VisiMix[®] OFF-CENTER

Quick Start Manual and an Application Example

1. Introduction

VisiMix OFF-CENTER is a brand-new software tool for mathematical modeling and design of mixing tanks with one or two identical or different impellers installed at an **off-centered shaft**.

The projects created and saved with VisiMix OFF-CENTER tool have extension .vxo.

Terms **nonconcentric shaft** or **off-center shaft** mean that the shaft axis does not coincide with the vertical axis of the tank.

This tool is a complimentary software incorporated into VisiMix Turbulent.

This version, which is the first one for the tool, includes an analysis sections covering simulation of hydrodynamics, turbulence, single-phase liquid mixing and heat transfer phenomena in cylindrical tanks with one or two impellers on a shaft of any configuration selected from the following list:

- a vertical off-center shaft;
- an inclined shaft; or
- a bottom-entering shaft.

The program supports configurations with one or two impellers installed on the same shaft. It enables user to conduct analysis of hydrodynamic characteristics of each impeller with consideration for interaction of the impellers with each other. Asymmetric position of the mixing hardware results in highly complicated flow pattern. Therefore, simulation is based on a simplified description of this pattern that is still sufficient to enable engineers to design mixing tanks and reactors with off-center shafts and analyze characteristics of processes conducted there.

2. User's Guide and an Application Example for a New Project

Step 1. Open VisiMix OFF-CENTER

Open VisiMix OFF-CENTER tool. The main toolbar shown below is displayed on the screen:



New project quick-start button

Project | New

To start a new project either click the new project quick-start button designated in Fig. 1 OR:

- Select New under the Project tab.
- When the new project dialogue appears, enter a project name in the name field, then click Save.

Step 2. Select Tank Configuration

Entering input data for a new project | Tank

After you enter the name of a new project and click OK, a selection of tank configurations (Fig. 2) is displayed. Each configuration is characterized by its own types of the bottom (flat, conic or elliptical) and the heat transfer hardware (insulation without a jacket, or conventional, half-pipe coil, or embossed/dimpled jacket).

The jacket may comprise one or two sections connected in series or in parallel. Choose a tank by clicking anywhere inside the selected sketch. The tank selected is displayed in the **Current choice** window on the right. Click OK to confirm your choice.

NOTE:

If you do not expect to conduct heat transfer analysis for the current project, select an unjacketed tank from the **Insulated Tanks without Jacket** group rather than a jacketed tank, even if your tank is outfitted with heat transfer hardware.

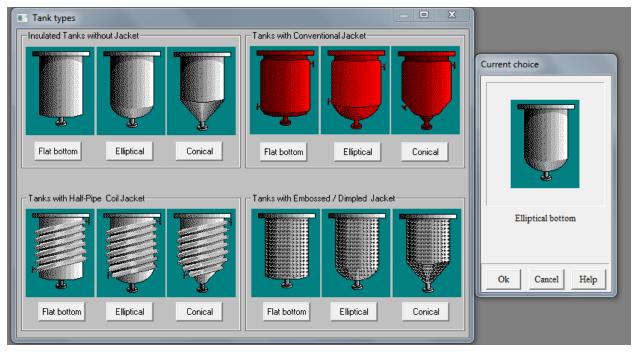


Figure 2. Tank Type Selection

When the sketch of a selected tank is displayed in the **Current choice** box at the right, enter the requested values of tank parameters by completing the table of dimensions.

We continue discussion of this example by selecting **Insulated Tanks without Jacket** with **Elliptical** bottom. Press **OK**. The input window for tank geometry is displayed, see Fig. 3.

C:\Users\visimix\Documents\VISIMIX\TEST\OFF-CENTER EXAMPLE.vxo			
TANK WITH ELLIPTICAL BOTTOM			
Inside diameter	1000 mm 💌		
Total tank height	1357 mm 💌		
Total volume	1000	1357	
Level of media	1102 mm 💌		
Volume of media	800 💌	< ∅1000 >	
OK Cancel	Choose new tank Print	Help	

Figure 3. Tank Geometry Input Window

Enter the three input tank characteristics: Inside diameter, Total tank height (or Total volume) and Level of media (or Volume of media).

