VISIMIX DI.
KEY MIXING PARAMETERS OF REACTOR WITH DISC TURBINE AND A310 IMPELLER.

Purpose of application of the program VisiMix DI in this example:

- Calculation of the main mixing parameters – power, mixing time and shear in a tank with two different impellers on the shaft
- Evaluation of importance of each impeller

Initial data

Tank with a flat bottom:
Inside diameter = 3000 mm;
Total tank height = 5000 mm;
Level of media = 3500 mm.

Baffles (flat, attached to the tank wall)
Number = 4;
Width = 300 mm;
Length = 4000 mm;
Distance from bottom = 0 mm;
Angle to radius = 0 deg.

Impellers:

1. Disc turbine (Rushton type)
Tip diameter = 1000 mm;
Diameter of disc = 750mm;
Number of blades = 6;
Pitch angle = 90 deg;
Width of blade = 200 mm;
Length of blade = 250 mm;
Distance from bottom = 600 mm;

2. Lightnin A310 type.
Tip diameter – 1400 mm;
Pumping direction: down;
Distance between impellers – 1200 mm;

Shaft rotation speed: 60 rpm;
Power of drive = 10,000 W;

Media properties
The media is a Newtonian liquid with the following average properties:
Density = 1000 kg/cub. m;
dynamic viscosity = 0.001Pa*s.

1. Entering the initial data.

1.1. Tank. After the program is started, it provides a graphic menu for selection of the tank type (Fig.1). In our case a tank with elliptical bottom without jacket has to be selected. After the tank type has been selected, the program defines the list of necessary dimensions and provides the corresponding input table. 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.

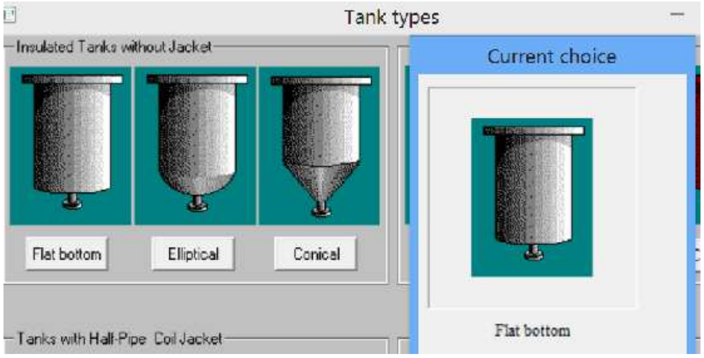

Figure 1. Graphic menu for tank selection (fragment).

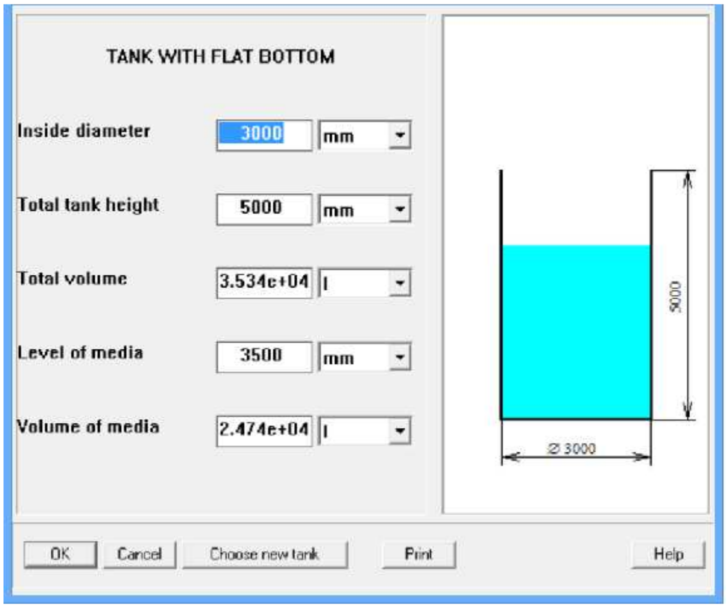

Figure 2. Entering tank data.

1.2. Baffles. The Flat baffles are selected from a graphic menu (Fig.3). Dimensions are entered into the table supplied by the program (Fig.4).

