

A New Tool
for Simulation of Tanks and Columns
with Bubble Mixing Based on VisiMix Turbulent
Software

User's Guide and Application Example

Step 1

The tool start window is shown in Fig. 1.

Prepare ViSiMix input for Heat Transfer calculations in Columns with Air Mixing

INITIAL DATA

INPUT DATA FOR VISIMIX TURBULENT PROGRAM

Jacketed Tank with Flat Bottom

Inside diameter, m

Total tank hight, m

Level of media, m

FLAT BAFFLE-1

Length, m

Number

Angle to radius (fi)

Width, m

Dist. from bottom

ESTIMATED FLOW CHARACTERISTICS

Circulation Flow, cub.m/s

Near Wall Velocity, m/s

Impeller Pitch Paddle. Multistage

Dist. between stages, m

Tip diameter(D), m

Pitch angle, deg

Impellers number

Number of blades

Dist. from bottom, m

Motor power, kW

Width of blade, m

Rotation speed, rpm

Total Column Hight (H) , m

Column Diameter (D) , m

Liquid Depth (H1) , m

Gas Flow Rate , cub.m/s

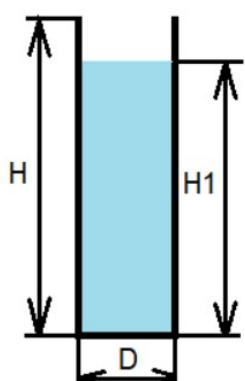
Print Calculate Exit

Figure 1

Enter column basic geometry characteristics and feed flow rate of bubbling gas into the left-hand side box and click “**Calculate**” button. Design characteristics of the “equivalent” reactor configured as a bubble mixing tank or column are calculated and displayed in the right-hand side box as shown in Fig. 2.

Prepare ViSiMix input for Heat Transfer calculations in Columns with Air Mixing

INITIAL DATA



Total Column Hight (H) , m

Column Diameter (D) , m

Liquid Depth (H1) , m

Gas Flow Rate , cub.m/s

INPUT DATA FOR VISIMIX TURBULENT PROGRAM

Jacketed Tank with Flat Bottom

Inside diameter, m

Total tank hight, m

Level of media, m

Impeller Pitch Paddle. Multistage

Dist. between stages, m

Tip diameter(D), m

Pitch angle, deg

Impellers number

Number of blades

Dist. from bottom, m

Motor power, kW

Width of blade, m

Rotation speed, rpm

FLAT BAFFLE-1

Length, m

Number

Angle to radius (fi)

Width, m

Dist. from bottom

ESTIMATED FLOW CHARACTERISTICS

Circulation Flow, cub.m/s

Near Wall Velocity, m/s

Figure 2

Enter these characteristics as input data for VisiMix Turbulent program. Internal circulation flow rate and near-wall velocity in your bubble column are estimated and displayed in the bottom right-hand side box.

3

Step 2

Open VisiMix Turbulent program and start a new project using VisiMix menu.

The tank type selection window is displayed as shown in Fig. 3. Select flat-bottom tank with your type of jacket.

