



ViSiMix RSDE – Program for Selection, Scaling Up and Successful Application of **Rotor/Stator Dispersers**

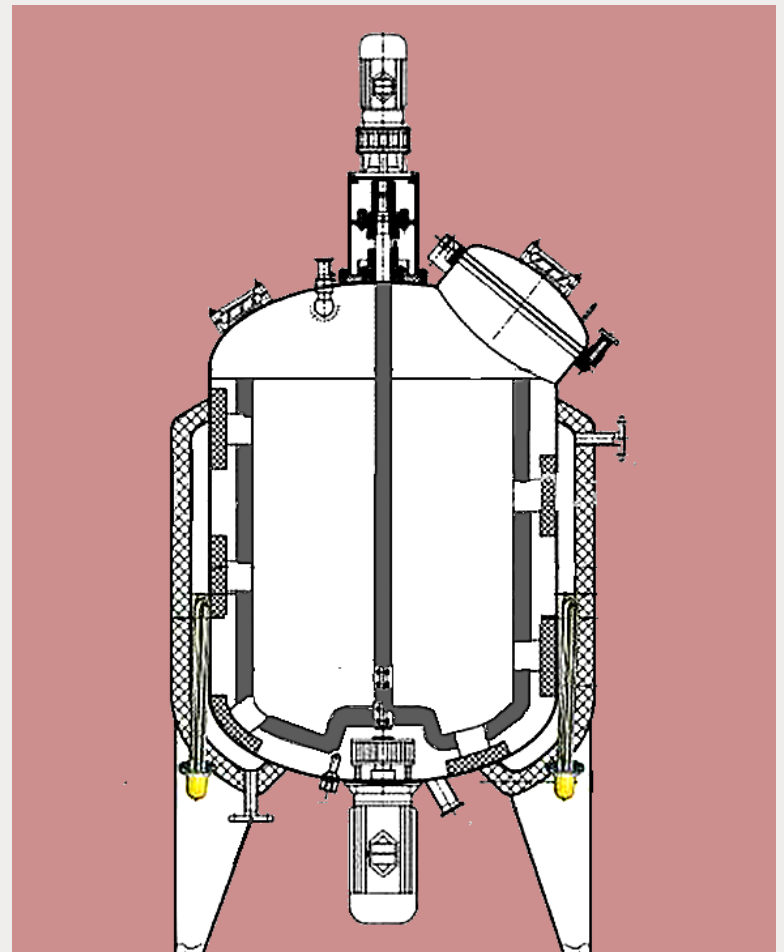
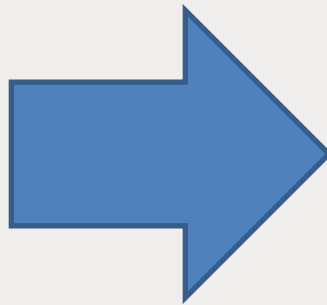
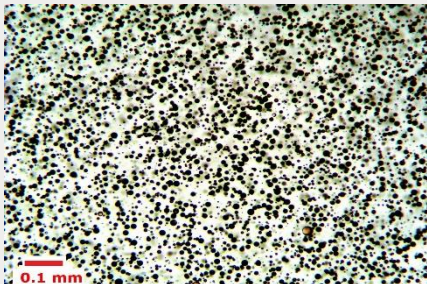
VisiMix Ltd.

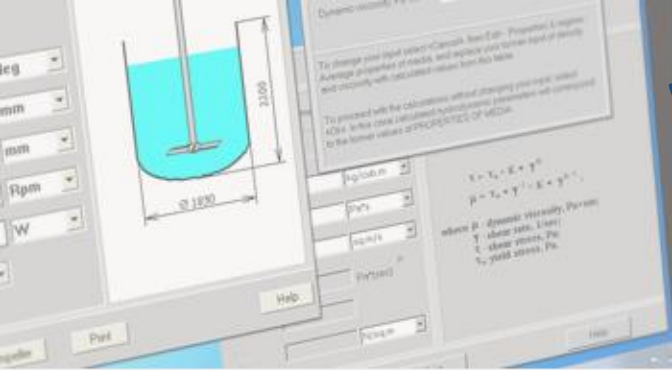
PO Box 45170, Jerusalem, 91450, Israel
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E-mail: info@visimix.com



Process developed in Lab

How do we scale it up?





ViSiMiX Ltd.

Founded in 1995

Manufactures software products that allow for solving most practical problems connected with mixing in chemical reactors

Commercial Products:

- ViSiMiX Turbulent
- ViSiMiX Laminar
- ViSiMiX DI
- ViSiMiX PL
- **ViSiMiX RSDE**



ViSiMiX RSDE

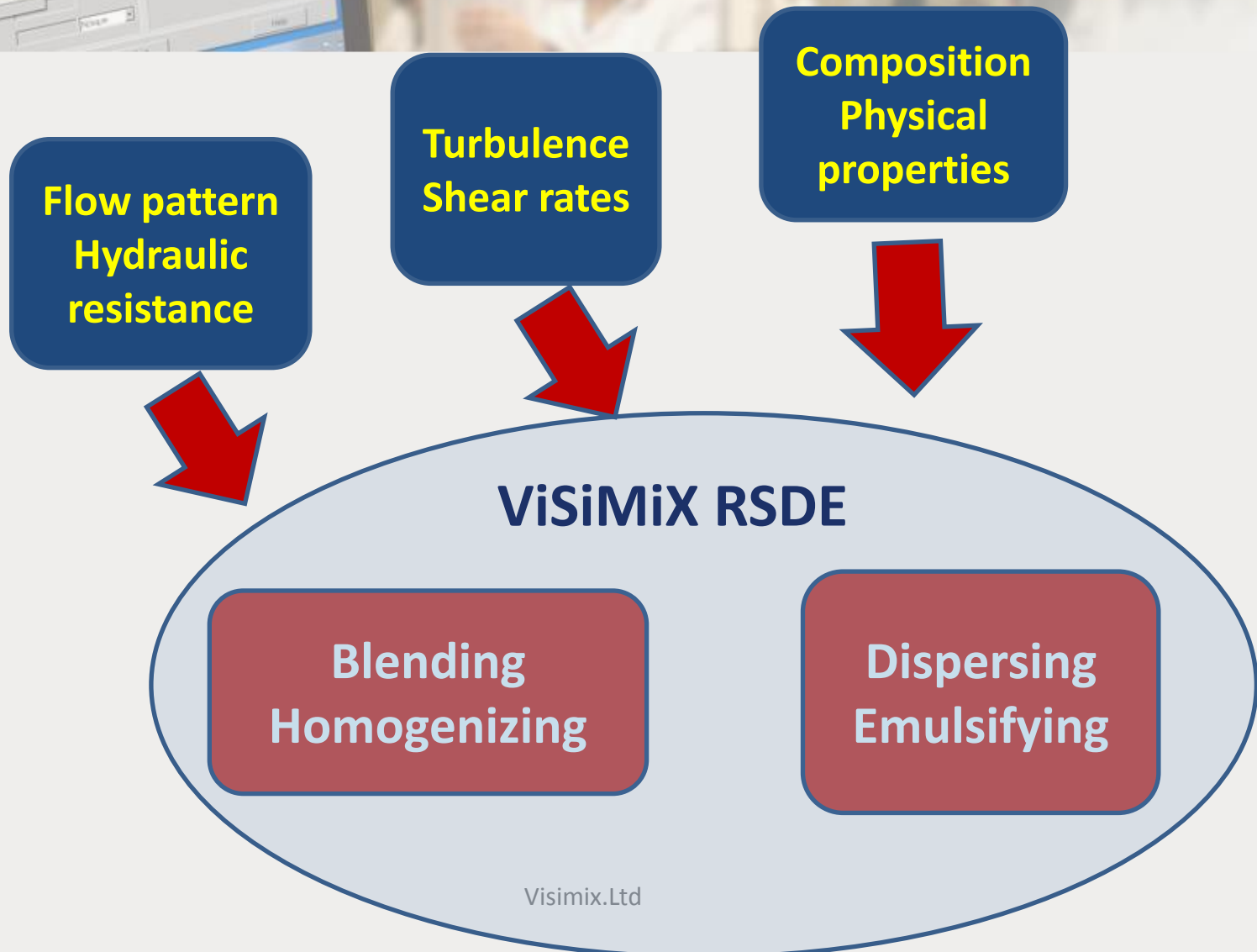
(Rotor-Stator Dispersers and Emulsifiers)

