

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.

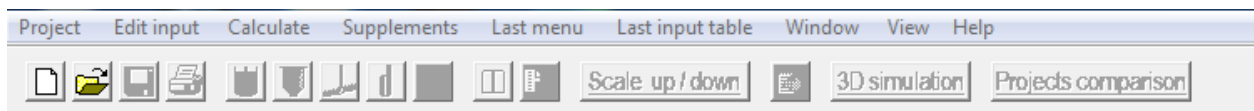
Initial data for scaling up / down:

- 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:



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.

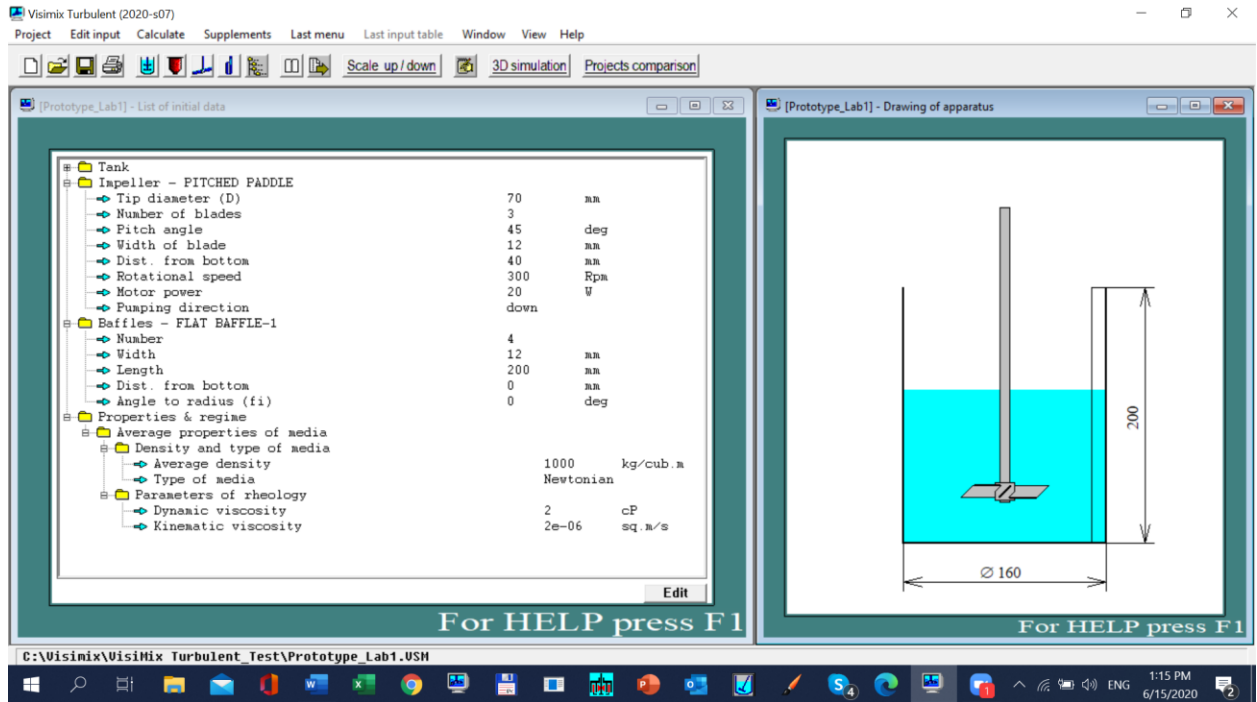


Figure 1. Prototype project. Tank drawing and initial data explorer.

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.

