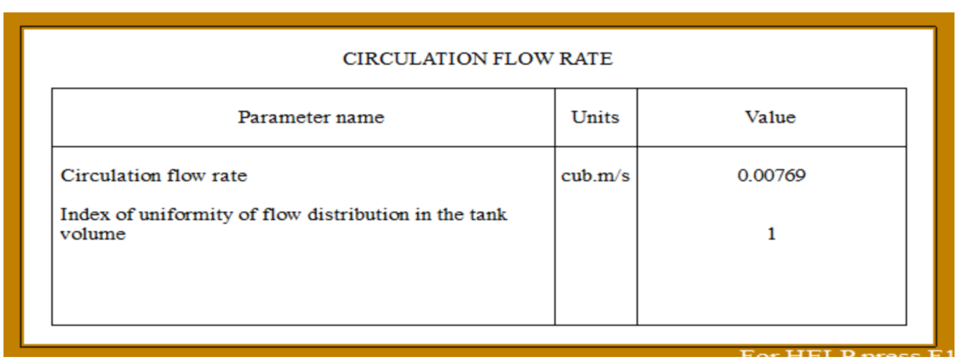


Figure 11. Simulation results. Scheme of circulation cycles.


CIRCULATION FLOW RATE

Parameter name	Units	Value
Circulation flow rate	cub.m/s	0.00769
Index of uniformity of flow distribution in the tank volume		1

Figure 12. Simulation results. Main characteristics of axial circulation flow.

Results of simulation presented in the Figs 10-12 show that:

- Accordingly to the data of the Fig. 8, Re number is low and corresponds to laminar regime. So, flow in the tank is laminar.

- The scheme in the Fig.9 shows that, along with evident tangential flow, liquid in the tank is involved in axial circulation cycle that provides axial and radial exchange necessary for mixing.

- Accordingly to data of the Fig 12, rate of the axial flow is about 450 liter per min (compare it with the volume of media 400 l).

- An important parameter in this table is the **Index of uniformity of flow distribution in the tank volume.** The higher this index is, the higher is the uniformity of the flow distribution, and the smaller part of flow is "short circuited" in vicinity of the impeller. Value '1' is the maximum value, it shows that circulation cycle involves 100% of the liquid.

For defining power, let us use menu option **Calculate>Power and forces>Mixing power (**Fig.13**).**

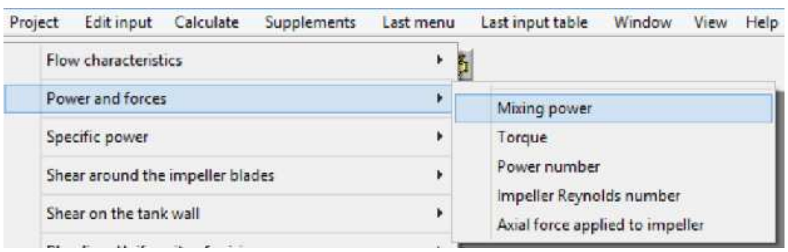
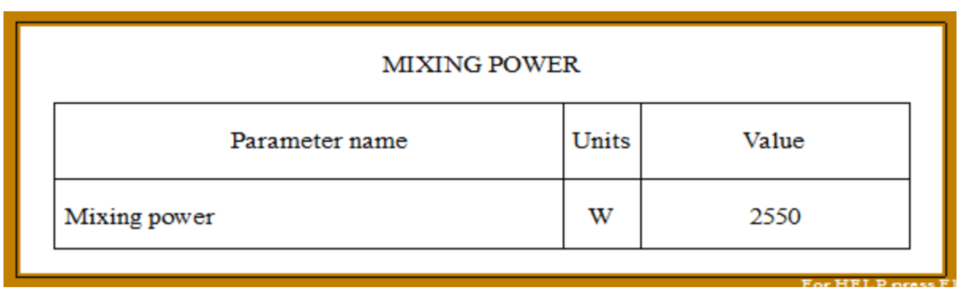


Figure 13. Menu options for calculation of power.

