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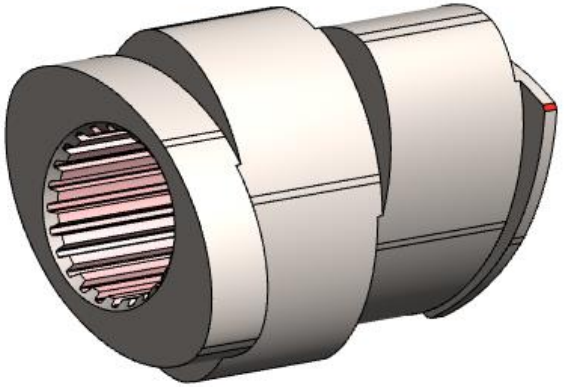
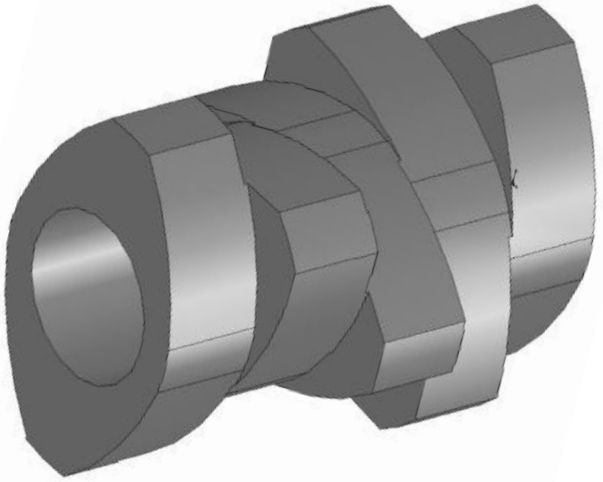
NEW INVOLUTE EXTRUDER SCREW ELEMENTS FOR IMPROVED PRODUCTIVITY AND QUALITY





Paul Andersen, Ph.D
Process Technology Consultant
Coperion Corporation, Sewell, NJ

Frank Lechner, Dipl. Ing.
Head of Process Technology
Coperion GmbH, Stuttgart

Involute Screw Elements: Improved Productivity and Quality

Background

Twin-screw compounding system: Overview

Involute Elements: Design basis

Involute Elements: Impact

- Productivity
- Quality

Summary

Involute Screw Elements: Improved Productivity and Quality

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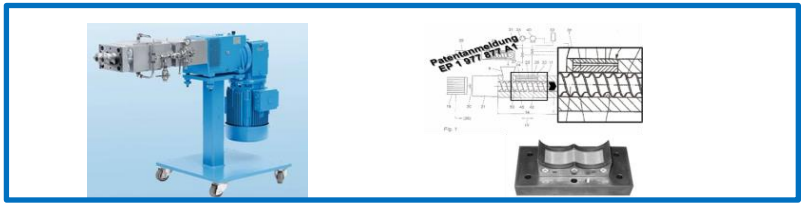
Summary

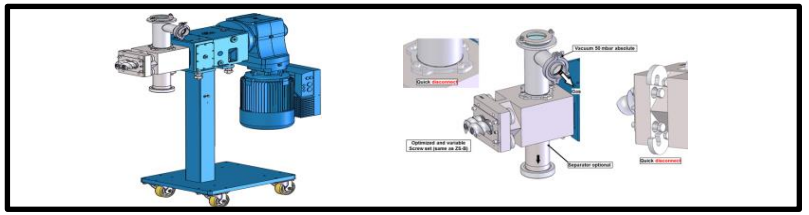
Background: Main factors limiting compounding capacity

Limit:
Motor power

Limit:
Feed intake



Limit:
Degassing



Limit:
Screw Design
Mixing/Quality

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Background: Filled Material Screw Design Limitation Points

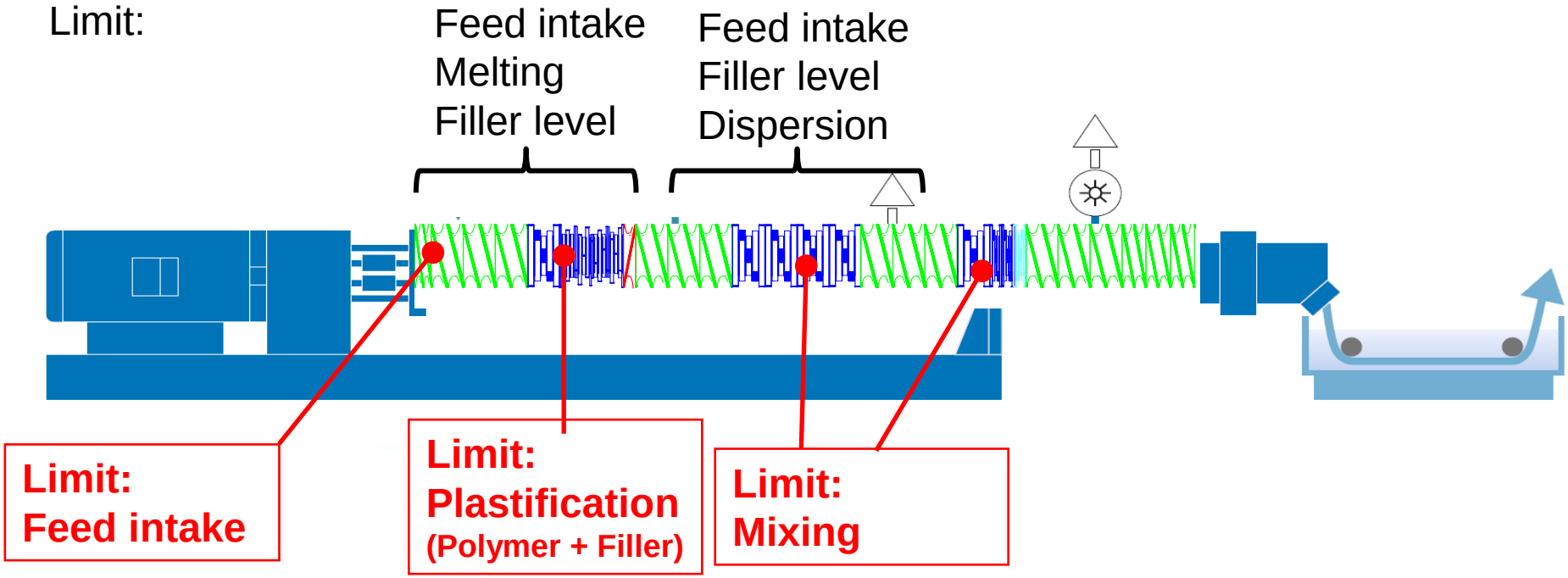
Reduced filler intake

- Main feed or side feed locations

Insufficient filler incorporation

- Vent flow of raw filler
- Poor dispersion

Limit:



Involute Screw Elements: Improved Productivity and Quality

Background

Twin-screw compounding system: Overview

Involute Elements: Design basis

Involute Elements: Impact

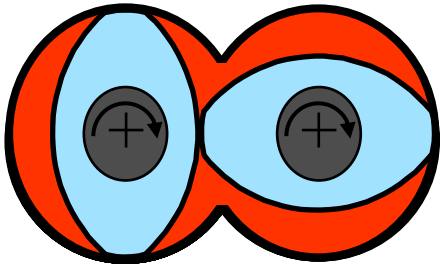
- Productivity
- Quality

Summary

ZSK: Modular Design

Drive power of 10 kW up to 12 MW for rates from 0.5 kg/h and 100 t/h

Operating principle



Modular design
for screw elements and kneading blocks

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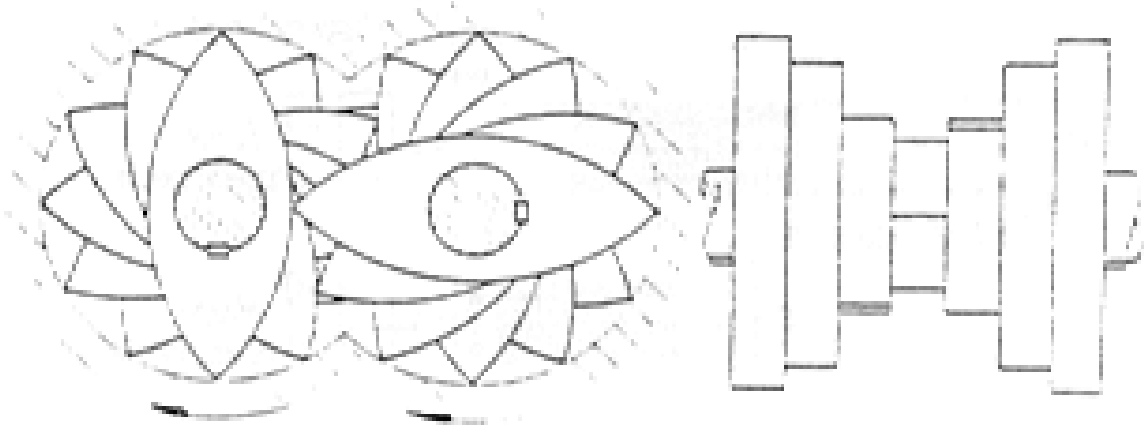
Twin-screw Compounder Kneading Block Evolution