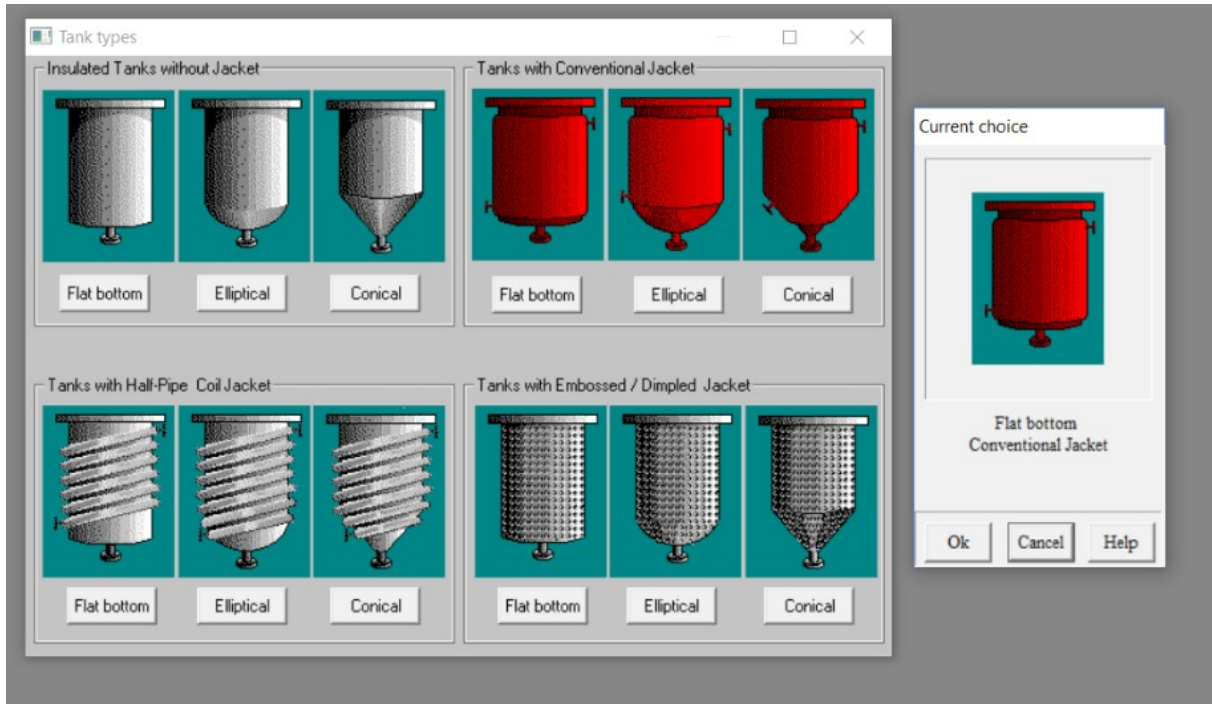


Figure 3. Tank Type Selection

Press OK. The input window for tank geometry is displayed, see Fig. 4. Enter the three input tank characteristics (inside diameter, total tank height and level of media) shown in Fig. 2. The total tank volume and volume of liquid in the tank are calculated and displayed also.

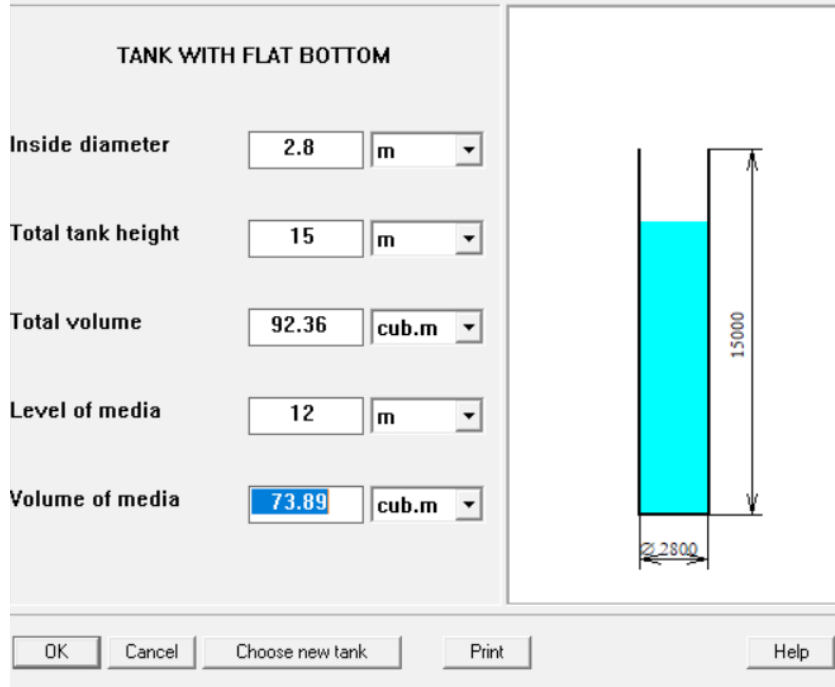


Figure 4. Tank Geometry Input Window

Press OK. The baffle type selection window is displayed as shown in Fig. 5. Select “Flat baffle - 1.”

