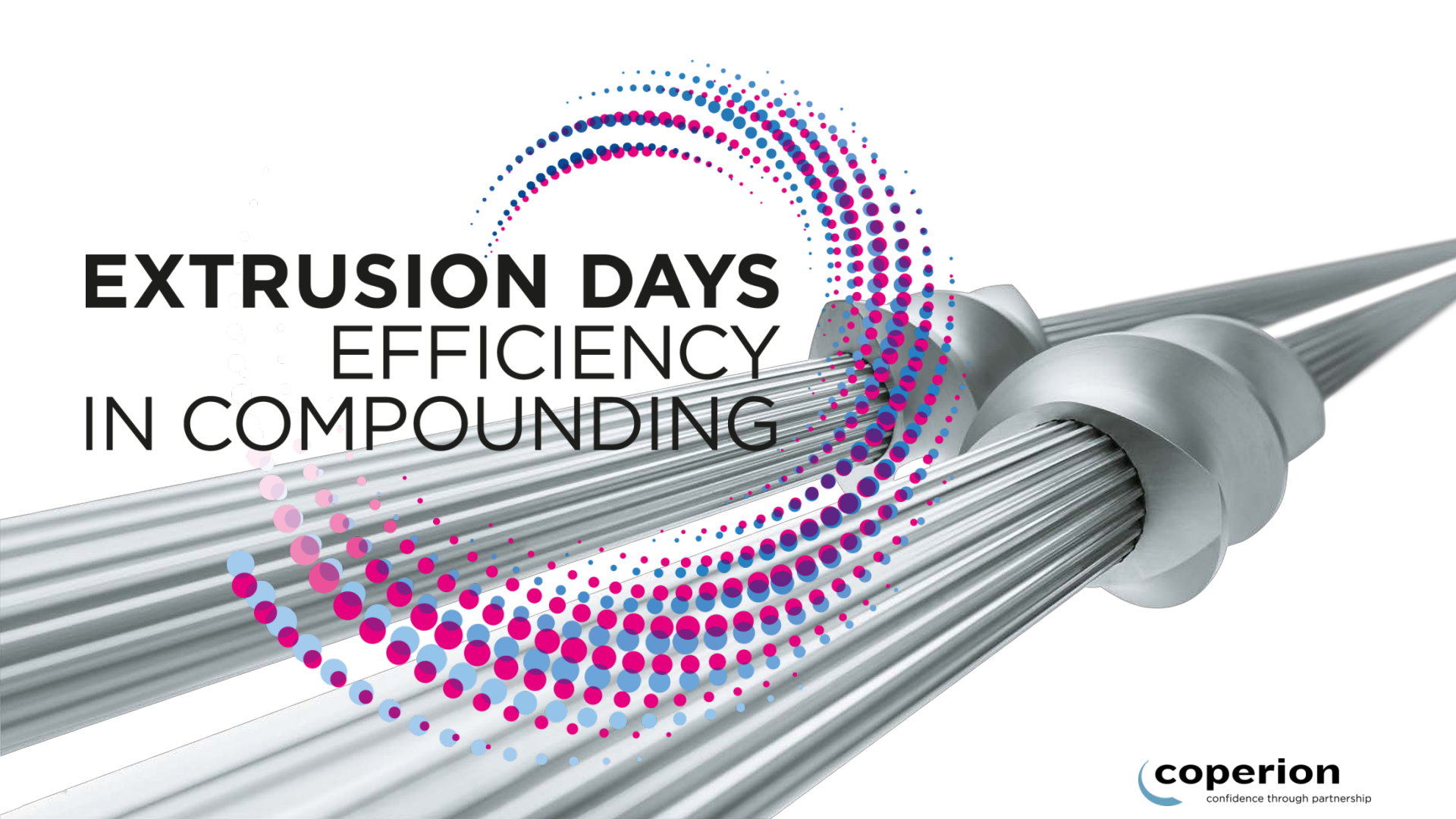
EXTRUSION DAYS
EFFICIENCY IN COMPOUNDING



coperion
confidence through partnership

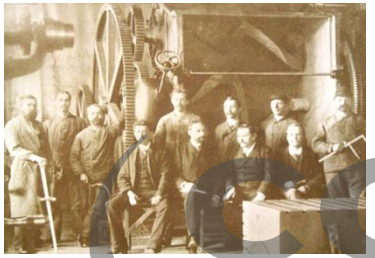
Over 60 Years of ZSK: Process related Modularity and Flexibility Meets High Quality and Efficiency

