

## VisiMix TURBULENT. POWER. MACRO- AND MICRO-MIXING AND SHEAR IN REACTOR WITH LIGHTNIN IMPELLER.

This example illustrates application of the program VisiMix Turbulent for mathematical modeling of turbulent mixing in reactor with 2-stage Lightnin impeller.

### Reactor:

Tank with elliptical bottom  
Internal diameter – 32 in,  
Total height – 42 in,

### Baffles.

Number – 4,  
Width – 3 in,  
Length – 30 in,  
Distance from wall – 1.5 in.

### Mixing device:

2-stage Lightnin A310.  
Tip diameter – 16 in,  
Distance between stages – 15 in,  
Distance from bottom – 6 in.

### Drive:

Rotation velocity - 160 rpm  
Power – 1.5 HP.

### Media:

#### Water solution.

Volume – 110 gal,  
Density -1020 kg /cub.m.  
Dynamic viscosity – 1cP.

### Step 1. Entering initial data.

#### 1.1. Tank.

After the program is started, it provides a graphic menu for selection of the tank type (Fig.1). After the tank a tank with elliptical bottom without jacket has been selected, the program provides an input table with 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.

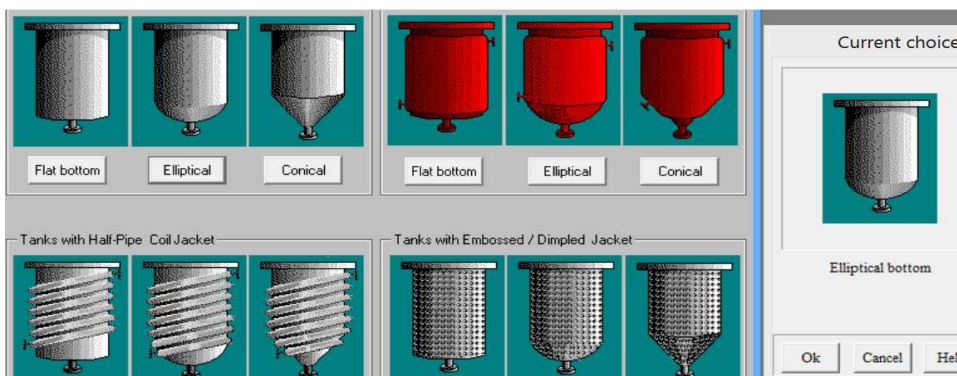


Figure 1. Graphic menu for selecting of the tank design.

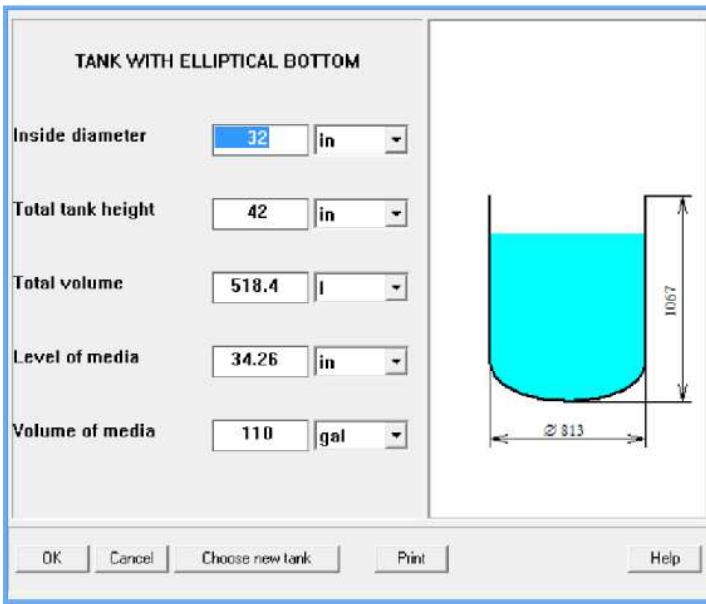


Figure 2. . Entering dimensions of the tank.

### 1.2. Baffles.

Graphic menu of baffles is shown in the Fig. 3, and the input table corresponding to this selected baffle design – in the Fig.4.