NOTE:

The **Total tank height** is a distance from the lowest point of the bottom to the upper edge of the joint between the tank and its head.

Press OK.

Step 3. Select Baffle Configuration

The baffle type selection window is displayed as shown in Fig. 4. In this example, we select the **No Baffle** option.

B	affle types				×	
	FLAT E	AFFLES	TUBULA	R BAFFLES	^	
				d		Current choice
	Flat baffle - 1 (on the wall)	Flat baffle - 2 (at a distance from the wall)	Tubular baffle - 1	Tubular baffle	- 2	
	ł		lo Baffle			No Baffle
	- -					Ok Cancel Help
- III	De Dietrich Reavertail haffle		No Baffle			

Figure 4. Baffle Type Selection

Press OK.

Step 4. Select Impeller Configuration

The Impeller Design window is displayed as shown in Fig. 5.

Enter **Rotational speed** and **Motor Power**. By pressing **Add**, user adds an impeller to the shaft. The impeller type selection window is displayed as shown in Fig. 6.

C:\Users\visimix\Documents\VISIMIX\TEST\OFF-CENTER EX	AMPLE.vxo
IMPRLLERS DESIGN	
Impellers list new impeller Add View/Edit Remove Restore Rotational speed Rpm Motor power hp	
OK Cancel Print	Help

Figure 5. Impeller Design Window

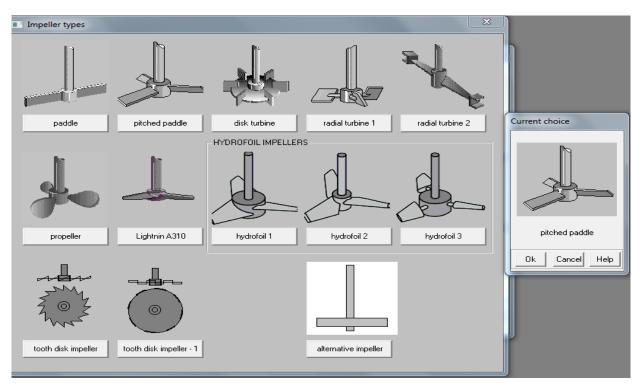


Figure 6. Impeller Type Selection Window

Select an impeller type. In this example, we select **pitched paddle** and press **OK**.

Step 5. Select Impeller Dimensions and Add a Second (Optional) Impeller

The impeller geometry input window is displayed, see Fig. 7. Enter impeller characteristics and press **OK**. The same impeller dimension window with all parameters entered is displayed as shown in Fig. 8.

C:\Users\visimix\Documents\VISIMIX\TEST\OFF-CENTER	EXAMPLE.vxo	23
PITCHED PADDLE		
Tip diameter mm		
Number of blades		
Pitch angle deg		1357
Width of blade mm		
Dist.from shaft end		
OK Cancel Choose new impeller	н	elp

Figure 7. Impeller Geometry Input Window

C:\Users\visimix\Documents\	VISIMIX\TEST\OFF-CENTE	R EXAMPLE.vxc		X
PITCHEI	D PADDLE			
Tip diameter	500 mm	•		
Number of blades	3		i	
Pitch angle	45 deg	•		1357
Width of blade	120 mm	-		Ø 1000
Dist.from shaft end	0 mm	-		≪ ,∞
OK Cancel	Choose new impeller			Help

Figure 8. Selected Impeller with Dimensions

Press **OK**, and a new window shown in Fig. 9 is displayed. "!1" shown in red at the left from the impeller sketch indicates that the first impeller is selected.