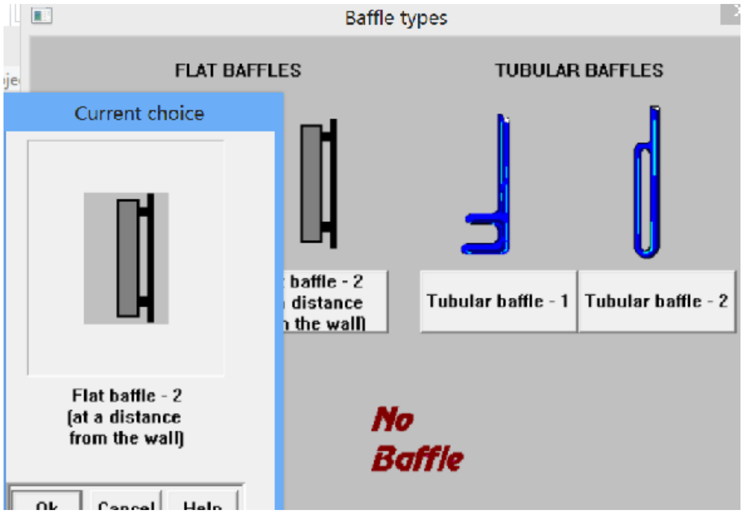

Figure 3. Graphic menu for selection of baffles (fragment).

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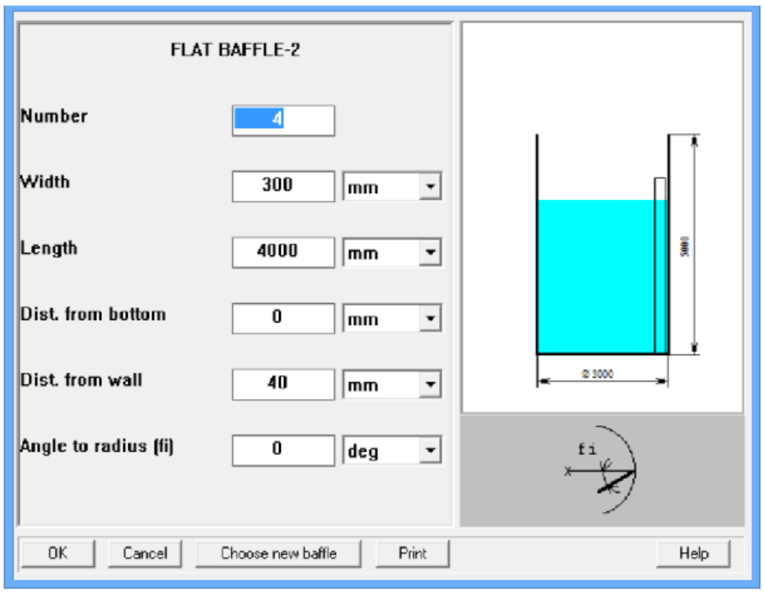

Figure 4. Entering data for the baffles.

1.3. Mixing device. After these data are entered, the **Mixing device** input table appears (Figure 5).

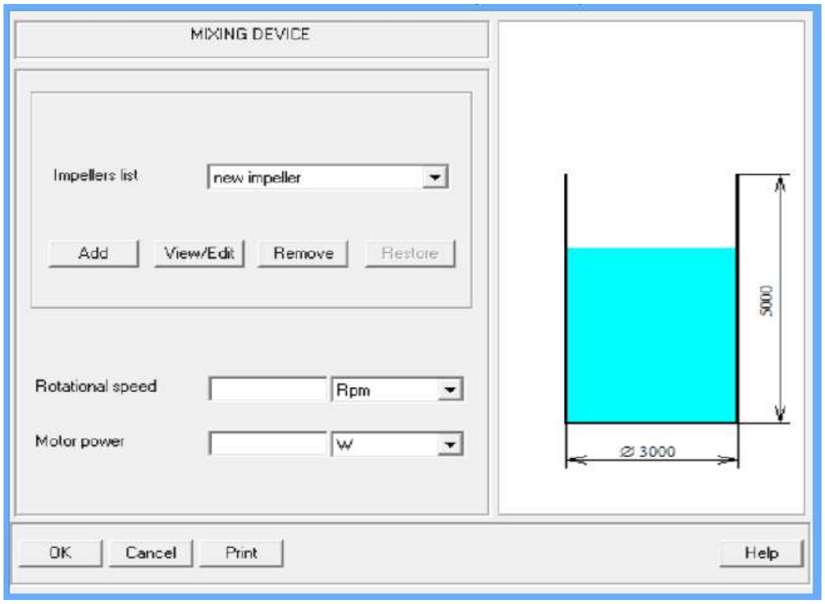

Figure 5. Mixing device input table.