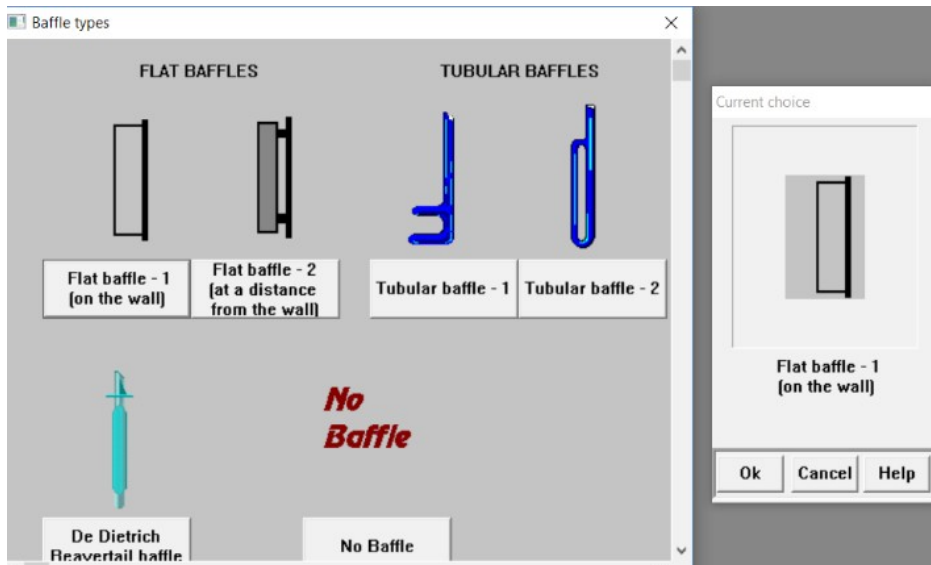


Figure 5. Baffle Type Selection

Press OK. The window for entering baffle geometry is displayed as shown in Fig. 6. Enter baffle details shown in Fig. 2.

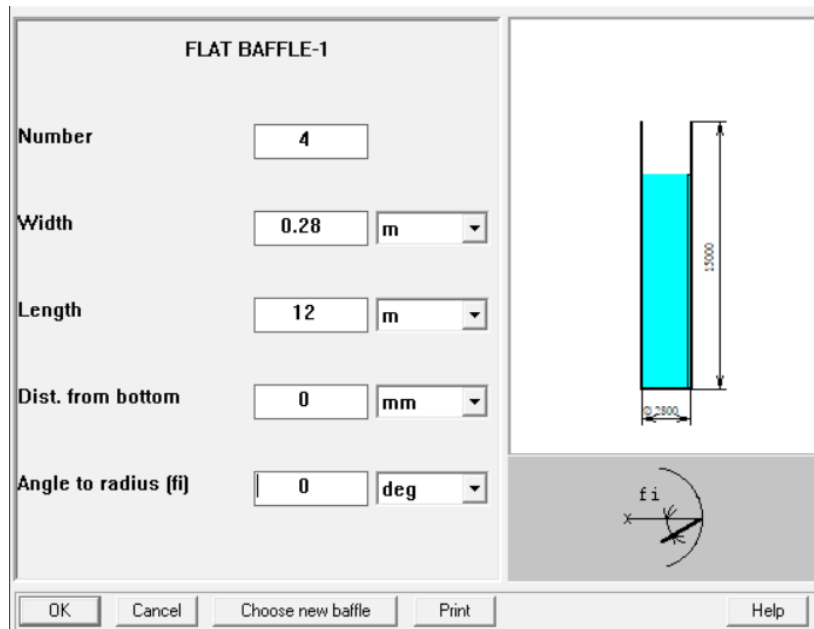


Figure 6. Baffle Geometry Input Window

Press OK. Impeller selection window is displayed as shown in Fig. 7. Select a pitch paddle multistage impeller.

