VisiMix Turbulent Scaling Up/Down User's Guide and Application Example

1. Introduction

Use this option to perform for *scaling up / down* procedure using modelling possibilities of the VisiMix Turbulent program.

Purpose of operation: transfer of a technological process from a prototype mixing tank to a geometrically similar target mixing tank of different size.

Initial data for scaling up / down:

- VisiMix project corresponding to the basic mixing tank (laboratory, pilot, or production) serving as a prototype
- Size of the target (scaled) mixing tank
- Scaling parameter one of mixing or process-related parameters, defined by VisiMix, which is selected by user as a key scaling parameter that value must be the same in the prototype and target tanks

Key process characteristic in this program is understood as an important parameter of the process that is dependent on mixing and can be changed by change of mixing intensity (as, for example, size of droplets or suspending of solid particles). For a short description of connection between some mixing and process parameters – press Explanations button in the lower right part of screen.

2. User's Guide and Application Example

Open VisiMix Turbulent Scaling Up/Down program and the main VisiMix menu appears on the screen. It has the following structure:

Project	Edit input	Calculate	Supplements	Last menu	Last input table	Win	dow View He	lp
				II F	Scale up/down		3D simulation	Projects comparison

Step 1. Start VisiMix Scaling Procedure

Open the project corresponding to the prototype-mixing tank. Drawing of the tank and opened window of initial data explorer are shown on the fig.1.

<pre> Control of the control of</pre>	Visimix Turbulent (2020-s07) Project Edit input Calculate Supplements Last menu Last input	table Window View Help	- 0 ×
Prototype_Labij-Lated initial das Prototype_Labij-Labig-Drawing of apparatus Impeller - PITCHED PADDLE Impeller - PITCHED PITCHES PITCHED Impeller - PITCHED PITCHES PITCHED Impeller - PITCHED PITCHES Impeller Impeller - PITCHED PITCHE <td>🗅 🗃 🔲 🎒 📕 📕 🥼 🎉 🔟 🐚 Scale up/dx</td> <td>wm 30 simulation Projects comparison</td> <td></td>	🗅 🗃 🔲 🎒 📕 📕 🥼 🎉 🔟 🐚 Scale up/dx	wm 30 simulation Projects comparison	
Tank Tank Tipelier - PITCHED PADDLE Tipelier - PITCHED PADDLE Tipelier - PITCHED PADDLE The Angle - State - Pitch angle - State -	Prototype_Lab1] - List of initial data	Prototype_Lab1] - Drawing of apparatus	
C:\Visimix\VisiHix Turbulent_Test\Prototype_Lab1.VSM	Tank Tank Tank Tinpeller - PITCHED PADDLE Tinpeller - DITCHED PADDLE Tinpeller - Tinpeller Tinpeller - Dist. from bottom Tinpeller - FLAT BAFFLE-1 Vidth Tength Dist. from bottom Vidth Vidth Vidth Density and type of media Porperties of media Pomanic viscosity Visimix\VisiMix Turbulent_Test\Prototype_Lab1.VS	70 mn 3 45 45 deg 12 mn 40 mn 20 W down 4 12 mn 20 W down 4 12 mn 200 mn 0 deg 1000 kg/cub.m Newtonian 2 2 cP 2e=06 sq.m/s Edit For HELP press F1	000 HELP press F 1

Figure 1. Prototype project. Tank drawing and initial data explorer.

Click **Scale Up/Down** under **Project** tab or the **Scale Up/Down** quick start button in the Command line on the upper part of VisiMix screen.

The SCALE UP/DOWN dialog is displayed, see fig.2.

