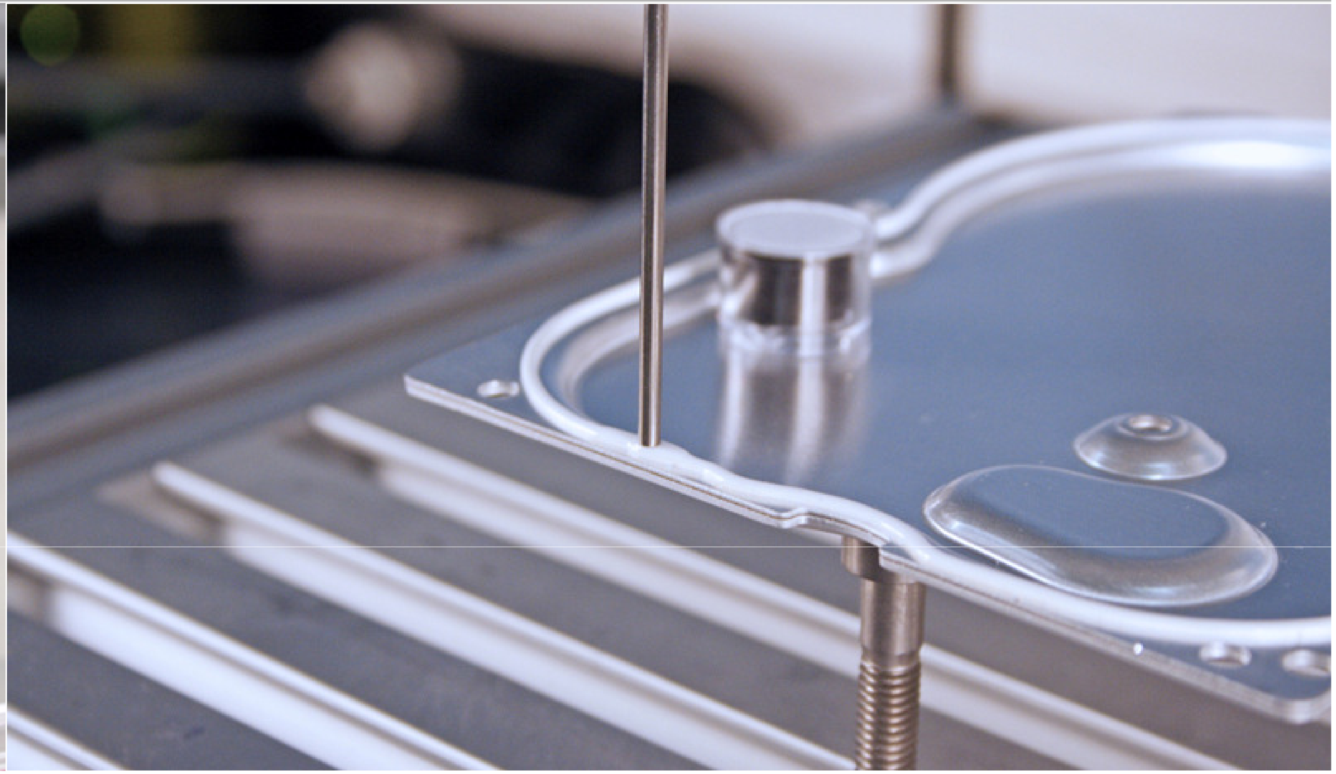


Welcome!

