

VISIMIX LAMINAR. MODERNIZATION OF MIXING TANK FOR PROCESSING HIGHLY VISCOUS LIQUID.

In this example VisiMix Laminar is used to find a simple way to use an existing reactor for mixing of a much more viscous media without replacement of drive.

Reactor design

Tank:

Tank with elliptical bottom.

Internal diameter 1200 mm

Total height 1400 mm

Impeller:

Type – INTERMIG

Number of stages – 3

Tip diameter -720

Distance from bottom – 250 mm

Distance between impellers – 650 mm

Drive:

Rotational velocity – 120 rpm

Power – 4 kW.

Description of the problem.

Reactor was developed and successfully used for manufacturing of a product (2100 liter per batch) with density 1100 kg /cub.m and maximum viscosity 7000-8000 cP.

Application of this reactor for manufacturing of a new product with density 1030 kg/cub.m and final viscosity 22000 -24000 cP become problematic because of overloading of the motor. It was possible to use the reactor for production of smaller batches - reduced to about 1600 liter.

Purpose of application of the program VisiMix Laminar – finding a way to increase volume of the batch without overloading the motor.

Step 1. Entering design data and properties and calculations for the ‘old’ production process.

A graphic menu for selection of the tank is provided by the program. After type of the tank is selected, the corresponding list of dimensions is presented by program and has to be filled (Fig.1).

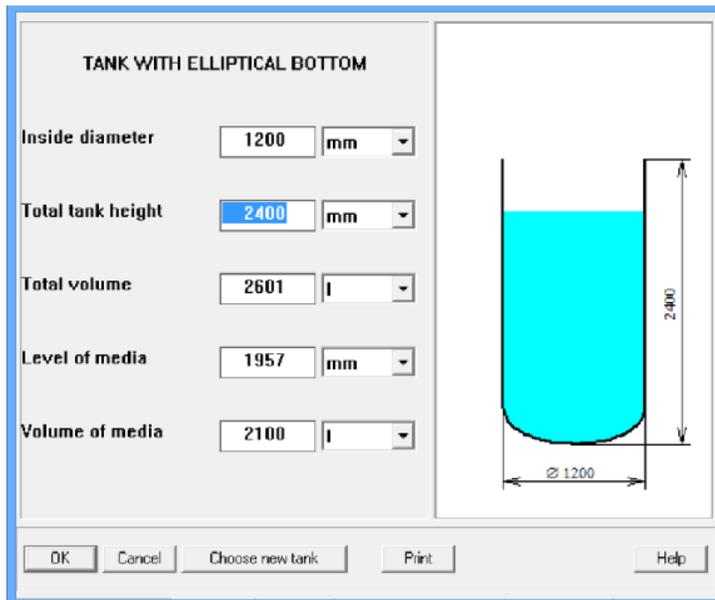


Figure 1. Entering dimensions of the tank.

Type and dimensions of impellers are entered the same way (see Figs 2).

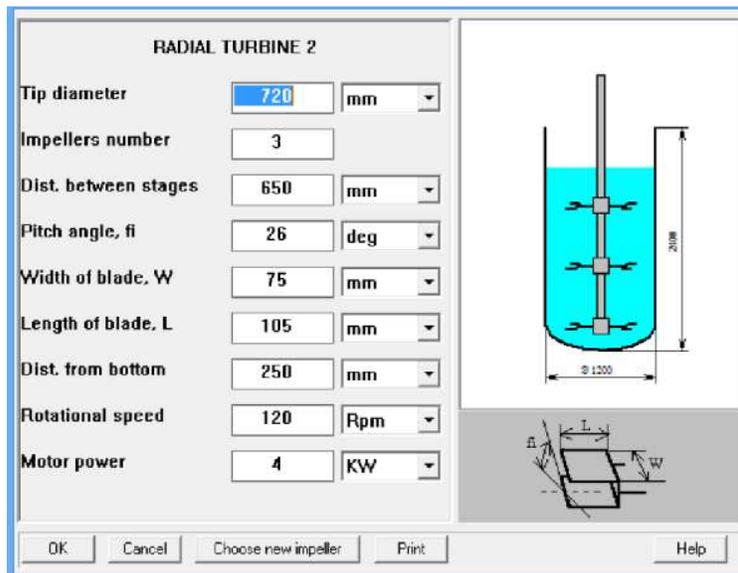


Figure 2. Entering data for impellers and drive.