Prototype_Lab1] - List of in	itial data	O O	
 □ Tank □ Tank geor □ Inside □ Total □ ↓ Ivel □ ↓ Ip diam □ ↓ Fich an <	Source project : C/Visimik/VisiMix Turbulent, Tes SCALE UP / DOWN Tank size Tank volume, cub.m Tank volume, cub.m Rotation speed, rpm Main mixing parameters Impeller tip velocity, m/s 11. Average energy dissipation rate, W/kg Movinum local energy dissipation rate, W/kg Muing time, s 3.3 Characteristic time of micromixing, s Impeller Reynolds number	APrototype_Lab1.VSM - × a Target Scale up/down similarity variables (key mixing parameters to be reproduced) a · Impeller tip velocity c Average energy dissipation rate c Maximum shear rate c Maximum shear rate c · d ·	
	For H	Edit IELP press F1 For HE	LP press 1

Figure 2. SCALE UP/DOWN dialog.

Main dimensions and values of main mixing parameters of prototype are shown in the PROTOTYPE column.

Enter diameter or volume of the *Target* tank.

STEP 2. Defining the scaling parameter - key mixing parameter that must be the same in the prototype and target.

The scaling parameter - key parameter that must be the same in the prototype and target – must be selected from the list of *key mixing parameters or from the list of key process characteristics**. List of accessible key mixing parameters to be reproduced is presented in the right section of the window. Key process characteristic is chosen from the selection box below.

There is a strict connection between each process characteristic and one of the key mixing parameters, so the program automatically defines the mixing parameter corresponding to the selected key mixing characteristic. To learn more about this connection, click button Explanations.

Click button *Estimate* or radio button corresponding selected key mixing parameter.

After the key scaling parameter is selected, rotation speed of impeller and expected values of main mixing parameters of the target tank are defined by VisiMix and arrive in the right column of the left section of the window, see fig.3.

rototype_Lab1] - List of in	itial data			🗖 🔲 🔀 📕 [Prototype_Lab1] - Drawing of apparatus	
 Tank Tank geor Inside Total Total Level Tip diam Number of the second second	Source project : CAVIsimik/VisiMix Tur- SCALE UP / DOWN Tank size Tank volume, cub.m Tank diameter, mm Rotation speed, rpm Main mixing parameters Impeller tip velocity, m/s Average energy dissipation rate. W/kg Maximum local energy dissipation rate, W/kg Turbulent shear rate near the impeller blades. 1/s Mixing time, s Characteristic time of micromixing, s Impeller Reynolds number	Prototype 0.00402 160 300 Visimix results 1.10 0.0922 9.75 22200 3.38 5.23 12300	totoppe_Lab1 Target 26.5 3000 42.5 Estimate 2.90 0.0920 9.70 2200 24 5.20 6.1e+05	NSM Implementation Scale up/down similarity variables (key mixing parameters to be reproduced) Implementation Implementation Implementation Average energy dissipation rate Implementation Maximum local energy dissipation rate Implementation Maximum shear rate Implementation Micro-mixing time Implementation speed, rpm Key process characteristic to be reproduced Implementation Motion Implementation Maximum Implementation Maximum local Implementation Micro-mixing time Implementation Implementation Implementation Maximum local Implementation Maximum local energy dissipation rate Implementation Implementation Implementation Implementation Implementation Maximum local Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation Implementation	
	F	or HI	ELP 1	Edit press F1 For HELF	press

Figure 3. Selection of key mixing parameter to be reproduced and estimated values of target project main mixing parameters

Key process characteristic to be reproduced may be selected from the selection box below. The program automatically adjusting selection of key mixing parameter by selection of the key mixing parameter governing selected process characteristic, see fig.4.



Figure 4. Selection of key process characteristic and governing mixing parameter to be

reproduced.

User can define rotational speed of impeller in the target tank independently, as alternative to selection of scaling parameters. To do it, click option radio button corresponding to the line *Enter target rotation speed, rpm* and enter the rotation speed value, see fig. 5.

Press button *Estimate.* Expected values of main mixing parameters of the target tank arrive in the right column of the left section of the window.



Figure 5. Entering rotation speed value.