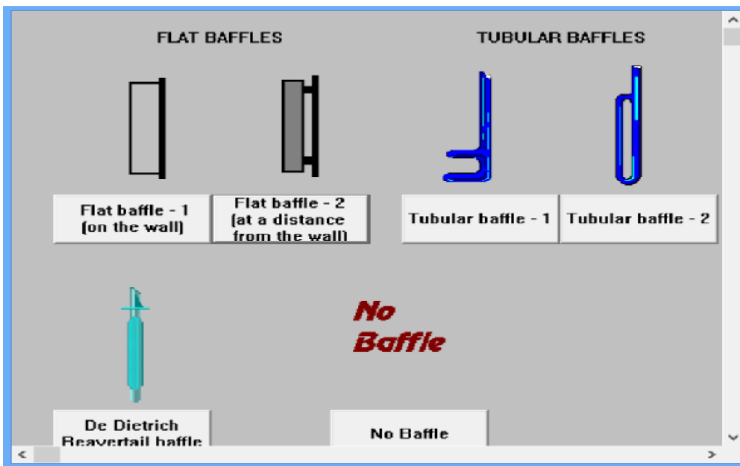


Figure 3. Types of baffles.

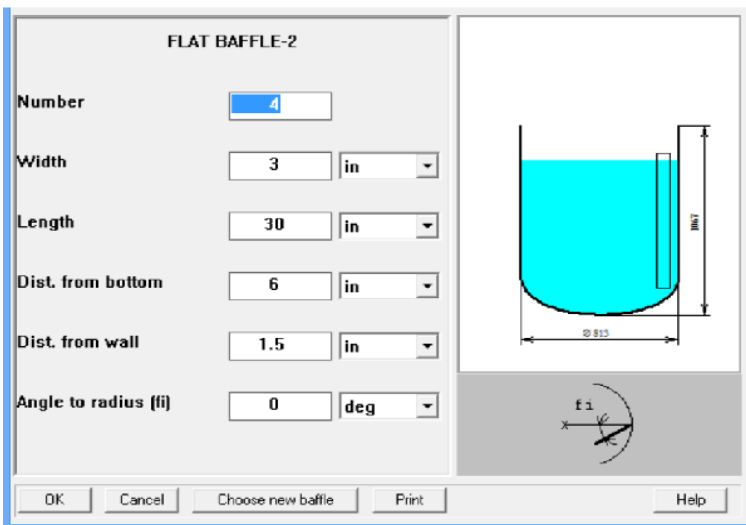


Figure 4. Entering of dimensions for selected baffles.

### 1.3 Impeller.

The VisiMix impeller selection standard is presented as a graphic menu (Fig.5). It allows for selection and entering practically any type of impellers currently used in industry. Selected impeller type –in our case the multistage Lightnin A310 impeller – is shown in the **Current choice** window (Fig.5), the corresponding input table arrives after the selection is confirmed (Fig.6).

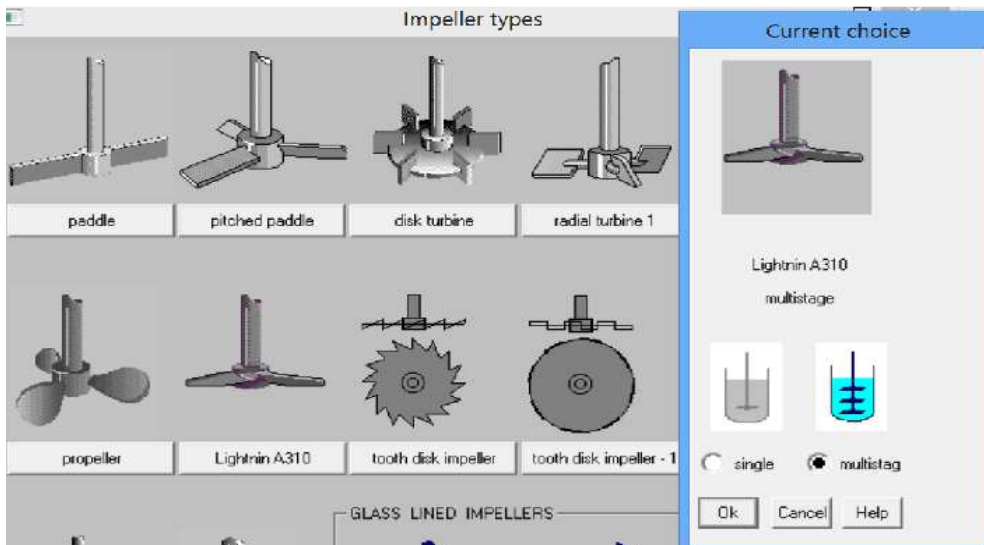


Figure 5. Graphic menu of impeller types (fragment).