The next step – entering the first impeller **-** the i**mpeller 1.**
It is performed using Add button. The impeller type, in this case – the **disc turbine** impeller – is selected from the graphic menu (Fig.6), and the impeller data are entered in the next table (Fig.7).

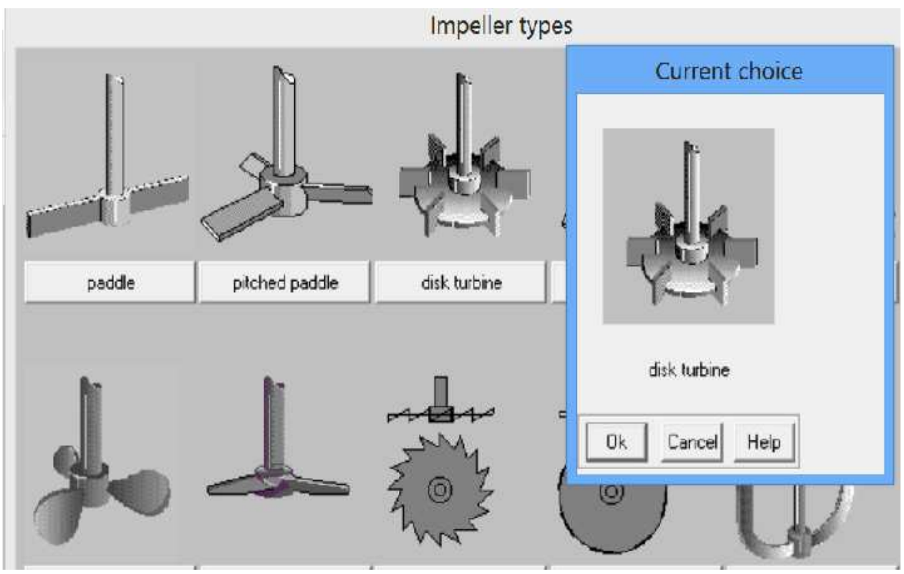

Figure 6. Graphic menu of impellers (fragment).

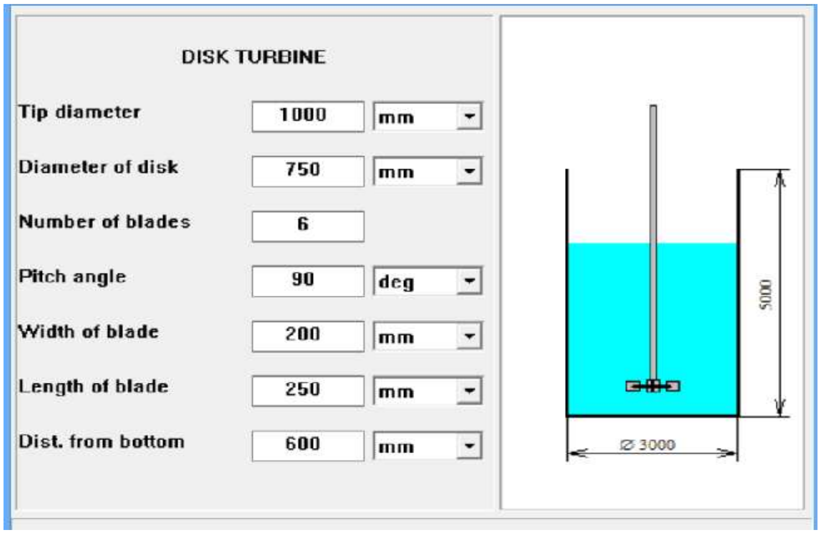

Figure 7. Entering the Impeller 1 - disc turbine.

After filling this table, the **Mixing device** with the Impeller 1 in the C**urrent choice** window arrives. The impeller **1** line is shown in **Impellers list** scrolling box (see Figure 8).