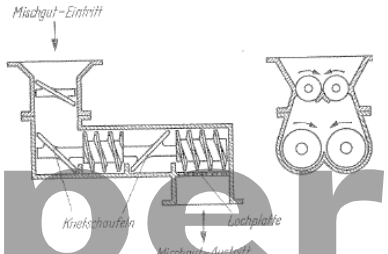
Frank Lechner
Process Technology, Compounding & Extrusion

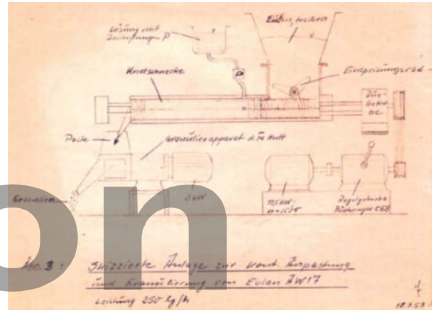
coperion
confidence through partnership

History of Kneading and Compounding

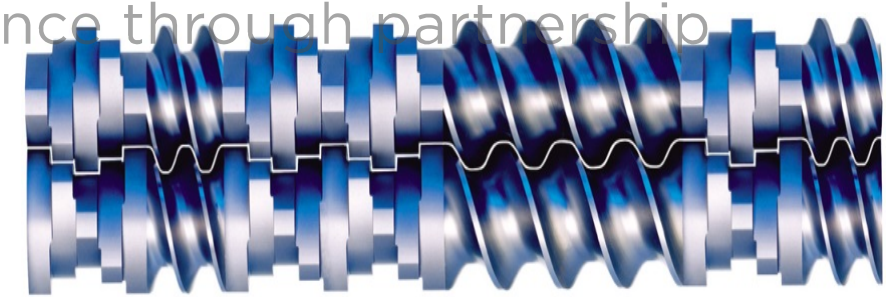
1879 Paul Pfleiderer founded the company in Stuttgart and Hermann Werner started the production of Universal Kneaders UK.





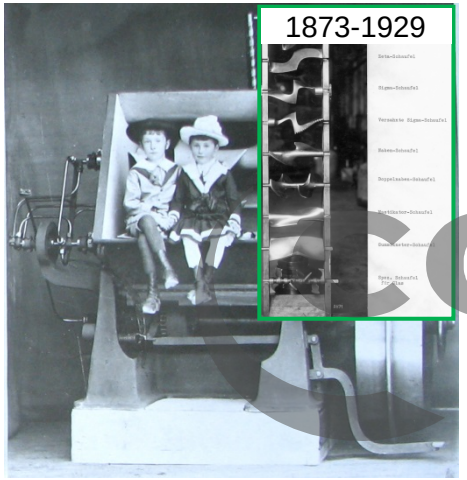


1953 License from Bayer (Erdmenger) was taken for the continuous Twin Screw Kneader ZSK.



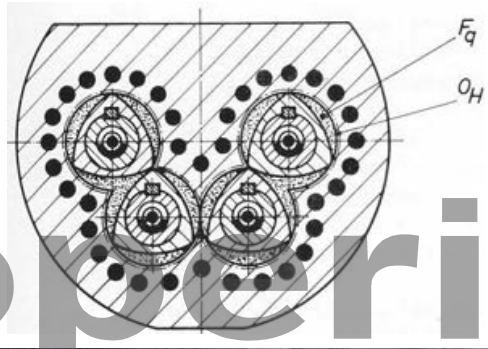
➡ **2010** Constant increase of volume and torque

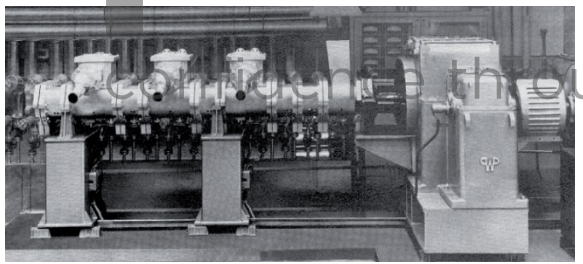
Machine and Process Technology Since 1879



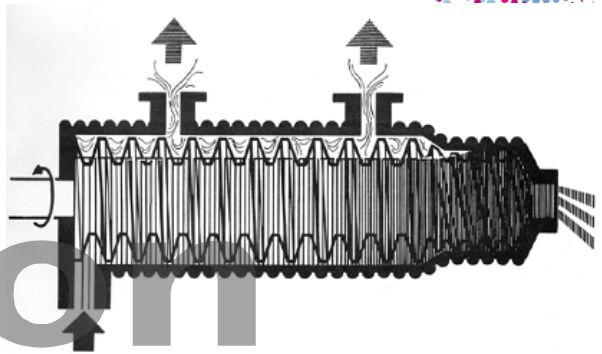
Richard und Julie Werner in einer Knetmaschine, etwa 1884.