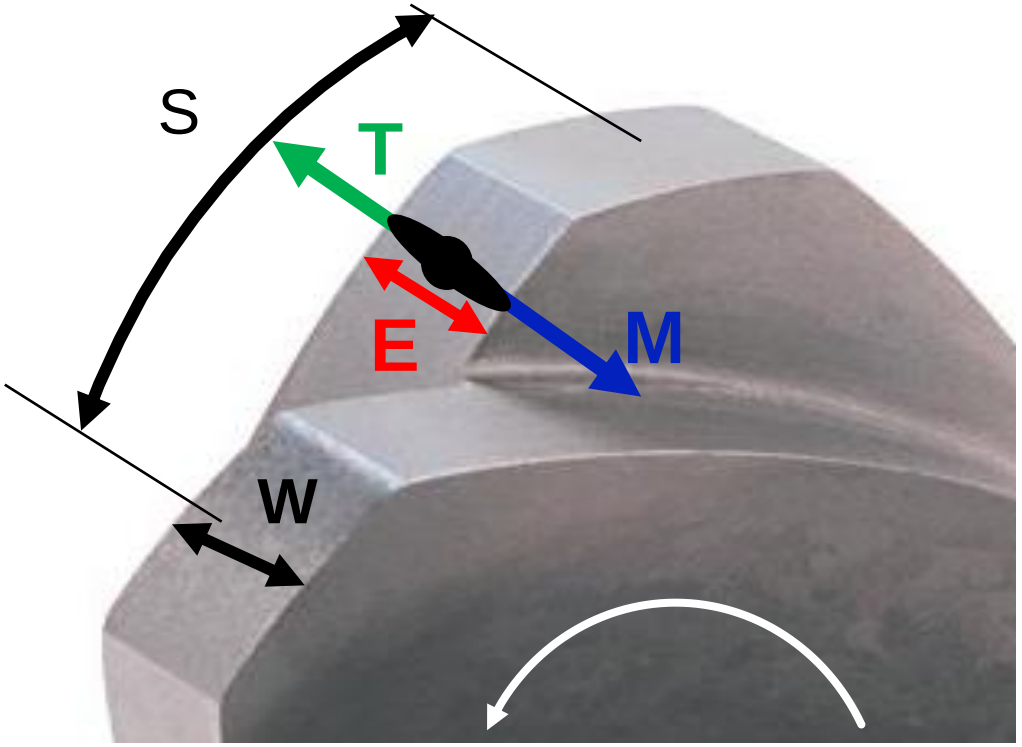
Erdmenger KB Geometry (1949)

Current Standard KB Geometry

Kneading elements: Working principle

Large staggering angle S:
--> reduced transport T
--> improved mixing M
Small staggering S:
--> improved transport T
--> reduced mixing M

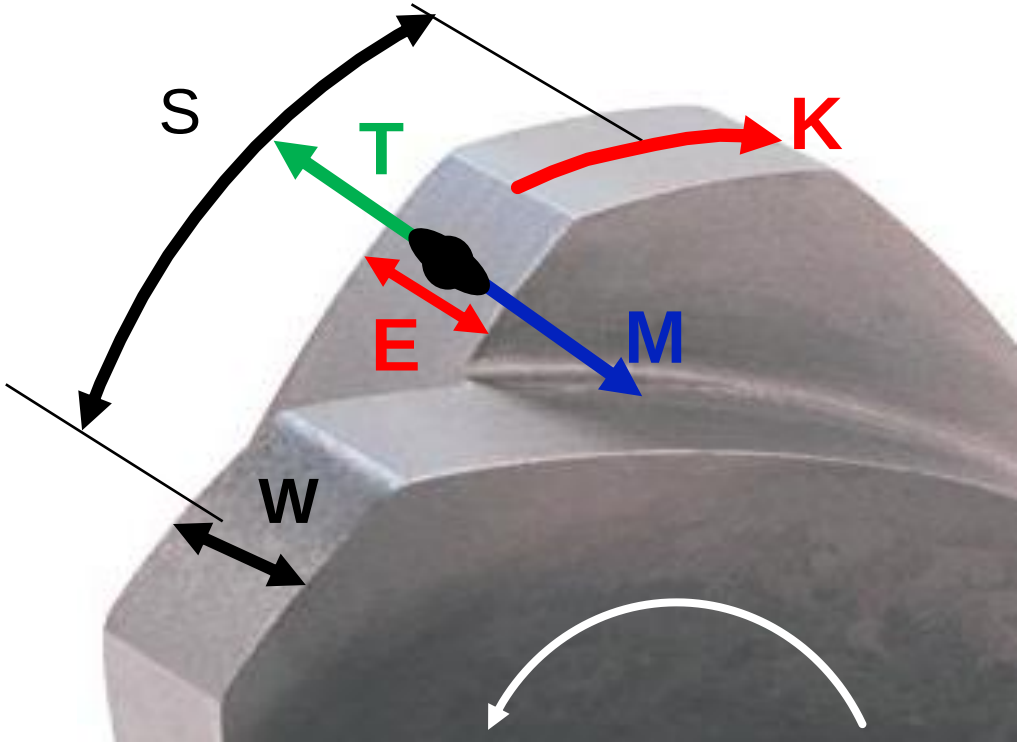
Small disk W:
--> improved mixing M
--> reduced dispersion E
Large disk W:
--> reduced mixing M
--> improved dispersion E



W – Disk Width
S – Stagger Angle

T – MaterialTransport
M – Distributive (Back) Mixing
E – Dispersive Mixing

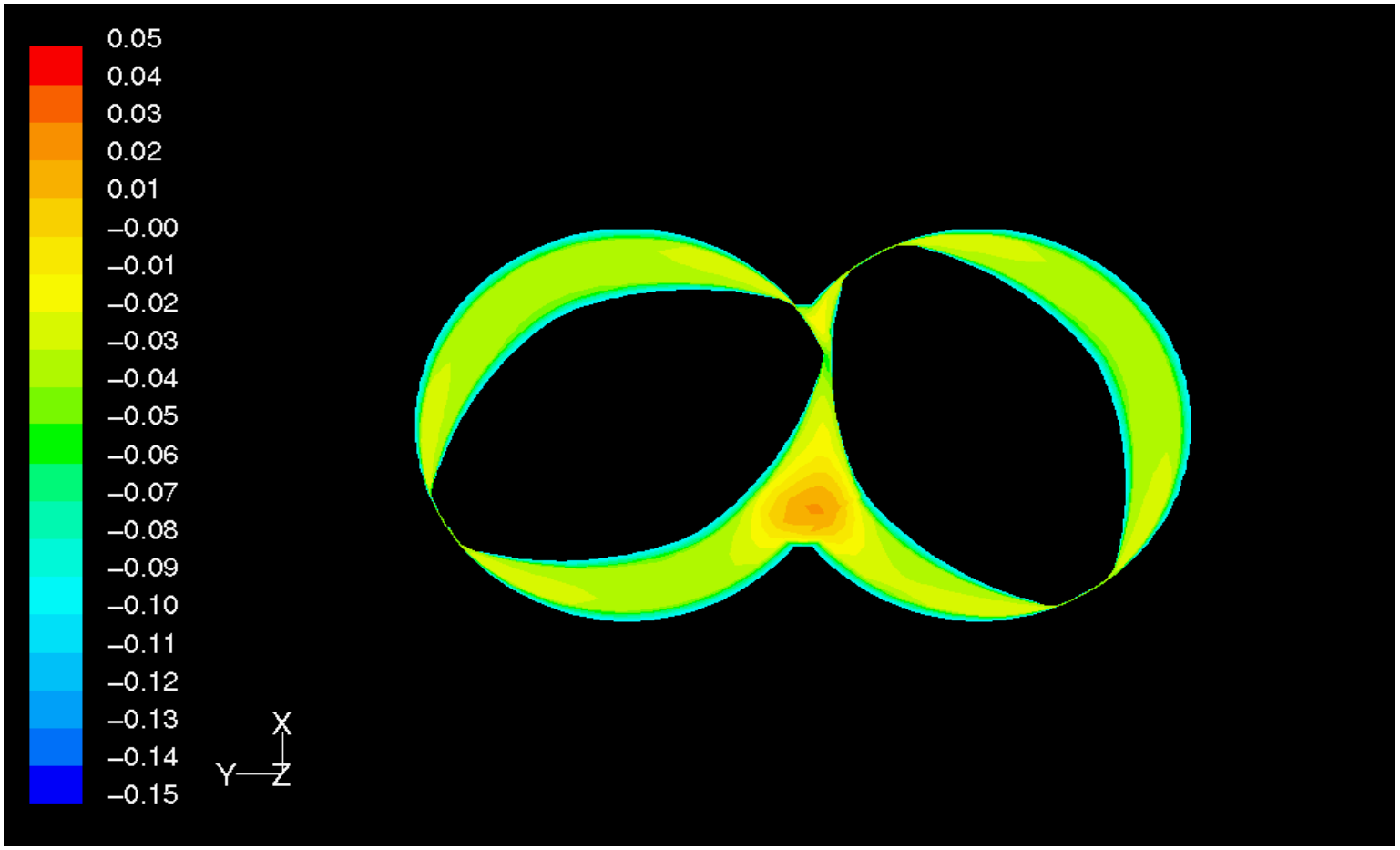
Kneading elements: Working principle for reduced diameter