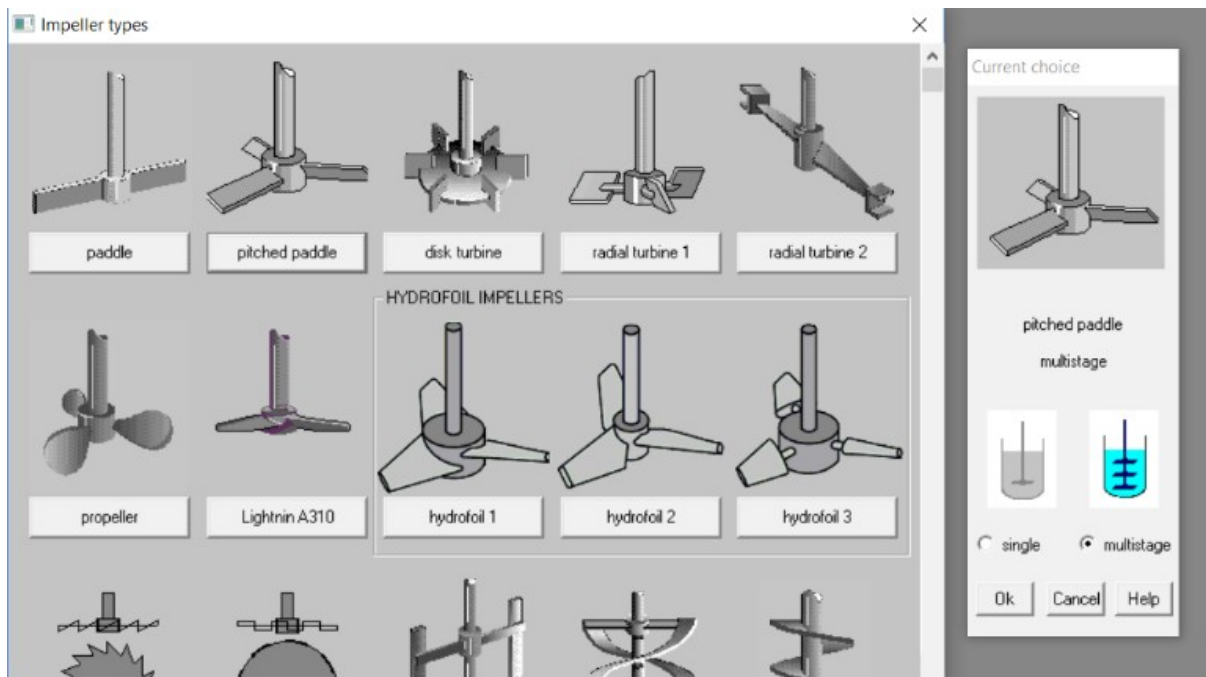


Figure 7. Impeller Type Selection Window

Press OK. The impeller geometry input window is displayed, see Fig. 8.

Enter impeller characteristics shown in Fig. 2.

PITCHED PADDLE. MULTISTAGE

Tip diameter (D)	1.4	m
Impellers number	3	
Dist. between stages	2.4	m
Number of blades	3	
Pitch angle	30	deg
Width of blade	0.14	m
Dist. from bottom	2.4	m
Rotational speed	111.2	Rpm
Motor power	102.8	KW

OK Cancel Choose new impeller Print Help

Figure 8. Impeller Geometry Input Window

Press OK. The window for jacket characteristics is displayed, see Fig. 9. Enter characteristics of your reactor jacket.