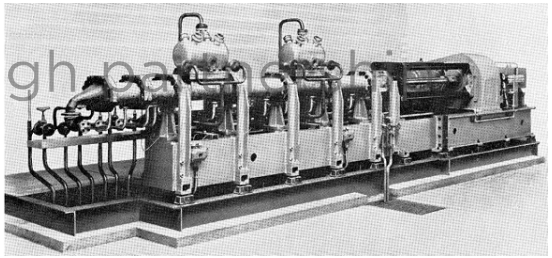
UK





VDS-V

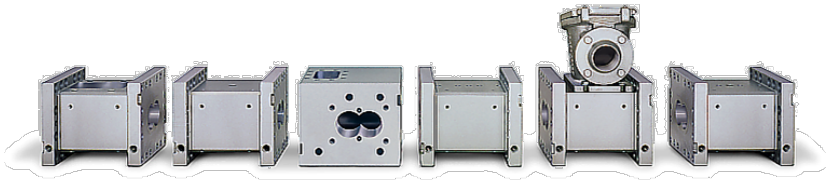




ZDS-RS

Modular Design

Motor Coupling Gear box Processing section Discharge



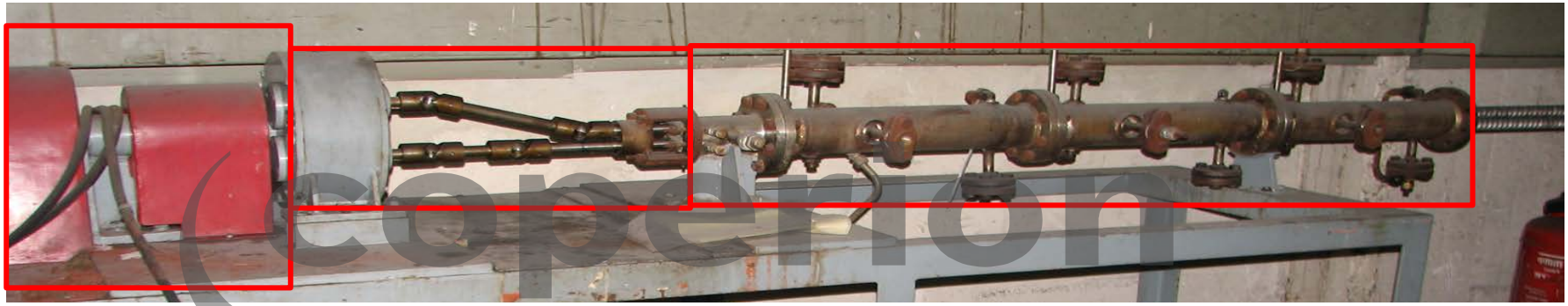
Modular design for screw elements and barrels

Modular Design: Early Twin Screw Lab Extruder

Motor

Gear Box

Modular Process Section



Lab Extruder 1940's, R. Erdmenger

Screw Elements

Development of Torque, Volume and Screw Speed

ZSK Standard
$D_o / D_i = 1,22$
$M_d / a^3 = 5,0$ Nm/cm³ / n = 150 rpm

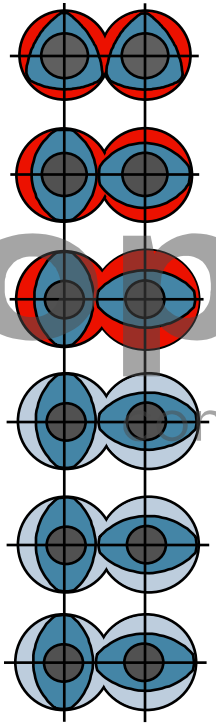
ZSK variable
$D_o / D_i = 1,44$
$M_d / a^3 = 5,0$ Nm/cm³ / n = 300 rpm