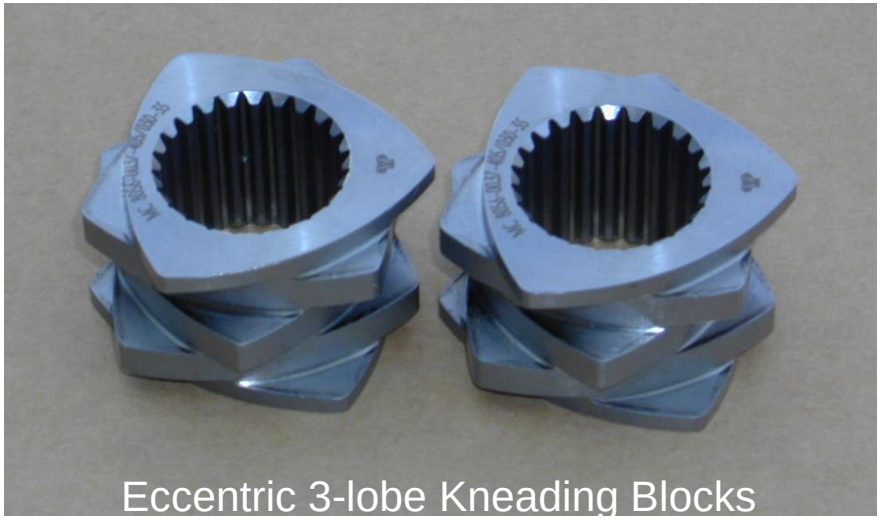
W – Disk Width
S – Stagger Angle

K – Dispersive shear mixing
T – MaterialTransport (reduced)
M – Distributive (Back) Mixing (reduced)
E – Dispersive Extensional Mixing (reduced)