Unique software program for mathematical modeling and technical calculations of installations with RSDE

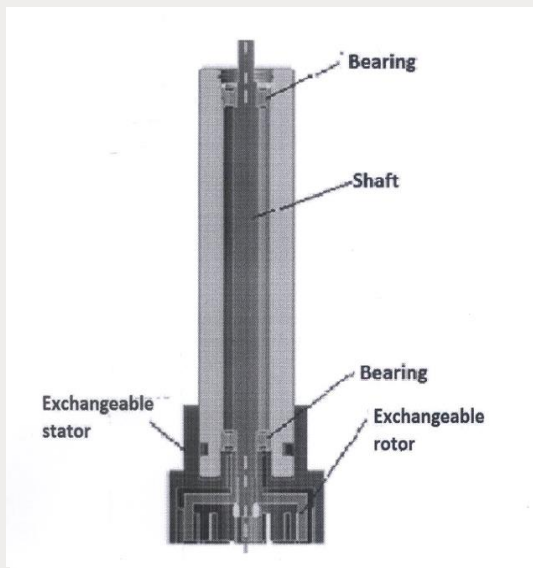
- power, flow characteristics, shear rates and stresses
- homogenizing and emulsion formation
- defining flow and shear parameters for scaling-up

Different types of rotor and stators. Different installation schemes

Methodology



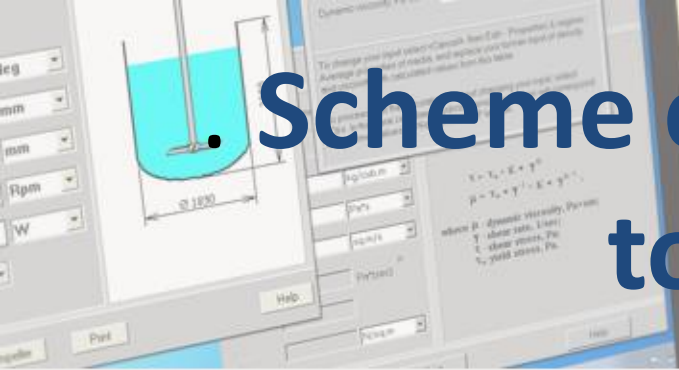
Rotor-Stator devices and Liquids used in experiments



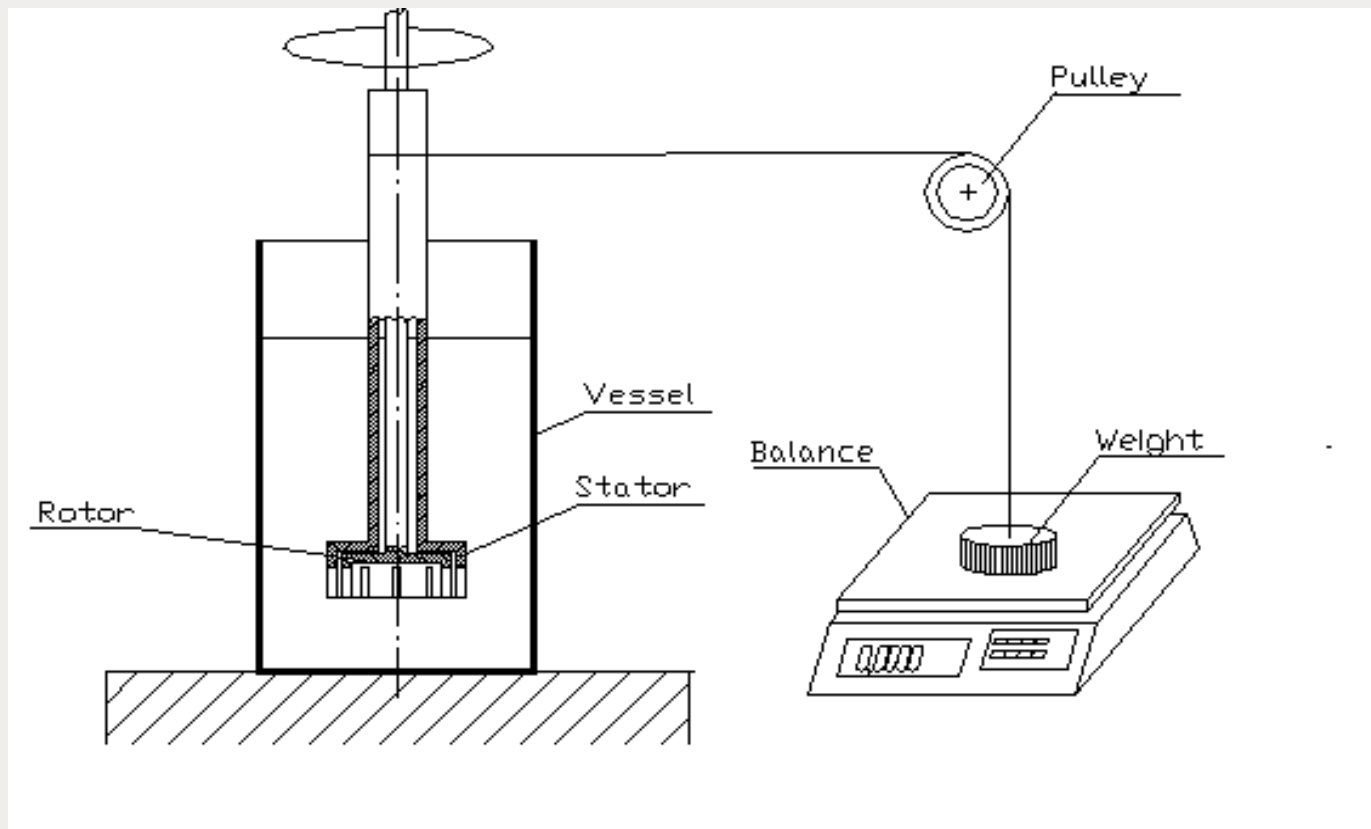
Water – glycerol solutions. Viscosity 1 – 1000 cP

Non – Newtonian liquids:

CMC concentration	Limits of shear rates, 1/s	Power law parameters	
		K	n
1.5 %	10 - 18000	0.251	0.702
2%	2 - 12000	0.890	0.605
2.5%	2 - 8100	1.075	0.630
3%	0.4 - 1800	5.95	0.514
5%	0.8 - 1400	18.77	0.521