Step 3. Creation of the target (scaled) VisiMix project

Click OK. VisiMix creates a project of the target mixing tank. Enter name for the created project and *Save it*, see fig. 6.

🛃 Enter a VSP name		\times
Save in: 🦳 VisiMix Turbulent_Test	▼ ← 🛍 📸 ▼	
Name	Date modified	^
Documentation	6/15/2020 11:40 AM	
TEMP	6/7/2020 2:16 PM	
DEM1.VSM	3/22/2007 2:16 PM	
DEM11#VSP#_2020-5-19_17-53.vsm	5/19/2020 6:00 PM	
DEM11#VSP#_2020-5-20_9-56.vsm	5/20/2020 10:04 AM	~
<	>	
File name: Target 12020-6-15 vsm	Save	
Save as type: VisiMix Project Files (*.vsm)	Cancel	

Figure 6. Creation of the target project.

VisiMix activates the target project and drawing of the target mixing tank appears on the ViSiMix screen, see fig. 7.

Visimix Turbulent (2020-s07) Project Edit input Calculate Supplements Last menu Last input tal	ole Window View Help	- 0 X
	ITarget12020-6-151 - Drawing of apparatus	Prototype Lab11 - Drawing of apparatus
 Tank geometry Tank geometry Tank geometry Total tank height Total volume Level of media Volume of nedia Volume of nedia Tip diameter (D) Number of blades Pitch angle Vidth of blade Dist. from bottom Rotational speed Motor power Pumping direction Baffles - FIAT BAFFLE-1 Number Vidth Dist. from bottom Average properties of media Properties & regime Average density Type of media Type of media C:\Visinix\VisiHix Turbulent_Test\Target12828-6-15.ve 	For HELP press F1	E E E E
U 2 H 🗖 🗹 🚺 🚾 🎦 🚫	🖳 📰 🛄 👘 🚰 🚺 🖌 🚱	💽 🚆 🎁 💞 ^ 🌾 🖼 🖓 ENG 6/15/2020 🔽

Figure 7. Both prototype and target projects are opened in Visimix.

The created project corresponds to the following conditions:

- Exact geometrical similarity of the tank bodies, impellers and all internal design elements of the target and prototype tanks.
- Complete identity of physical properties of media and process and regime parameters of the target and prototype projects.
- Identical or close values of the selected key scaling parameters of the target and prototype.

3. EXAMPLE

This example is a Liquid-solid process in which experience has shown that the best results are obtained in the following prototype when complete solid suspension of the solids is expected.

TANK WITH ELLIPTICAL BOTTOM	PITCHED PADDLE			
	Tip diameter (D) 150 mm 💌			
	Number of blades 4			
Total tank height 308 mm 💌	Pitch angle 45 deg 💌			
Total volume 20	Width of blade 20 mm 💌			
	Dist. from bottom 38 mm 💌			
Level of media 237.2 mm 💌	Rotational speed 200 Rpm 💌			
Volume of media	Motor power 1 KW 💌			
	Pumping direction down 💌			

Input data for the prototype



Purpose of operation: transfer of a technological process from a 20 L prototype mixing tank to a geometrically similar 2000 mixing tank.

Following the above mentioned indications:

Open the project corresponding to the prototype-mixing tank.- Click Scale Up/Down

Source project : C:\VisiMix\VisiMix Tu	irbulent_Test\	Liqsolid exam	nple.vsm	
SCALE UP/DOWN	Drotot inc	Toract		
Tank size			Scale up/down similarity variables (key mixing parameters to be reproduced)	
Tank volume, cub.m	0.0200		Impeller tip velocity	
Tank diameter, mm	300		O Average energy dissipation rate	
Botation speed rom	200		O Maximum local energy dissipation rate	
	Visimix	Estimate	C Maximum shear rate	
Main mixing parameters	results		O Mixing time	
Impeller tip velocity, m/s	1.57		 Micro-mixing time 	
Average energy dissipation rate, W/kg	0.186		C Impeller Reynolds number	
Maximum local energy dissipation rate, W/kg	12.0		C Enter target rotation speed, rpm	
Turbulent shear rate near the impeller blades, 1/s	2580		Key process characteristic to be reproduced	
Mixing time, s	7.07		·	
Characteristic time of micromixing, s	5.70			
Impeller Reynolds number	41300		OK Cancel Help Explanations 🔽	