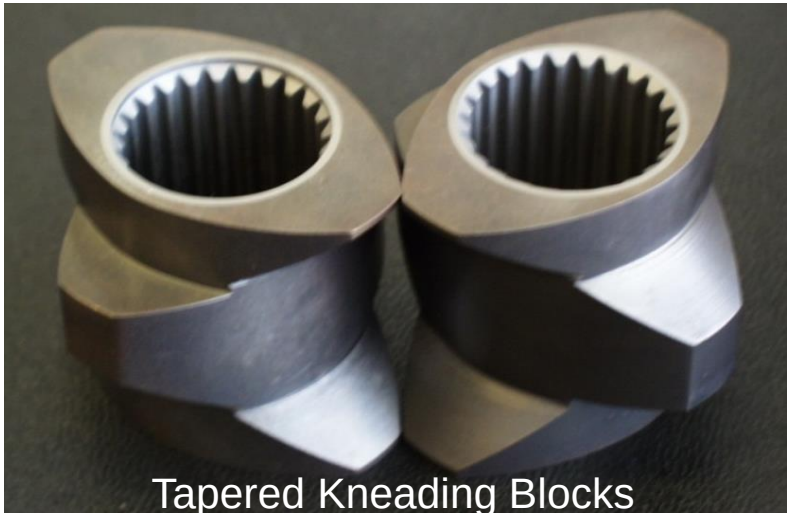
Kneading elements: Working principle



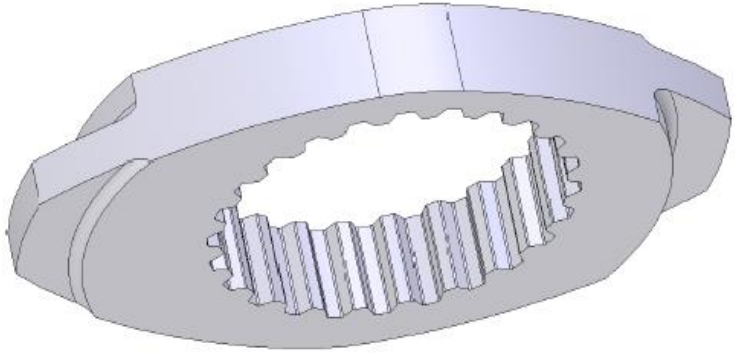
Kneading/Mixing Element Variants



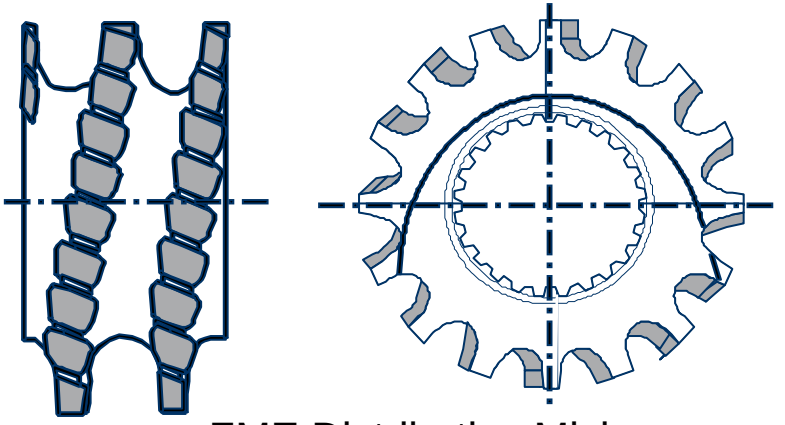
Eccentric 3-lobe Kneading Blocks



Tapered Kneading Blocks



SAM Kneading Disk



ZME Distributive Mixing

Involute Screw Elements: Improved Productivity and Quality

Background

Twin-screw compounding system: Overview

Involute Elements: Design basis

Involute Elements: Impact

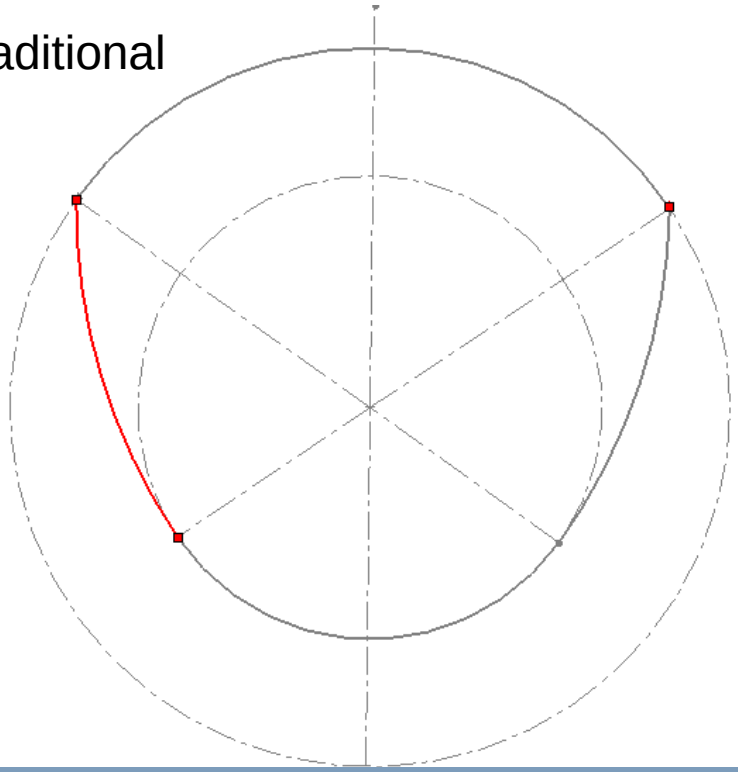
- Productivity
- Quality

Summary

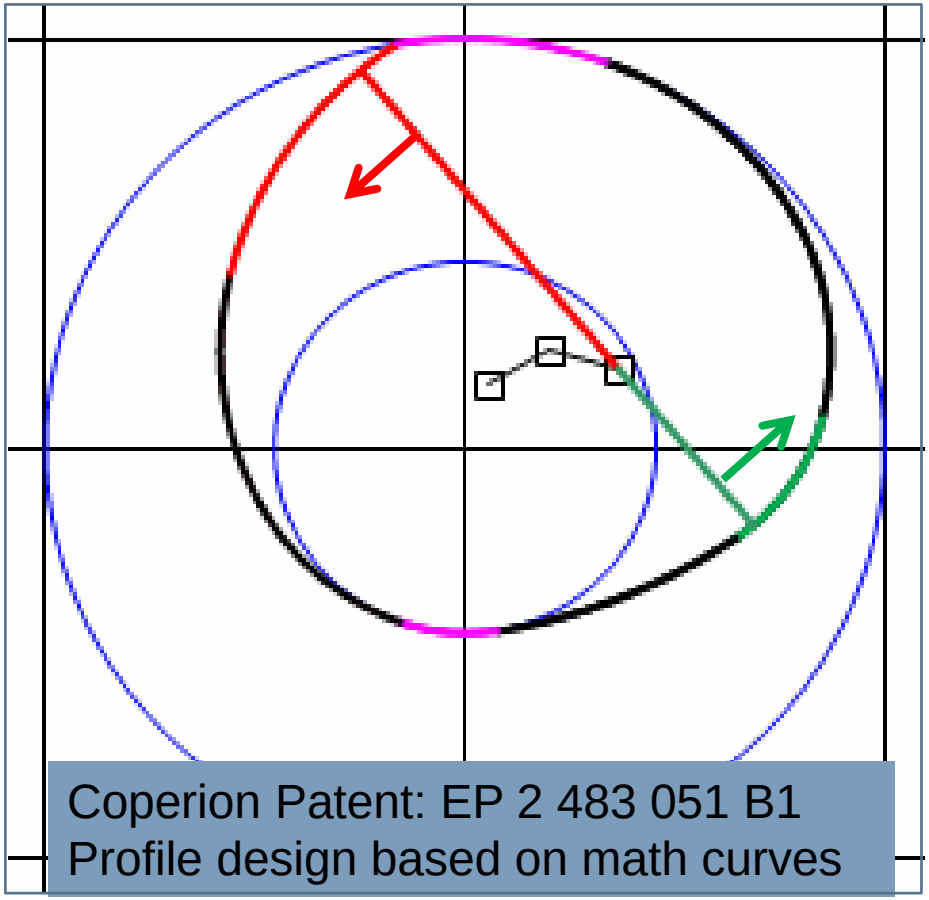
New Involute Screw Profile

Comparison of ”Traditional” vs. ”New” Single Flighted design

Traditional



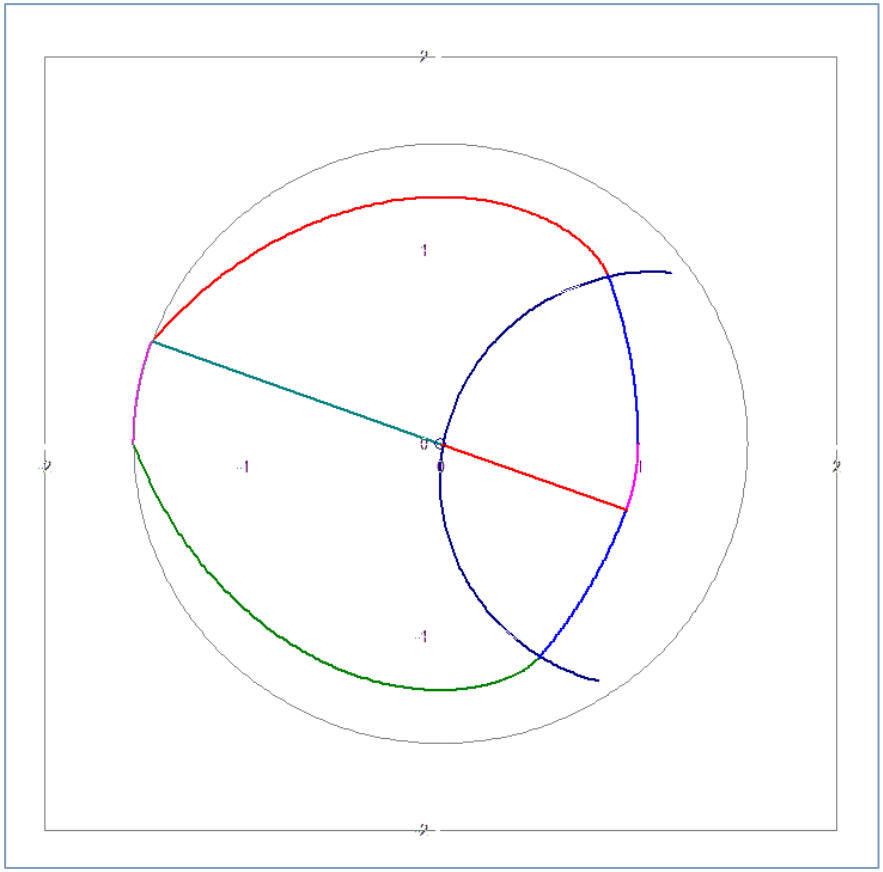
Erdmenger:
Profile design based on circular arcs