TANK HEAT TRANSFER GENERAL DATA Help

Jacket covers bottom

Number of jacket sections

Lower section

Distance from bottom m

Height, Hlow m

Heat transfer area for lower section sq.m

If unknown, enter 0 *

Upper section

Distance between two sections mm

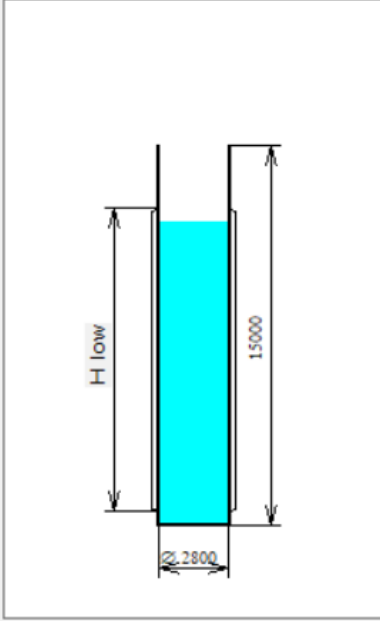
Height, Hup mm

Heat transfer area for upper section sq.m

If unknown, enter 0 *

Connection of jackets

* In this case heat transfer area will be evaluated by VisiMix



OK Cancel Print

Figure 9. Jacket General Characteristics

Press OK. The input windows for characteristics of liquid inside the bubble column are displayed consecutively, see Figs. 10 and 11. Enter characteristics of your liquid.

DENSITY AND TYPE OF MEDIA

Average density kg/cub.m

TYPE OF MEDIA

Newtonian

Power-law non-Newtonian

Carreau non-Newtonian

$\tau = \mu * \gamma$

$\tau = \tau_0 + K * \gamma^n$
 $\mu = \tau_0 * \gamma^{-1} + K * \gamma^{n-1}$

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

OK Cancel Print Help

Figure 10. Liquid Density and Rheological Characteristics

AVERAGE VISCOSITY OF MEDIA

Dynamic viscosity: 3 cP

Kinematic viscosity: 2.727 cSt

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

where τ - shear stress, Pa;
 μ - dynamic viscosity, Pa*sec;
 γ - shear rate, 1/sec;

OK Cancel Print Help

Figure 11. Liquid Viscosity

Press OK. A sketch of the equivalent mixing tank is displayed, see Fig. 12.

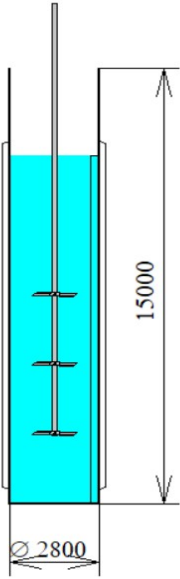


Figure 12. Tank Sketch

From “**Calculate**” menu at VisiMix Turbulent main window, select a characteristic of heat transfer you want to calculate for your bubble column, see Fig. 13.