Scheme of measurement of the torque moment



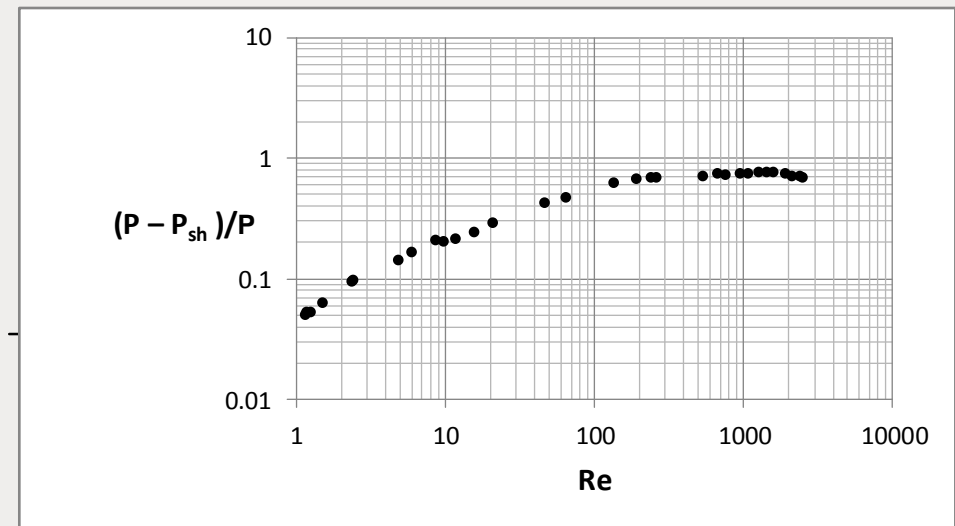
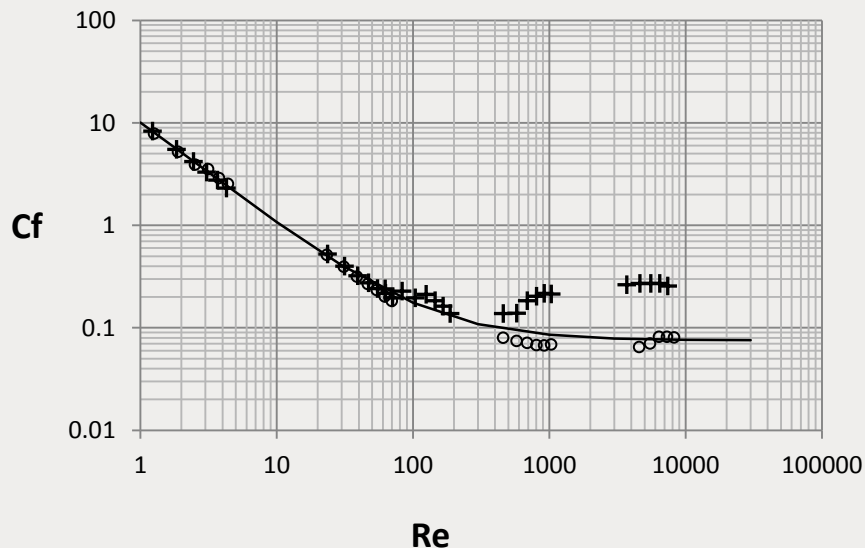
Power consumption due to hydraulic resistance in annular channels between rotor and stator

$$P_{sh} = \omega M_{sh}$$

$$\tau_{sh} = C_f \rho V_{tg}^2 / 2$$

$$M_{sh} = \tau_{sh} F_{st} R_{st}$$

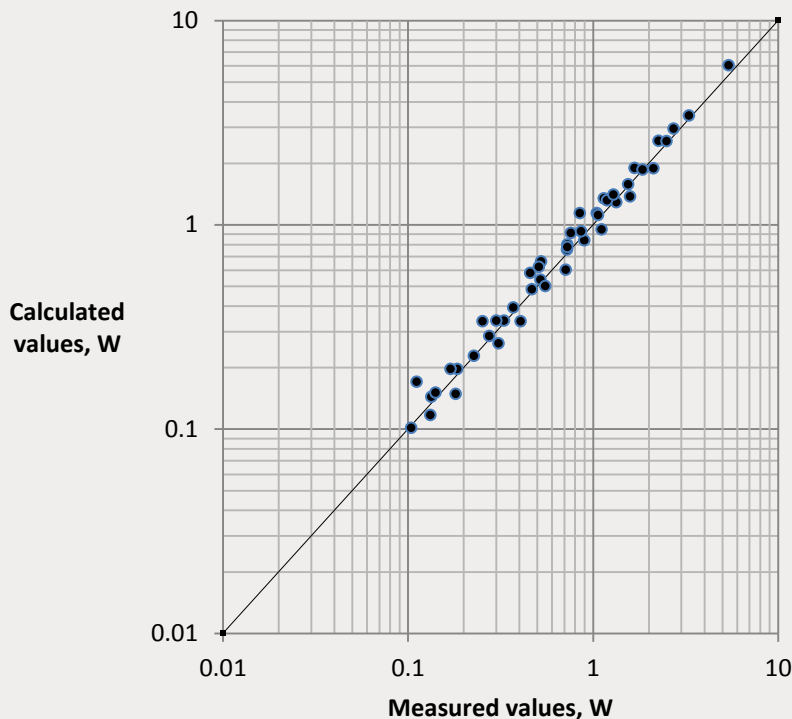
$$C_f = K_1 / Re + K_2$$



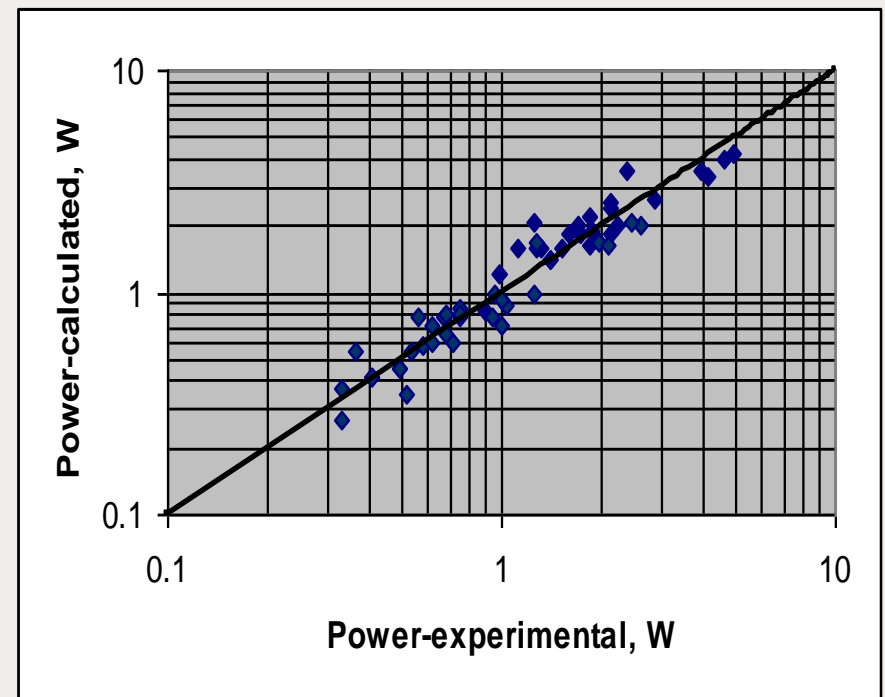
Comparison of Calculated and Measured values of RSD power.

RSD with 'closed' stator.

Newtonian media



Non – Newtonian media



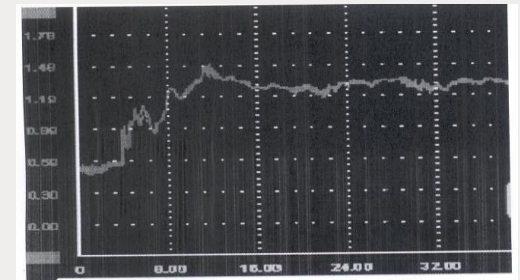
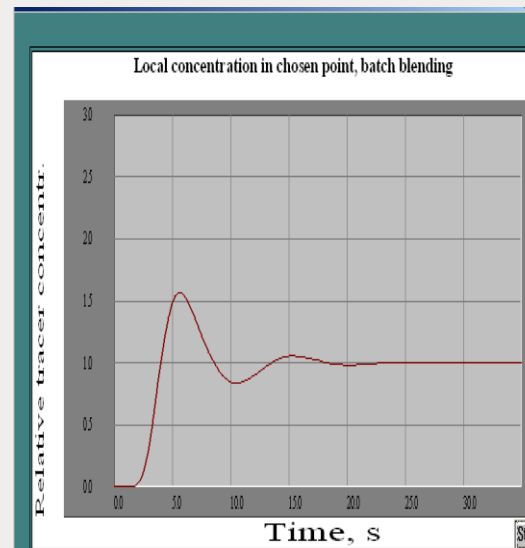
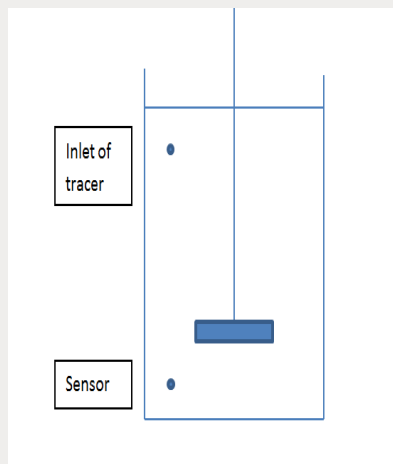
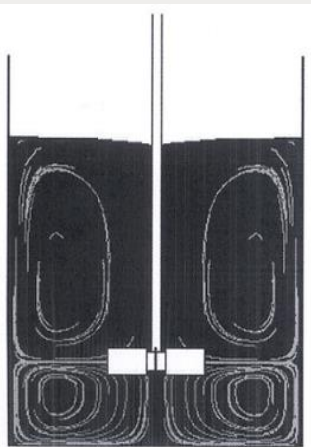
Experimental evaluation of flow capacity of RSD devices