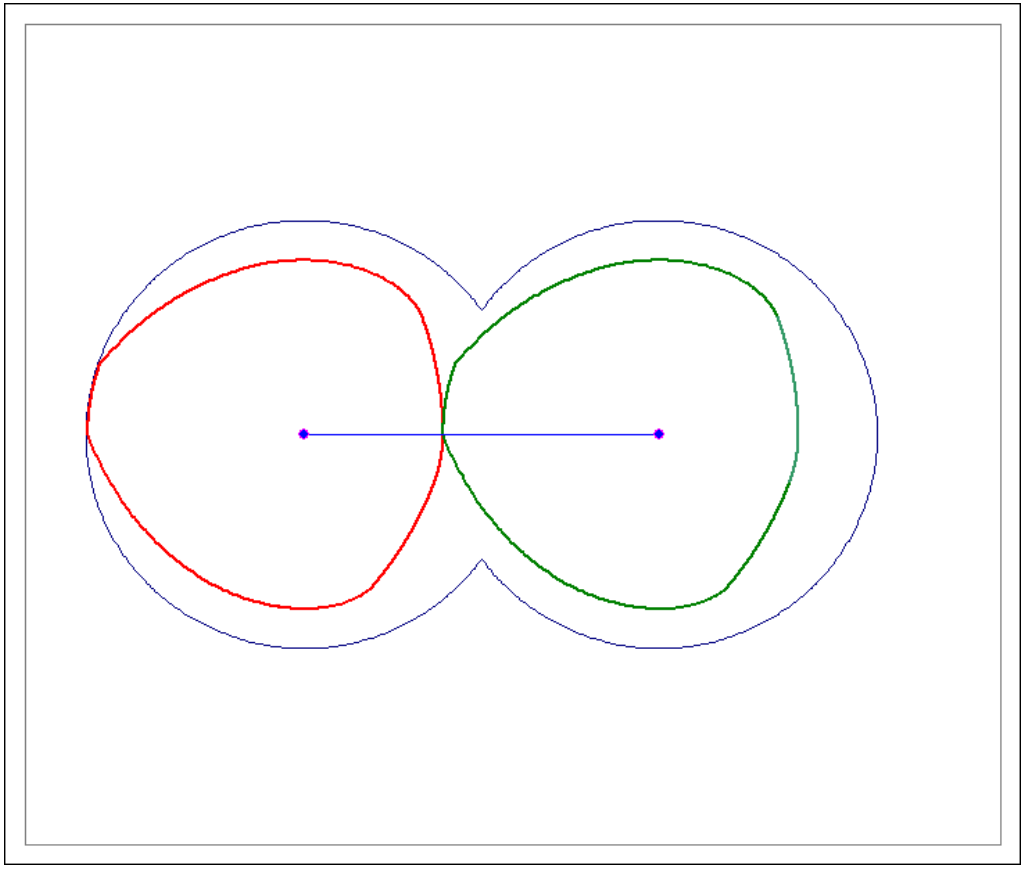


Coperion Patent: EP 2 483 051 B1
Profile design based on math curves

New Involute Screw Profile

Description of the 3-lobe design

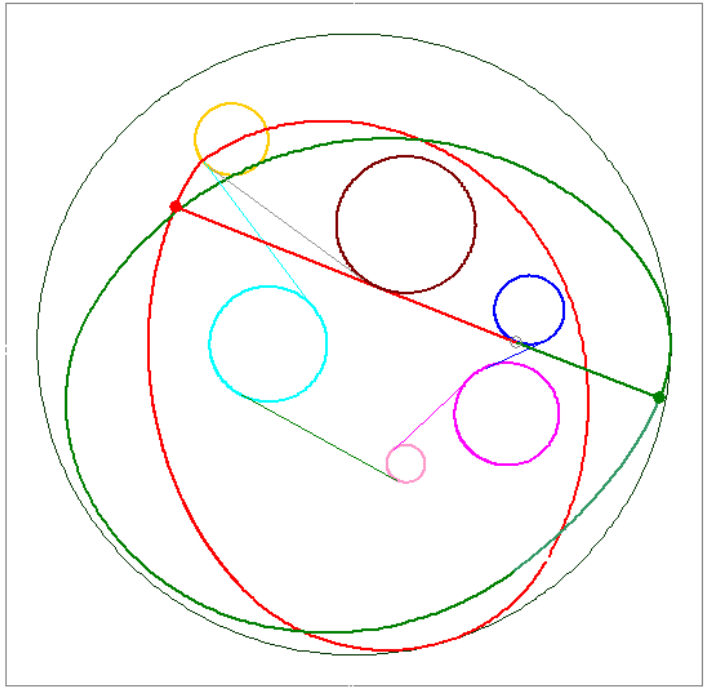


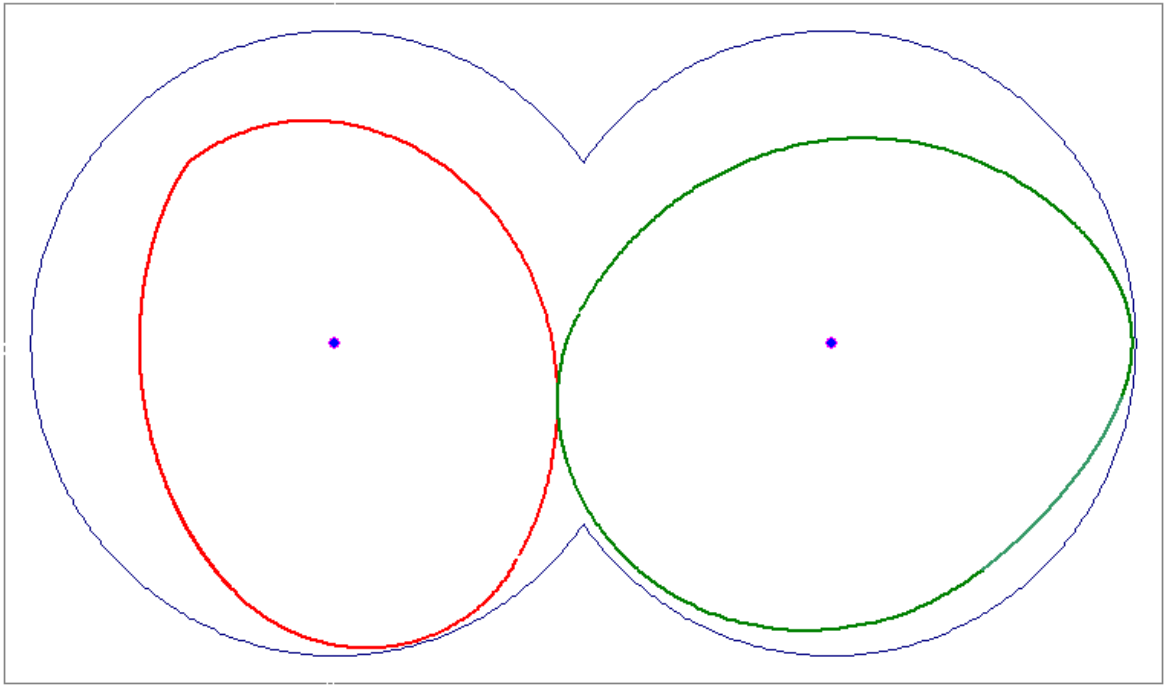


Patent: EP 2 483 051 B1

New Involute Screw Profile

Description of the asymetric 2-lobe design

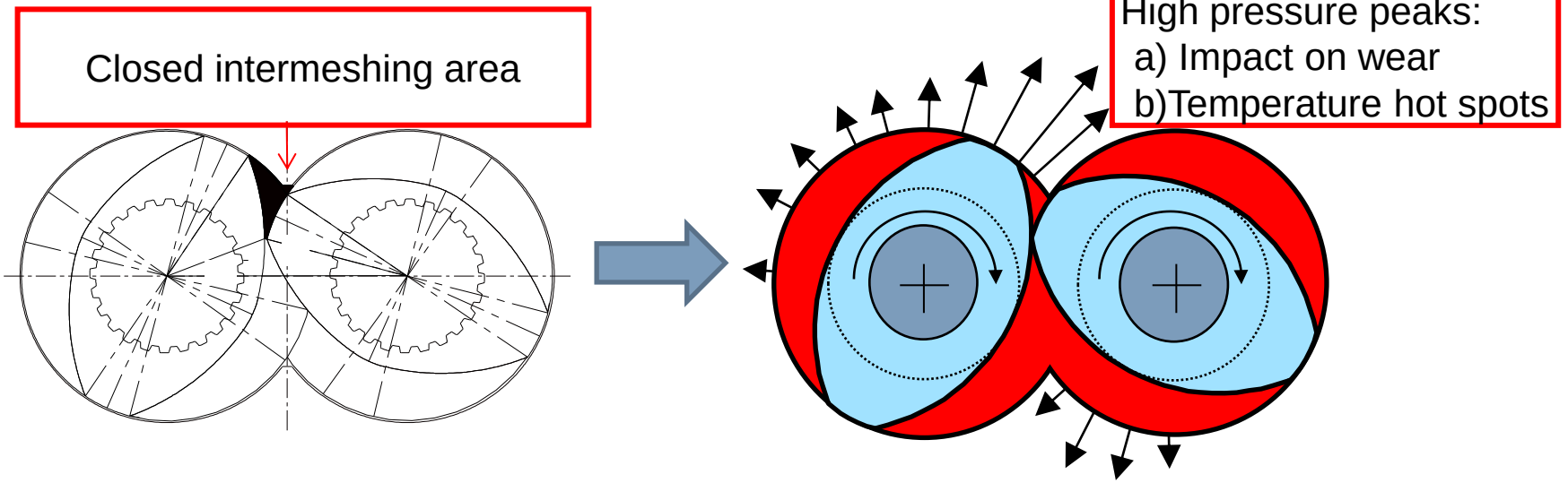




Patent: EP 2 483 051 B1

New Involute Screw Profile

Comparison of ”New” vs. ”Traditional” 2-lobe design

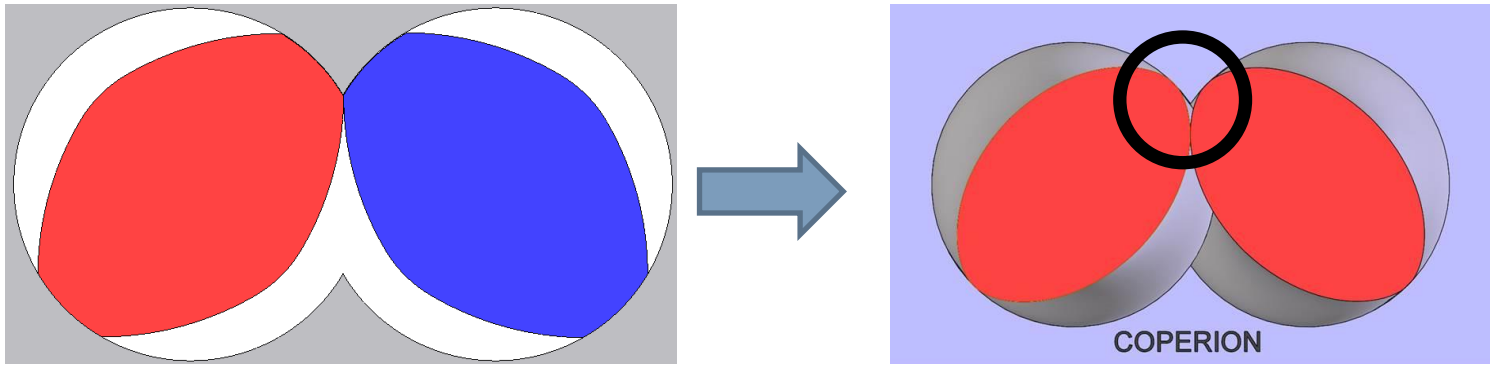


Closed area

$A_{ZW/Min} = 0$

Open Area

$A_{ZW/Min} > 0$



Patent:

EP 2 483 051 B1

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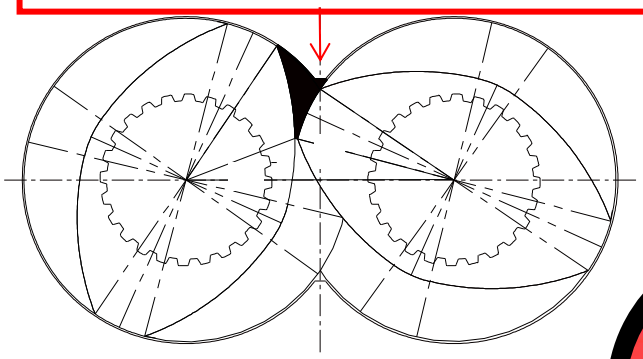
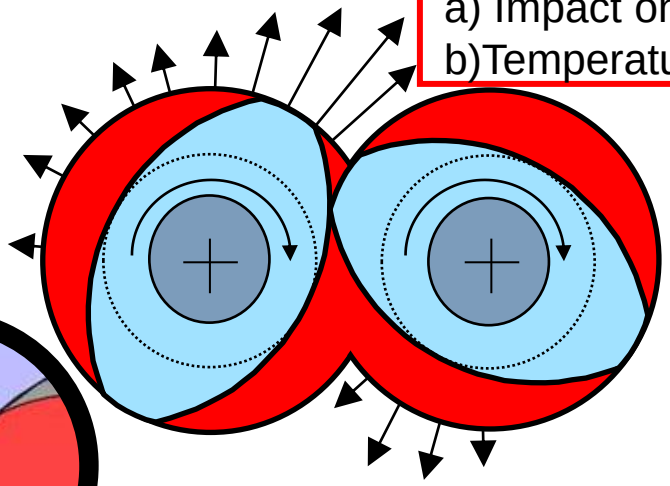
New Involute Screw Profile

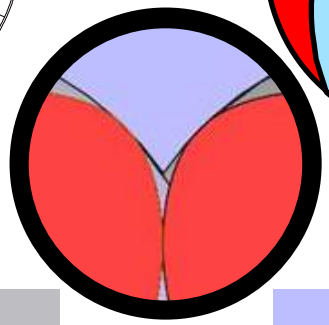
Comparison of ”New” vs. ”Traditional” 2-lobe design

