

RADE



ENGINEERING

Research And Development; Engineering



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Compound development
design of mixing processes
strainer process
gear pumps
screw design
extrusion dies
vulcanisation processes
heating time calculation
Control / simulation of IM
processes

Improving existing processes and plants – planning new plants

Team: RADE + contractors + experts (project-based)

Fit for the future with the mixing mill

What are the requirements for the rubber mixing units of the future?

Which rubber mixing units are used on the market today?

Internal mixer (tangential and intermeshing)
Open mills

Decision based on productivity and quality

automation & throughput

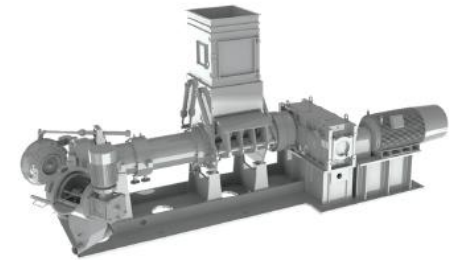
comparing intermeshing mixer with open mill

	internal mixer IM 190E	open mill 84 Zoll
Total volume	203 l	mill perimeter: perimeter x working width x thickness of cover ($2,090 \times 1,900 \times 6 = 23,826 \text{ cm}^3$) rolling bead: working width x diameter x pi ($1,900 \times 200 \times 3.14 = 11,938 \text{ cm}^3$) total: $35.764 \text{ cm}^3 = 35,764 \text{ l}$
Batch weight	ca. 150 – 190 kg filling factor: 0,7, density: 1,05 – 1,30	ca. 55 – 70 kg filling factor: 1,5, density: 1,05 – 1,30
Cycle time	approx. 240 – 420 s	approx. 900 – 1.800 s
Medium throughput	30 kg / min	2,8 kg / min
Manufact. costs	0,15 € / kg (3 employees)	0,60 € / kg (1 employees)

The internal mixer cannot produce a suitable form/shape for further processing!

No internal mixer without suitable downstream equipment:

single screw extruder /1/

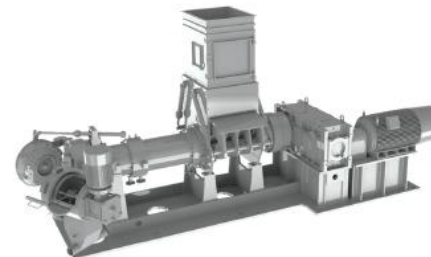


double screw extruder



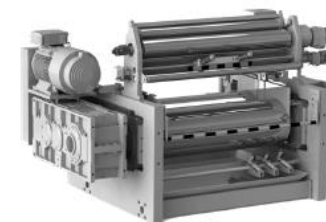
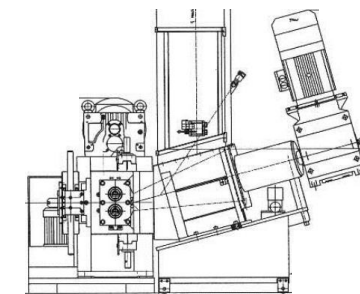
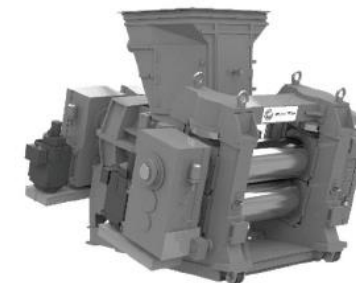
open mill