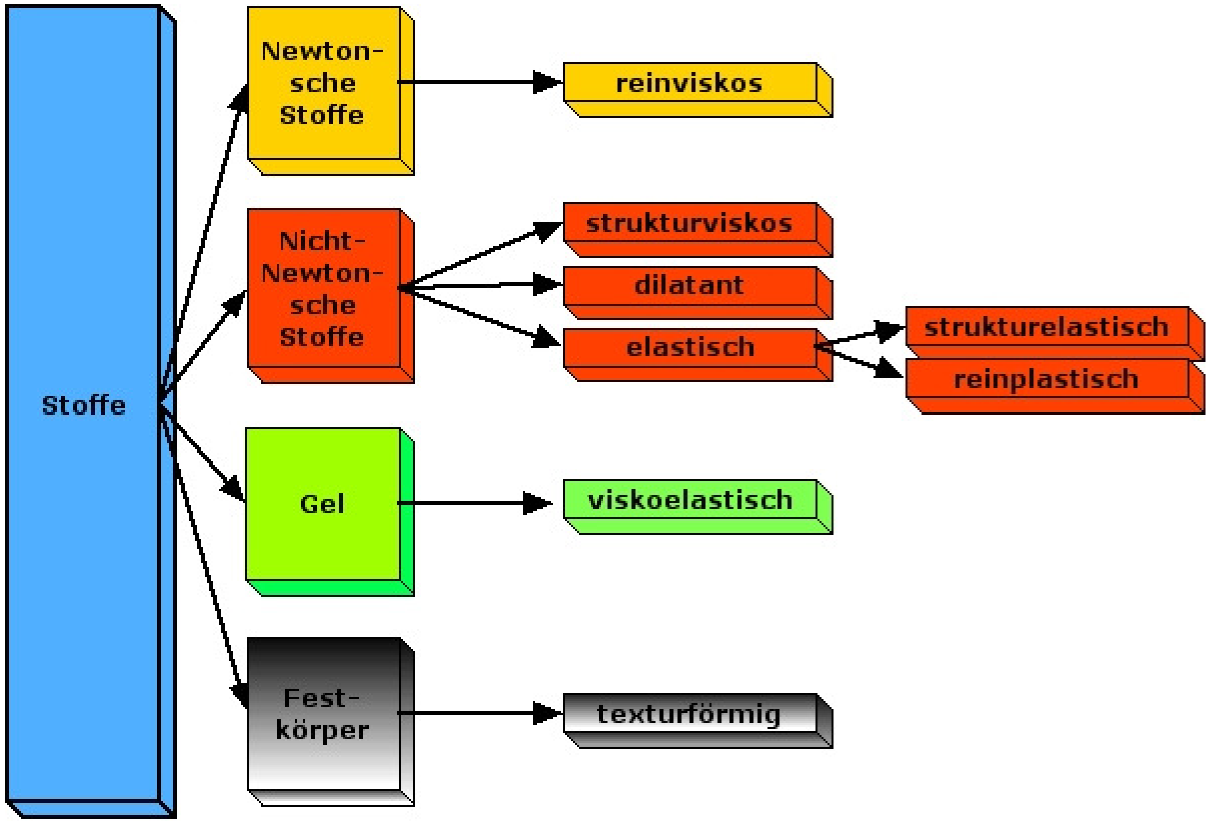
„Bernoulli & Friends“ – Rheolgy basics

Rheologie

Rheology (pronounced /ri□ɒlədʒi/) is the study of the flow of matter: primarily in the liquid state, but also as 'soft solids' or solids under conditions in which they respond with plastic flow rather than deforming elastically in response to an applied force.[1] It applies to substances which have a complex molecular structure, such as muds, sludges, suspensions, polymers and other glass formers (e.g. silicates), as well as many foods and additives, bodily fluids (e.g. blood) and other biological materials.
The flow of these substances cannot be characterized by a single value of viscosity (at a fixed temperature). While the viscosity of liquids normally varies with temperature, it is variations with other factors which are studied in rheology. For example, ketchup can have its viscosity reduced by shaking (or other forms of mechanical agitation) but water cannot. Since Sir Isaac Newton originated the concept of viscosity, the study of variable viscosity liquids is also often called *Non-Newtonian fluid mechanics*.[1]

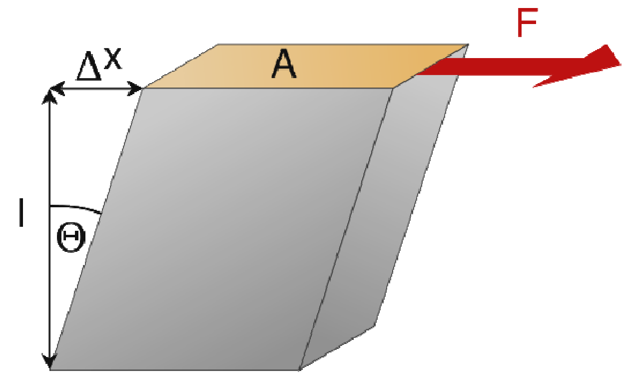
Quelle Wikipedia

Rheology



Stoffe
Newton-sche Stoffe
Nicht-Newton-sche Stoffe
Gel
Fest-körper
reinviskos
strukturviskos
dilatant
elastisch
strukturelastisch
reinplastisch
viskoelastisch
texturförmig

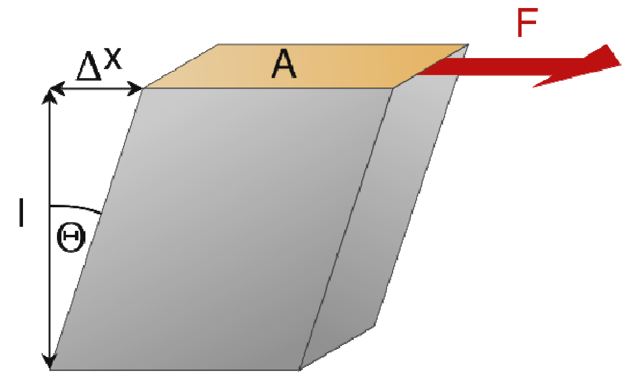
Fluid



„Ideal “ Fluid:

No resistance against lowest possible stress

Fluid



Bingham - Fluid:

All fluids which behave like rigid body at low stresses but flow at higher stress.