C:\Users\visimix\Documents\VISIMIX\TEST\OFF-CENTER EXA	MPLE.vxo	×
IMPRLLERS DESIGN		
	IMPELLER	
Impellers list impeller 1		1357
Rotational speed 100 Rpm 💌 Motor power 10 hp 💌	!1	₹ 2 1000
OKCancelPrint		Help

Figure 9. Impeller Design Window after Data Input

If the reactor has two impellers, press Add button shown in Fig. 9 to add the second impeller. Then, select a type of the second impeller per Fig. 6 and its geometry per Figs. 7 and 8.

After clicking OK in Fig. 8 for the second impeller, a new window with design of a two-level impeller is displayed as shown in Fig. 10. The impeller sketch is changed, and "!2" is displayed now at the left from the second impeller indicating that this impeller is currently selected.

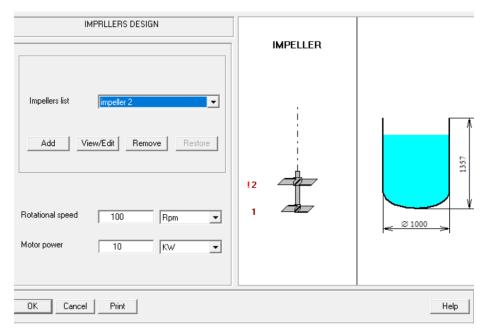


Figure 10. Impeller Design Window after Input of the Second Impeller Data

NOTE:

For the first impeller we entered zero as a distance from the shaft end (see Fig. 8). For the second impeller, this distance should be positive.

It is possible now to select either impeller by clicking it in Fig. 10 and edit parameters of the selected impeller or remove it.

In this example, a configuration with a single impeller is used.

Select impeller 2 and press **Remove**. A configuration with one impeller is displayed as shown in Fig. 11.

C:\Users\visimix\Documents\VISIMIX\TEST\OFF-CENTER EXA	MPLE.vxo	x
	IMPELLER	
Impellers list new impeller Add View/Edit Remove Restore Rotational speed 100 Rpm	1	137
Rotational speed 100 Rpm Motor power 10 hp OK Cancel Print		<u>< ∅ 1000</u> >

Figure 11. Impeller Design Window. One-Impeller Configuration

Click OK. A new window, Shaft Position Options, is displayed as shown in Fig. 12.

Step 6.	Select S	haft Configuration
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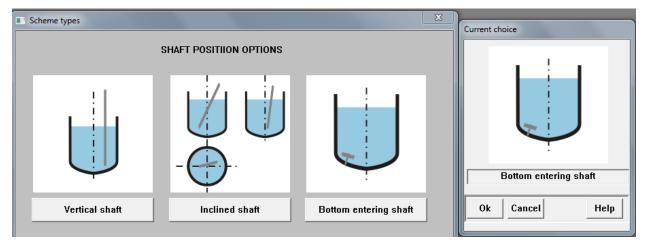


Figure 12. Shaft Position Options

There are three options for defining the shaft configuration (see Fig. 12).

Option 1. A vertical shaft

Select this option and click **OK**. The window for defining of the shaft position is displayed, see Fig.13.

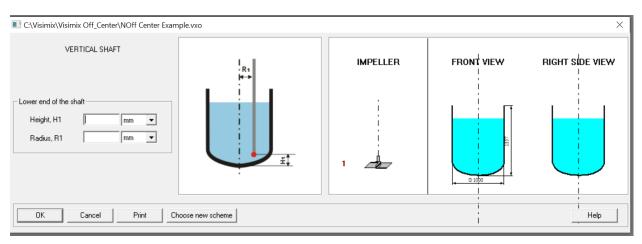


Figure 13. Shaft Position. Vertical Shaft Option before Input

Enter distance from the bottom to the shaft end, H1, and radial distance between the shaft and the tank axis, R1. Press **OK**. A sketch of the tank with the impeller is displayed, see Fig. 14.