Now we enter density and viscosity of the less viscous liquid. Corresponding forms are presented by the program automatically (Figs. 3 and 4).

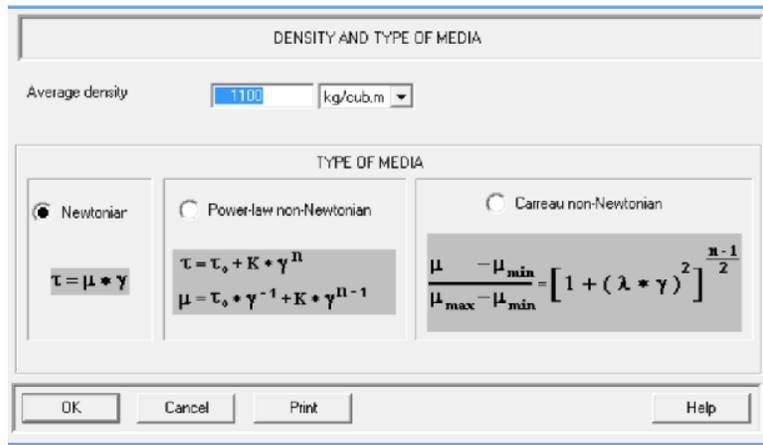


Figure 3. Entering density and type of liquid media for the ‘old’ process.

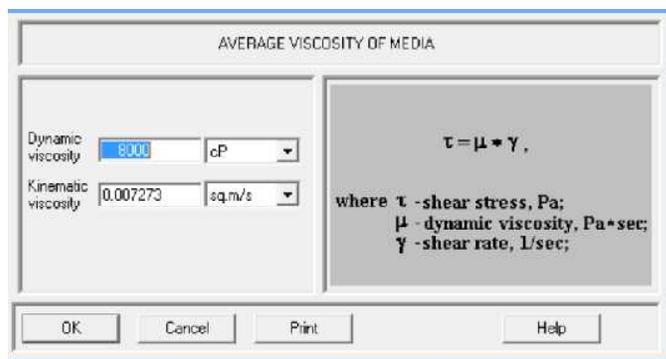


Figure 4. Entering viscosity of liquid for the ‘old’ process.

Calculation of power consumption.

Calculation is performed by selecting and pressing the **Mixing power** option in the **Calculate** menu, as it is shown in the Fig. 5.

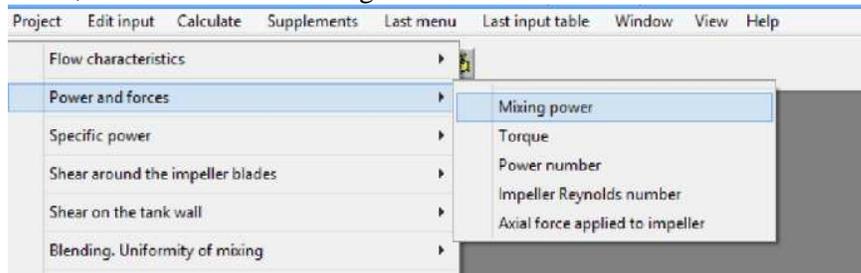


Figure 5. Menu option for calculation of mixing power.

Result of calculation arrives as an output table (Fig.5). The obtained figure – 2770 W- shows that power of the 4 kW motor in this case is high enough and provides necessary reservation.

MIXING POWER		
Parameter name	Units	Value
Mixing power	W	2770

For HELP press F1

Figure 6. Calculated power for 3-stage impeller system in tank with 8000 cP liquid.

Step 2. Entering data and calculation for ‘new’ process application of the reactor.

In order to replace values of density and viscosity of liquid in the input tables with the new ones, the menu option Edit **input** is used. The changed input tables are shown in the Figs 7 and 8.

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 7. Entering density and type of liquid media for the ‘new’ process.

AVERAGE VISCOSITY OF MEDIA

Dynamic viscosity: cP

Kinematic viscosity: sq.m/s

$\tau = \mu * \gamma$

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

OK Cancel Print Help

Figure 8. Entering the maximum viscosity of liquid for the ‘new’ process.

After the new inputs are confirmed, the program repeats the calculation automatically. The message that arrives in the screen (Fig.9) informs that power of motor is not high enough.