ZSK Supercompounder
$D_o / D_i = 1,55$
$M_d / a^3 = 8,7$ Nm/cm³ / n = 600 rpm

ZSK MEGAcompounder
$D_o / D_i = 1,55$
$M_d / a^3 = 11,3$ Nm/cm³ / n = 1200rpm

ZSK MEGAcompounder PLUS
$D_o / D_i = 1,55$
$M_d / a^3 = 13,5$ Nm/cm³ / n = 1200rpm

ZSK Mc¹⁸
$D_o / D_i = 1,55$
$M_d / a^3 = 18$ Nm/cm³ / n = 1200rpm

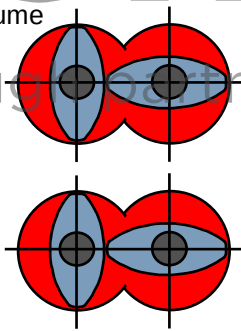


Increase of
free volume (100%)
and of specific torque

Increase of free volume
(additional 40%)

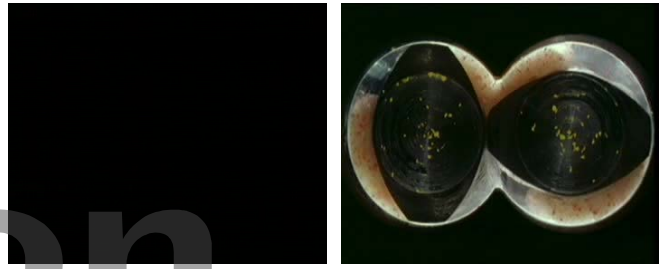
Increase of torque

Increase of torque

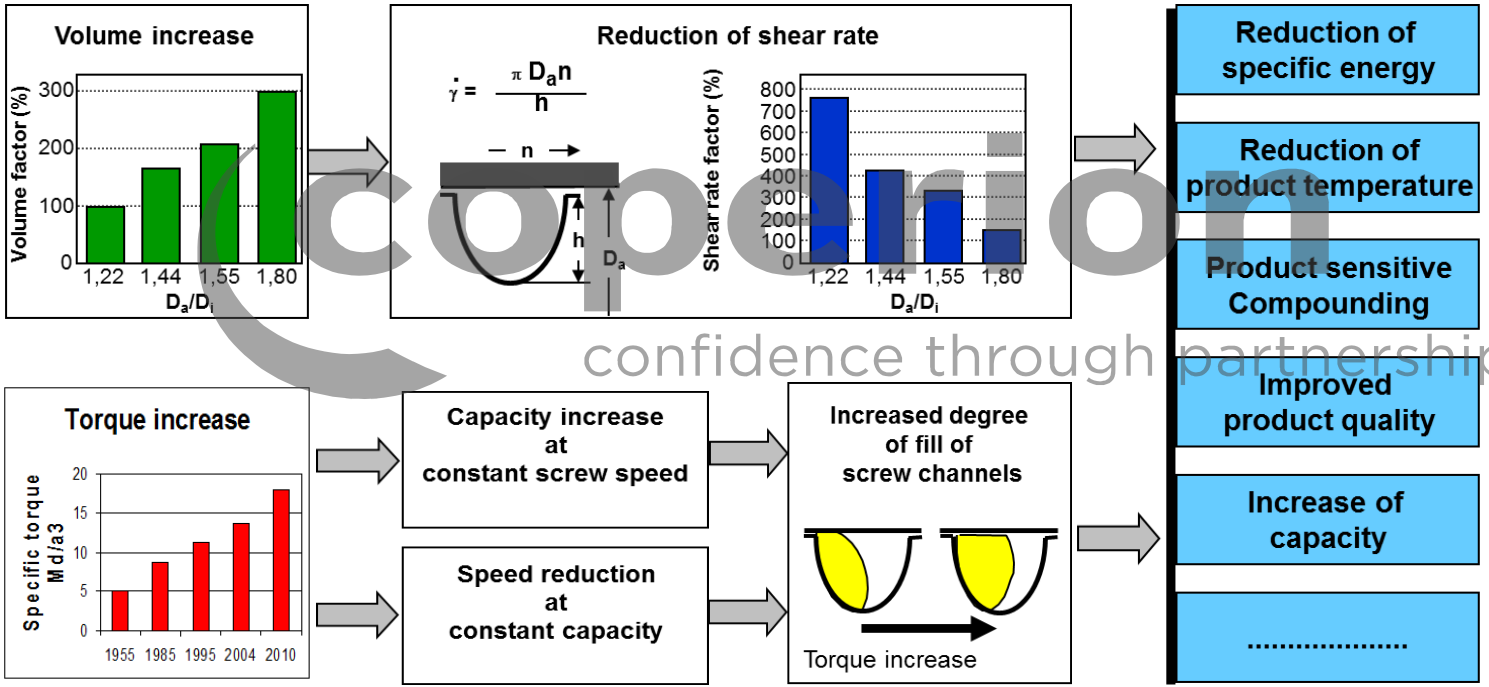


ZSK MEGAvolume
$D_o / D_i = 1,80$
$M_d / a^3 = 8,7$ Nm/cm³/ n = 1800rpm

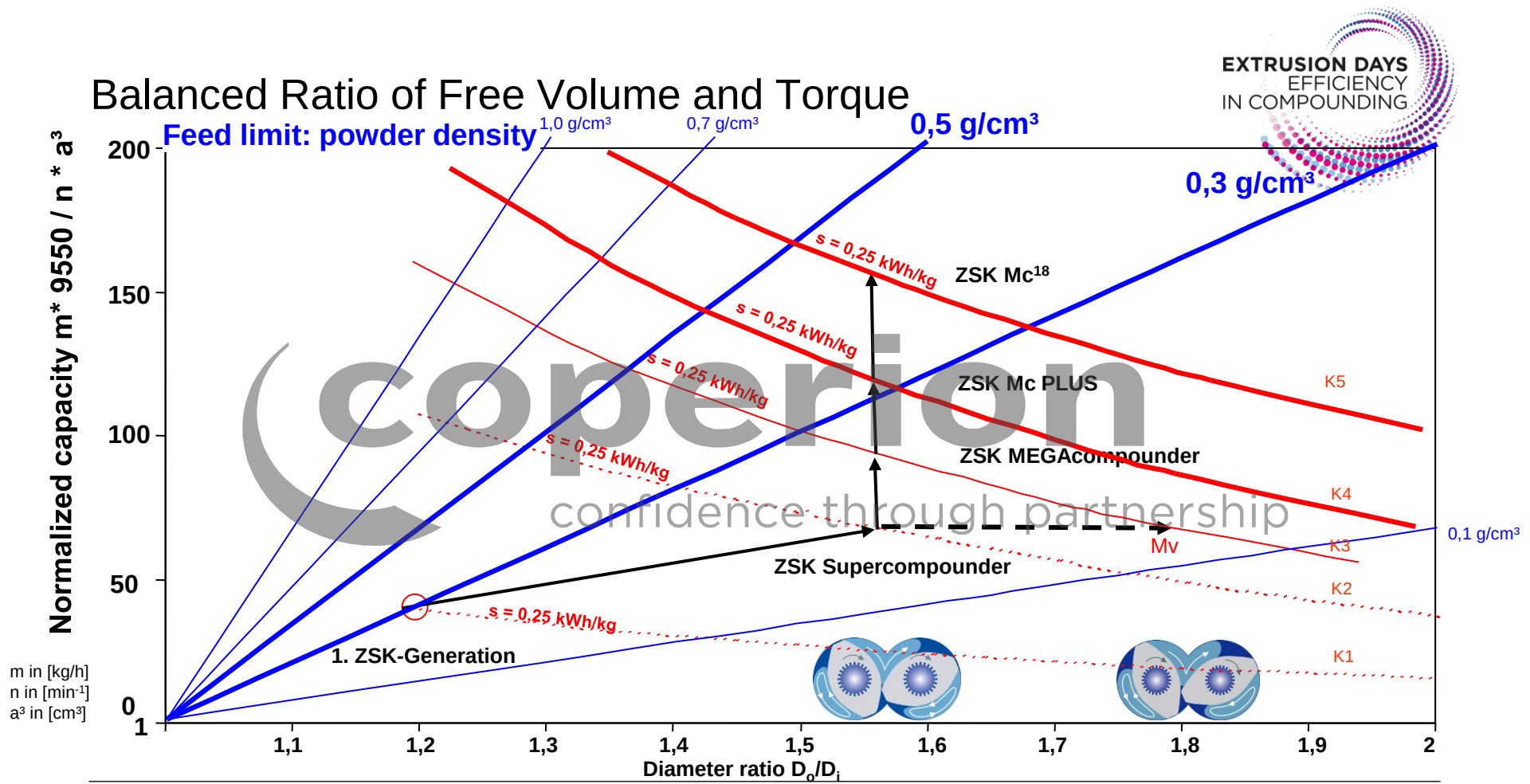
ZSK MEGAvolume PLUS
$D_o / D_i = 1,80$
$M_d / a^3 = 11,3$ Nm/cm³ / n = 1200rpm