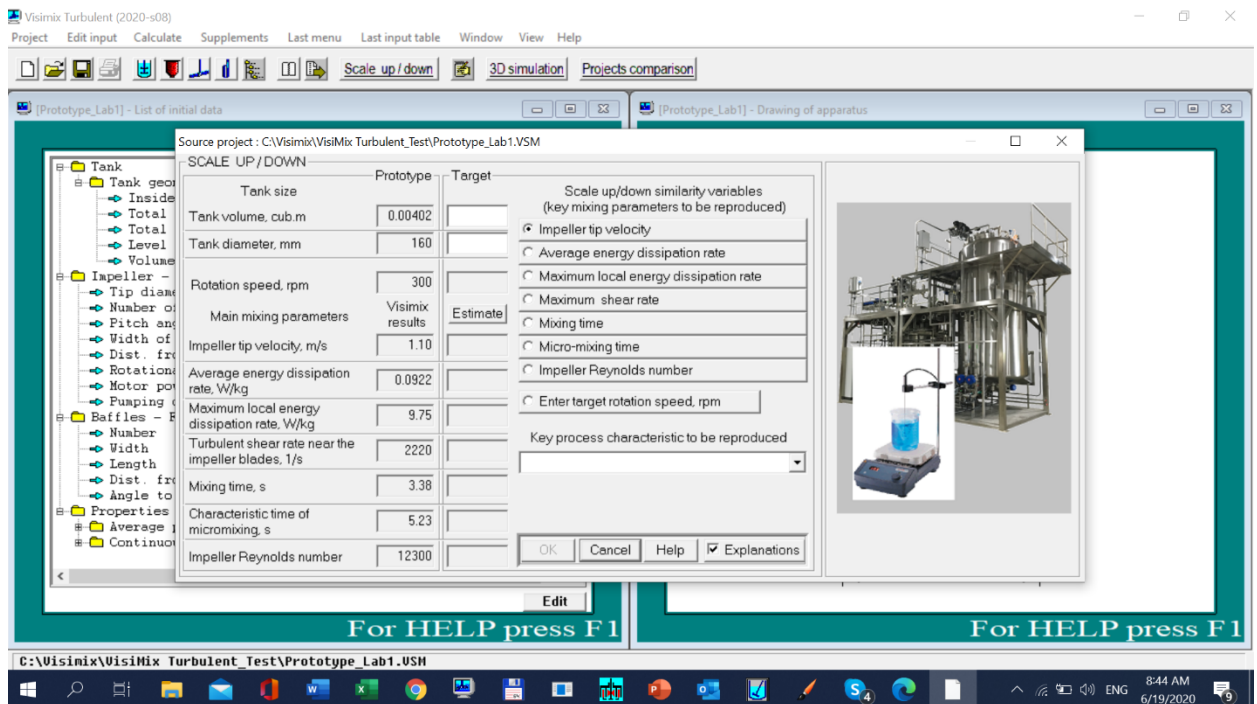


Figure 2. SCALE UP/DOWN dialog.

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.