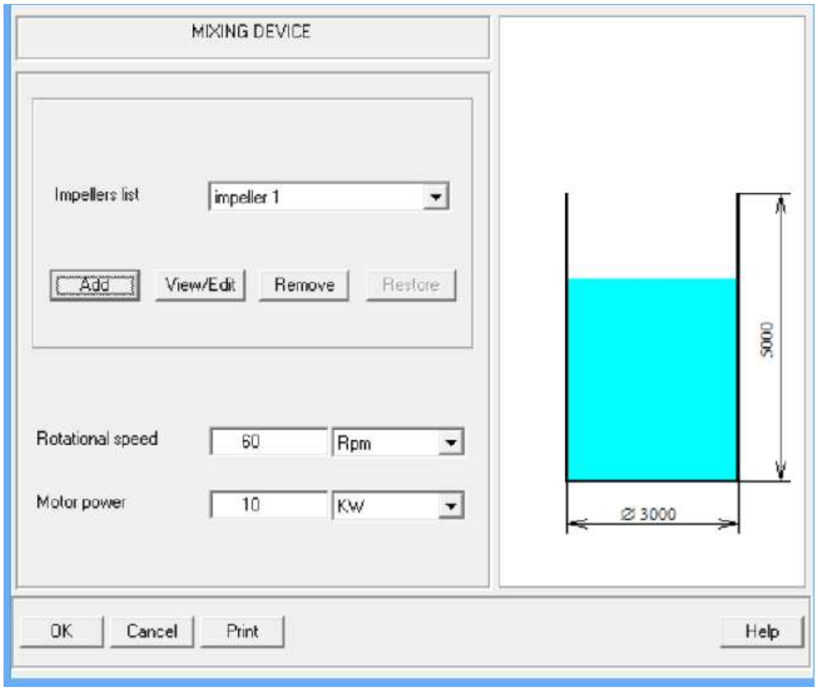

Figure 8.

After selection **New impeller** in the scrolling box, the **Impeller selection** screen will arrive once more, and it is possible to select and enter the next impeller. In our case impeller A310 is entered as the **impeller 2**. The final scheme of the mixing vessel provided by the program is shown in the Fig.9.

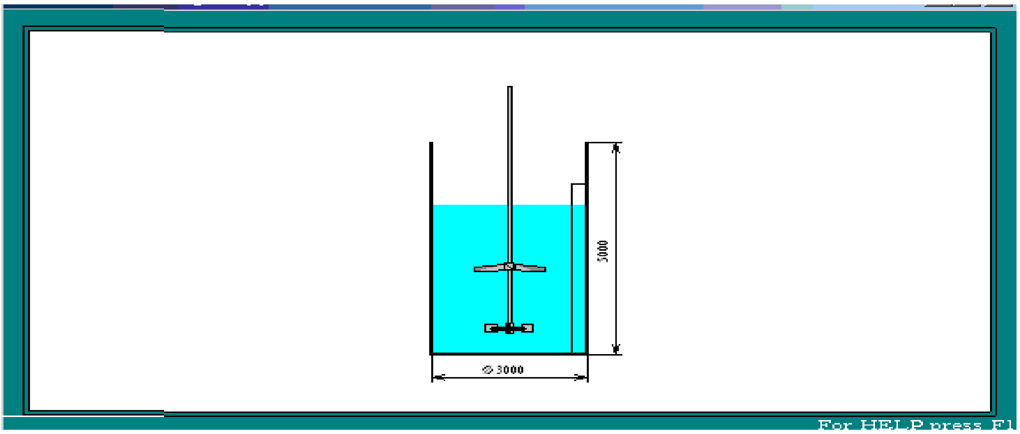

Figure 9. Scheme of the tank with impellers.

After the scheme is confirmed, the average properties of media are entered, and it is possible to start the calculations.