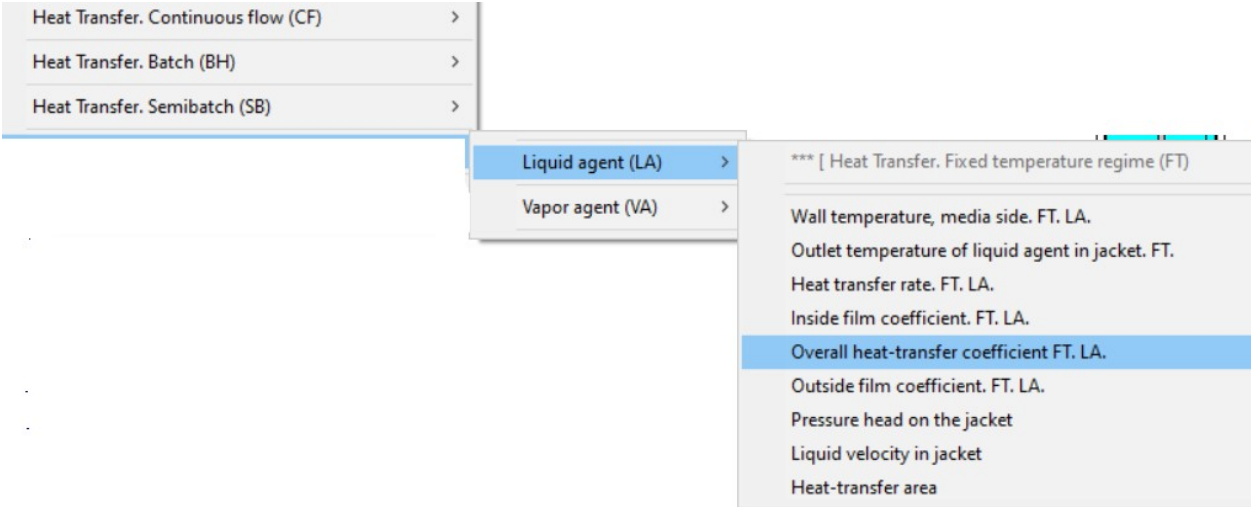


Figure 13. VisiMix Heat Transfer Section Menu

We consider overall heat-transfer coefficient calculation for liquid agent below as an example.

After selection, the tank shell characteristic input window (Fig. 14) is displayed.

Enter characteristics of your column wall.

TANK SHELL CHARACTERISTICS

Material: Hastelloy B-2

Wall thickness: 6 mm

Thermal resistance of fouling: 0 (m²K)/W

Tank mass (without drive)
If unknown, enter 0 *: 0 kg

Buttons: OK, Cancel, Print, Help

* In this case tank mass will be evaluated by VisiMix

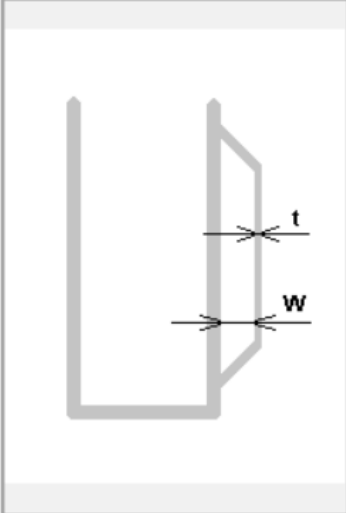
Figure 14. Tank Wall Characteristics

Press OK. The input window for specific characteristics of jacket is displayed as shown in Fig. 15.

Enter characteristics of your Jacket.

CONVENTIONAL JACKET. SPECIFIC CHARACTERISTICS.

Heat-transfer enhancing device	absent	Lower section	Width, W	30	mm
Diameter of nozzle			Wall thickness, t	4	mm
			Number of inlets		
			Number of nozzles		
Spiral channel height		Upper section	Width, W		mm
Leakage, %			Wall thickness, t		mm
			Number of inlets		
			Number of nozzles		



OK Cancel Print Help

Figure 15. Jacket Characteristics

Press OK. The window for entering your process temperature limits is displayed as shown in Fig. 16. Enter characteristics of your process.

HEAT TRANSFER. CHEMICAL REACTION DATA AND TEMPERATURE LIMITS

Will you enter reaction kinetics?	NO	Reaction velocity constant K is described by Arrhenius equation :
Arrhenius constant		$K = A \exp(-E / RT)$,
Energy of activation		where
Lower limit of temperature	10	A is Arrhenius constant ,
Upper limit of temperature	40	E is energy of activation ,
Heat effect of reaction		$R = 8.314 \text{ J / (mol}^\circ\text{K)} =$
		$= 1.986 \text{ Btu / (lb}^\circ\text{mol)} / ^\circ\text{F}$
		is universal gas constant ,
		T is absolute temperature .

OK Cancel Print Help

Figure 16. Process Characteristics

Press OK. The input window for entering characteristics of heating or cooling liquid supplied to the jacket is displayed as shown in Fig. 17.

Enter characteristics and flow rate of your heating or cooling liquid.

HEATING / COOLING LIQUID AGENT IN JACKET.