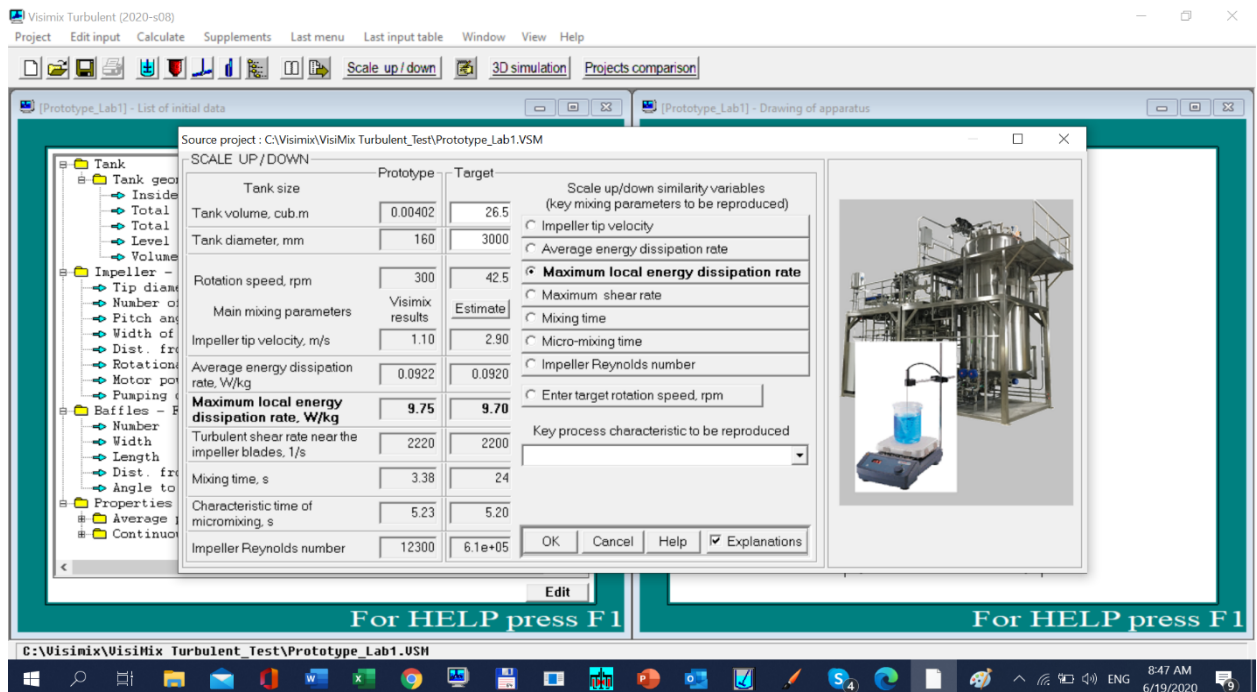


Figure 3. Selection of key mixing parameter to be reproduced and estimated values of target project main mixing parameters

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.

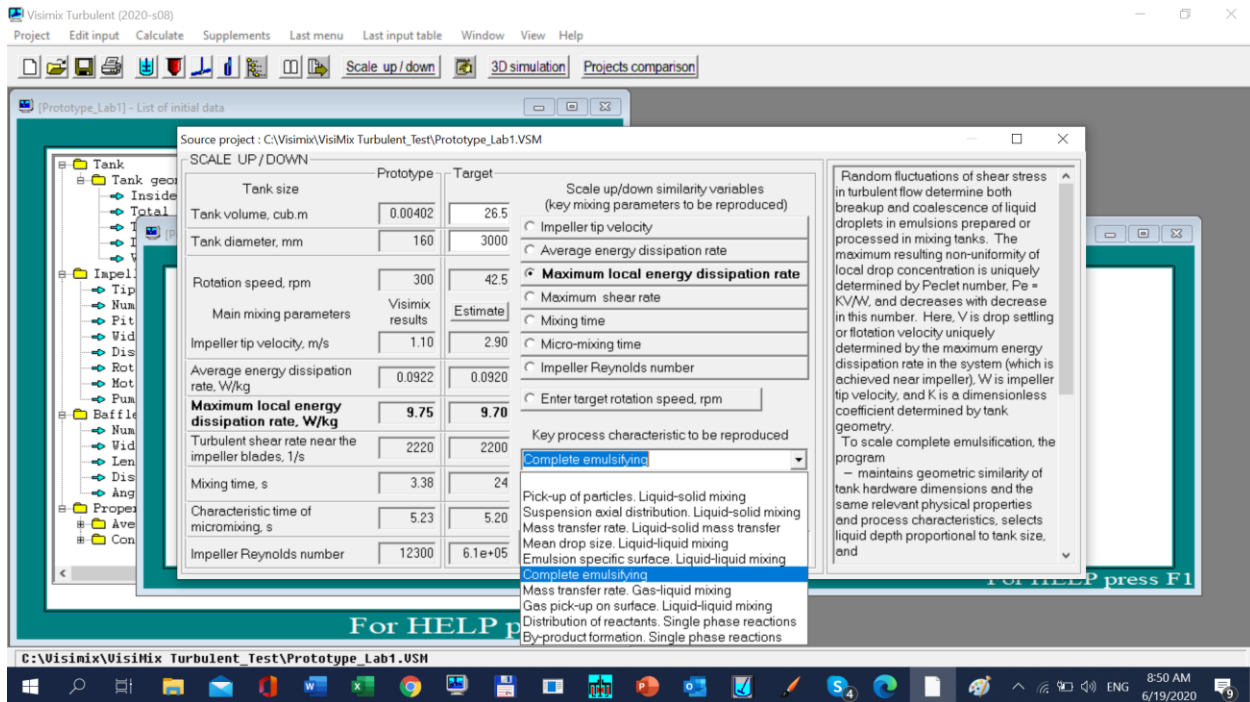


Figure 4. Selection of key process characteristic and governing mixing parameter to be reproduced.