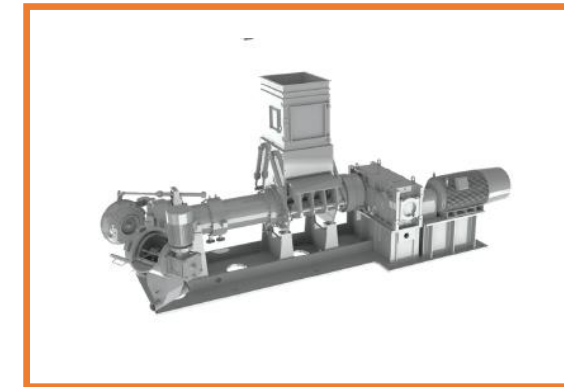
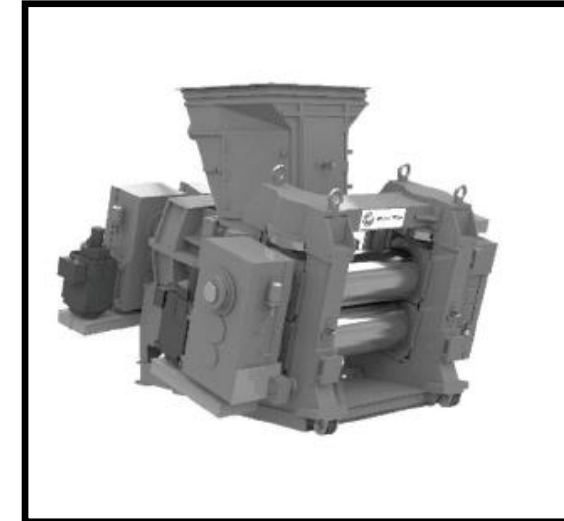
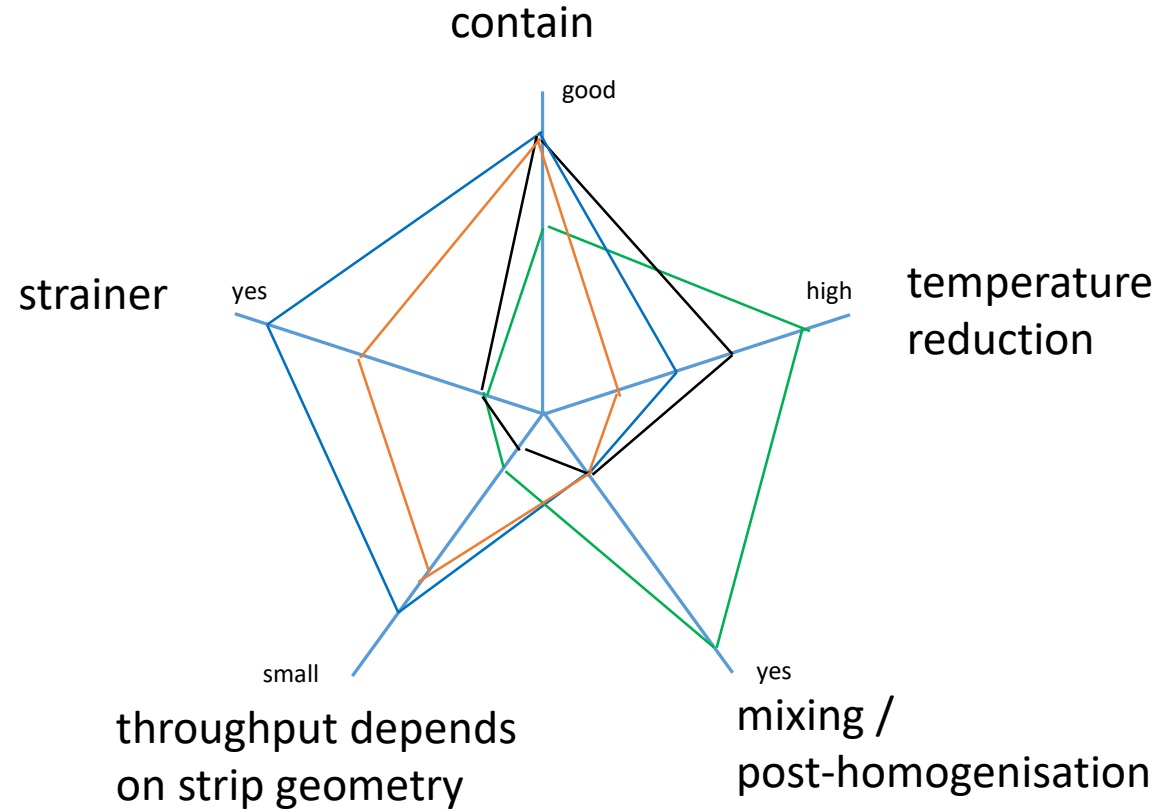
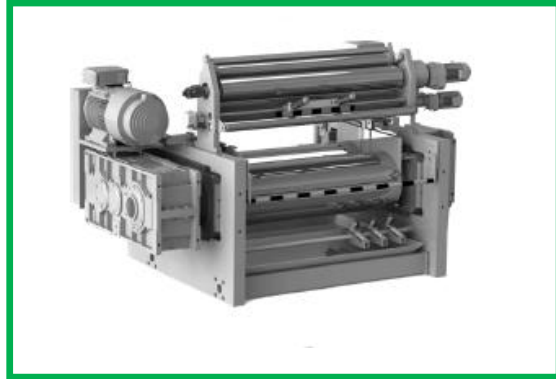
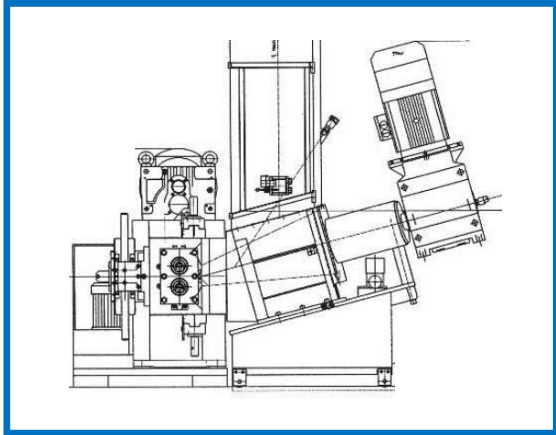