Closed intermeshing area

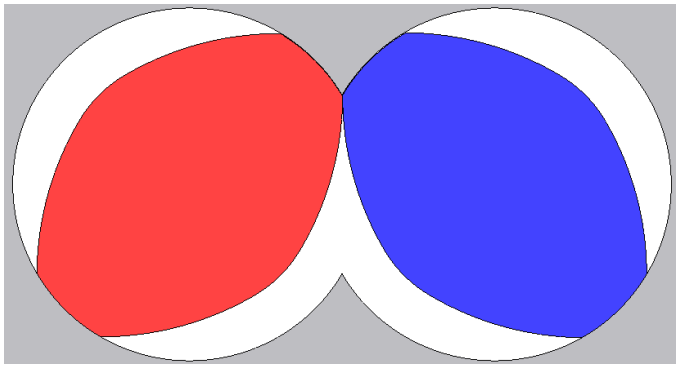


High pressure peaks:
a) Impact on wear
b)Temperature hot spots

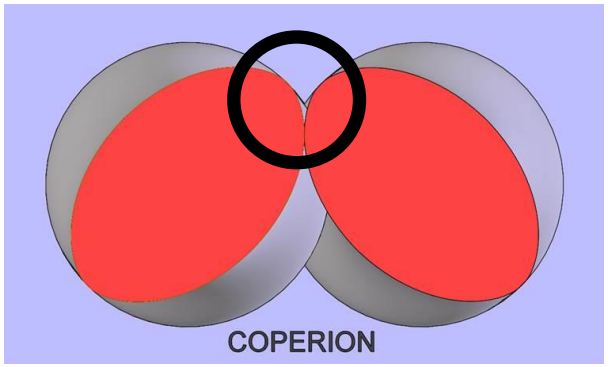




Closed area
$A_{ZW/Min} = 0$

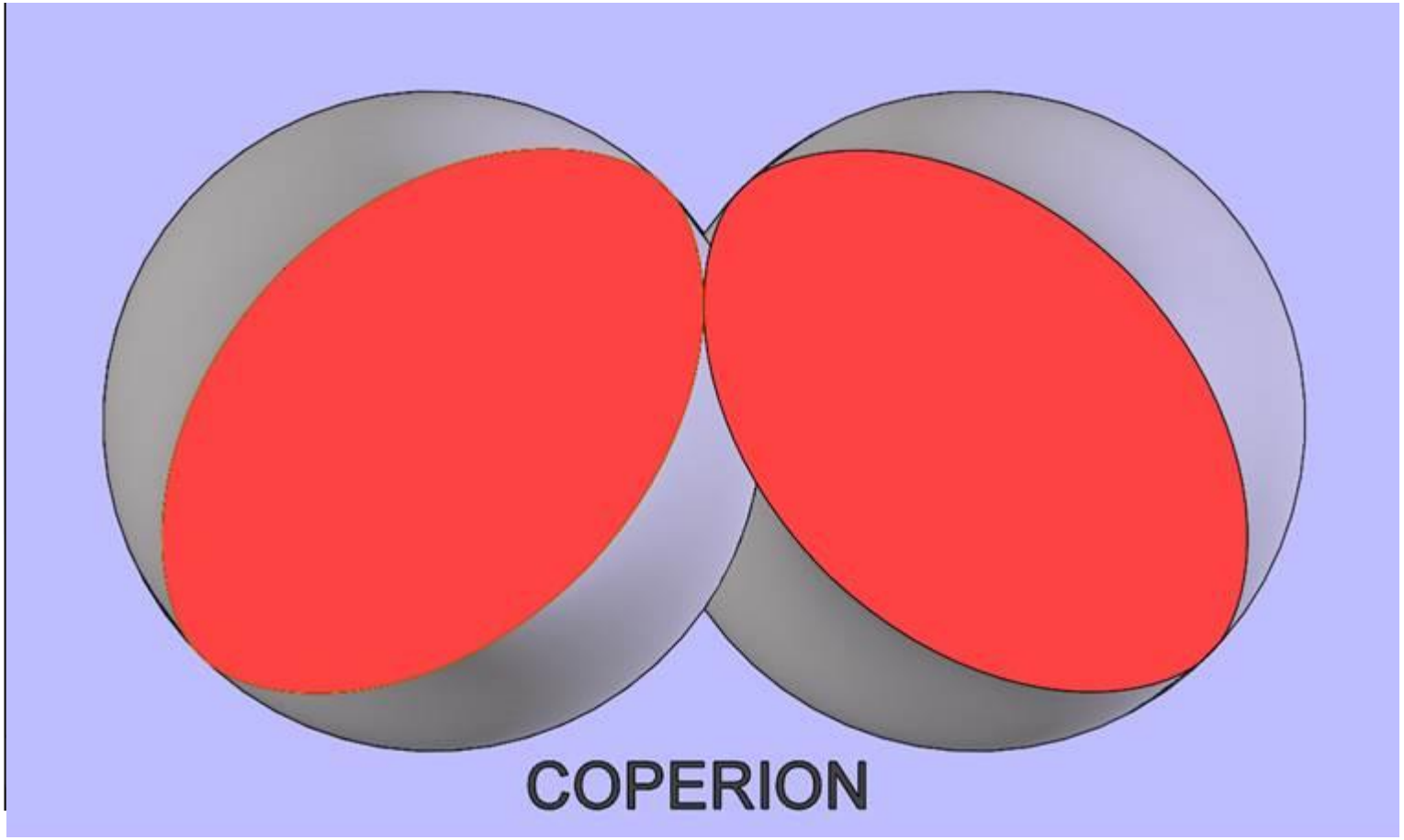


Open Area
$A_{ZW/Min} > 0$



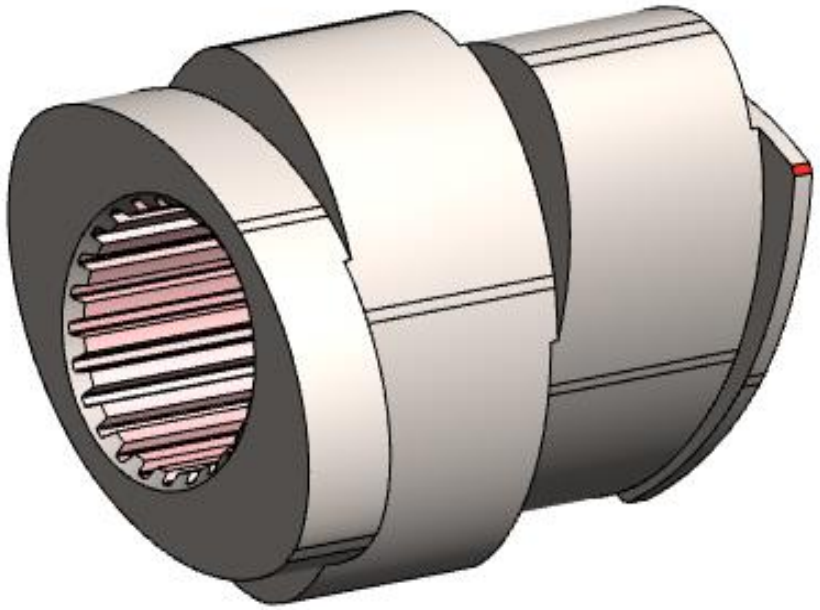
Patent:
EP 2 483 051 B1

New Involute Screw Profile
2-lobe Geometry



Patent: EP 2 483 051 B1

Summary:
New Involute Screw Profile



- Self wiping
- Closely intermeshing
- Improvement for elongational stress
- Shear sensitive
- Highest flexibility for profile generation
- Patented

Involute Screw Elements: Improved Productivity and Quality

Background

Twin-screw compounding system: Overview

Involute Elements: Design basis

Involute Elements: Impact

- Productivity
- Quality

Summary

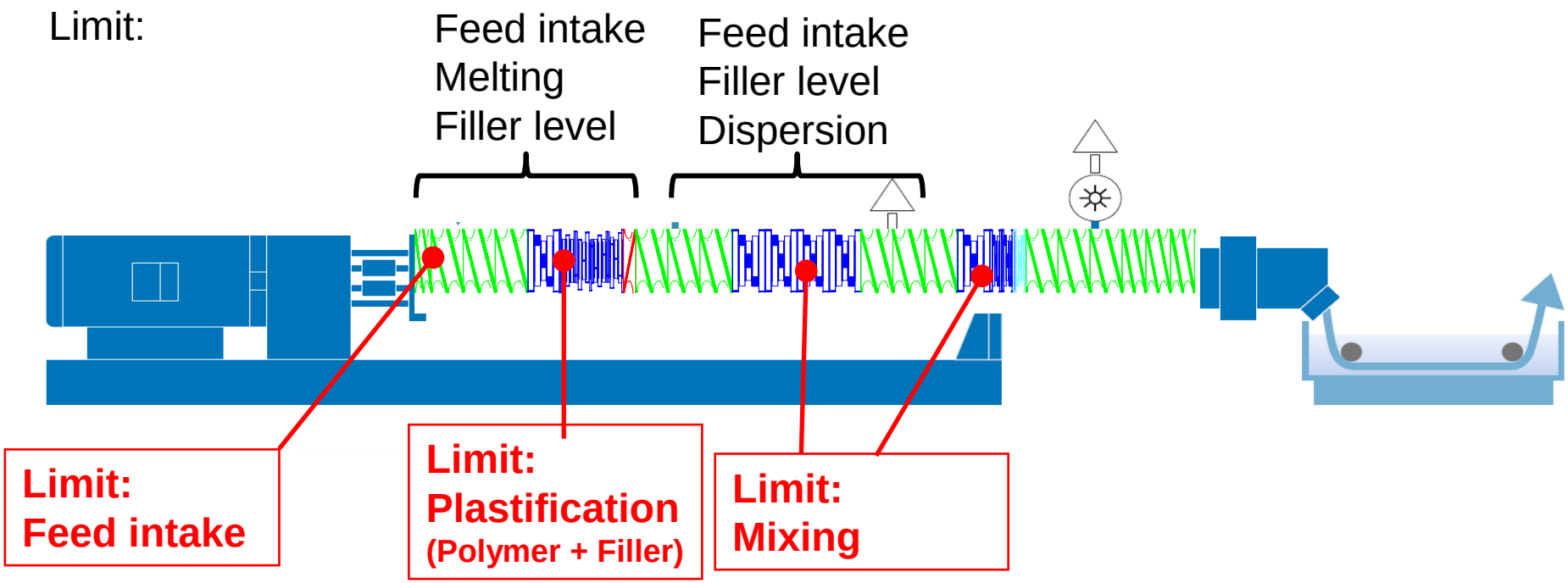
Background: Filled Material Screw Design Limitation Points