Method 1 : Using power consumption

$$P_{\text{kin}} = \rho Q \omega^2 R_{\text{rot}}^2 / 2$$

$$Q = 2(P - P_{\text{sh}}) / \rho \omega^2 R_{\text{rot}}^2$$

Method 2 : By comparison of tracer distribution curves



Flow numbers N_q based on flow rate values defined by two different methods

Stator Internal Diameter, mm	Rotor Diameter, mm	$N_q = Q/ND_{rot}^3$	
		Tracer distribution	Power measurements
34	30	0.203	0.223
44	40	0.1	0.0922
44	42	0.165	0.182

FLOW CAPACITY AND POWER CONSUMPTION OF RSD DEVICES

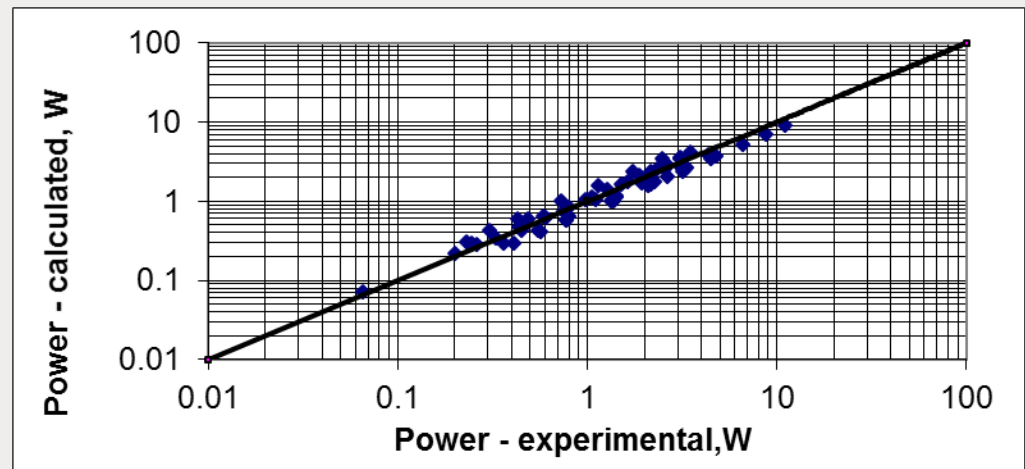
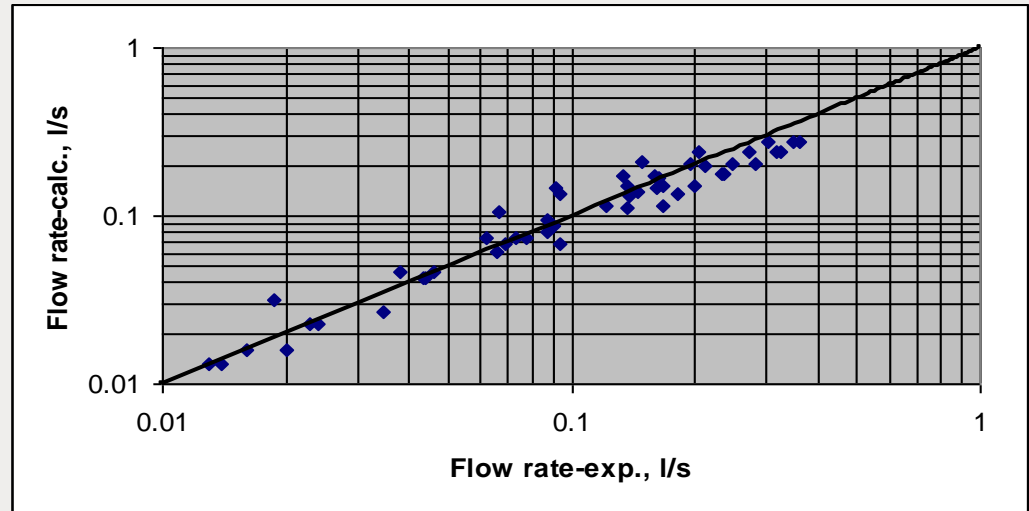
$$P_{cf} = \Delta P_{res}$$

$$P_{cf} = \rho \int \omega^2 r dr$$

$$\Delta P_{res} = \sum C_{f,i} \rho W_{rad,i}^2 / 2$$

$$C_{f,i} = K_3 / Re + K_4$$

$$W_{rad,i} = Q / A_i$$



Shear rates in RSD channels

Power depends on viscosity

$\mu_{\text{eff}} = F(\gamma_{\text{eff}})$ – Rheology law

$M_{\text{sh}} = F(\gamma_{\text{eff}})$

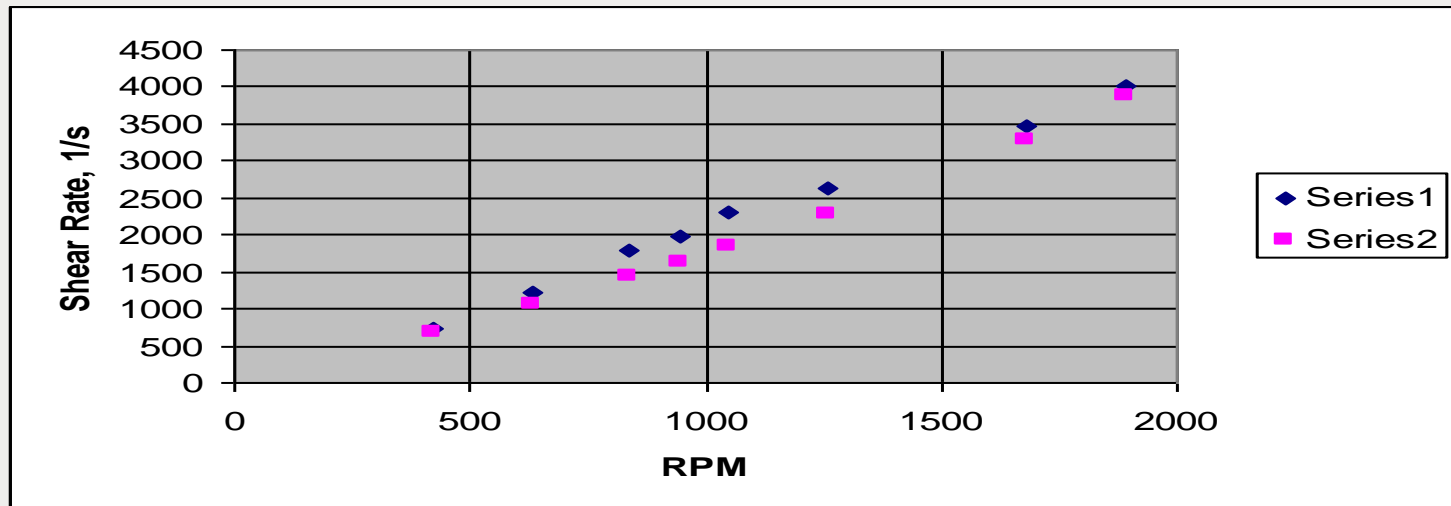
$\varepsilon = \omega M_{\text{sh}} / (2\pi \rho R_{\text{st}} H_{\text{st}}) = \mu_{\text{eff}} \gamma_{\text{eff}}^2$