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.

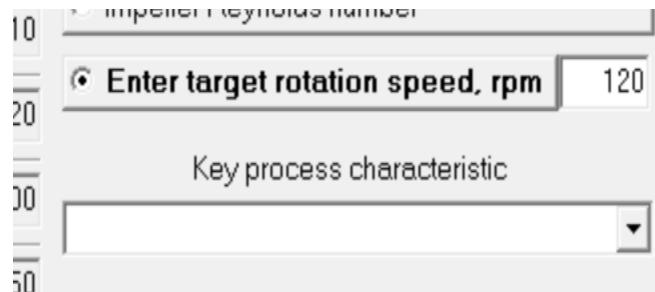


Figure 5. Entering rotation speed value.

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.

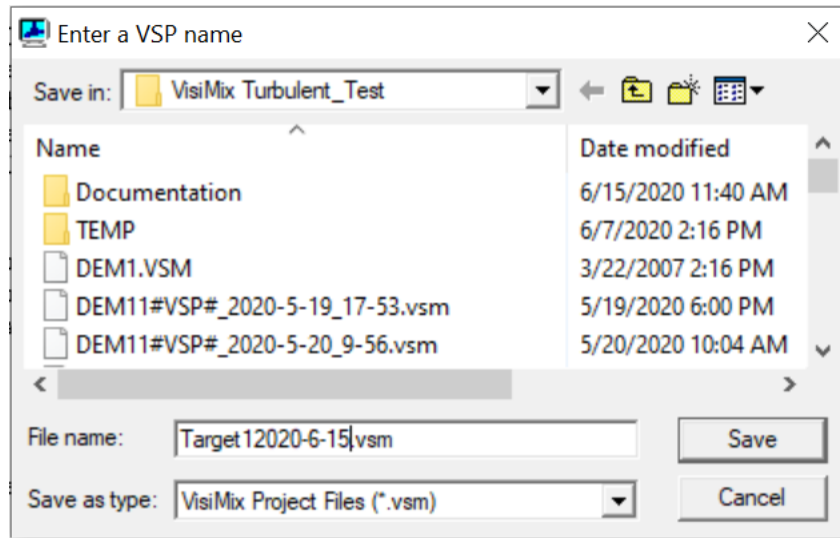


Figure 6. Creation of the target project.