2. Calculation of general mixing parameters – power consumption, mixing time and maximum shear.

2.1. Power consumption. Calculation of power consumption of the mixing device is performed using the option **Calculate** in the main menu. We select (Fig. 10) **Calculate > Hydrodynamics > Mixing power.**

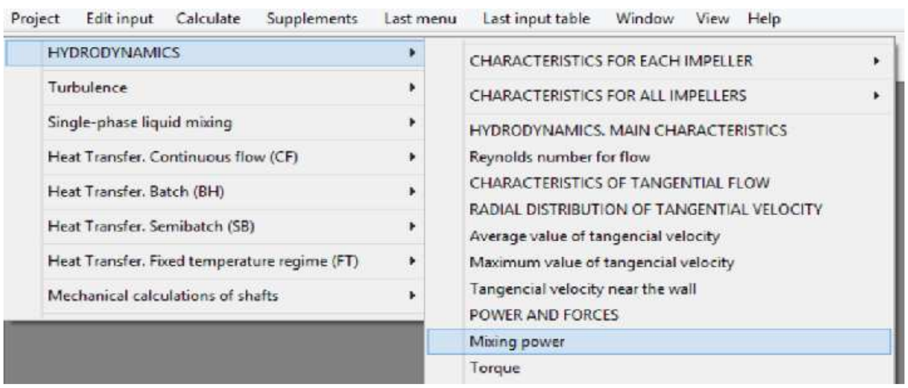

Figure 10. Menu option for calculation of mixing power.

The corresponding output table arrives on the screen (Fig.11)

MIXING POWER

Parameter name	Units	Value
Mixing power	W	6640

Figure 11. Output table of the Mixing power.

2.2. Mixing time. For calculation of mixing time we use menu option **Calculate >Single-phase mixing > Macromixing time** as shown in the Fig. 12. The calculated result arrives in the output table in the Fig.13.

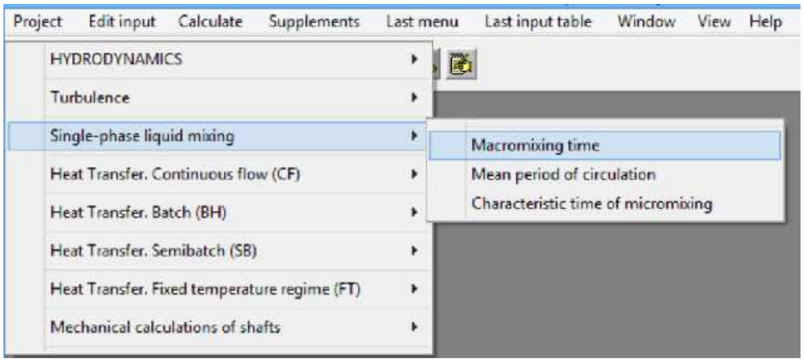

Figure 12. Menu option for calculation of the mixing time.

MACROMIXING TIME

Parameter name	Units	Value
Macromixing time	s	37.8

Figure 13. Output table of the Macromixing time.

2.3. The maximum shear rate. Shear rate and shear stress are local parameters and are defined by modeling of distribution of turbulence. The maximum value of shear rate is defined using the **Turbulence** sub-menu as **Calculate > Turbulence > Turbulent shear rates in different zones**. It is presented in the Fig.14.

TURBULENT SHEAR RATES IN DIFFERENT ZONES

Parameter name	Units	Value
Turbulent shear rate in zone of impeller with maximum dissipation	1/s	8990
Turbulent shear rate in zone near baffles	1/s	305
Turbulent shear rate in bulk	1/s	305

Figure 14. Output table of the Turbulent shear rates.

3. Evaluation of input of each impeller.

3.1. Power and circulation flow for each impeller. Data for comparison of hydrodynamic parameters of impellers are accessible via the menu option **Hydrodynamics > Characteristics for all impellers** (Fig.15).

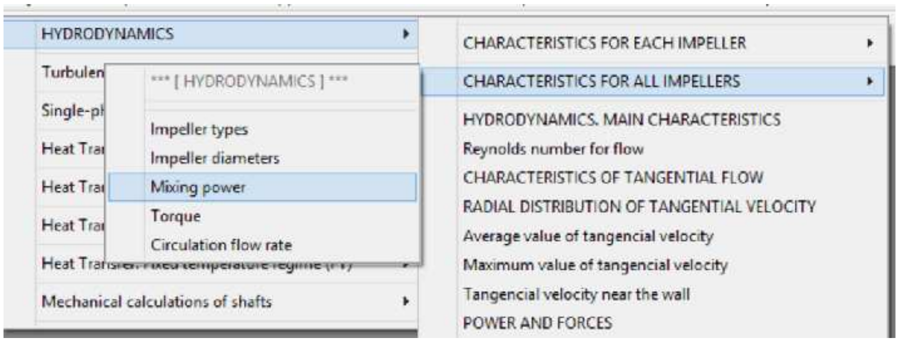

Figure 15. Menu options for comparison of impellers. Hydrodynamics.