$\mu_{\text{eff}} = F(\gamma_{\text{eff}})$

Measure power → Know viscosity

Know viscosity → Know Shear rate

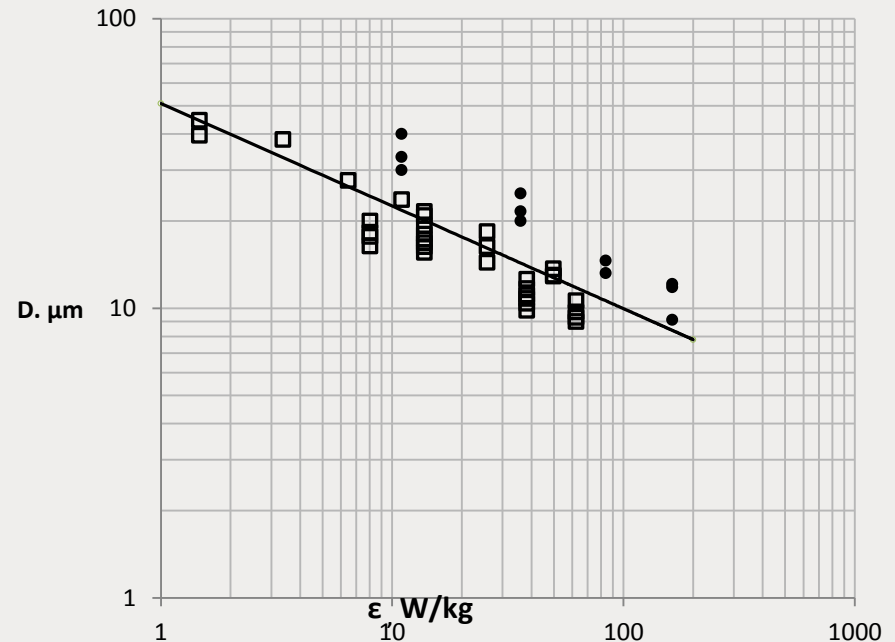
Solve for **Moment**,
Viscosity and **Share rate**



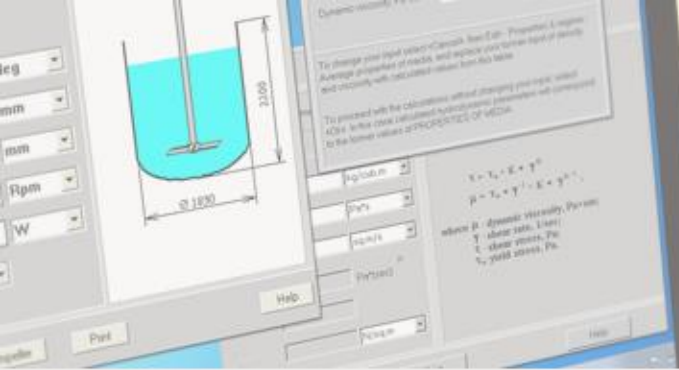
Emulsifying action of RSD

Breaking and coalescence of droplets in high shear channels of RSD

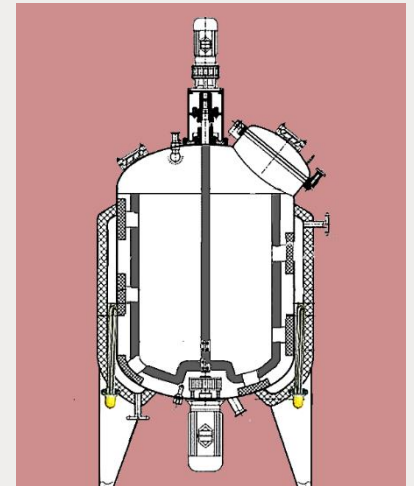
- Mathematical model of drop breaking / coalescence has been successfully used for practical application in the program VisiMix Turbulent (see www.visimix.com) starting from 1996.
- Drop breaking and drop coalescence are result of turbulence
- Frequencies of drop breaking and drop coalescence depend on energy dissipation rate, calculated by RSDE program, drop diameter and physical properties



**Sauter mean drop size
vs mean energy dissipation
in 50 mm RSD**

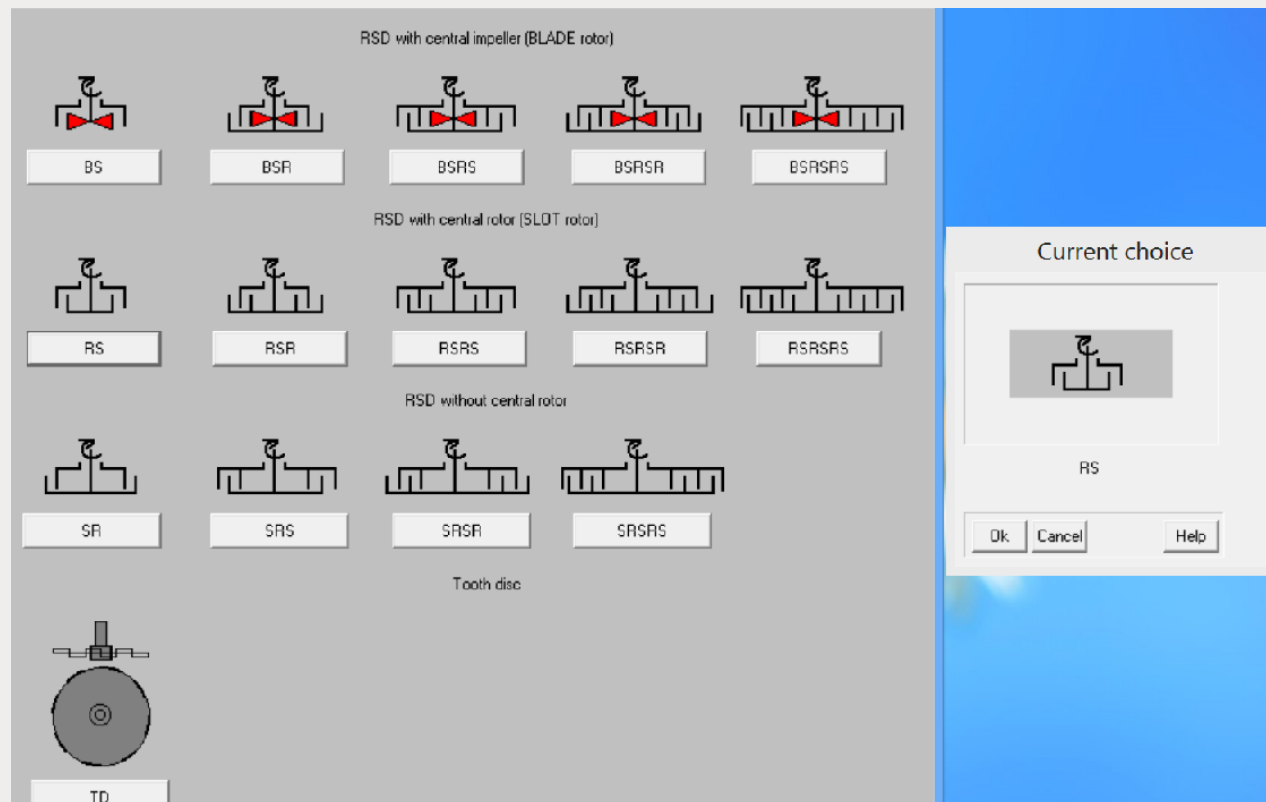


EXAMPLE OF VISIMIX RSDE SOFTWARE APPLICATION



Homogenizing of shampoo in tank
with a rotor/stator disperser

Entering of design and dimensions of the rotor/stator device (RSD)




**Selection
of RSD
design
scheme**

Entering of design and dimensions of the rotor/stator device (RSD)