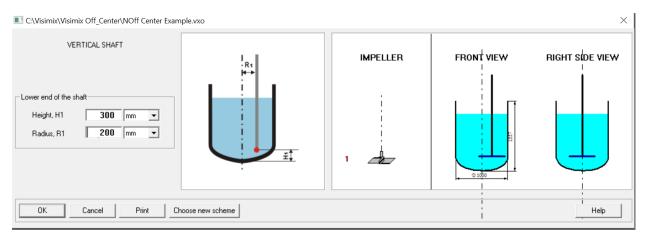


Figure 14. Shaft Position. Vertical Shaft Option after Input

Click **Chose new scheme** button. The Shaft Position Options window is displayed again as shown in Fig. 12.

Option 2. An inclined shaft

Select this option in Fig. 12 and click OK. The window for selecting shaft position is displayed as shown in Fig. 15.

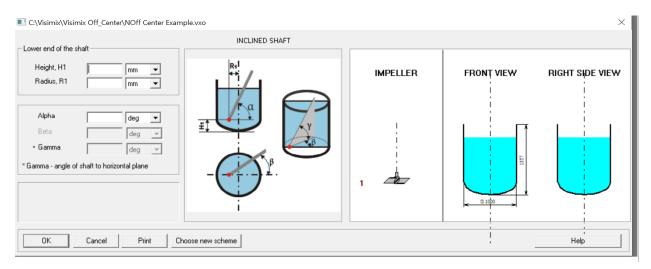


Figure 15. Shaft Position. Inclined Shaft Option before Input

Enter distance from the bottom to the shaft end, H1, radial distance between the shaft and tank axis, R1, and Alpha and Betta (or Gamma) shaft inclination angles as shown in the sketch in Fig. 15. A sketch of the tank with the impeller is displayed, see Fig. 16.

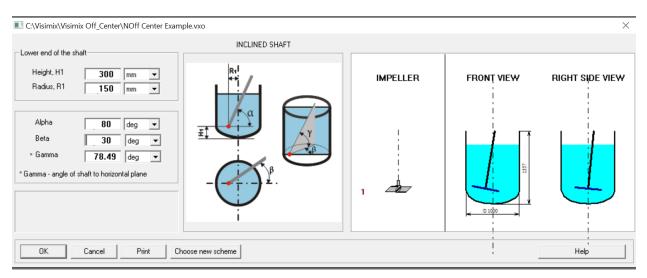


Figure 16. Shaft Position. Inclined Shaft Option after Input

Click the **Chose new scheme** button. The Shaft Position Options window is displayed again as shown in Fig. 12.

In this example, the third option, Bottom-entering shaft, is discussed.

Option 3. Bottom-entering shaft

NOTE:

This option is available for tanks with the elliptical bottom and the one-impeller configuration.

Select this option and click OK. The window for defining shaft position is displayed as shown in Fig.17.

Enter distance of the shaft entering point from the tank axis, R, and shaft length, L. A sketch of the tank with an impeller is displayed as shown in Fig. 17.

C:\Users\visimix\Documents\VISIMIX\TEST\OFF-CENTER EXAMPLE.vxo		X
BOTTOM ENTERING SHAFT	IMPELLER	FRONTVIEW
Radius, R 200 mm	1	
OK Cancel Print Choose new scheme		Help

Figure 17. Shaft Position and Dimensions

Click **OK** and a sketch of the mixing tank is displayed as shown in Fig 18.

[NOff Center Example] - Drawing of apparatus	
IMPELLER	FRONTVIEW
IMPELLER	
	For HELP press F1

Figure 18. Mixing Tank Sketch

Step 7. Simulation of mixing parameters (optional)

Under **Calculate** tab of the main toolbar shown in Fig, 1, select **Hydrodynamics, Turbulence** or **Single-Phase Liquid Mixing** option from the drop-down menu shown in Fig. 19.