Example: Steel, Glass, Ketchup…

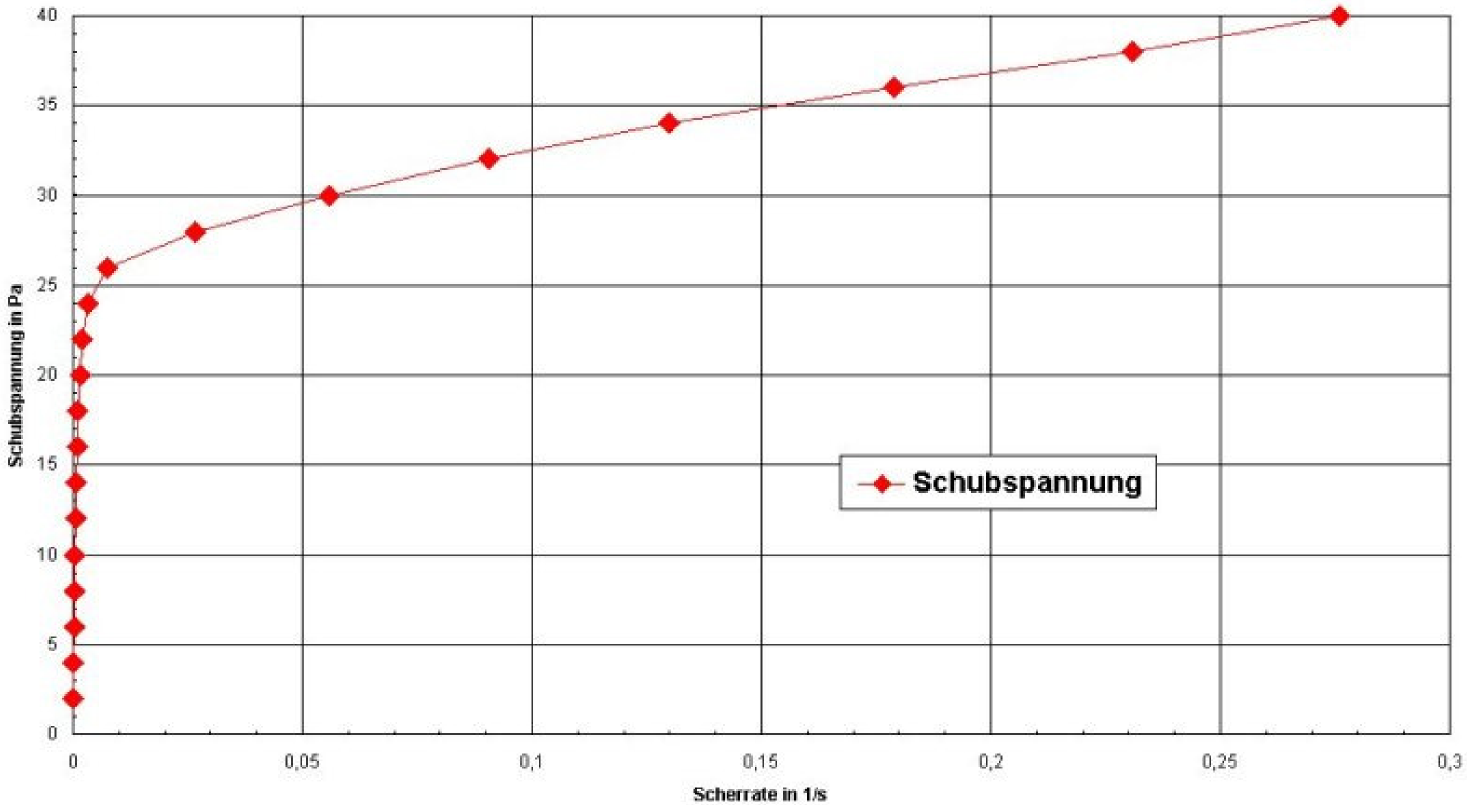
Fluid

- Newtonian Fluids

- Non Newtonian Fluids

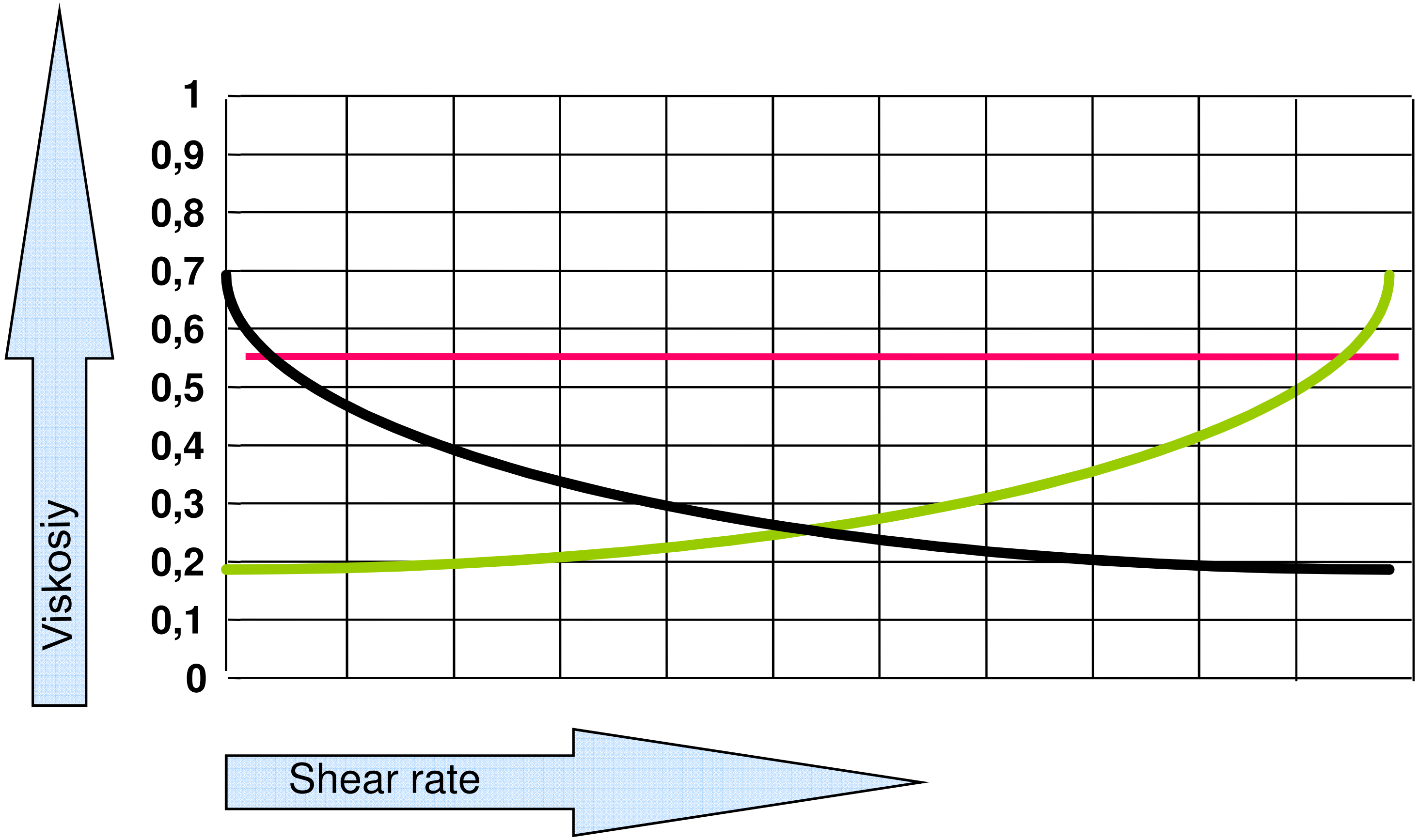
Yield point

Stress limit to be exceeded to make a fluid flow



Viscosity

Newtonian, Thixotropic, Dilatancy(shear thickening)



Fluid mechanics

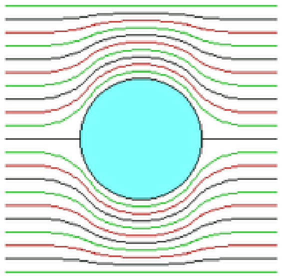
Fluid mechanics is the study of fluids and the forces on them. (Fluids include liquids, gases, and plasmas.) Fluid mechanics can be divided into fluid kinematics, the study of fluid motion, and fluid dynamics, the study of the effect of forces on fluid motion, which can further be divided into fluid statics, the study of fluids at rest, and fluid kinetics, the study of fluids in motion.

Fluid mechanics

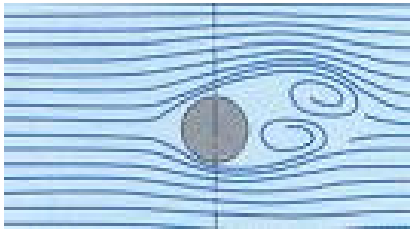
$$\mathrm{Re} = \frac{v \cdot l}{\nu} = \frac{v \cdot l \cdot \rho}{\mu}$$