In Target column:

Tank Volume = 2 m3 (2000 L)

Key process characteristic to be reproduced: Pick-up of particles liquid-solid mixing and following information appear:

SCALE UP/DOWN				
Tank size Tank volume, cub.m Tank diameter, mm	- Prototype 0.0200 300	Target 2	Scale up/down similarity variables (key mixing parameters to be reproduced) C Impeller tip velocity • Average energy dissipation rate	Random upward turbulent fluctuations of sufficiently high intensity pick-up solids by offsetting their gravitational settling to the tank bottom and preventing accumulation of solids there
Rotation speed, rpm	200 Visimix	72.0	C Maximum local energy dissipation rate C Maximum shear rate	To scale solids pick-up, the program – maintains geometric similarity of
Main mixing parameters	results	2.60	C Mixing time C Micro-mixing time	tank hardware dimensions and the same relevant physical properties and process characteristics, selects
Average energy dissipation rate, W/kg	0.186	0.190	C Impeller Reynolds number	and eselects impeller rom to maintain
Maximum local energy dissipation rate, W/kg	12.0	12	C Enter target rotation speed, rpm	the same intensity of turbulent fluctuations by keeping either
Turbulent shear rate near the impeller blades, 1/s	2580	2600	Rey process characteristic to be reproduced Pick-up of particles. Liquid-solid mixing	* the same mean energy dissipation rate for a BAFFLED TANK,
Mixing time, s	7.07	20	,	the same impeller tip velocity for
Characteristic time of micromixing, s	5.70	5.70		
Impeller Reynolds number	41 300	3.2e+05	OK Cancel Help Explanations 🔽	

In target column estimated values of target project main mixing parameters, in **bold** key mixing parameter related with Key process characteristic selected. On the right, an explanation about selected key process characteristic.

Click OK. VisiMix creates a project of the target-mixing tank. Enter name for the created project and Save it as usual in VisiMix Turbulent. VisiMix activates the target project and the reactor 2000 L is as follow:

— r

TANK WITH E	LLIPTICAL BOTTOM	PITCH	ED PADDLE	FLA	FLAT BAFFLE-2		
Inside diameter	1392 mm 💌	Tip diameter (D)	696.2 mm 💌	Number	4		
Total tank height	1430 mm v	Number of blades Pitch angle	4	Width	92.83 mm 💌		
		Width of blade	92.83 mm •	Length	965.1 mm 💌		
l otal volume	2000	Dist. from bottom	176.4 mm 💌	Dist. from bottom	232.1 mm 💌		
Level of media	1101 mm 💌	Rotational speed	72 Rpm •	Dist. from wall	46.41 mm 🔻		
	-	Pumping direction	down •	Angle to radius (fi)	0 deg 🔻		
1		Same properties	as in prototype				
	1430						
Ø 13	92						

Properties & regime		
🗄 🦲 Average properties of media		
🖻 🧰 Density and type of media		
🛶 Average density	1100	kg/cub.m
> Type of media	Newton	ian
🗄 💼 Parameters of rheology		
> Dynamic viscosity	2	cP
🛶 Kinematic viscosity	1.82e-	06 sq.m∕s
🗄 🗖 Solid and liquid phases		
> Density of liquid phase	1100	kg/cub.m
Dyn. viscosity of cont.phase	2	cP
Concentration of solid phase	200	kg/cub.m
> Density of solid phase	2200	kg/cub.m
🛶 Average particle size	100	micron
	200	micron
-> Position of outlet-height	0	mm

Comparison of the result desired