RSD DESIGN

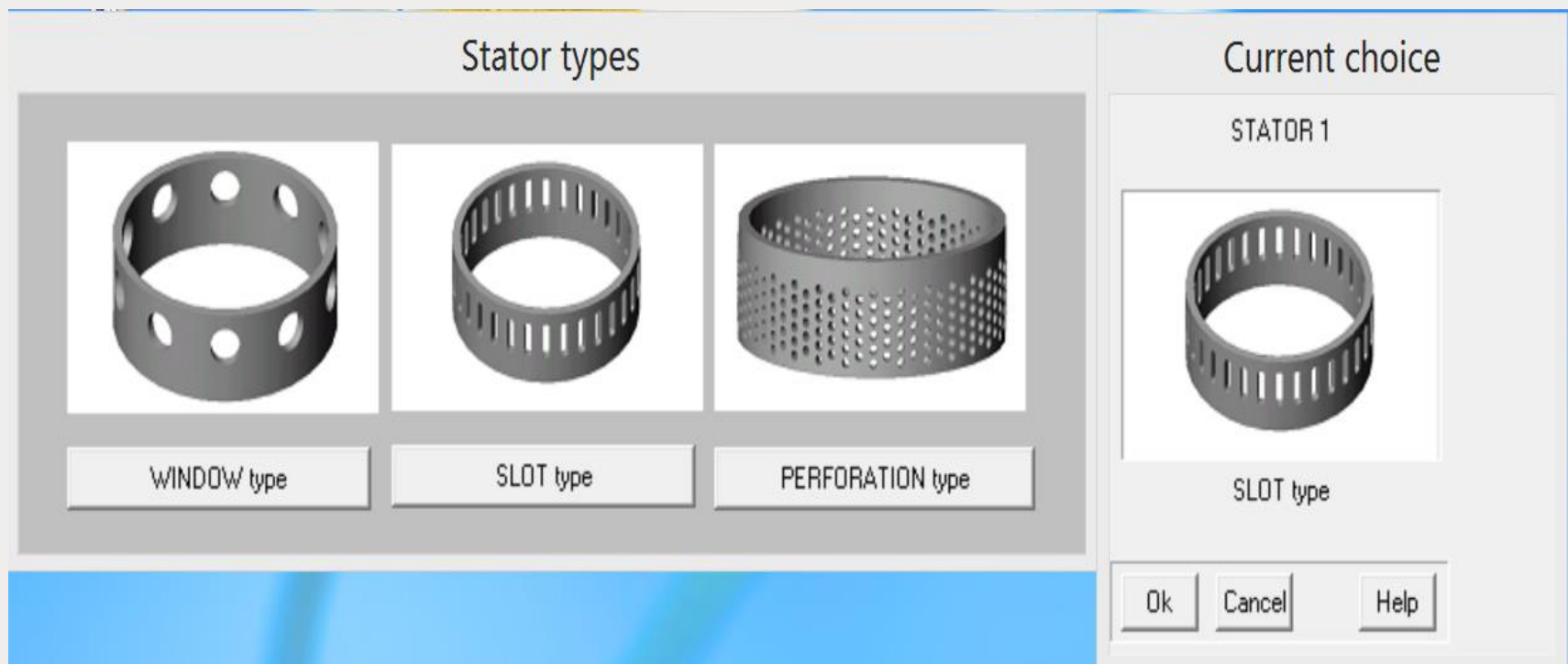
Rotational speed:



ROTORS		STATORS	
Internal diameter	<input type="text" value="92"/> mm	<input type="text" value="102"/> mm	<input type="text" value="mm"/>
External diameter	<input type="text" value="100"/> mm	<input type="text" value="110"/> mm	<input type="text" value="mm"/>
Internal diameter	<input type="text"/> mm	<input type="text"/> mm	<input type="text"/> mm
External diameter	<input type="text"/> mm	<input type="text"/> mm	<input type="text"/> mm
Internal diameter	<input type="text"/> mm	<input type="text"/> mm	<input type="text"/> mm
External diameter	<input type="text"/> mm	<input type="text"/> mm	<input type="text"/> mm

Entering
of main
RSD data

Entering of design and dimensions of the rotor/stator device (RSD)



Entering Stator type

Entering of design and dimensions of the rotor/stator device (RSD)

STATOR 1: SLOT type

Internal height (h1) mm

External height (h2) mm

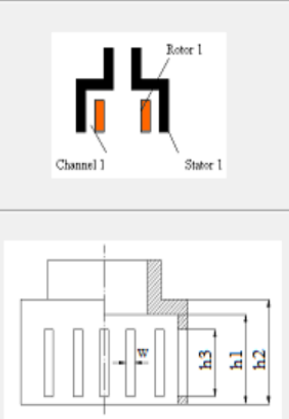
Number of slots

Height of slots (h3) mm

Width of slots (w) mm

Reference information:
Internal diameter 0.102 m
External diameter 0.11 m

OK Cancel Choose new stator Print Help



The diagram shows a cross-section of a stator slot. It is a semi-circular shape with a central channel. The dimensions are labeled: h1 is the internal height, h2 is the external height, h3 is the height of the slot, and w is the width of the slot. The diagram also shows the rotor and stator components.

ROTOR 1: SLOT type

Internal height (h1) mm

External height (h2) mm

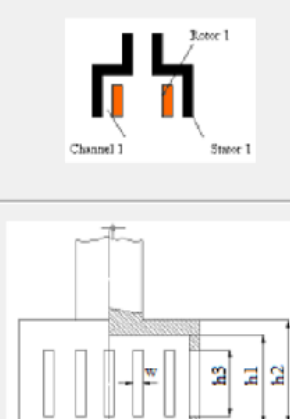
Number of slots

Height of slots (h3) mm

Width of slots (w) mm

Reference information:
Internal diameter 0.092 m
External diameter 0.1 m

OK Cancel Print Help



The diagram shows a cross-section of a rotor slot. It is a semi-circular shape with a central channel. The dimensions are labeled: h1 is the internal height, h2 is the external height, h3 is the height of the slot, and w is the width of the slot. The diagram also shows the rotor and stator components.

Entering dimensions of stator and rotor

Entering density and viscosity of media

DENSITY AND TYPE OF MEDIA

Average density of media
1050 kg/cub.m

TYPE OF MEDIA

☒ Newtonian
 $\tau = \mu * \gamma$

☐ Power-law non-Newtonian
 $\tau = \tau_0 + K * \gamma^n$
 $\mu = \tau_0 * \gamma^{-1} + K * \gamma^{n-1}$