$Re < Re_{krit}$	Flow laminar
$RE > Re_{krit}$	Flow turbulent

Flow type



Laminar Flow



Turbulent Flow

Laminar Flow = no turbulence in any case

In dispensing technology we have to be in the Laminar Flow area

Fluid mechanics

Reynoldszahl: $\mathrm{Re} = \frac{v \cdot l}{\nu} = \frac{v \cdot l \cdot \rho}{\mu}$

$$\tau = \eta \frac{dv}{dy} + \tau_0$$

$$\rho \frac{v^2}{2} + p = \text{const.}$$

$$\dot{V} = \frac{dV}{dt} = \frac{\pi r^4}{8\eta} \frac{\Delta p}{l} = \frac{\pi r^4}{8\eta} \frac{\partial p}{\partial z}$$

$$\dot{\gamma} = \nabla \vec{v} = \begin{pmatrix} \frac{\partial v_x}{\partial x} & \frac{\partial v_x}{\partial y} & \frac{\partial v_x}{\partial z} \\ \frac{\partial v_y}{\partial x} & \frac{\partial v_y}{\partial y} & \frac{\partial v_y}{\partial z} \\ \frac{\partial v_z}{\partial x} & \frac{\partial v_z}{\partial y} & \frac{\partial v_z}{\partial z} \end{pmatrix}$$

Hagen-Poiseuille: $\Delta p = \frac{128 \cdot Q \cdot \eta \cdot l}{\pi \cdot d^4}$

Newtonsches Fluid: $\tau = \eta \frac{\mathrm{d}u}{\mathrm{d}y}$

kritische Reynoldszahl: $\mathrm{Re}_{\mathrm{krit}} = \frac{v_{\mathrm{m}} \cdot d}{\nu}$

Fluid mechanics: pressure loss

Hagen-Poiseuille: $$\Delta p = \frac{128 \cdot Q \cdot \eta \cdot l}{\pi \cdot d^4}$$

Pressure loss at laminar flow

Q: flow rate in m^3/s
η: dynviscosity in Pa*s
l: length of tube in m
d: diam of tube in m

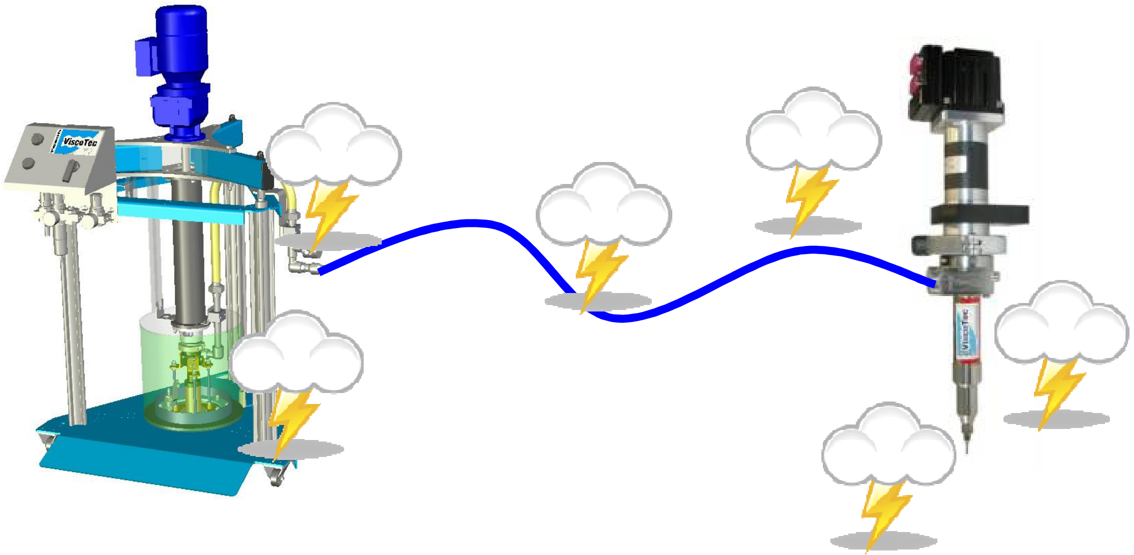
Hagen-Poiseuille: $$\Delta p = \frac{128 \cdot Q \cdot \eta \cdot l}{\pi \cdot d^4}$$

Q: flow rate in m^3/s
η: dyn viscosity in Pa*s
l: length of tube in m
d: diam of tube in m

- Flow stream is linear
- Viscosity is linear
- Length is linear

DIAMETER IS TO THE POWER OF 4 IN THE FORMULA!!!!

Auswirkung an der Dosieranlage



This is influencing many places in our system.

-Hose
-Pump inlet
-Statorsize
-Nozzle
-……

How to choose right:

Example:
Customer x wants to make glass bonding:

Dosing nozzle must have 1.6 mm outer diameter due to tech reasons.
Needed Flow speed: 120 ml in 10 min
Dispensing nozzle needed = 100 mm
Viskosity DELO Photobond 50.000 mPas @ 20℃

Calculation

http://www.druckverlust.de/Online-Rechner/index.html

Rechenbeispiel

Druckverlust Online-Rechner

Berechnungsausgabe

Fördermedium:	Wasser 20 °C / flüssig
Volumenstrom:	0,012 l/min
Dichte:	998,206 kg/m³
Dynamische Viskosität:	50000 mPa s
Rohrleitungselement:	Kreisrohr
Elementabmessungen:	Rohrdurchmesser D: 1 mm
	Rohrlänge L: 0,1 m
Strömungsgeschwindigkeit:	0,25 m/s
Reynolds-Zahl:	0
Strömungsgeschw.2:	-
Reynolds-Zahl 2:	-
Strömungsform:	laminar
Rohrrauhigkeit:	0 mm
Rohrreibungszahl:	12588,96
Zeta-Wert:	1258895,52
Zeta-Wert abzw.Rohr:	-
Druckv. abzw.Rohr:	-
Druckverlust:	407436,65 mbar
	407,44 bar

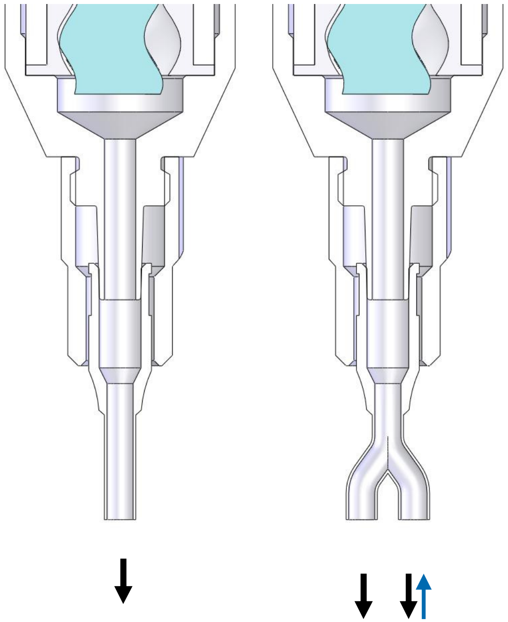
Druckverlust Online-Rechner

Berechnungsausgabe

Fördermedium:	Wasser 20 °C / flüssig
Volumenstrom:	0,012 l/min
Dichte:	998,206 kg/m³
Dynamische Viskosität:	50000 mPa s
Rohrleitungselement:	Kreisrohr
Elementabmessungen:	Rohrdurchmesser D: 2 mm
	Rohrlänge L: 0,1 m
Strömungsgeschwindigkeit:	0,06 m/s
Reynolds-Zahl:	0
Strömungsgeschw.2:	-
Reynolds-Zahl 2:	-
Strömungsform:	laminar
Rohrrauhigkeit:	0 mm
Rohrreibungszahl:	25177,91
Zeta-Wert:	1258895,52
Zeta-Wert abzw.Rohr:	-
Druckv. abzw.Rohr:	-
Druckverlust:	25464,79 mbar
	25,46 bar