Accordingly to the obtained results (Fig.14), power of the drive is high enough for mixing and provides necessary reservation.


MIXING POWER

Parameter name	Units	Value
Mixing power	W	2550

Figure 14. Simulation results. Power consumption of impeller.

<u>Step 3. Mathematical modeling of macro-mixing. Mixing uniformity. Mixing time.</u>

For a simple evaluation of mixing dynamics let us use the menu option **Calculate> Blending. Uniformity of mixing>Mixing time** (Fig.15)

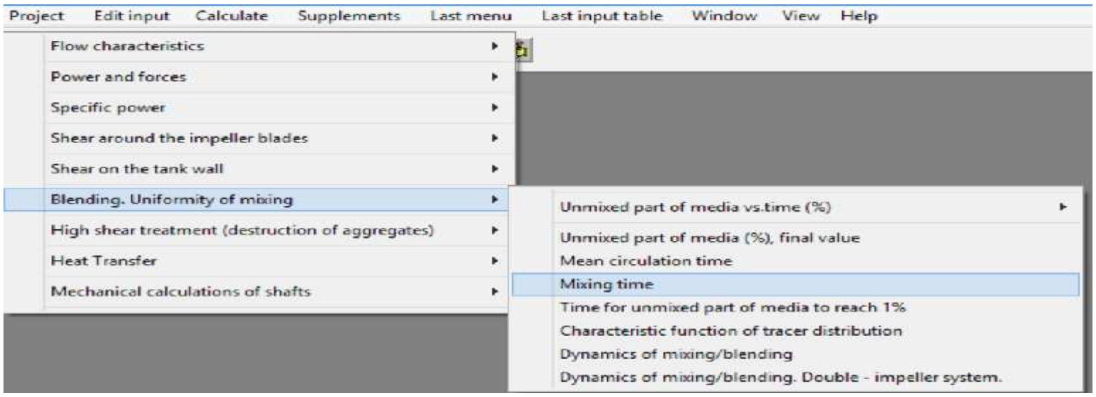
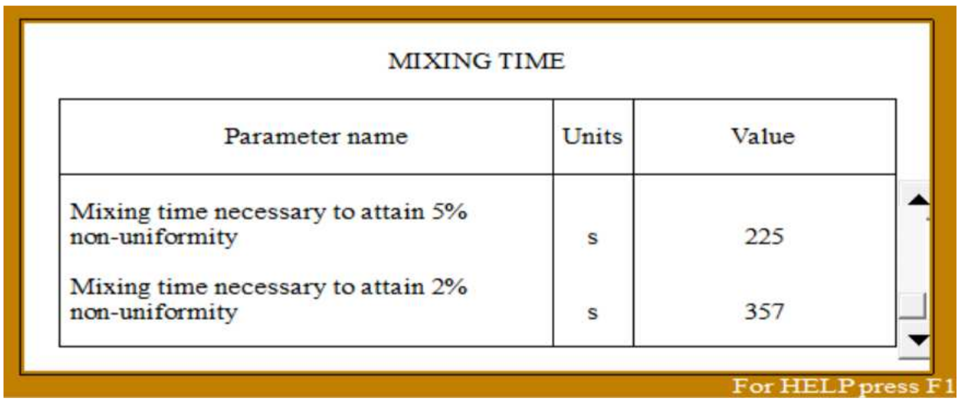


Figure 15. Menu options for mathematical modeling of macro-mixing.


MIXING TIME

Parameter name	Units	Value
Mixing time necessary to attain 5% non-uniformity	s	225
Mixing time necessary to attain 2% non-uniformity	s	357

For HELP press F1

Figure 16. Simulation results. Mixing time values for different degrees of uniformity.

Significance of this information is clear from the text below that is extracted from the **Help** section of the program (see also **User's Guide**).

Output Parameters
Blending. Uniformity of mixing.
Mixing time
The required duration of the mixing process depends on the desired degree of non-uniformity of the final mixture, i.e. ± 5% or 2 % of the final change in concentration.