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Proj	ect Edit input Calculate Last menu	Last input table	Window	View	Help
	Hydrodynamics	> 	≣ ≥		
	Turbulence	>			
	Single-phase liquid mixing	>			
	Heat Transfer. Continuous flow (CF)	>			
	Heat Transfer. Batch (BH)	>			
	Heat Transfer. Semibatch (SB)	>			
	Heat Transfer. Fixed temperature regime (FT)	>			
	Mechanical calculations of shafts	>			

Figure 19. Drop-down Menu under Calculate Tab

Click **Hydrodynamics** (this is an option that we discuss below as an example) to open the dropdown of turbulence parameters shown in Fig. 20.

Visimix OFF-CENTER(release 2020)

Project Edit input Calculate Last menu Last input table Window View Help

Hydrodynamics	>	CHARACTERISTICS FOR EACH IMPELLER >
Turbulence	>	CHARACTERISTICS FOR ALL IMPELLERS
Single-phase liquid mixing	>	HYDRODYNAMICS. MAIN CHARACTERISTICS
Heat Transfer. Continuous flow (CF)	>	Reynolds number for flow
Heat Transfer. Batch (BH)	>	CHARACTERISTICS OF TANGENTIAL FLOW
Heat Transfer. Semibatch (SB)	>	RADIAL DISTRIBUTION OF TANGENTIAL VELOCITY Average value of tangencial velocity
Heat Transfer. Fixed temperature regime (FT)	>	Maximum value of tangencial velocity
Mechanical calculations of shafts	>	Tangencial velocity near the wall POWER AND FORCES
		Mixing power
		Torque
		Force applied to baffle
		VORTEX PARAMETERS
		Vortex depth
		Increase of media level due to vortex

Figure 20. Drop-down Menu for Hydrodynamics Options

Click a turbulent characteristic of interest. The first input window shown in Fig. 21 is displayed. In this example, enter **Average density** of 1100 kg/m³ and **Newtonian** for **Type of Media**. The

C:\Users\visimix\Docu	ments\VISIMIX\TEST\OFF-CENTER	EXAMPLE.vxo					
DENSITY AND TYPE OF MEDIA							
Average density	1100 kg/cub.m	J					
TYPE OF MEDIA							
Newtonian	C Power-law non-Newtonian	C Carreau non-Newtonian					
τ=μ * γ	$\tau = \tau_{o} + K * \gamma^{n}$ $\mu = \tau_{o} * \gamma^{-1} + K * \gamma^{n-1}$	$\frac{\mu - \mu_{\min}}{\mu_{\max} - \mu_{\min}} = \left[1 + (\lambda * \gamma)^2\right]^{\frac{n-1}{2}}$					
	Cancel Print	Нер					

second input window shown in Fig. 22 is displayed. In this example, enter **Viscosity** of 2 **cP**.

С	C\Users\visimix\Documents\VISIMIX\TEST\OFF-CENTER EXAMPLE.vxo								
	AVERAGE VISCOSITY OF MEDIA								
	Dynamic 2 CP \checkmark Kinemalic 1.819e-06 sq.m/s \checkmark where τ - shear stress, Pa; μ - dynamic viscosity, Pa*sec; γ - shear rate, 1/sec;								
ļ	OK Cancel Print Help								

Figure 21. Density and Type of Media

Figure 22. Average Viscosity of Media

Press **OK** and the output characteristic requested is displayed instantly. Continue selecting output characteristics of interest one-by-one. They are displayed in the output windows as shown below in Figs. 23 through 25 in addition to the optional output characteristics previously requested.