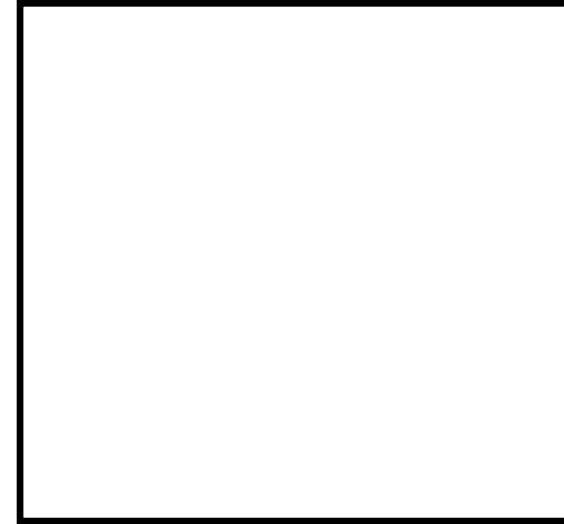
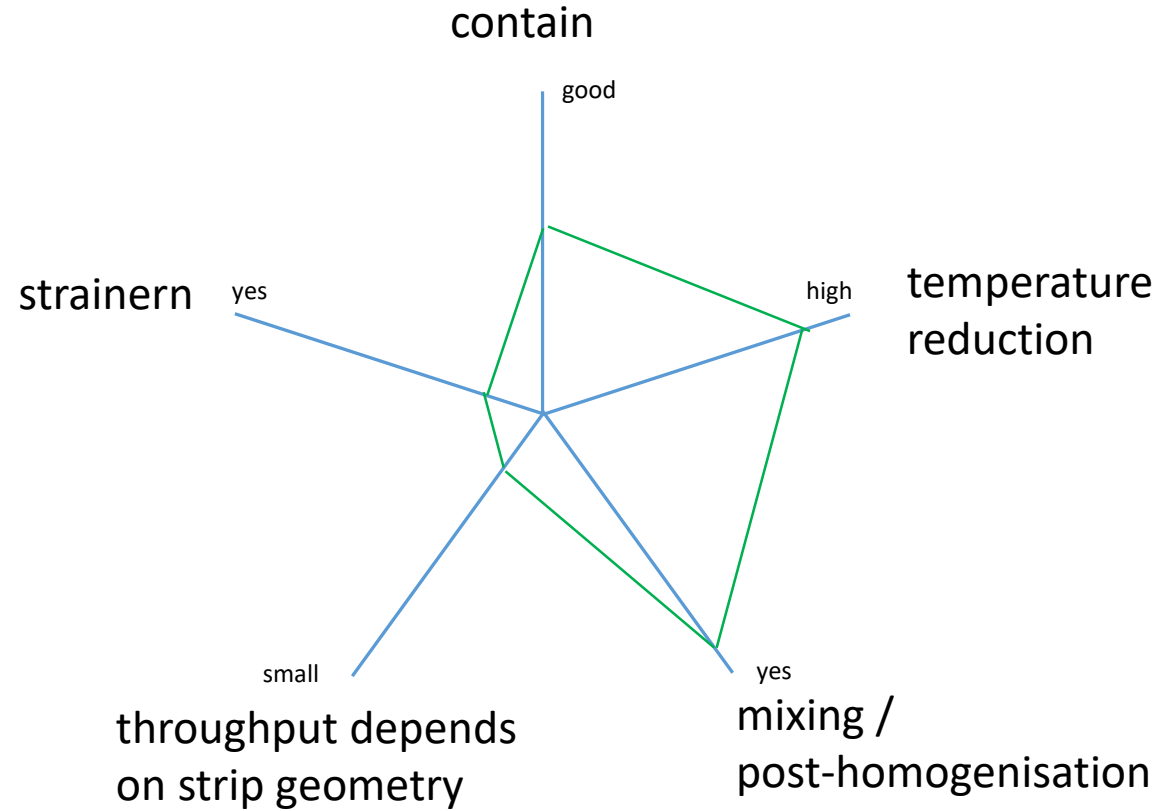
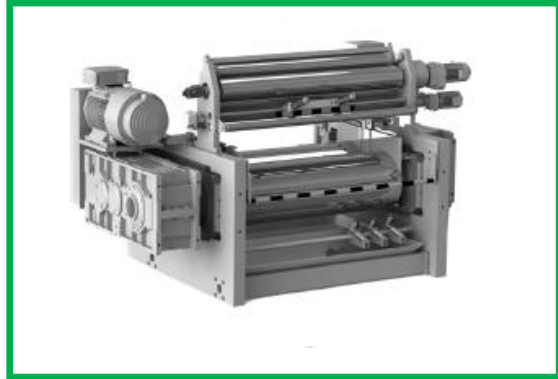
Assessment of the machine concepts on the basis of the following requirements

- containing the shapeless, warm compound
- reducing temperature
- homogenising / final mixing
- production of a suitable shape for further processing **in reference to the throughput**
- **strainer**





Result of the "Mixing Room Workshop" at the DIK in Oct. 2019:

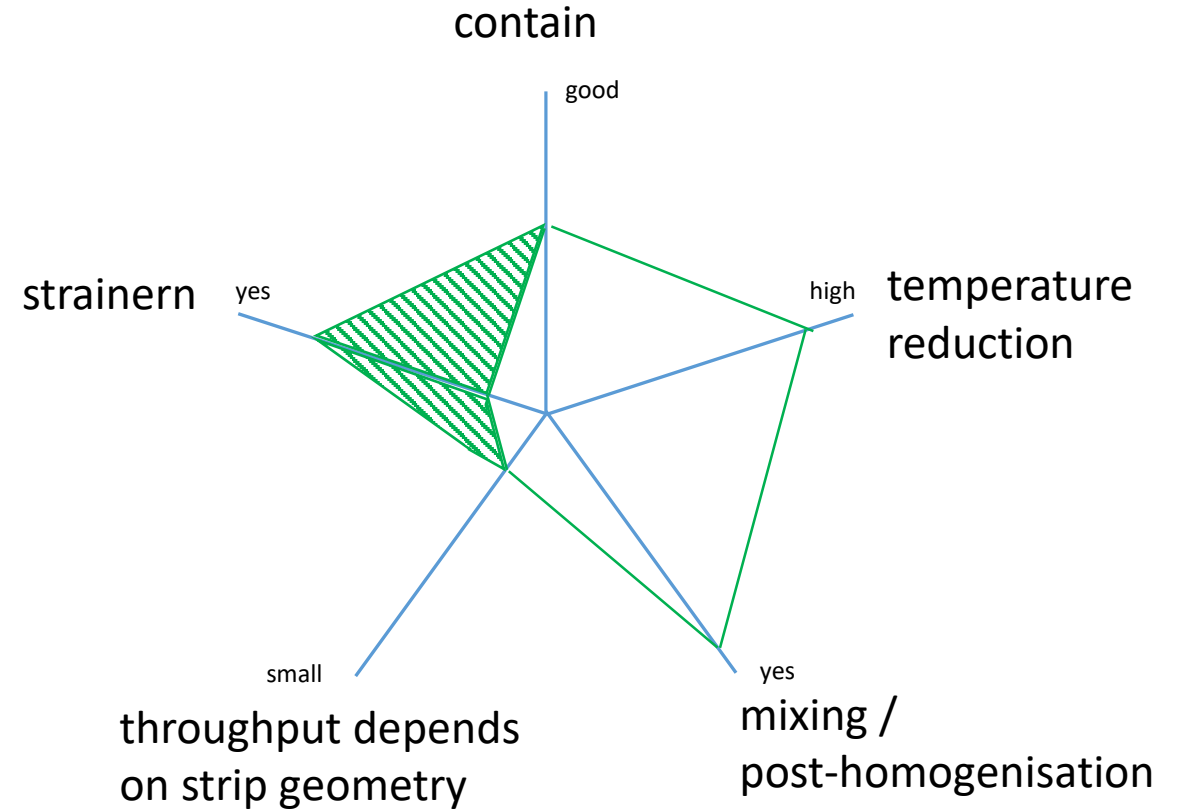


My rating:

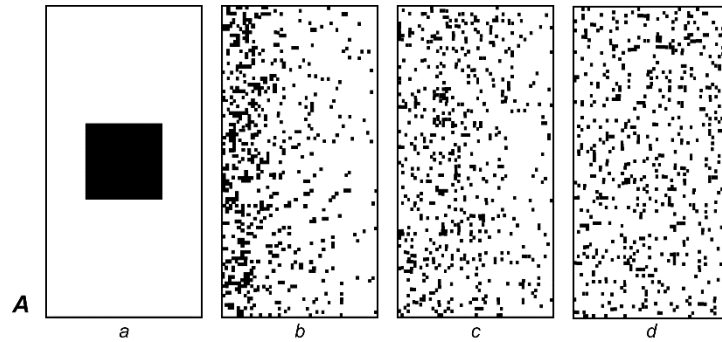
Open mill in refiner form can fulfil the same quality requirements as a strainer.

advantages:

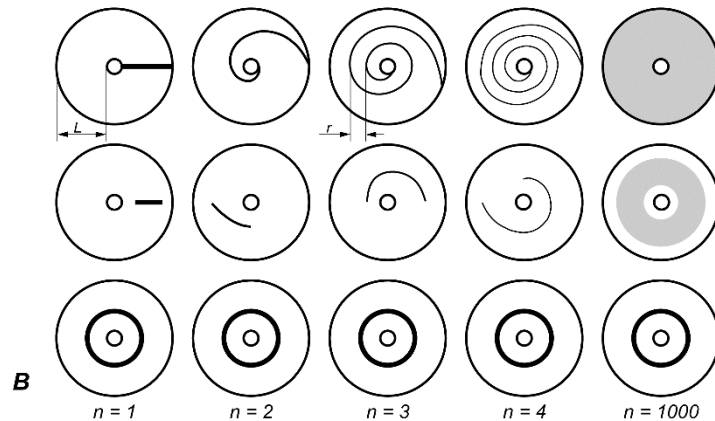
- Lower heat - history
- accuracy of the formulation – undistributed / poorly distributed raw materials are not sieved out, but crushed.



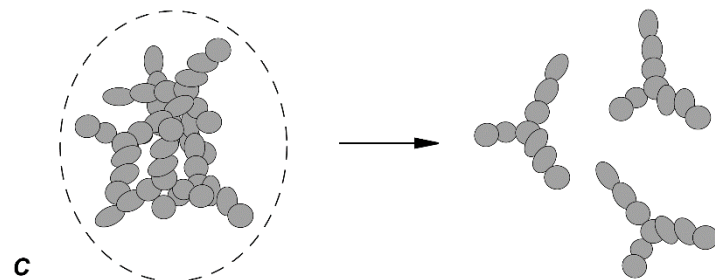
Decision based on productivity and quality



distributive mixing



laminar mixing



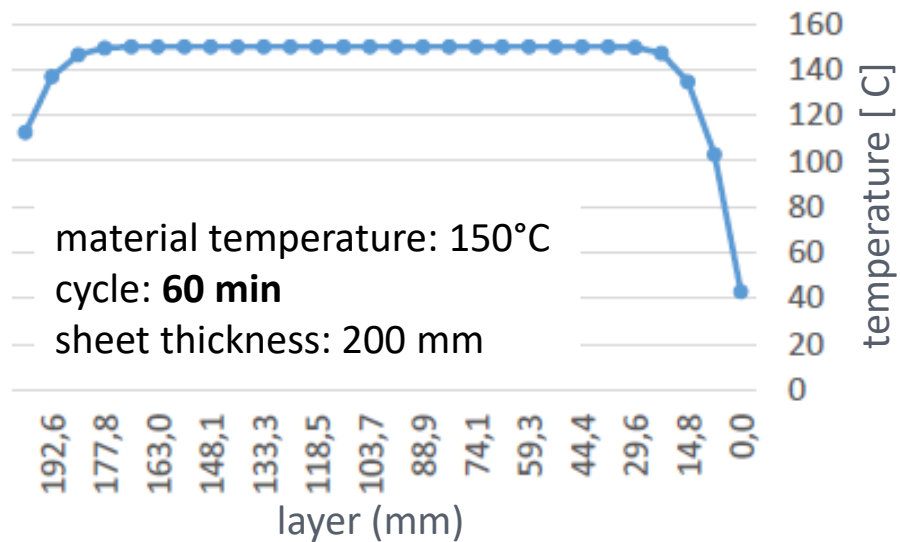
dispersive mixing

The quality of all three different mixing steps depends on the temperature control and shearing of the compound!