As follows from the obtained simulation results, during the first 5-6 minutes of mixing the media is quite non-uniform, and time necessary for a uniform mixing must be a few times longer. In order to define the necessary time, let us use menu option **Calculate>Blending. Uniformity of mixing>Unmixed part of media (%), final value** (see Fig.15).

After we press the corresponding menu line, the program provides request for estimated process duration (Fig 17). Let us start with 20 minutes.

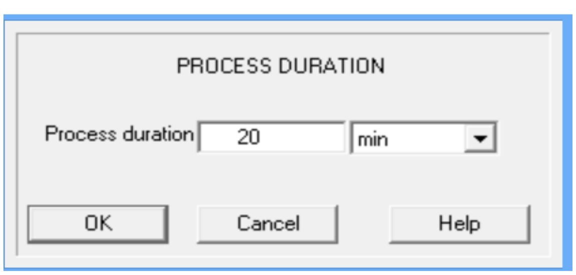


Fig. 15. Entering of process duration.

UNMIXED PART OF MEDIA (%), FINAL VALUE

Parameter name	Units	Value
Process duration	s	1200
Unmixed part of media (%), final value		0.0990

Figure 18. Simulation results. Achieved degree of uniformity.

Result of modeling presented in the Fig.18 shows that after 20 min of mixing composition of about 0.1% of media is not exactly equal to composition of the another 99.9%. In the most practical cases this can be considered insignificant.

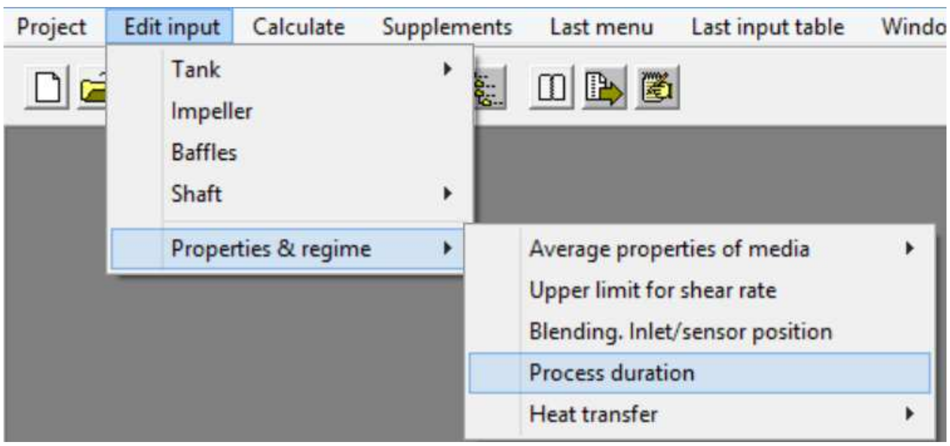


Figure 17. Menu option for changing process parameters.

In order to define possibility of further reduction of this value, we can select the menu option **Edit input > Properties & regime>Process duration** (Fig.17) and increase the **Process duration** value up to 30 min. The program repeats the modeling automatically and provides the new result (see Fig.18).

UNMIXED PART OF MEDIA (%), FINAL VALUE

Parameter name	Units	Value
Process duration	s	1800
Unmixed part of media (%), final value		0.0660

Figure 19. Simulation results. Achieved degree of uniformity.

In order to define possibility of further reduction of this value, we can select the menu **option Edit input** > **Properties & regime** > **Process duration** (Fig.19) and increase the **Process duration** value up to 30 min. The program repeats the modeling automatically and provides the new result (see Fig.20).

UNMIXED PART OF MEDIA (%), FINAL VALUE

Parameter name	Units	Value
Process duration	s	1800
Unmixed part of media (%), final value		0.0660

Figure 20.

As follows from the obtained data, on this stage effect of increase of mixing duration is not too significant.

Degree of uniformity achieved in the tank looks acceptable, and process duration may be limited to 20-30 min.