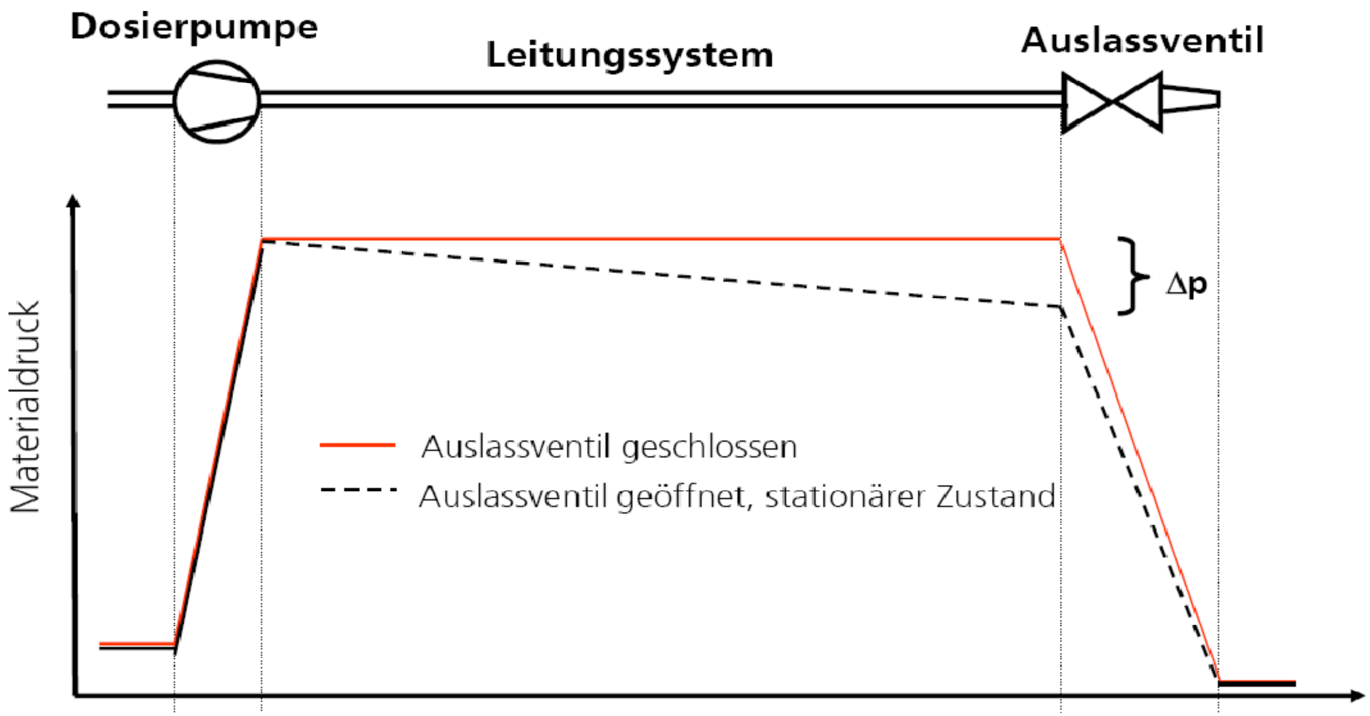
Multi Port Nozzle

FAQ: can I use a multiport nozzle with your dispenser?



Advice of specialist: NO –THANK YOU!!

Pressure behaviour in long lines:

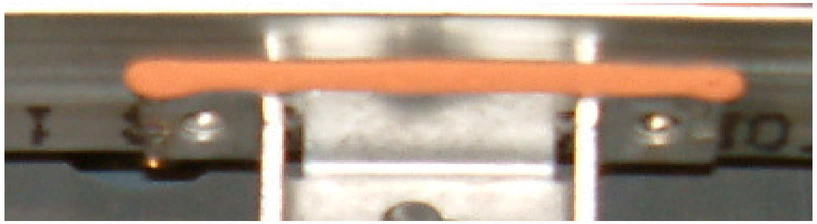


Long lines:

Hose and valve vs. ViscoTec-Dispenser

before:

After optimization:



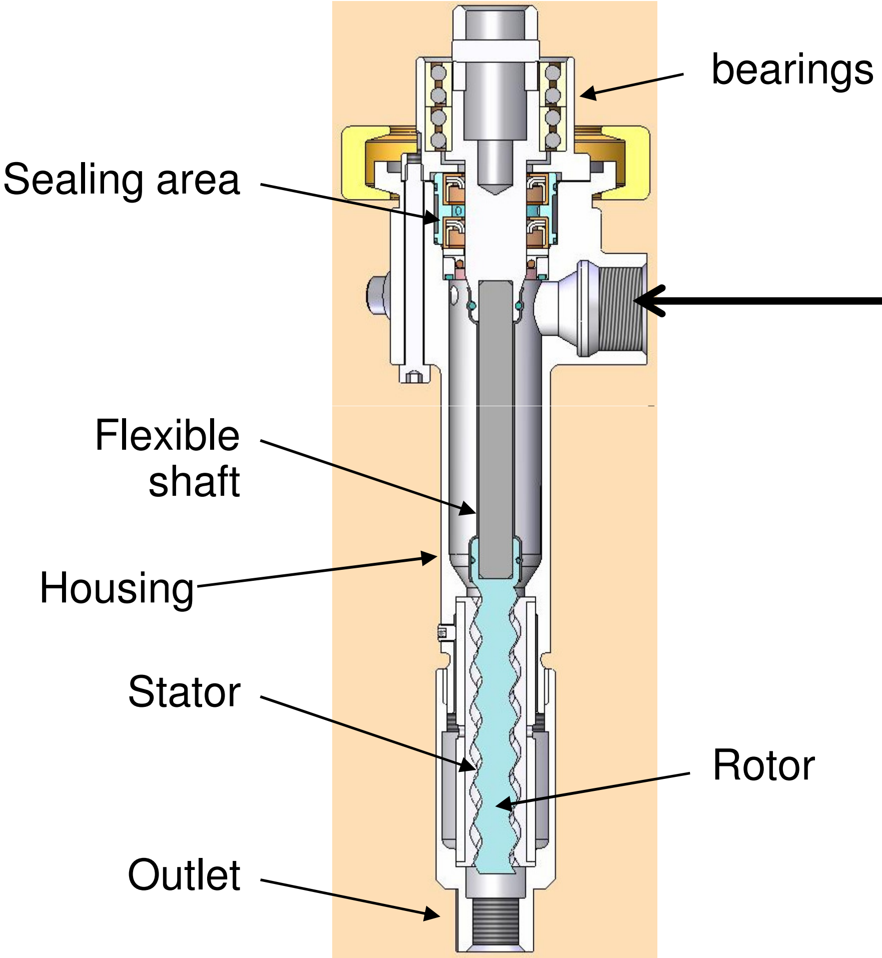
Gas bubbles!