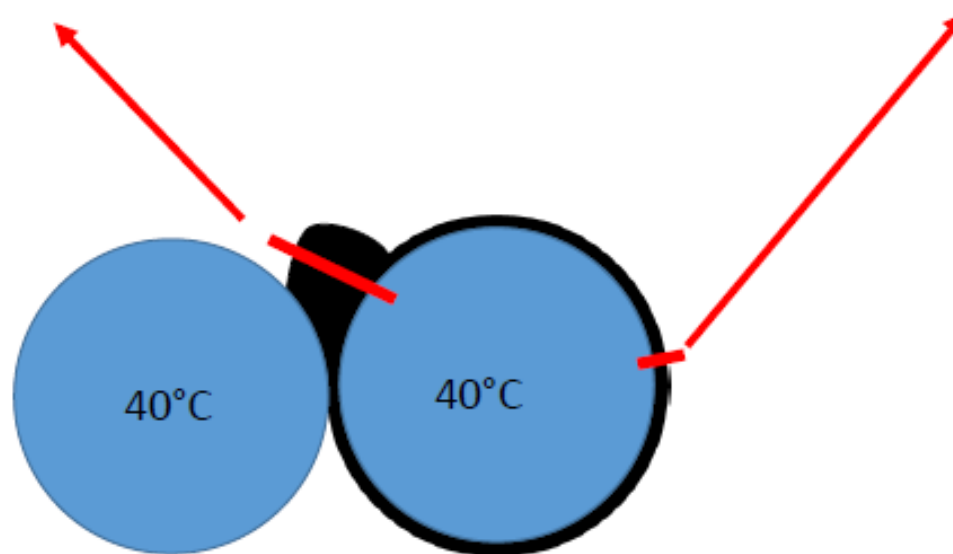
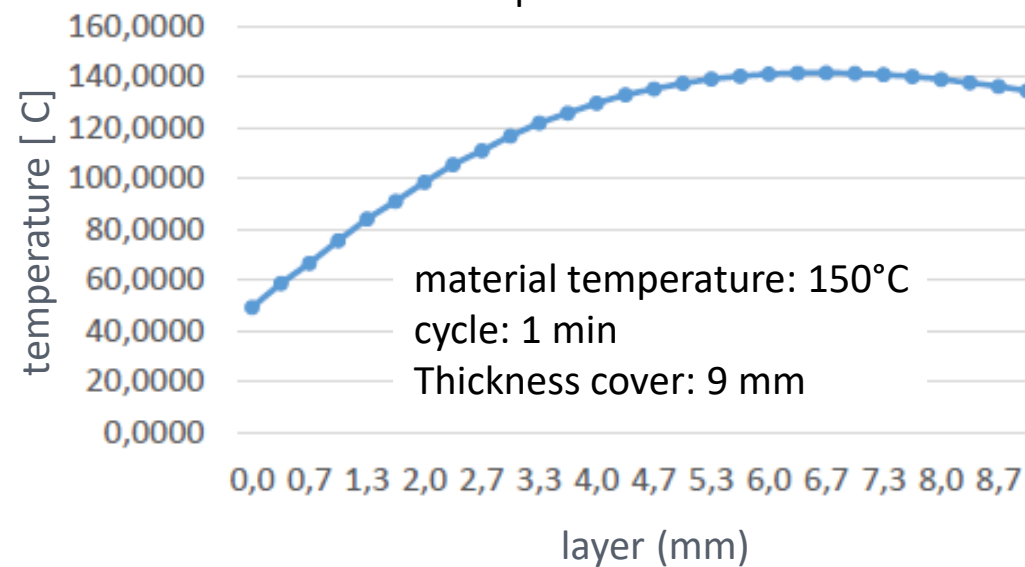
		batch weight	surface	volume	ratio	min. clearance (mm)
		[kg]	A	O	A/O	
		(1,2 kg/l)	[cm ²]	[dm ³]	[1/cm]	
internal mixer	K2A		22357	46	0,49	5,8
	K4		34711	84	0,41	6
	K5		45916	132	0,35	6
	K6		62236	189	0,33	7
	K7		82499	315	0,26	8
open mill	84"	60	44349	50	0,89	0 - 15
	84"	80	44349	67	0,67	0 - 15
	84"	100	44349	83	0,53	0 - 15
	84" + Stockblender	100	69410	83	0,83	0 - 15

The ratio of surface to volume is higher at the open mill by a factor of 2 to 3!