Heating/cooling agent: Water

Inlet temperature: 20 °C

Flow rate of heat transfer agent in lower jacket: 20 cub.m/h

Flow rate of heat transfer agent in upper jacket: cub.m/h

OK Cancel Print Help

Operating temperature range: 5 - 204°C [41 - 400°F]
Properties of the agent
density...1000 kg/m³ [62.4 lbm/ft³]
specific heat...4190 J/(kg*K) [1.01 Btu/(lbm*°F)]
thermal conductivity...0.603 W/m*K [0.348 (Btu*ft)/(h*ft²*°F)]
dynamic viscosity at 100°C(212°F)...0.000284 Pa*sec [0.284 cP]

Figure 17. Heating or Cooling Liquid Characteristics

Press OK. As the fixed temperature mode was selected for simulation as shown in Fig. 13, the input window for entering the process temperature is displayed as shown in Fig. 18.

Enter your process temperature.

HEAT TRANSFER
MEDIA TEMPERATURE
FOR FIXED TEMPERATURE REGIME

Temperature °C

OK Cancel Print Help

Figure 18. Process Temperature

Press OK. Finally, the input window for thermal characteristics of the liquid in your column is displayed as shown in Fig. 19.

HEAT TRANSFER PROPERTIES OF THE MEDIA

Media

	PARAMETER		TEMPERATURE	
Average density	<input type="text" value="1100"/>	<input type="text" value="kg/cub.m"/>	<input type="text" value="20"/>	<input type="text" value="°C"/>
Dynamic viscosity	<input type="text" value="3"/>	<input type="text" value="cP"/>	<input type="text" value="20"/>	<input type="text" value="°C"/>
Specific heat	<input type="text" value="4200"/>	<input type="text" value="J/(kg*K)"/>	<input type="text" value="20"/>	<input type="text" value="°C"/>
Heat conductivity	<input type="text" value="0.6"/>	<input type="text" value="W/(m*K)"/>	<input type="text" value="20"/>	<input type="text" value="°C"/>

OK Cancel Print Help

Fig. 19. Thermal Properties of the Mixing Liquid

Press OK.

Now all necessary input data are entered, and the heat transfer characteristic selected in Fig. 13 are calculated as shown in Fig. 20.

OVERALL HEAT-TRANSFER COEFFICIENT FT. LA.

Parameter name	Units	Value
Overall heat-transfer coefficient, lower jacket. FT.	W/(sq.m*K)	167
Overall heat-transfer coefficient, upper jacket. FT	W/(sq.m*K)	0

For HELP press F1

Figure 20. Output Window - Heat Transfer Characteristic Selected

You can select more parameters from the VisiMix calculation menu and obtain their values as shown in Fig. 21.