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

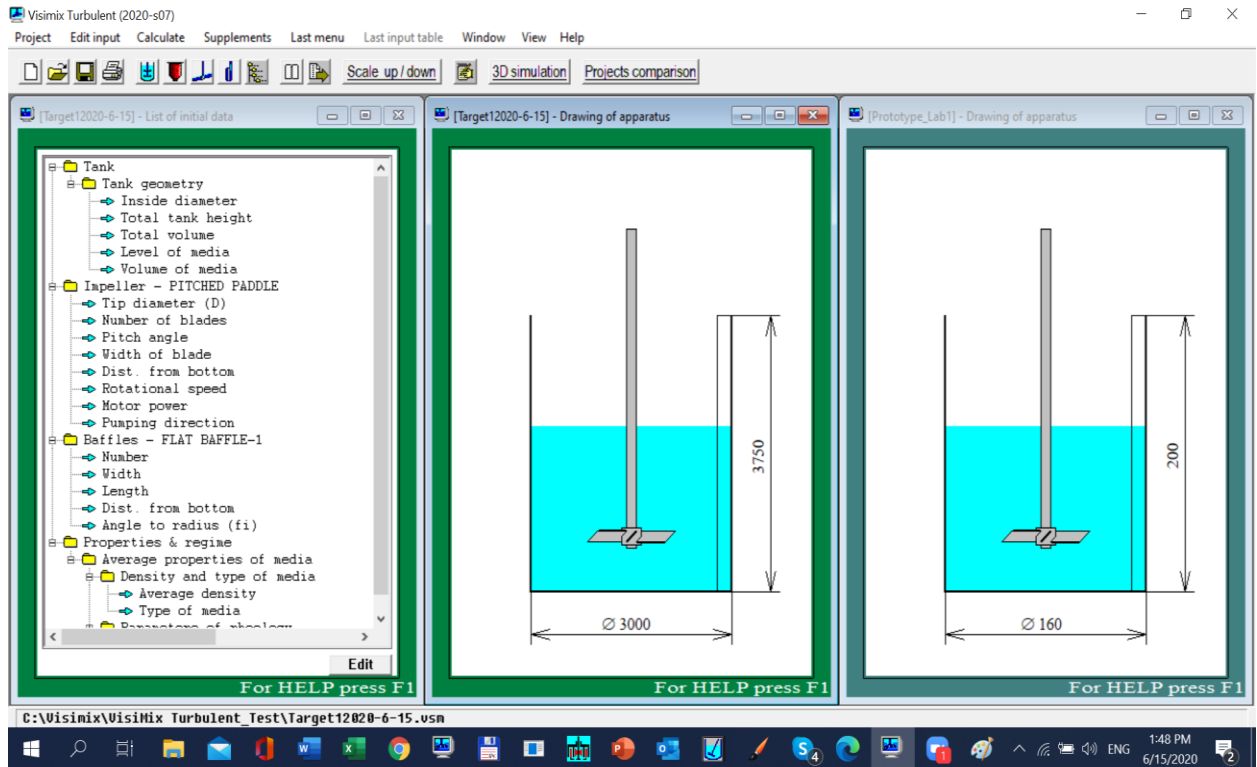


Figure 7. Both prototype and target projects are opened in Visimix.

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 | |
|-----------------------------|----------|-------------------|---------|
| Inside diameter | 300 mm | Tip diameter (D) | 150 mm |
| Total tank height | 308 mm | Number of blades | 4 |
| Total volume | 20 l | Pitch angle | 45 deg |
| Level of media | 237.2 mm | Width of blade | 20 mm |
| Volume of media | 15 l | Dist. from bottom | 38 mm |
| | | Rotational speed | 200 Rpm |
| | | Motor power | 1 KW |
| | | Pumping direction | down |

Input data for the prototype

FLAT BAFFLE-2

Number

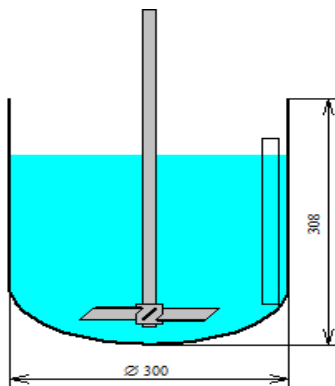
Width mm

Length mm

Dist. from bottom mm

Dist. from wall mm

Angle to radius (fi) deg



- Properties & regime
 - Average properties of media
 - Density and type of media
 - Average density
 - Type of media
 - Parameters of rheology
 - Dynamic viscosity
 - Kinematic viscosity
 - Solid and liquid phases
 - Density of liquid phase
 - Dyn. viscosity of cont. phase
 - Concentration of solid phase
 - Density of solid phase
 - Average particle size
 - Size of largest particles
 - Position of outlet-height

1100 kg/cub.m
Newtonian

2 cP
1.82e-06 sq.m/s

1100 kg/cub.m
2 cP
200 kg/cub.m
2200 kg/cub.m
100 micron
200 micron
0 mm

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 Turbulent_Test\Liq.-solid example.vsm

SCALE UP / DOWN

| | Prototype | Target |
|--|-----------------|----------|
| Tank size | | |
| Tank volume, cub.m | 0.0200 | |
| Tank diameter, mm | 300 | |
| Rotation speed, rpm | 200 | |
| Main mixing parameters | Visimix results | Estimate |
| Impeller tip velocity, m/s | 1.57 | |
| Average energy dissipation rate, W/kg | 0.186 | |
| Maximum local energy dissipation rate, W/kg | 12.0 | |
| Turbulent shear rate near the impeller blades, 1/s | 2580 | |
| Mixing time, s | 7.07 | |
| Characteristic time of micromixing, s | 5.70 | |
| Impeller Reynolds number | 41300 | |

Scale up/down similarity variables
(key mixing parameters to be reproduced)