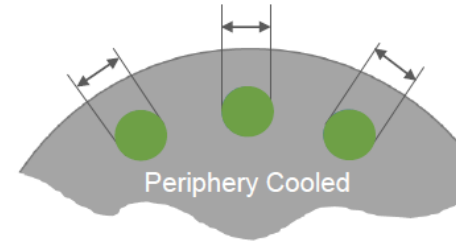
temperature in the rolling bead



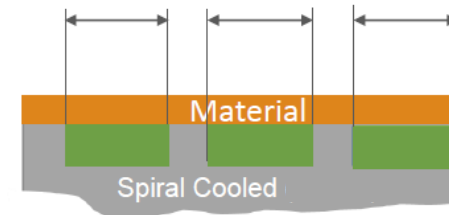
temperature cover



1. hollow roll
2. peripherally drilled roll
3. spiral water flow

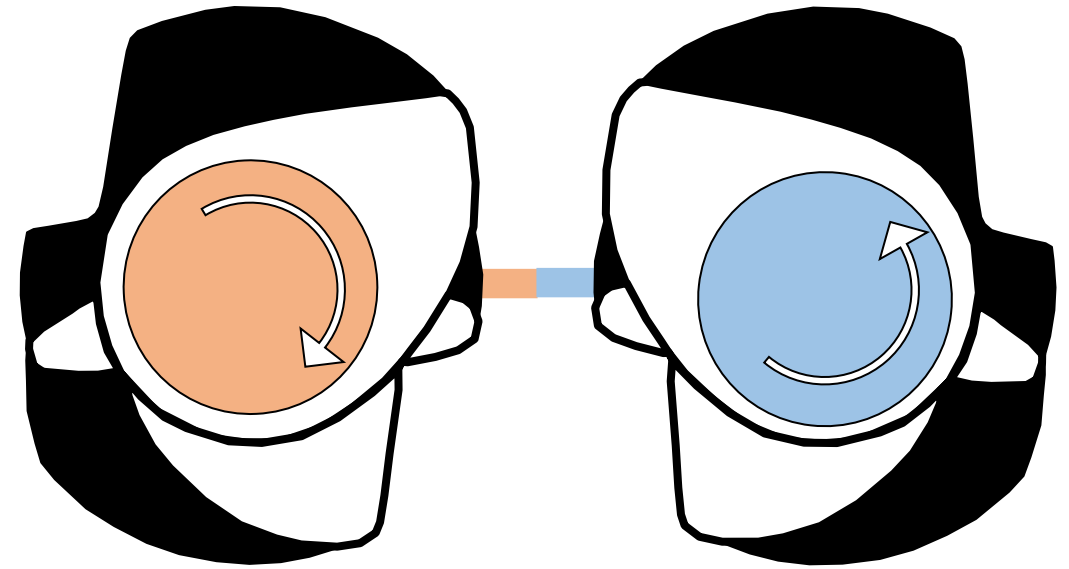
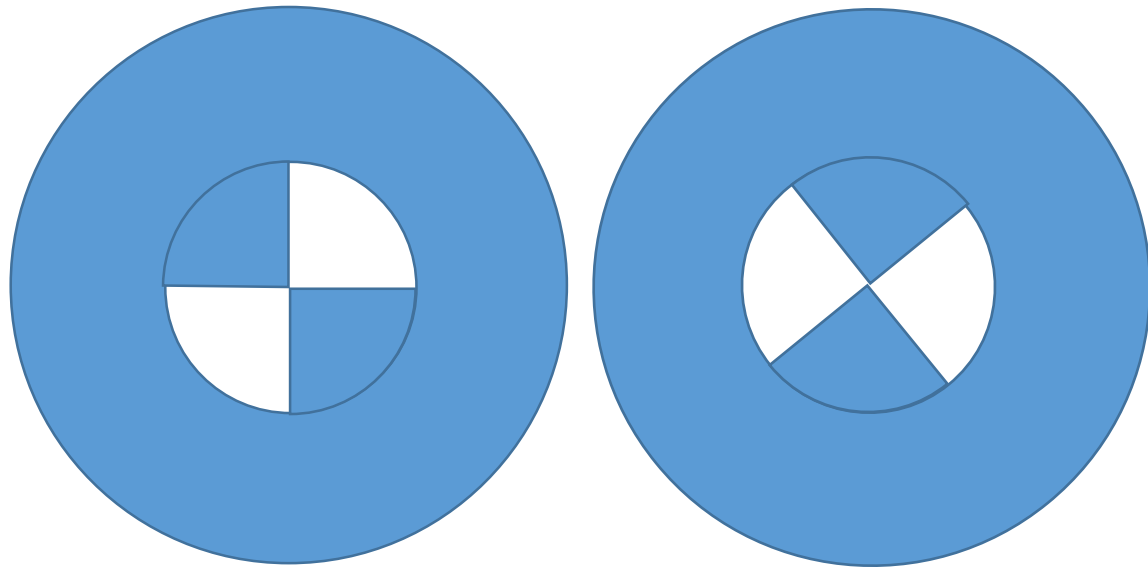


Improvement of the cooling capacity by approx. factor 4

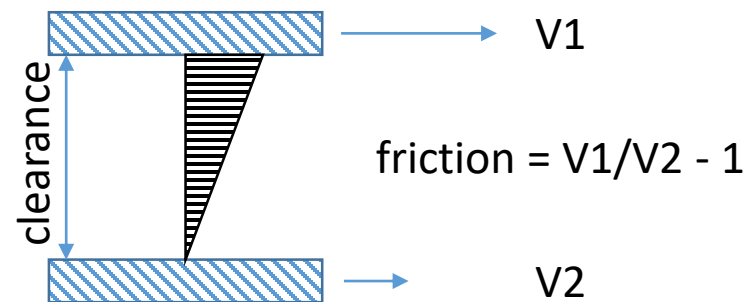


- extremely fast water cooling
- cooling channel very close to roller surface
- excellent temperature distribution in perimeter and axial direction

softer surface - use of no metal knives recommended!

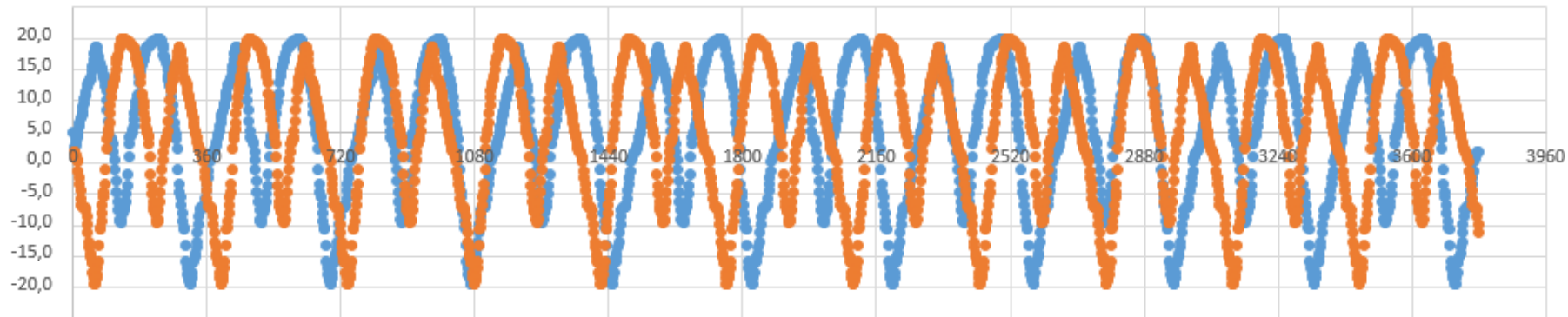
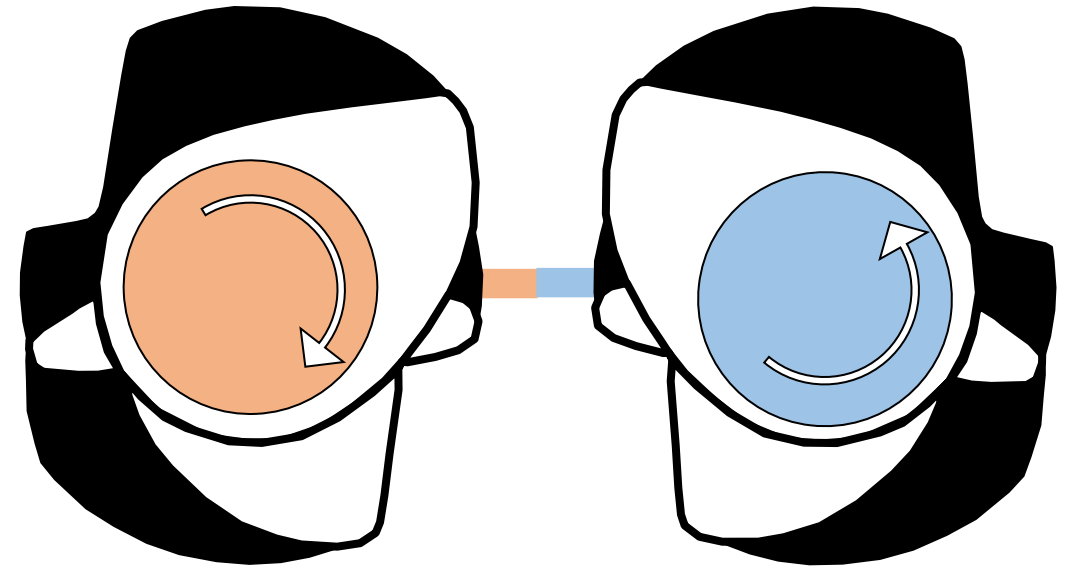