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

OK Cancel Print Help

AVERAGE VISCOSITY OF MEDIA

Dynamic viscosity 300 cP

Kinematic viscosity 0.0002857 sq.m/s

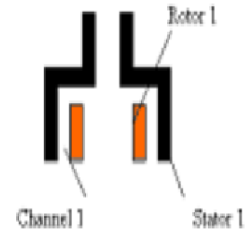
$\tau = \mu * \gamma$

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

OK Cancel Print Help

Mathematical modeling and calculations

Defining shear characteristics of the RSD



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

POWER AND FLOW

SHEAR CHARACTERISTICS OF RSD CHANNELS

CHARACTERISTICS OF EACH CHANNEL

BATCH HOMOGENIZATION

CONTINUOUS FLOW HOMOGENIZATION

BATCH EMULSIFYING

CONTINUOUS FLOW EMULSIFYING

Shear Rates

Shear Stresses

Specific Power

Effective Viscosity

Surface Velocity of Rotors

Width of Channels

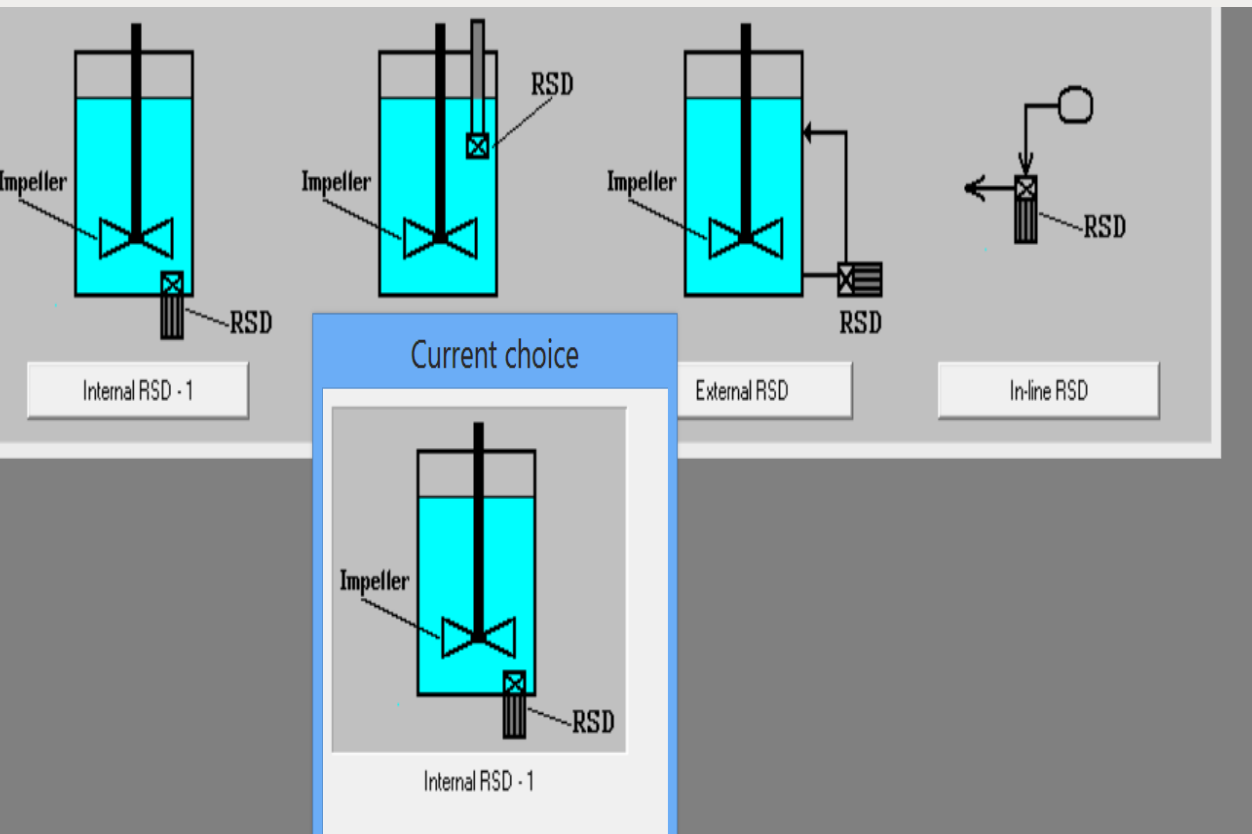
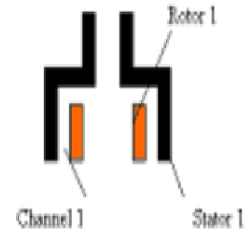
SHEAR RATES

Parameter name	Units	Value
Channel 1	1/sec	16100

For HELP press F1

Mathematical modeling and calculations

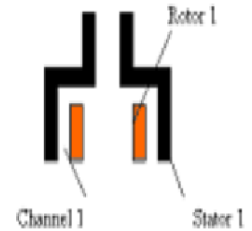
homogenization of media in the tank



Entering
Installation
Scheme

Mathematical modeling and calculations

homogenization of media in the tank



INSTALLATION DATA

Volume of media

Number of impellers

Mixing time *

Visimix program

* Mixing time is defined using one of Visimix programs

Impeller

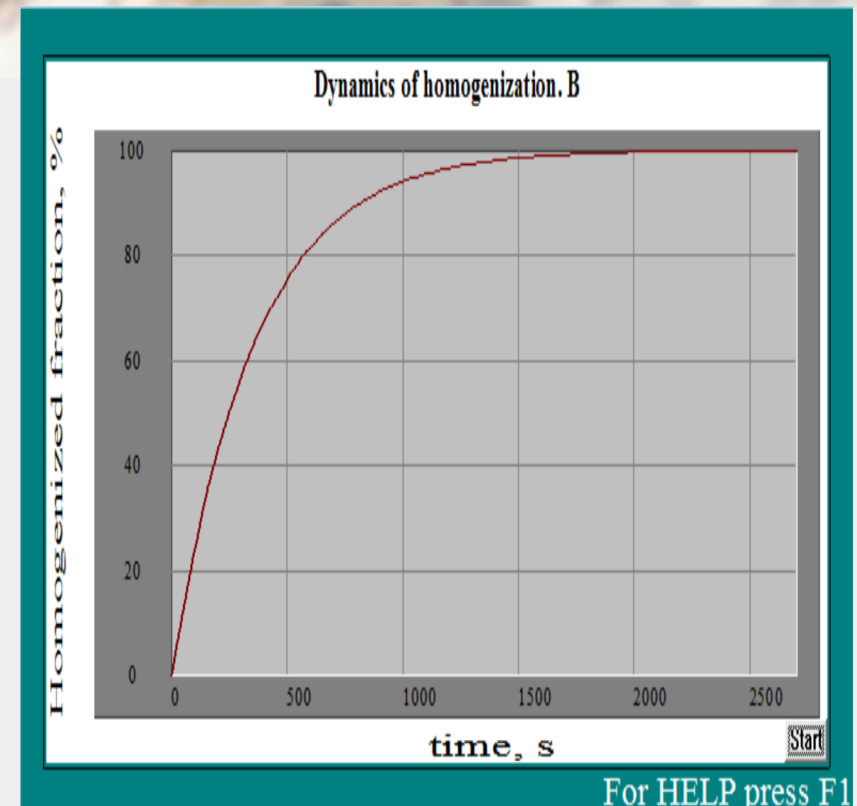
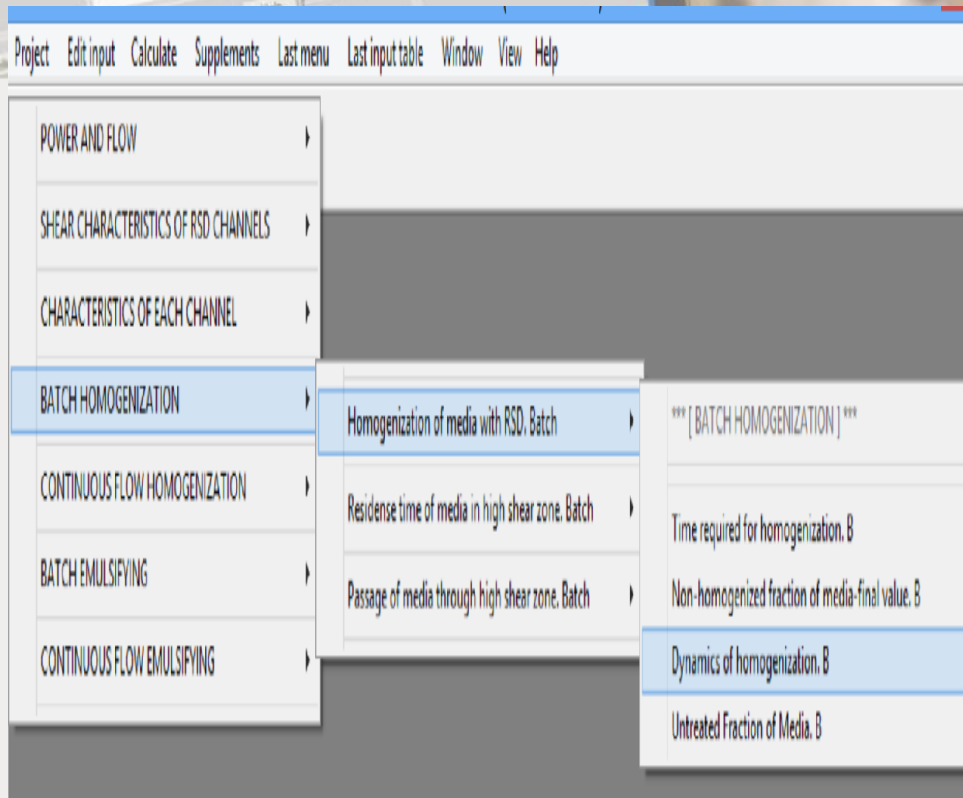
RSD