In a mixture of ideal gases, each gas has a **partial pressure** which is the pressure which the gas would have if it alone occupied the volume.[1] The total pressure of a gas mixture is the sum of the partial pressures of each individual gas in the mixture.

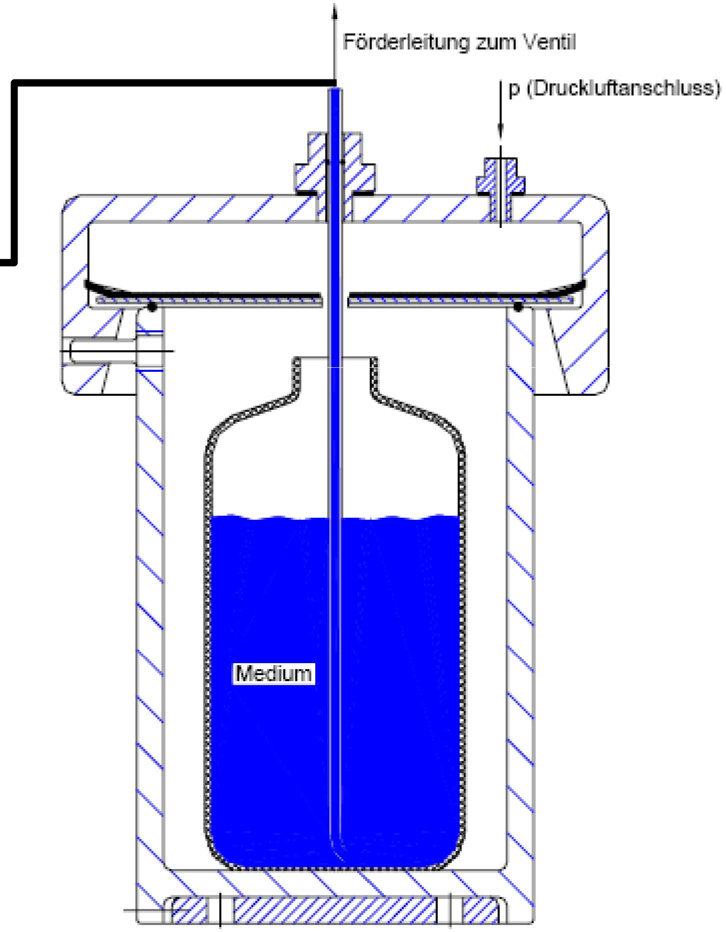
In chemistry, the partial pressure of a gas in a mixture of gases is defined as above. The partial pressure of a gas dissolved in a liquid is the partial pressure of that gas which would be generated in a gas phase in equilibrium with the liquid at the same temperature. The partial pressure of a gas is a measure of thermodynamic activity of the gas's molecules. Gases will always flow from a region of higher partial pressure to one of lower pressure; the larger this difference, the faster the flow. Gases dissolve, diffuse, and react according to their partial pressures, and not necessarily according to their concentrations in a gas mixture