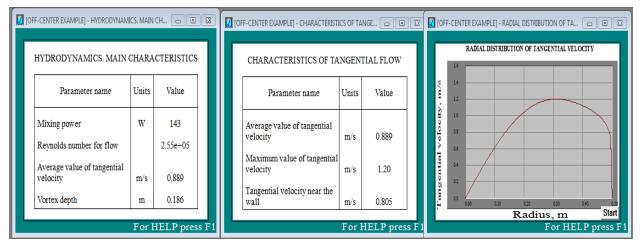


Figure 23. Hydrodynamics. Selected Output Characteristics

LOCAL VALUES OF ENERGY DISSIPATION				TURBULENT SHEAR RATES IN DIFFERENT ZONES			
Parameter name	Units	Value		Parameter name	Units	Value	
Energy dissipation near impeller - max. value	W/kg	7.34		Turbulent shear rate in zone of impeller with maximum dissipation	1/s	2020	
Energy dissipation - average value	W/kg			Turbulent shear rate in zone near baffles	1/s	201	
Energy dissipation in the bulk of volume	W/kg	0.0727				201	
Energy dissipation near baffles FF-CENTER EXAMPLE] - RESIDENCE TIME IN ZONES WITH DIFFE	W/kg	0.0727		Turbulent shear rate in bulk	1/s DIFFERENT		
Energy dissipation near baffles	W/kg				DIFFERENT	ZONES	
Energy dissipation near baffles	W/kg			OFF-CENTER EXAMPLE] - MICROSCALES OF TURBULENCE IN	DIFFERENT	ZONES	
Energy dissipation near baffles FF-CENTER EXAMPLE] - RESIDENCE TIME IN ZONES WITH DIFFE RESIDENCE TIME IN ZONES WITH D	W/kg	NT TURBULENCE		OFF-CENTER EXAMPLE] - MICROSCALES OF TURBULENCE IN MICROSCALES OF TURBULENCE	DIFFERENT IN DIFF Units	ZONES CONES	
Energy dissipation near baffles FF-CENTER EXAMPLE] - RESIDENCE TIME IN ZONES WITH DIFFE RESIDENCE TIME IN ZONES WITH D Parameter name Relative residence time in zone near impeller	W/kg	NT TURBULENCE		OFF-CENTER EXAMPLE] - MICROSCALES OF TURBULENCE IN MICROSCALES OF TURBULENCI Parameter name Microscale of turbulence in zone of impeller	DIFFERENT IN DIFI Units m	ZONES EERENT ZONES Value	

Figure 24. Turbulence. Selected Output Characteristics

	OFF-CENTER EXAMPLE] - Mean period of	circulatio	n 🗖 🖻 🕅		[OFF-CEN	TER EXAMPLE] - Macromixing	g time	
	MEAN PERIOD OF CIRCULATION				MACROMIXING TIME			
	Parameter name	Units	Value			Parameter name	Units	Value
	Mean period of circulation	s	71.4		Macro	omixing time	s	28.3
For HELP press F1								For WELP press Fi
CHARACTERISTIC TIME OF MICROMIXING						ROMIXING		
	Parameter name			•	Units	Value		
		Characteristic time of micromixing			s	9.09		
					For HELP press F1			

Figure 25. Single-Phase Liquid Mixing. Selected Output Characteristics

Step 9. Simulation of heat transfer parameters (optional)

VisiMix OFF-CENTER tool also supports simulation of heat transfer characteristics for tanks operated under different heating or cooling conditions.

It can utilize the entire scope of heat transfer simulations supported by VisiMix Turbulent for tanks with liquid- or gas-fed heating/cooling jackets of the following configurations:

- Simple or sectional jackets;
- Jackets with heat transfer enhancing hardware;
- Half-pipe coil jackets; or
- Embossed/ dimpled jackets.

The tool can be used for simulation of various cooling/heating modes of tank operation, such as:

- Steady state or batch dynamics;
- Semi-batch or continuous flow heat transfer operations;
- Temperature-dependent chemical reactions with heat release and/or consumption.

In addition, the tool provides access to the heat-transfer oriented VisiMix databases of tank materials, fouling characteristics, and physical properties of various liquids and heating/cooling fluids.

Step 10. Mechanical analysis of a shaft (optional)

Options for calculation of torsion shear and shaft vibration characteristics are available.