OK Cancel Change installation scheme Print Help

Entering
mixing tank
data

Mathematical modeling and calculations

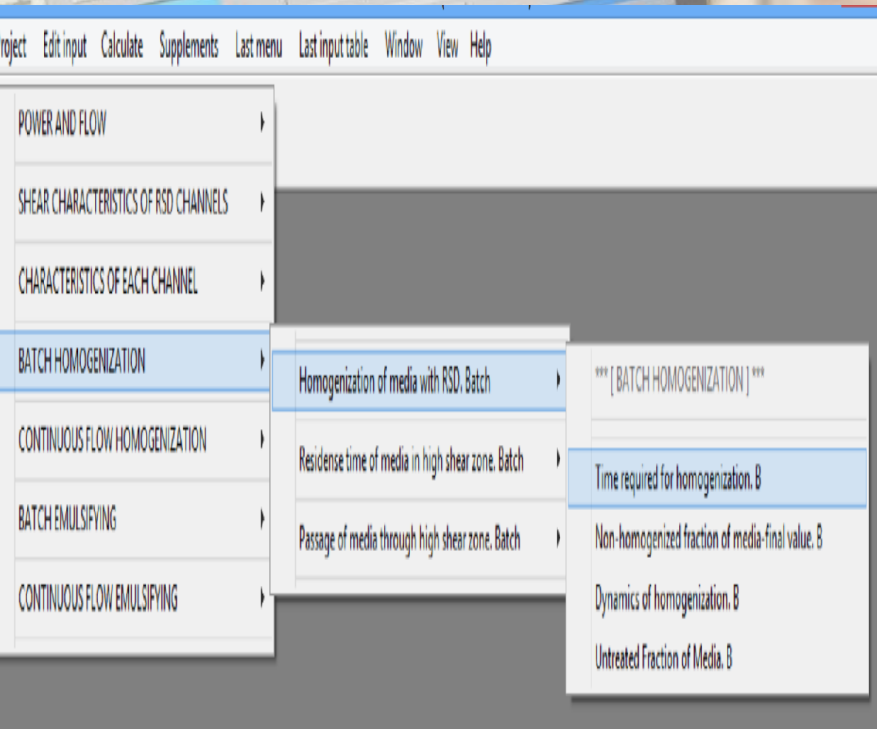
homogenization of media in the tank



The **Homogenized fraction of media** is a part of media that has passed through the homogenizer for one or more times

Mathematical modeling and calculations

Defining necessary batch duration



TIME REQUIRED FOR HOMOGENIZATION. B		
Parameter name	Units	Value
Time for 95% homogenization. B	s	1060
Time for 98% homogenization. B	s	1390
Time for 99% homogenization. B	s	1630
Time for 99.9% homogenization. B	s	2450
Time for 99.99% homogenization. B	s	3270

For HELP press F1

Define process duration corresponding to the required product quality

Mathematical modeling and calculations

Batch Emulsifying

C:\VisiMix\VisiMix RSDE\BS-01.rsd

PROPERTIES OF CONTINUOUS AND DISPERSE LIQUID PHASES.

Continuous phase

Density kg/cub.m

Dynamic viscosity cP

Interfacial surface tension N/m

Disperse phase

Volume fraction

Density kg/cub.m

Dynamic viscosity cP

Index of admixtures

0 - 0.5 - no emulsifier

0.5 - 1 - weak emulsifiers

>1 - strong emulsifiers

OK

Cancel

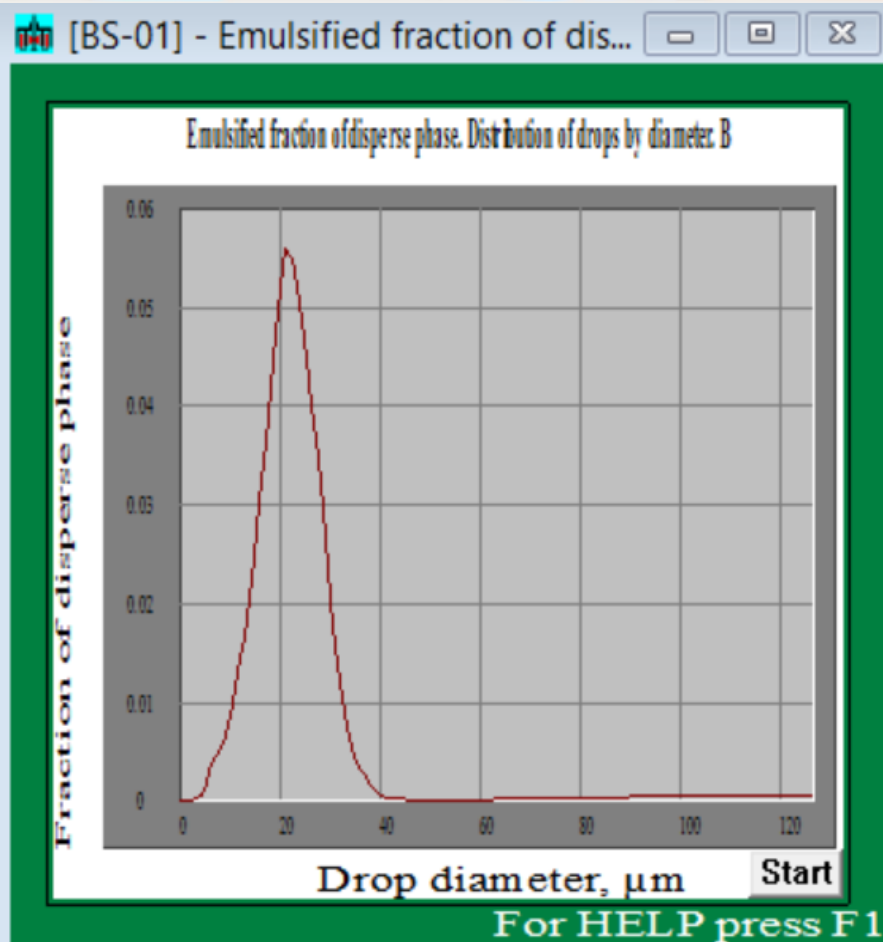
Print

Help

Entering
Characteristics
of Continuous
and Disperse
liquid phases

Mathematical modeling and calculations

Batch Emulsifying

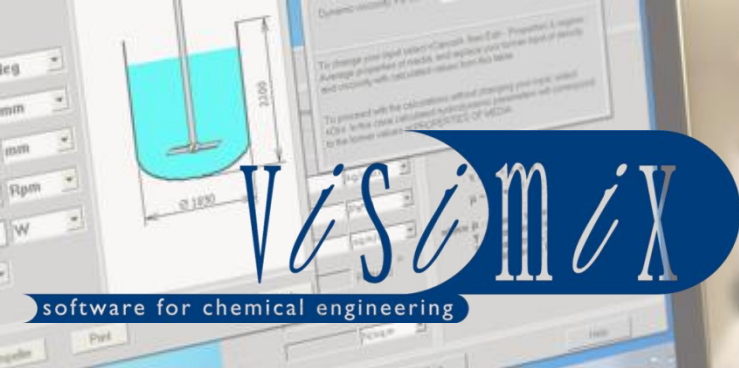


[BS-01] - NON-EMULSIFIED FRACTION OF...

NON-EMULSIFIED FRACTION OF DISPERSE PHASE. B

Emulsifying time	Fraction
1.0 min	68.8 %
2.0 min	47.2 %
3.0 min	32.5 %
4.0 min	22.3 %
5.0 min	15.3 %

For HELP press F1



Thank You

Come and visit us at our stand

A33, Hall 9.1

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