How to create gas bubbles…

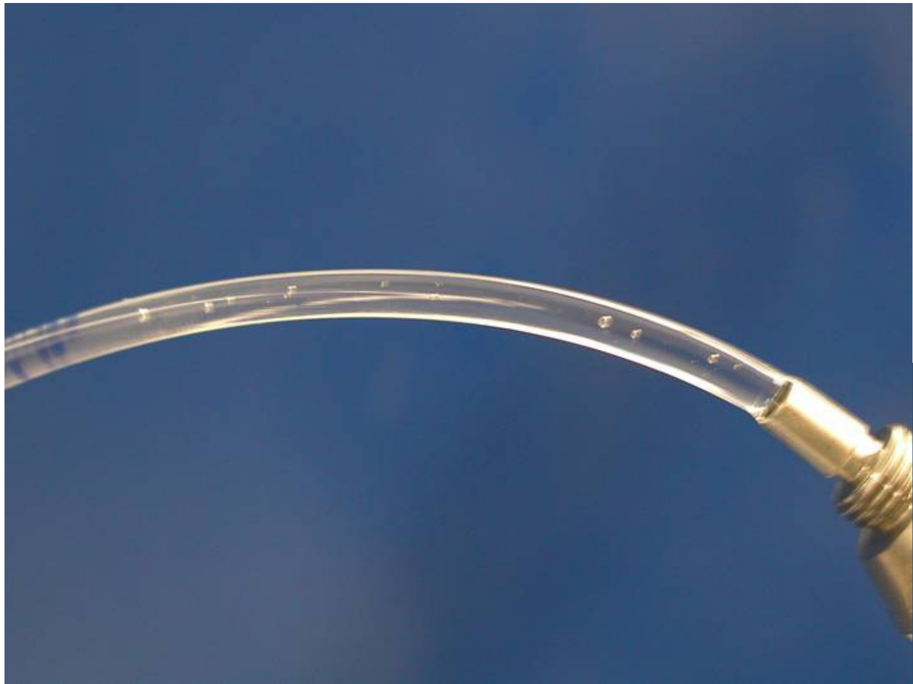
Aufbau / Schnitt



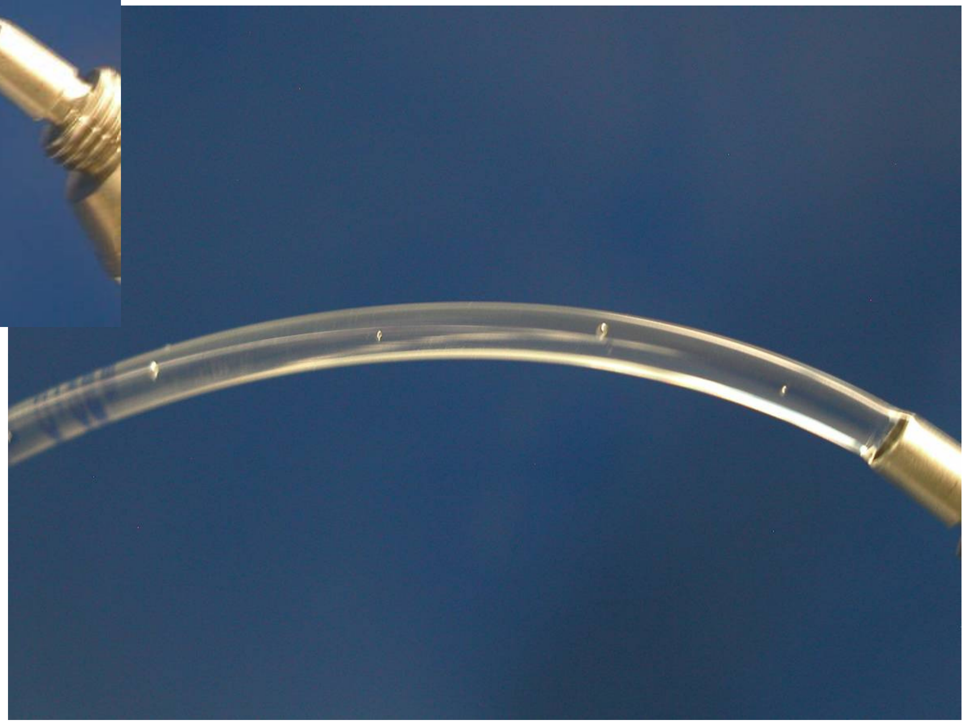
Product supply tank



How to create gas bubbles

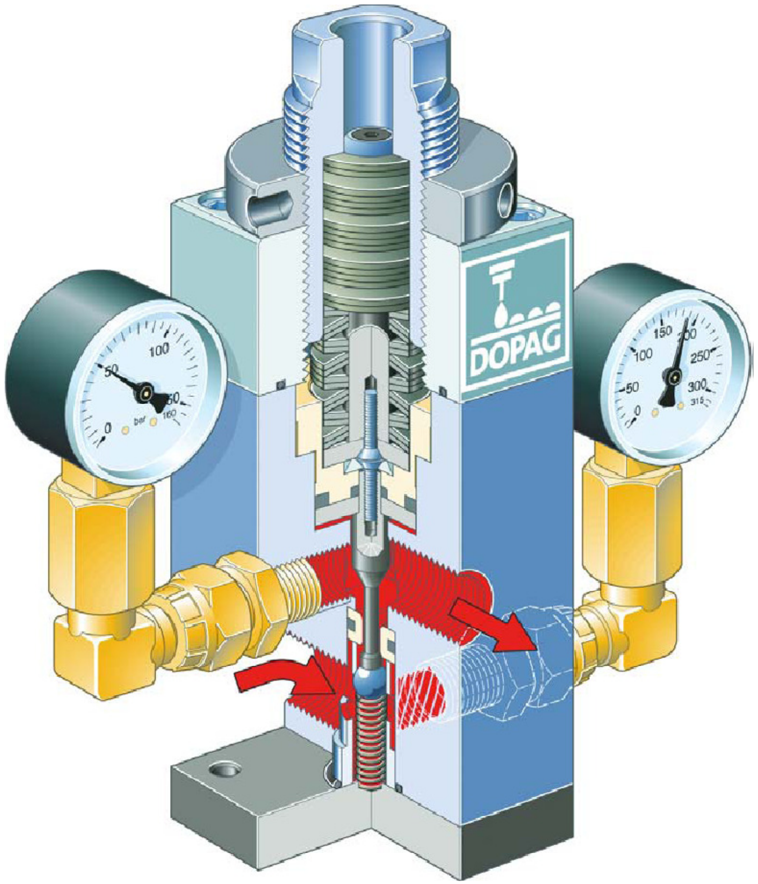


Bilder Kavitation:
Delo Photobond



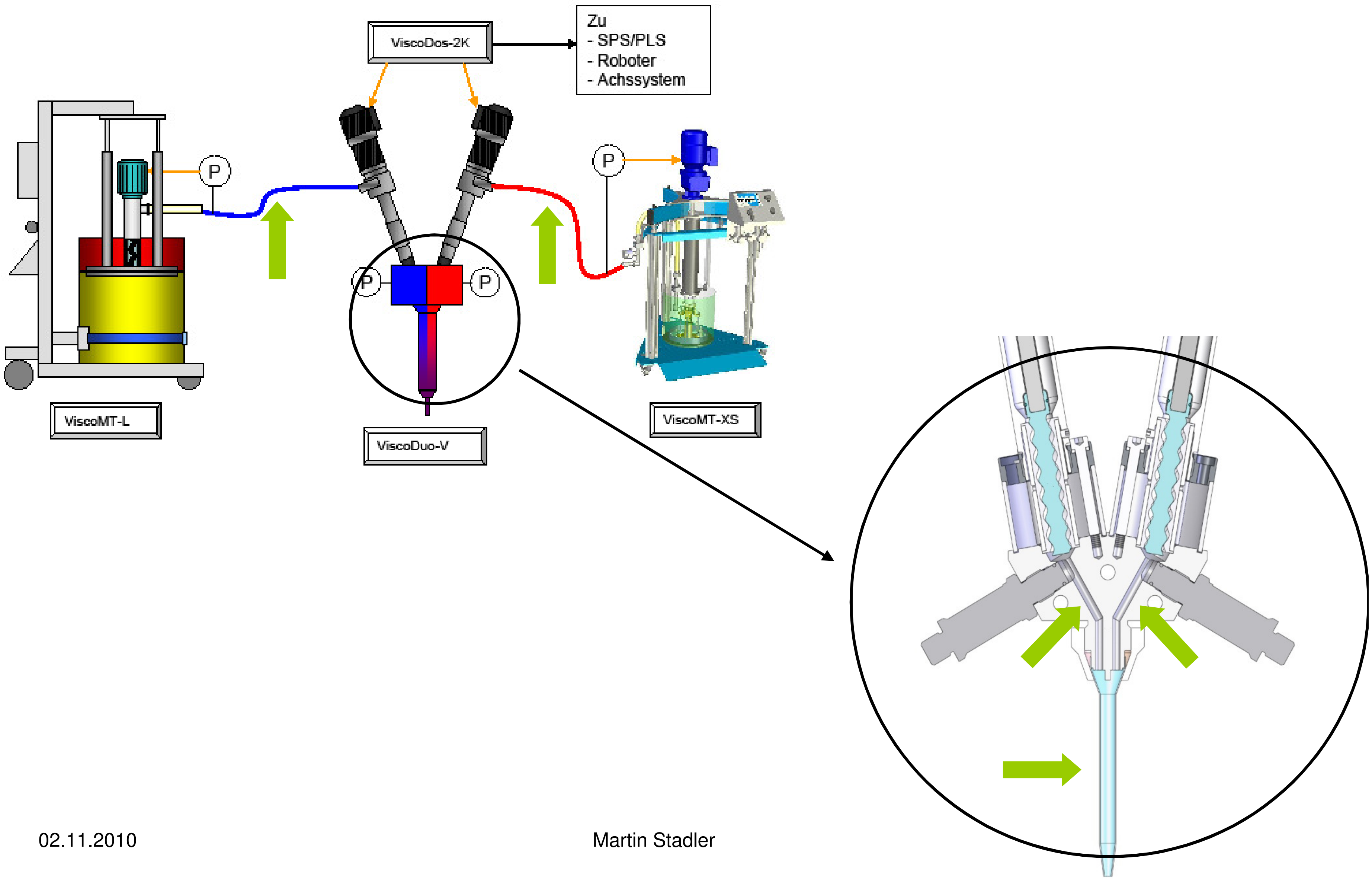
Pressure reducer

Piston equipped pressure reducer



Quelle Dopag Homepage

2K-Systems



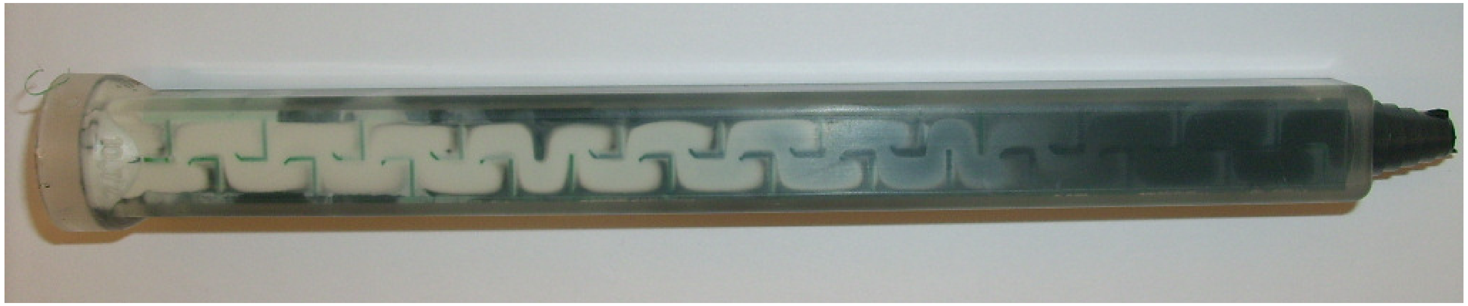
ViscoDos-2K
Zu
- SPS/PLS
- Roboter
- Achssystem
P
P
P
P
ViscoMT-L
ViscoDuo-V
ViscoMT-XS

Aus der Praxis: 2K-Anlage

Schichtenbildung

Anzahl der Wendel	1	2	3	4	5

Anzahl der Schichten	2	4	8	16	32



Calculation 2K

Projekt / Angebots-Nr:	25540	Datum:	02.06.08		
Referenz / Kunde:	xx				

Angaben zu den Komponenten		**Komp. A**		**Komp. B**	
Mischungsverhältnis gem.Datenblatt	Volumen	**4**		**1**	
Dispensertyp		3RD12		3RD8	
Fördervolumen/Umdrehung	ml/U	1,65		0,38	
Dispenser-Drehzahl	U/min	69,0		75,0	
Durchflussmenge	ml/min	113,85		28,50	
Durchflussmenge	l/min	0,114		0,029	
Schlauch-Innendurchmesser	mm	20		16	
Viskosität	mPa s	70.000		60.000	
Fliessgeschwindigkeit im Schlauch	m/s	0,006		0,002	
Schlauchlänge in der Zuführung	m	16,000		16,000	