Reduced filler intake

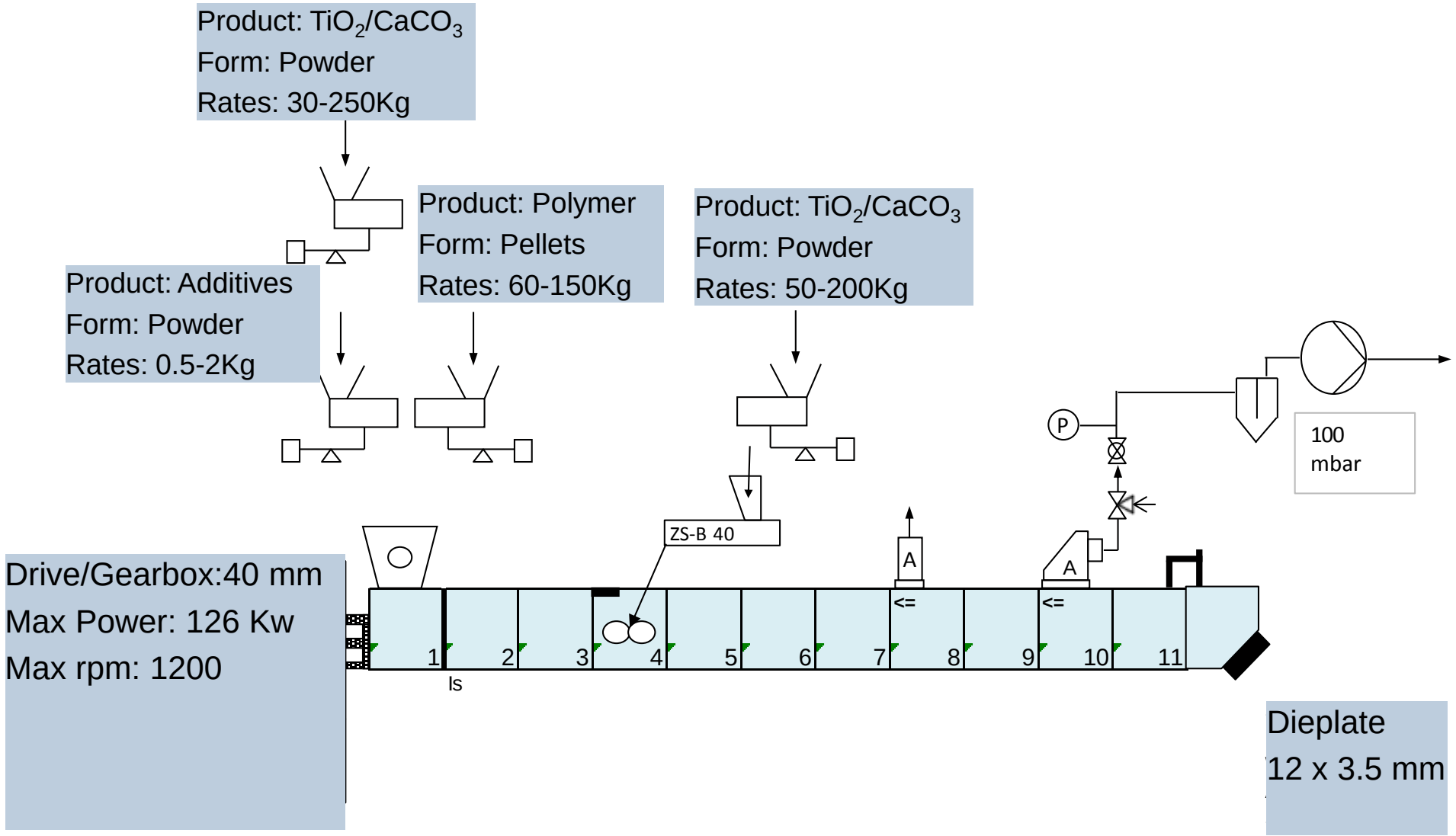
- Main feed or side feed locations

Insufficient filler incorporation

- Vent flow of raw filler
- Poor dispersion



Process Flow Diagram: Involute Elements Lab Evaluation



Involute Screw Profile: Filled PP compounds

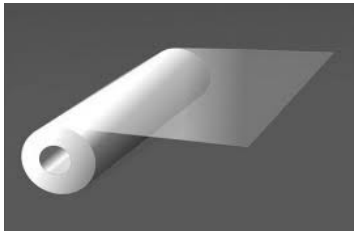
Formulation	Max. Rate Standard-Screw profile (kg/h)	Max. Rate New Screw profile (Involute) (kg/h)	Increase [%]
PP + 55 % Talc	180	220	+ 22%
PP + 70% $CaCO_3$	180	250	+ 38%

Involute Screw Profile: Breathable film

Formulation	Max. Rate Standard-Screw profile (kg/h)	Max. Rate New Screw profile (Involute) (kg/h)	Increase [%]
LLDPE (MI 6) + 45% CaCO3	200	350	+75%
LLDPE (MI 6) + 70% CaCO3	235	400	+ 70%

Involute Screw Profile:
Filled PP/PE compounds (Masterbatch)

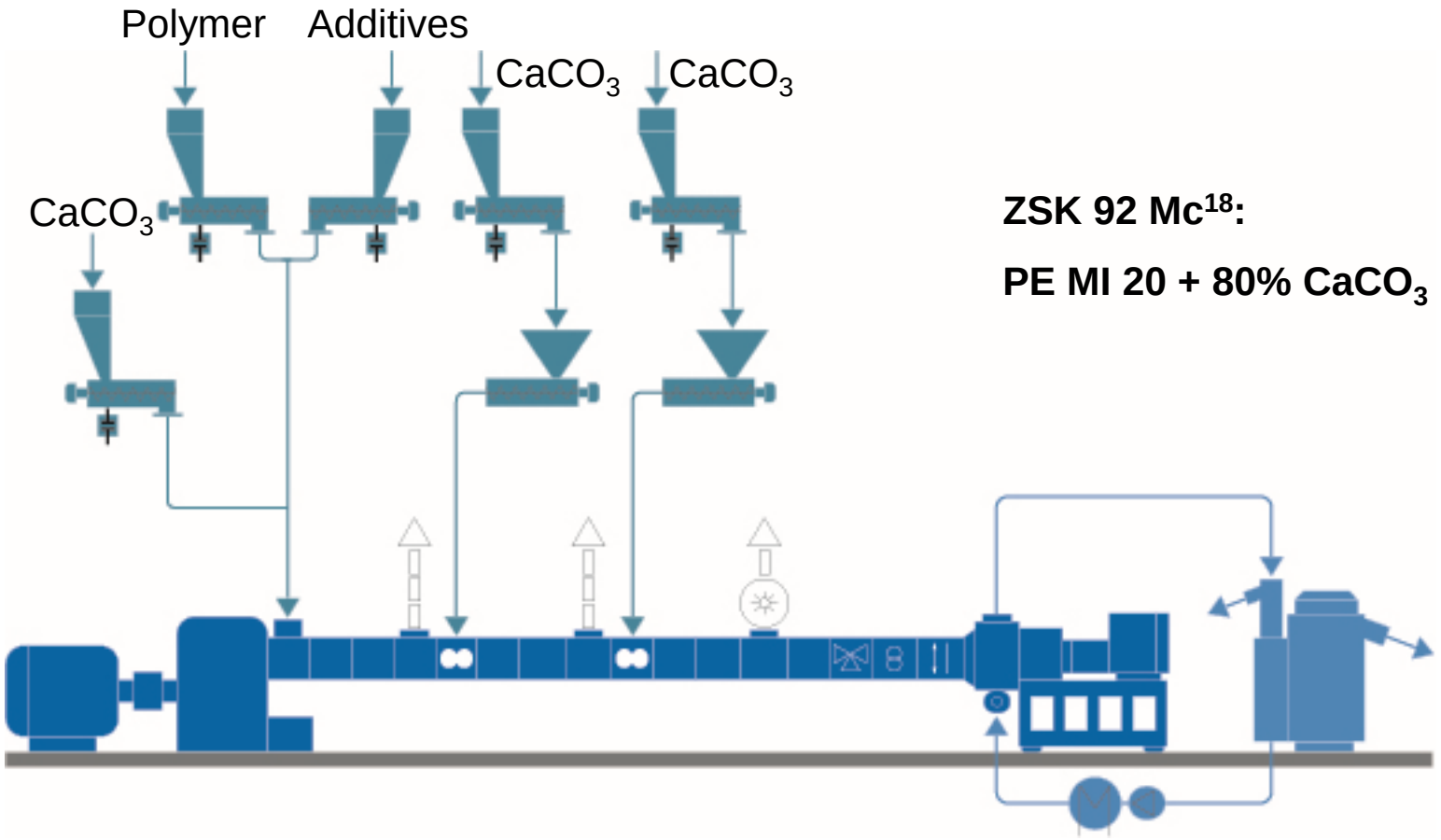
Formulation	Max. Rate Standard-Screw profile (kg/h)	Max. Rate New Screw profile (Involute) (kg/h)	Increase [%]
LLDPE (MI 20) + 28% TiO2 + 42% CaCO3	110	290	+ 160%
PP (MI 12) + 70% CaCO3	130	300	+ 125%
PP (MI 12&70) + 75% Talc	100	200	+ 100%



Involute Screw Profile: Automotive PP grades

Formulation	Max. Rate Standard-Screw profile (kg/h)	Max. Rate New Screw profile (Involute) (kg/h)	Increase [%]
PP + 71% Talc	140	220	+57%
PP + Elastomer + 70% Talc	130	200	+46%

Involute Screw Profile Scale up: Highly filled polyolefines



ZSK 92 Mc^{18}:

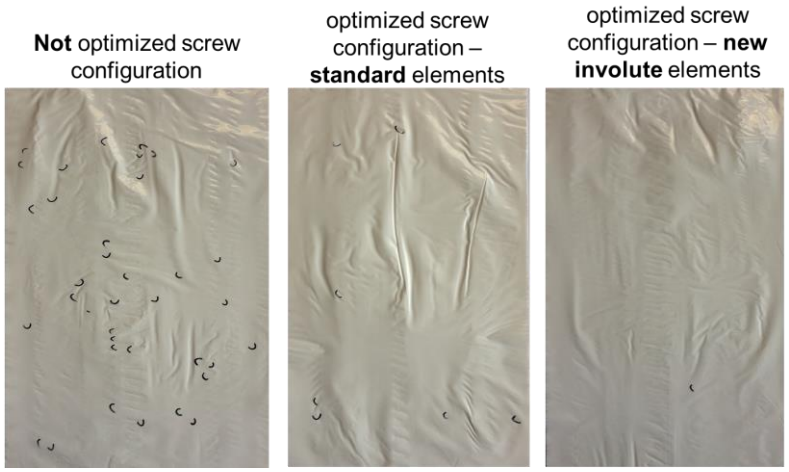
PE MI 20 + 80% $CaCO_3$

Impact of process conditions and screw design

Significant influence of screw configuration (Rate & Quality)