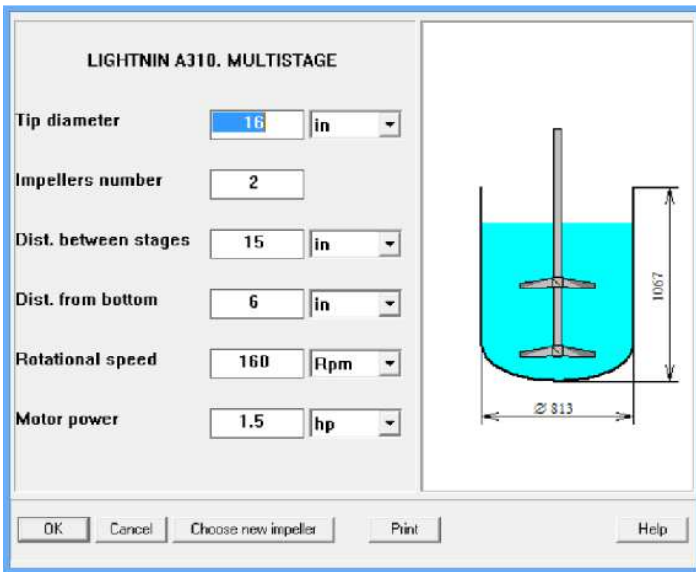


Figure 6. Entering data for impeller and drive.

#### 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.

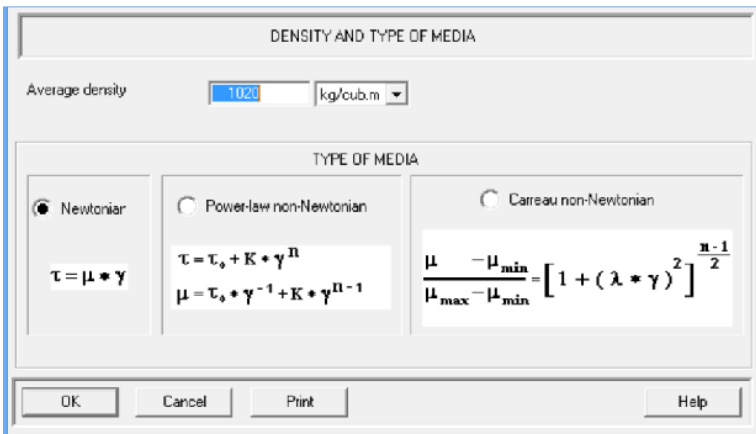


Figure 7. Entering density and type (rheological model) of liquid.

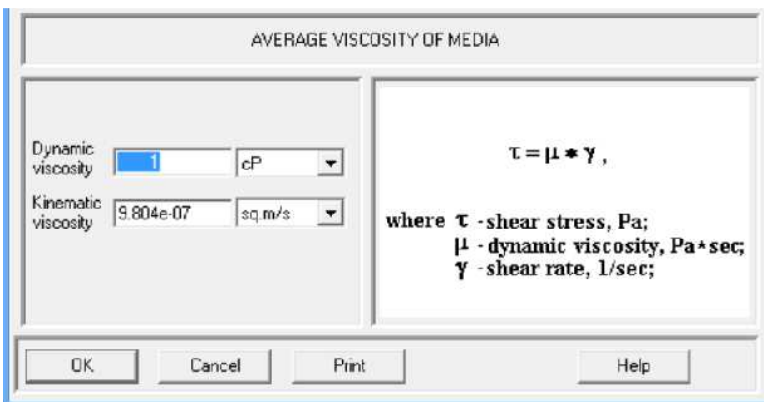


Figure 8. Entering viscosity of liquid.

## **Step 2. Hydrodynamic modeling. Circulation and power consumption.**

After the main initial data are entered, simulation can be started.

Hydrodynamic simulation is started with pressing one of the **Calculate> Hydrodynamics** menu options, for example **Calculate> Hydrodynamics > General flow pattern** (Fig.9). Results of a real time simulation of the flow are arriving on the screen (Fig.10).

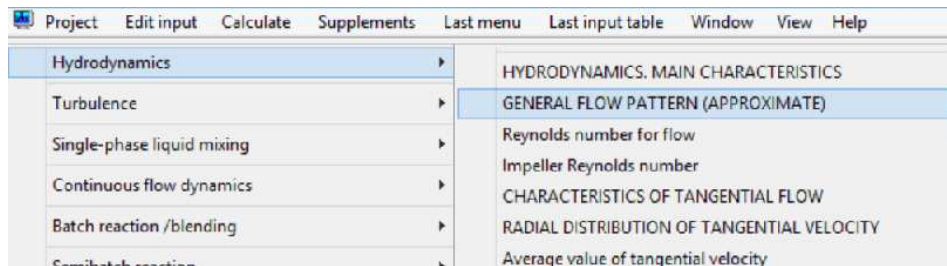


Figure 9. Menu option for simulation of the general flow pattern.