Feed Rate and Quality Relating Parameters



Balanced Ratio of Free Volume and Torque

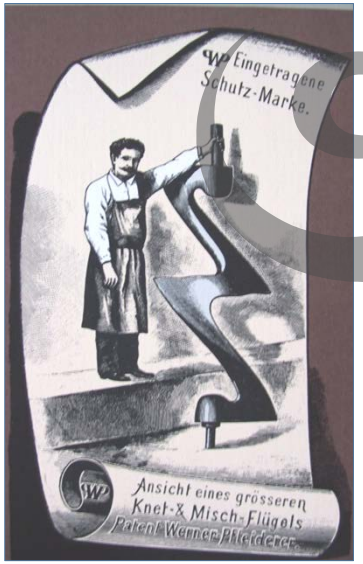


Kneading, Compounding and Efficiency Optimization

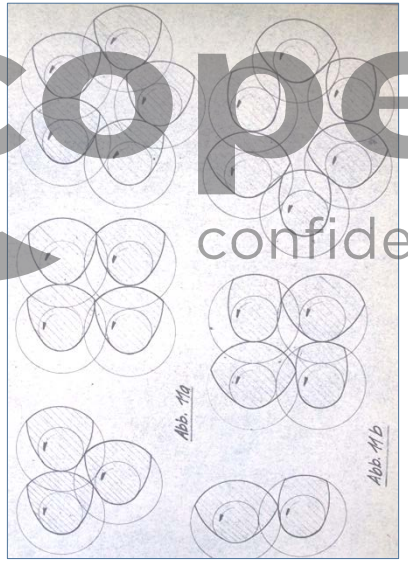
140 years of patents and innovation

EXTRUSION DAYS
EFFICIENCY
IN COMPOUNDING

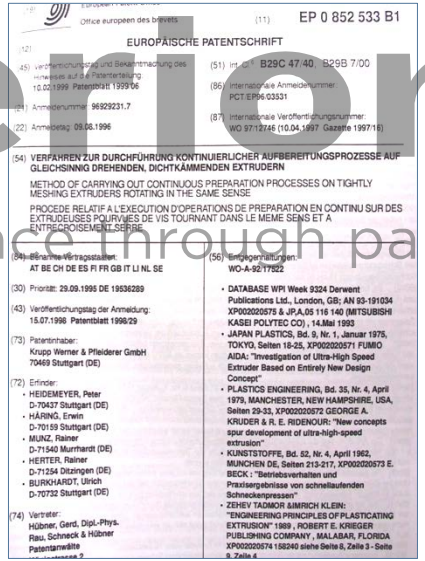
1877
The first
Batch kneader



1953
The first
Continuous Kneader



1995
The first
MEGAcompounder



EP 0 852 533 B1

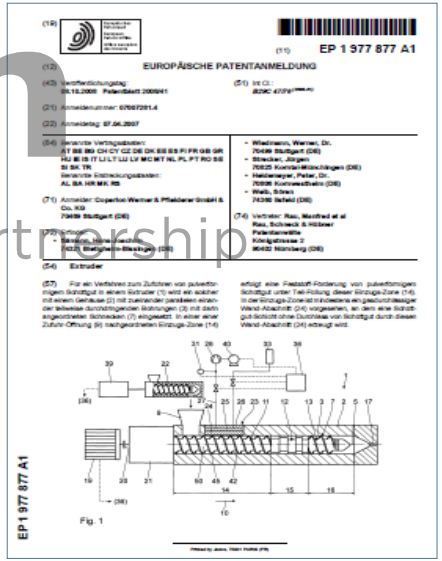
EUROPÄISCHE PATENTSCHRIFT

(54) VERFAHREN ZUR DURCHFÜHRUNG KONTINUIERLICHER AUFBEREITUNGSPROZESSE AUF GLEICHSINNIG DREHENDEN, DICHTKÄMMENDEN EXTRUDERN