Spez. Gewicht	kg/m³	1.210		1.430	
zu erwartende Druckdifferenz	bar	5,41		2,83	
Mischverhältnis volumetrisch	-	100	:	25,03	3,99 :1
Mischverhältnis gewogen	-	100	:	29,58	3,38 :1

Notiz:

Viskosität und Austragsleistung des gemischten Materials				
Volumen des gemischten Materials	l/min	0,142		
Volumen des gemischten Materials	ml/min	142,35	2,37	ml/s
Viskosität des gem. Mat.	m Pa s	67.998		
Spez. Gewicht des gem. Mat.	kg/m³	1.254		
Gewicht des gemischten Materials	g/min	178,51	2,98	g/s

Notiz:

Statischer Mischer	**Typ**	ME 10x24		
Menge des gemischten Materials	l/min	0,142	142,35	ml/s
Mischer-Aussendurchmesser	mm	14,0		
Mischrohr-Wanddicke $=(D_{out}-D_{in})/2$	mm	2,0	10,0	Ø Di mm
Mischelement-Dicke	mm	2,0		
Fliessgeschwindigkeit im Mischer	m/s	0,0472		
Fliessgeschwindigkeit im Mischer	mm/s	47,1994		
Länge eines Mischelementes	mm	10		
Anzahl Mischelemente	-	24		
Länge der Mischstrecke	mm	240		
zu erwartende Druckdifferenz	bar	11,55		

Typ:

Zusammenfassung:

Successfull dispensing = keep rheologic influences low!!

- Short, but big hoses
- Largest possible nozzle diameter
- Pump to the part!!!
- Lowest possible pressure loss

Fazit:

Physics cannot be switched off!!!!

Thank you for your attention!!