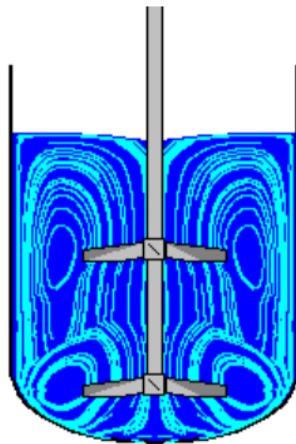


Figure 10. General flow pattern (approximate). Simulation result.

The next step – selection of the menu option **Hydrodynamics. Main characteristics** in the same menu (see Fig 9). Corresponding output table is shown below (Fig.11). Calculated parameters presented in this table help to evaluate quality of mixing in the reactor:

- Power consumption of the mixing device is relatively low (118 W), however a high value of the Re number confirms existence in the reactor of a fully developed turbulent flow. Note, that this Re number value is based not on impeller speed, but on average velocity of liquid in the tank.
- Mixing ensures an intensive axial circulation of liquid in the tank, along with tangential flow. It creates conditions necessary for efficient 3-dimensional distribution of substances.

HYDRODYNAMICS. MAIN CHARACTERISTICS		
Parameter name	Units	Value
Mixing power	W	118
Reynolds number for flow		1.41e+05
Average value of tangential velocity	m/s	0.236
Circulation flow rate	cub.m/s	0.107

For HELP press F1

Figure 11. Some results of hydrodynamic modeling.

### **Step 3. Modeling of macro- and micro-mixing.**

Additional information for evaluation of mixing in the tank is obtained with mathematical modeling of distribution of a tracer. To perform the modeling, the menu option **Calculate > Single-phase mixing > Macromixing time** is used (see Fig. 12).

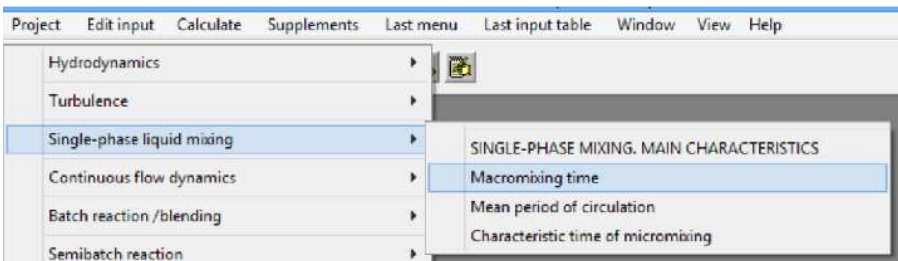


Figure 12. Menu option for calculation of mixing time.

Result of calculation is presented in the Fig.13. It is an analogue of the empirical **Mixing time** that is used for evaluation of macro-mixing in mixing tanks.

The next step – evaluation of influence of micro-mixing. Estimated value of the micro-mixing time is defined using the menu option **Characteristic time of micromixing** (see Fig.12)

MACROMIXING TIME		
Parameter name	Units	Value
Macromixing time	s	14.9

For HELP press F1

Figure 13. Calculated value of the Mixing time.

Result is presented in the Fig. 14. It shows that in this case influence of micro-mixing is insignificant, and uniformity of mixture is dependent mainly on the macro-mixing.

CHARACTERISTIC TIME OF MICROMIXING		
Parameter name	Units	Value
Characteristic time of micromixing	s	2.87

For HELP press F1

Figure 14. Calculated value of the Micro-mixing time.

**Step 4. Turbulence and shear.**

Characteristics of micro-scale turbulence in the tank, including local values of shear rates are defined using the menu section **Turbulence**. To define average specific power and maximum local value of turbulent energy dissipation rate in the tank, the menu option **Calculate > Turbulence > Turbulence. Main characteristics** can be used (see Fig.15). The result is presented in the Fig.16. It shows that local energy dissipation in zones around the blades of impellers is much higher than the average value defined as the specific power. However, total volume of these zones is very small.

TURBULENCE. MAIN CHARACTERISTICS		
Parameter name	Units	Value
Energy dissipation - average value	W/kg	0.278
Energy dissipation - maximum value	W/kg	56.2
Volume of zone of maximum dissipation	cub.m	0.000322

For HELP press F1

Figure 16. Specific power and the maximum energy dissipation rate.

It means also that existence of an extremely high shear rates in these zones can be expected. This conclusion is confirmed by results of modeling presented in the Fig. 17. The corresponding menu option is **Calculate > Turbulent > Turbulent shear rates in different zones** (see Fig 15).

TURBULENT SHEAR RATES IN DIFFERENT ZONES		
Parameter name	Units	Value
Turbulent shear rate near the impeller blade	1/s	7600
Turbulent shear rate near the baffle	1/s	342
Turbulent shear rate in the bulk volume	1/s	342

For HELP press F1

Figure 17. Non-uniformity of shear distribution in the tank.