<p>[Barbotage] - Heat-transfer area</p> <p style="text-align: center;">HEAT-TRANSFER AREA</p> <table border="1"> <thead> <tr> <th>Parameter name</th> <th>Units</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>Heat transfer area. Lower section</td> <td>sq.m</td> <td>106</td> </tr> <tr> <td>Heat transfer area. Upper section</td> <td>sq.m</td> <td>0</td> </tr> <tr> <td>Active heat transfer area. Lower section</td> <td>sq.m</td> <td>101</td> </tr> </tbody> </table> <p style="text-align: right;">For HELP press F1</p>	Parameter name	Units	Value	Heat transfer area. Lower section	sq.m	106	Heat transfer area. Upper section	sq.m	0	Active heat transfer area. Lower section	sq.m	101	<p>[Barbotage] - Pressure head on the jacket</p> <p style="text-align: center;">PRESSURE HEAD ON THE JACKET</p> <table border="1"> <thead> <tr> <th>Parameter name</th> <th>Units</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>Pressure head, lower jacket. FT. LA</td> <td>N/sq.m</td> <td>1.18e+05</td> </tr> <tr> <td>Pressure head, upper jacket. FT. LA</td> <td>N/sq.m</td> <td>0</td> </tr> </tbody> </table> <p style="text-align: right;">For HELP press F1</p>	Parameter name	Units	Value	Pressure head, lower jacket. FT. LA	N/sq.m	1.18e+05	Pressure head, upper jacket. FT. LA	N/sq.m	0
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Pressure head, upper jacket. FT. LA	N/sq.m	0																				
<p>[Barbotage] - Liquid velocity in jacket</p> <p style="text-align: center;">LIQUID VELOCITY IN JACKET</p> <table border="1"> <thead> <tr> <th>Parameter name</th> <th>Units</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>Liquid velocity, lower jacket</td> <td>m/s</td> <td>0.0211</td> </tr> <tr> <td>Liquid velocity, upper jacket</td> <td>m/s</td> <td>0</td> </tr> </tbody> </table> <p style="text-align: right;">For HELP press F1</p>	Parameter name	Units	Value	Liquid velocity, lower jacket	m/s	0.0211	Liquid velocity, upper jacket	m/s	0	<p>[Barbotage] - Outside film coefficient. FT. LA.</p> <p style="text-align: center;">OUTSIDE FILM COEFFICIENT. FT. LA.</p> <table border="1"> <thead> <tr> <th>Parameter name</th> <th>Units</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>Outside film coefficient, lower jacket. FT.</td> <td>W/(sq.m*K)</td> <td>192</td> </tr> <tr> <td>Outside film coefficient, upper jacket. FT.</td> <td>W/(sq.m*K)</td> <td>0</td> </tr> </tbody> </table> <p style="text-align: right;">For HELP press F1</p>	Parameter name	Units	Value	Outside film coefficient, lower jacket. FT.	W/(sq.m*K)	192	Outside film coefficient, upper jacket. FT.	W/(sq.m*K)	0			
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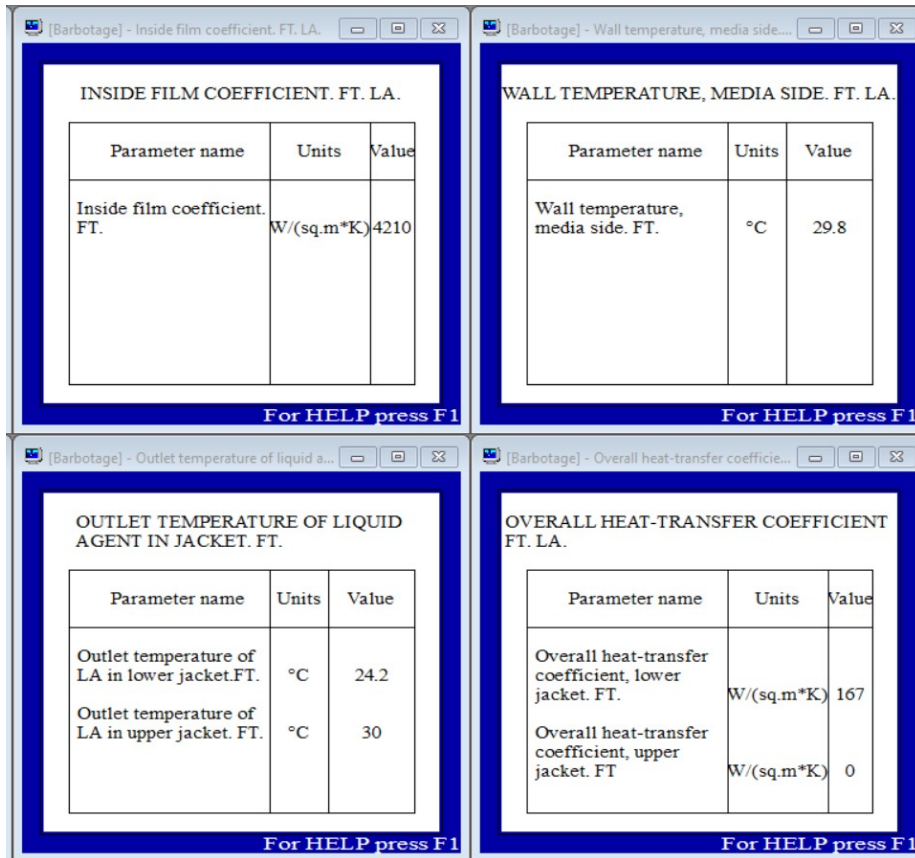


Figure 21. Output Window Examples

Note. Using the Gas Liquid section of VisiMix, one can obtain a value of mass transfer rate also.