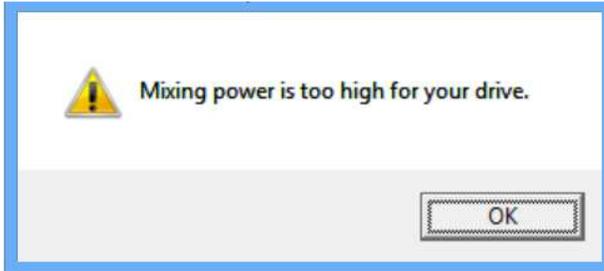


Figure 9. Result of calculations – information on probable overloading of the motor.

Step 3. Looking for a technical solution.

The simplest way to decrease the power consumption consists in reduction of number of impeller stages. However, it may be expected that a 2-stage impeller will provide significantly worse mixing than the existing 3-stage system. So, along with mixing **power**, the **Mixing time** in the reactor has also to be defined.

Mathematical modeling of blending is performed using the **Calculate** menu (via **Calculate>Blending. Uniformity of mixing > Mixing time**, see Fig.10).

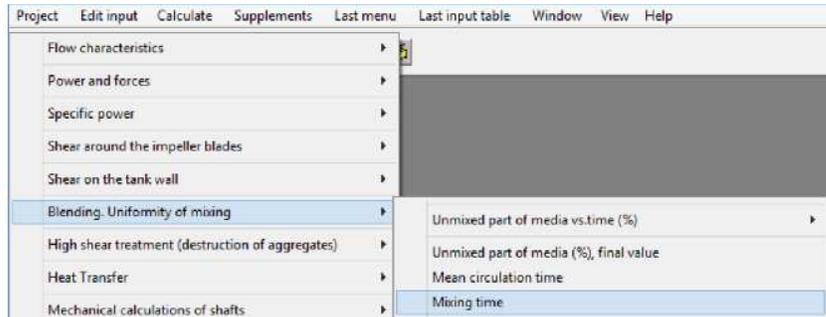


Figure 10. Menu option for calculation of mixing time.

MIXING TIME		
Parameter name	Units	Value
Mixing time necessary to attain 5% non-uniformity	s	569
Mixing time necessary to attain 2% non-uniformity	s	706

For HELP press F1

Figure 11. Calculated values of mixing time for the tank with 3-stage impeller.

Now we have to remove one of the impellers (Fig.12) and repeat the calculations. The new results are presented in the Figs 13 and 14.

Figure 12. Input table for the 2-stage impeller system

MIXING POWER		
Parameter name	Units	Value
Mixing power	W	2800

For HELP press F1

Figure 13. . Calculated power for 2-stage impeller system in tank with 24000 cP liquid.

MIXING TIME		
Parameter name	Units	Value
Mixing time necessary to attain 5% non-uniformity	s	459
Mixing time necessary to attain 2% non-uniformity	s	584

For HELP Press F1

Figure 14. Calculated values of mixing time for the tank with 2-stage impeller.

As follows from these results, power consumption of the 2-stage impeller system is low and allows to use the existing 4 kW drive with necessary reservation.

Comparison of the data in Figs 11 and 14 shows also that removal of the third impeller results in some reduction of mixing time. This result can be explained by comparison of the circulation schemes for the 2-stage and 3-stage impellers defined by flow simulation (via **Calculate>Flow characteristics>Scheme of the main circulation cycles**, see Fig. 15).

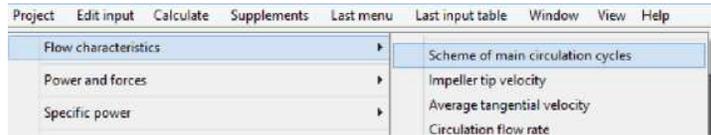


Figure 15.

As follows from the results, mixing with the 3-stage impeller system takes more time because of division of the reactor volume into a bigger number of circulation zones with limited exchange. However, effect of removal of the second impeller is negative. Accordingly to results of simulation (Fig.16), mixing **time** in this tank with a single impeller would be significantly longer (compare Figs 11, 14 and 16).

Parameter name	Units	Value
Mixing time necessary to attain 5% non-uniformity	s	931
Mixing time necessary to attain 2% non-uniformity	s	1320

For HELP press F1

Figure 16. Calculated values of mixing time for the tank with 1-stage impeller.

Conclusion.

VisiMix simulation helps to find a simple technical way for increasing of the batch volume: **to remove one of the three impellers and use the reactor with the 2-stage impeller.**