- ☒ Impeller tip velocity
- ☐ Average energy dissipation rate
- ☐ Maximum local energy dissipation rate
- ☐ Maximum shear rate
- ☐ Mixing time
- ☐ Micro-mixing time
- ☐ Impeller Reynolds number
- ☐ Enter target rotation speed, rpm

Key process characteristic to be reproduced

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 | | Prototype | Target |
|--|-----------------|--------------|--------------|
| Tank size | | | |
| Tank volume, cub.m | | 0.0200 | 2 |
| Tank diameter, mm | | 300 | 1390 |
| Rotation speed, rpm | | 200 | 72.0 |
| Main mixing parameters | Visimix results | Estimate | |
| Impeller tip velocity, m/s | | 1.57 | 2.60 |
| Average energy dissipation rate, W/kg | | 0.186 | 0.190 |
| Maximum local energy dissipation rate, W/kg | | 12.0 | 12 |
| Turbulent shear rate near the impeller blades, 1/s | | 2580 | 2600 |
| Mixing time, s | | 7.07 | 20 |
| Characteristic time of micromixing, s | | 5.70 | 5.70 |
| Impeller Reynolds number | | 41300 | 3.2e+05 |

| Scale up/down similarity variables (key mixing parameters to be reproduced) | |
|--|--|
| <input type="radio"/> Impeller tip velocity | |
| <input checked="" type="radio"/> Average energy dissipation rate | |
| <input type="radio"/> Maximum local energy dissipation rate | |
| <input type="radio"/> Maximum shear rate | |
| <input type="radio"/> Mixing time | |
| <input type="radio"/> Micro-mixing time | |
| <input type="radio"/> Impeller Reynolds number | |
| <input type="radio"/> Enter target rotation speed, rpm | |

| Key process characteristic to be reproduced | |
|---|--|
| Pick-up of particles. Liquid-solid mixing | |

| 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. | |
|--|--|
| To scale solids pick-up, the program – maintains geometric similarity of tank hardware dimensions and the same relevant physical properties and process characteristics, selects liquid depth proportional to tank size, and | |
| – selects impeller rpm to maintain the same intensity of turbulent fluctuations by keeping either | |
| * the same mean energy dissipation rate for a BAFFLED TANK, or | |
| * the same impeller tip velocity for an UNBAFFLED TANK. | |

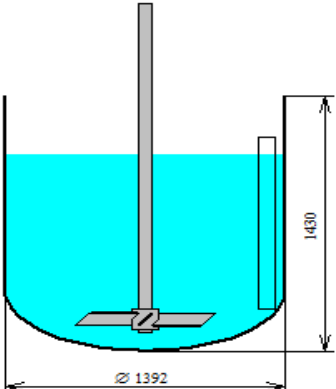
In target column estimated values of target project main mixing parameters, in **bold** key mixing parameter related with Key process characteristic selected. On the right, an explanation about selected key process characteristic.

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:

| TANK WITH ELLIPTICAL BOTTOM | |
|-----------------------------|---------|
| Inside diameter | 1392 mm |
| Total tank height | 1430 mm |
| Total volume | 2000 l |
| Level of media | 1101 mm |

| PITCHED PADDLE | |
|-------------------|-----------|
| Tip diameter (D) | 696.2 mm |
| Number of blades | 4 |
| Pitch angle | 45 deg |
| Width of blade | 92.83 mm |
| Dist. from bottom | 176.4 mm |
| Rotational speed | 72 Rpm |
| Motor power | 0.6163 KW |
| Pumping direction | down |

| FLAT BAFFLE-2 | |
|----------------------|----------|
| Number | 4 |
| Width | 92.83 mm |
| Length | 965.1 mm |
| Dist. from bottom | 232.1 mm |
| Dist. from wall | 46.41 mm |
| Angle to radius (fi) | 0 deg |



Same properties as in prototype

| | | |
|------------------------------|-----------|----------|
| Properties & regime | | |
| Average properties of media | | |
| Density and type of media | | |
| Average density | 1100 | kg/cub.m |
| Type of media | Newtonian | |
| 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 |
| Size of largest particles | 200 | micron |
| Position of outlet-height | 0 | mm |

Comparison of the result desired

Prototype (10 L Reactor)

Scaled up Reactor (2000 L Reactor)