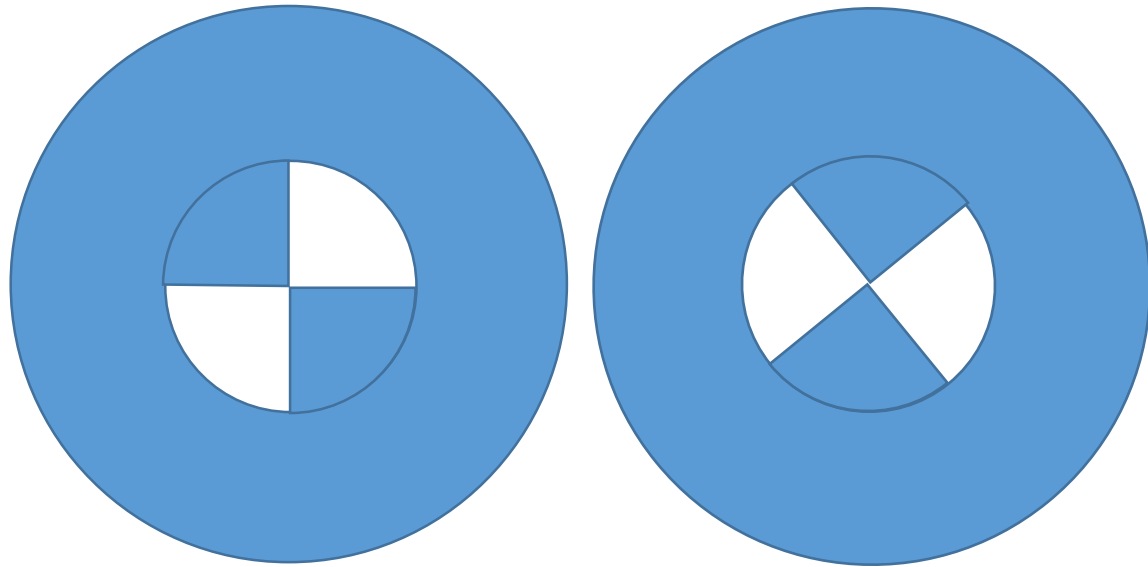
open mill



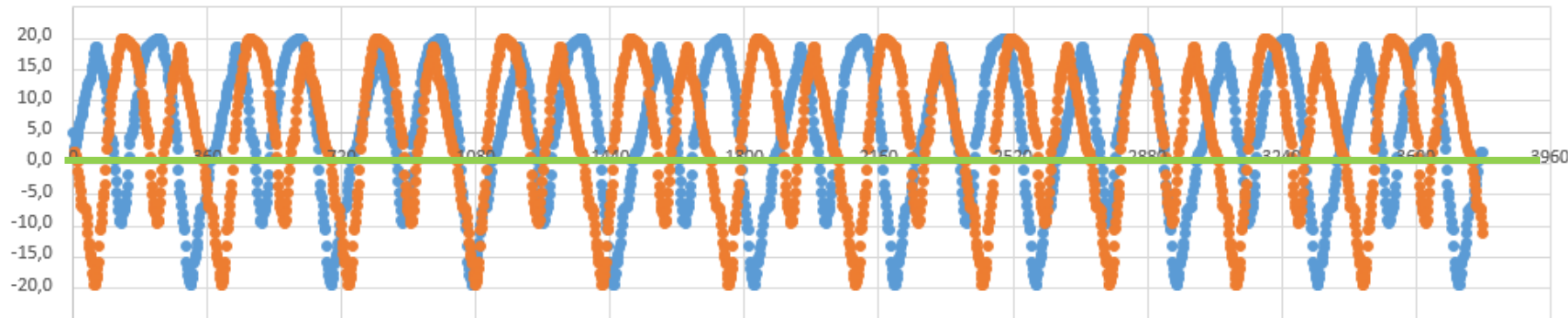
tangential internal mixer

tangential internal mixer



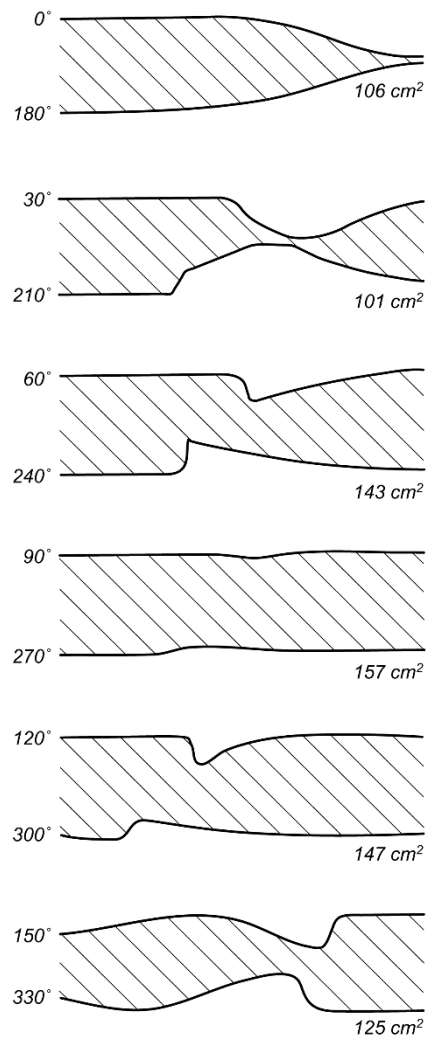


open mill

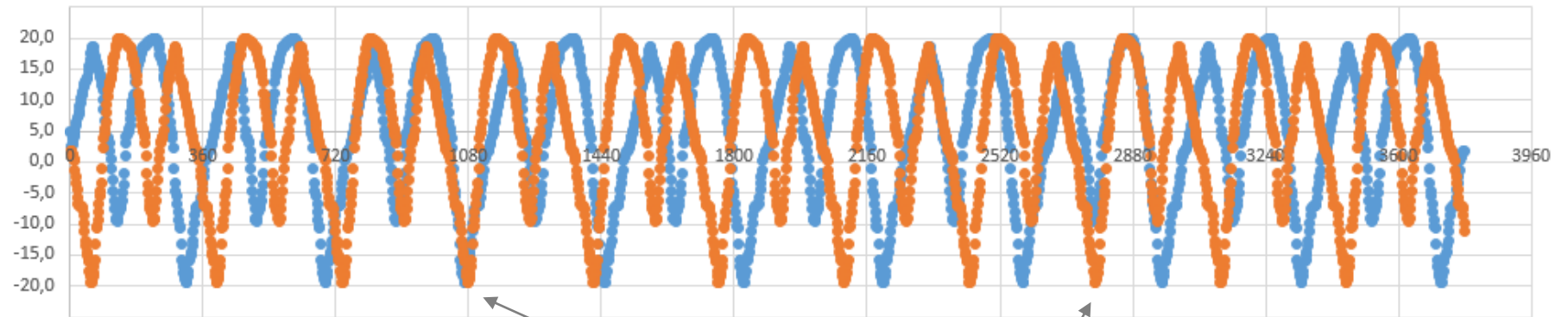


open mill

tangential internal mixer



/5/



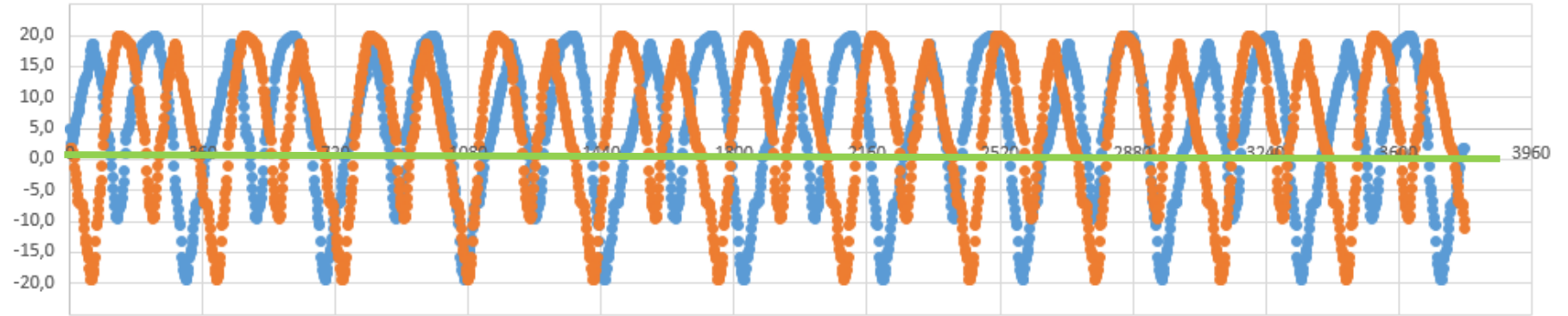
highest shear rate (hot spots)

- clearance dimension is not adjustable
- variations in clearance size lead to hot spots
- friction is usually not adjustable
- shearing can only be affected by the speed of the rotors

Shearing at roll mill

tangential internal mixer

open mill



- Clearance / gap dimension is adjustable
- constant gap dimension above a revolution
- friction is usually adjustable
- shear can be affected by speed, friction and gap size

Summary

temperature control

automation

The open mill is ready for the future, as it can be adjusted very flexible to the required needs!

shearing

batch weight

The one who always does
what he already can do,
will always be
what he already is! (Henry Ford)

list of references:

- | | | |
|-----|---------------|---|
| /1/ | M. Hesse | Präsentation Mischraumseminar 2016 |
| /2/ | F. Eweler | Präsentation Mischraumseminar 2016 |
| /3/ | J. Schlegel | Firmenunterlagen MaTech |
| /4/ | S. Klar | Diplomarbeit 1996 |
| /5/ | F. Röthemeyer | Kautschuktechnologie 2013 |
| /6/ | J. Jennissen | Dem Innenmischer nachfolgende Maschinenkonzepte – Stockblender für größere Mischungsmengen; DIK Mischraumseminar 2019 |
| /7/ | J. Jennissen | High efficient mixing by distinct utilisation of Friction, Speed and Rotor Positioning within the mixing process; TireTech 2018 |