By selecting **Mixing power** the output table is obtained that contains power consumption for each impeller (Fig. 16). The corresponding table for circulation flow created with each of impellers is released (Fig.17) by pressing **Last menu > Circulation flow rate**.

MIXING POWER

Parameter name	Units	Value
Impeller 1	W	5170
Impeller 2	W	1470

Figure 16. Power consumption of the impellers.

CIRCULATION FLOW RATE

Parameter name	Units	Value
Impeller 1	cub.m/s	2.13
Impeller 2	cub.m/s	1.79

Figure 17. Circulation capacity of the impellers.

3.2. Parameters of turbulence and shear for each impeller.

Data for comparison of shear parameters for the impellers are accessible via the menu option **Turbulence > Characteristics for all impellers** (Fig.18).

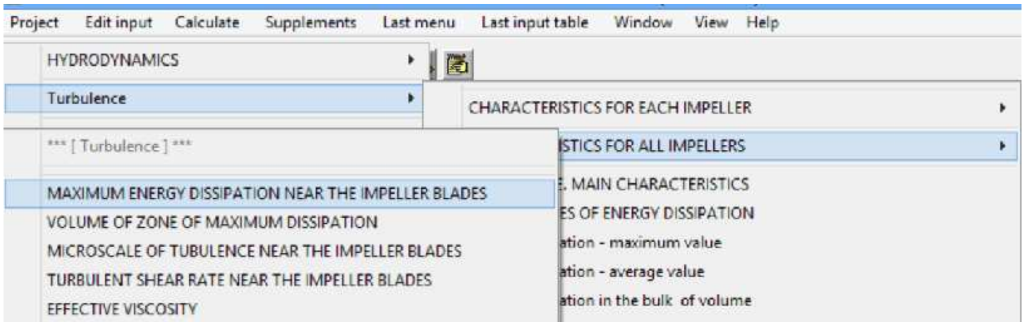

Figure 18. Menu options for comparison of impellers. Turbulence.

The output tables containing data on turbulent energy dissipation (specific energy) and shear rates created by each impeller are shown in the Figs! 9 – 21.

MAXIMUM ENERGY DISSIPATION NEAR THE IMPELLER BLADES

Parameter name	Units	Value
Impeller 1	W/kg	80.2
Impeller 2	W/kg	34.2

Figure 19. Maximum energy dissipation in vicinity of impellers.

TURBULENT SHEAR RATE NEAR THE IMPELLER BLADE

Parameter name	Units	Value
Impeller 1	1/s	8990
Impeller 2	1/s	5860

Figure 20. Maximum shear rates in vicinity of impellers.

VOLUME OF ZONE OF MAXIMUM DISSIPATION

Parameter name	Units	Value
Impeller 1	cub.m	0.0300
Impeller 2	cub.m	0.00659

Figure 21. Maximum shear zones in vicinity of impellers.

Conclusion.

The data presented in the Figs 16, 17 and 19 – 21 allow evaluating the influence of each impeller on mixing in the tank.

-The disk turbine (the Impeller 1) consumes the main part of power (Fig.16) and creates more than half of the total circulation flow (Fig 17).

- It creates a higher local energy dissipation and accordingly a higher shear rate than the Ligtnin 310 impeller (the Impeller 2), see Figs 18 and 19.

- Volume of the high shear zone around the disk turbine blades is much bigger then around the blades of the Lightnin 310 (Fig.21).

- The Lightnin 310 consumes much less power, but creates circulation flow close to a half of the total circulation.

It follows from these data that the disc turbine impeller, along with macro-mixing, is responsible for all mixing phenomena in the tank that require high shear treatment – for example, breaking of droplets. Function of the Lightnin 310 impeller is to provide additional circulation with the minimum additional power consumption.