ZSK92Mc^{18}

Recipe No.	Recipe	Max. Rate Standard-Screw profile	Max. Rate New Screw profile (Involute)	Rate increase
5	PE MI 20 + 80% CaCO3	2200 kg/h	3000 kg/h	+35 %



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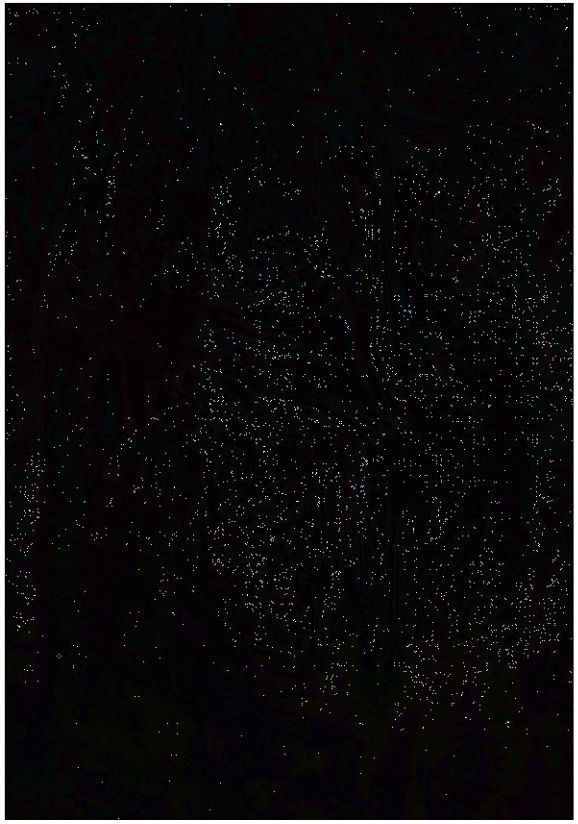
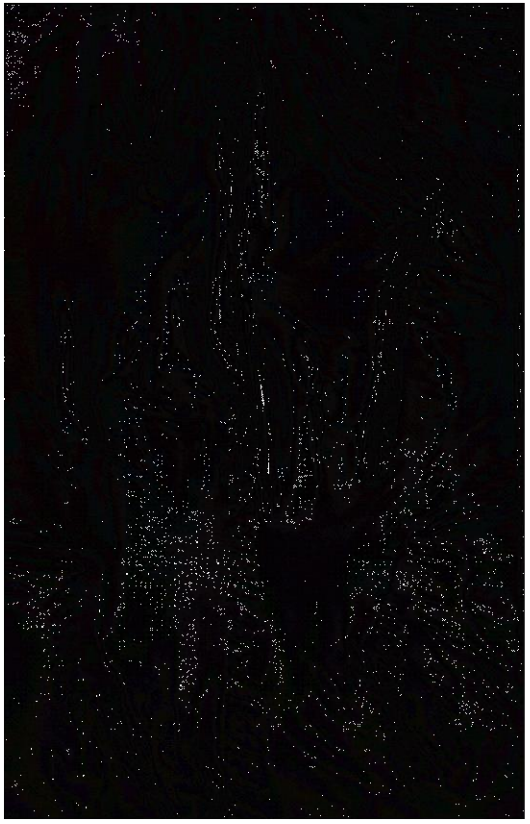
Impact of process conditions and screw design

Significant influence of screw configuration (Rate & Quality)

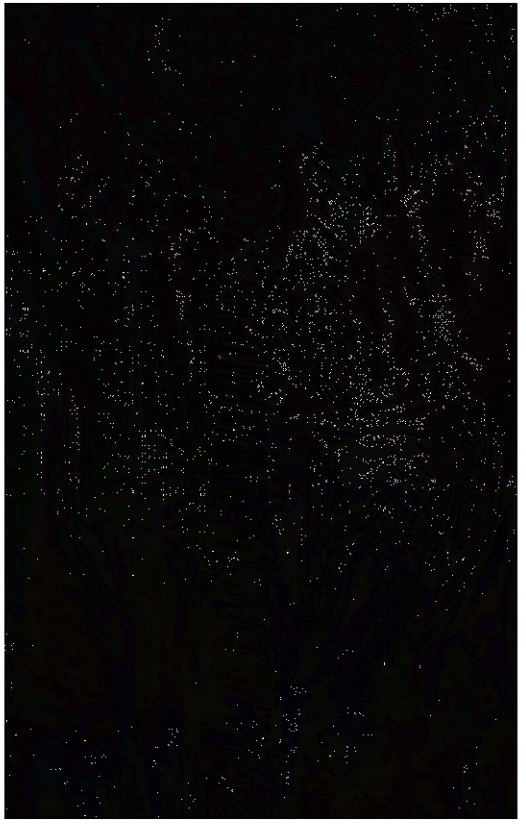
Not optimized screw configuration



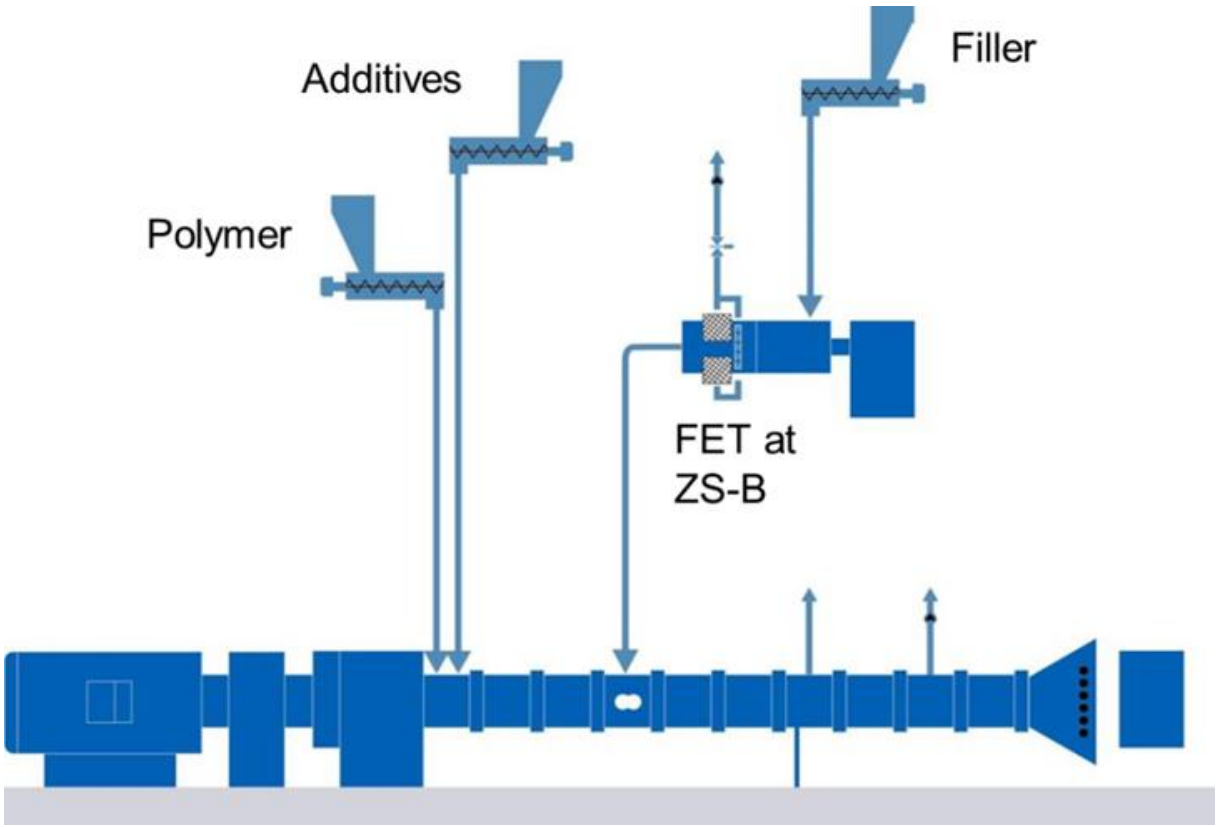
optimized screw configuration – **standard** elements



optimized screw configuration – **new involute** elements



Involute Screw Profile Scale up: PP compounding



ZSK 58 Mc^{18}:

PP MI 8 + 70 % CaCO3

(1.3 µm, Coating 1.6%)

Impact of process conditions and screw design

Significant influence of screw configuration (Rate & Quality)

ZSK58Mc[18]

Recipe No.	Recipe	Max. Rate Standard-Screw profile	Max. Rate New Screw profile (Involute)	Rate increase
4	PP MI 8 + 70% CaCO3	550 kg/h	900 kg/h	+60 %

- In operation since August 2016

Summary

- Higher throughput
- Higher loadings of filler
- Better dispersion and homogenization
- Lower energy consumption (SEI in kWh/kg)
- Increased profitability

- > 30% for filled polymers
- physical limitation can be reached
- FPV lowered
- 10 – 20 K lower temperature
- CAPEX, OPEX and OEE

Summary

- Increased operationing window for several mineral filled engineering plastics permits more efficient use high torque twin-screw compounders.

- Significantly increased throughput achieved for Talc, $CaCO_3$, TiO_2

- High potential for fillers, such as SiO_2, Microspheres, Nanocomposites, etc.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Thank you very much for your attention.