METHOD OF CARRYING OUT CONTINUOUS PREPARATION PROCESSES ON TIGHTLY MESHING EXTRUDERS ROTATING IN THE SAME SENSE

PROCEDE RELATIF A L'EXECUTION D'OPERATIONS DE PREPARATION EN CONTINU SUR DES EXTRUDEUSES POURVUES DE VIS TOURNANT DANS LE MEME SENS ET A ENTRECROISEMENT SERRE

2008
Feed Enhancement
Technology



EP 1 977 877 A1

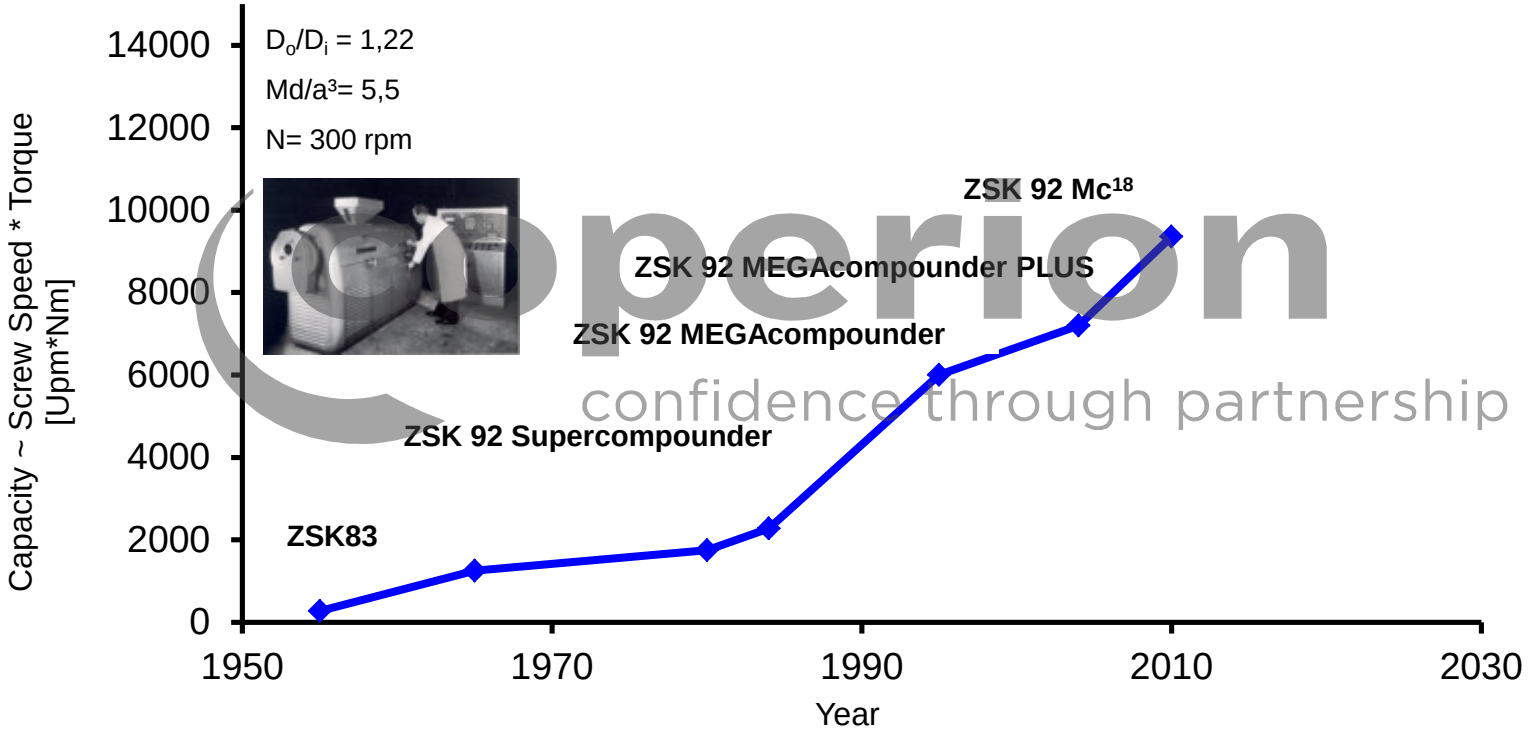
EUROPÄISCHE PATENTANMELDUNG

(54) Extruder

coperion
confidence through partnership

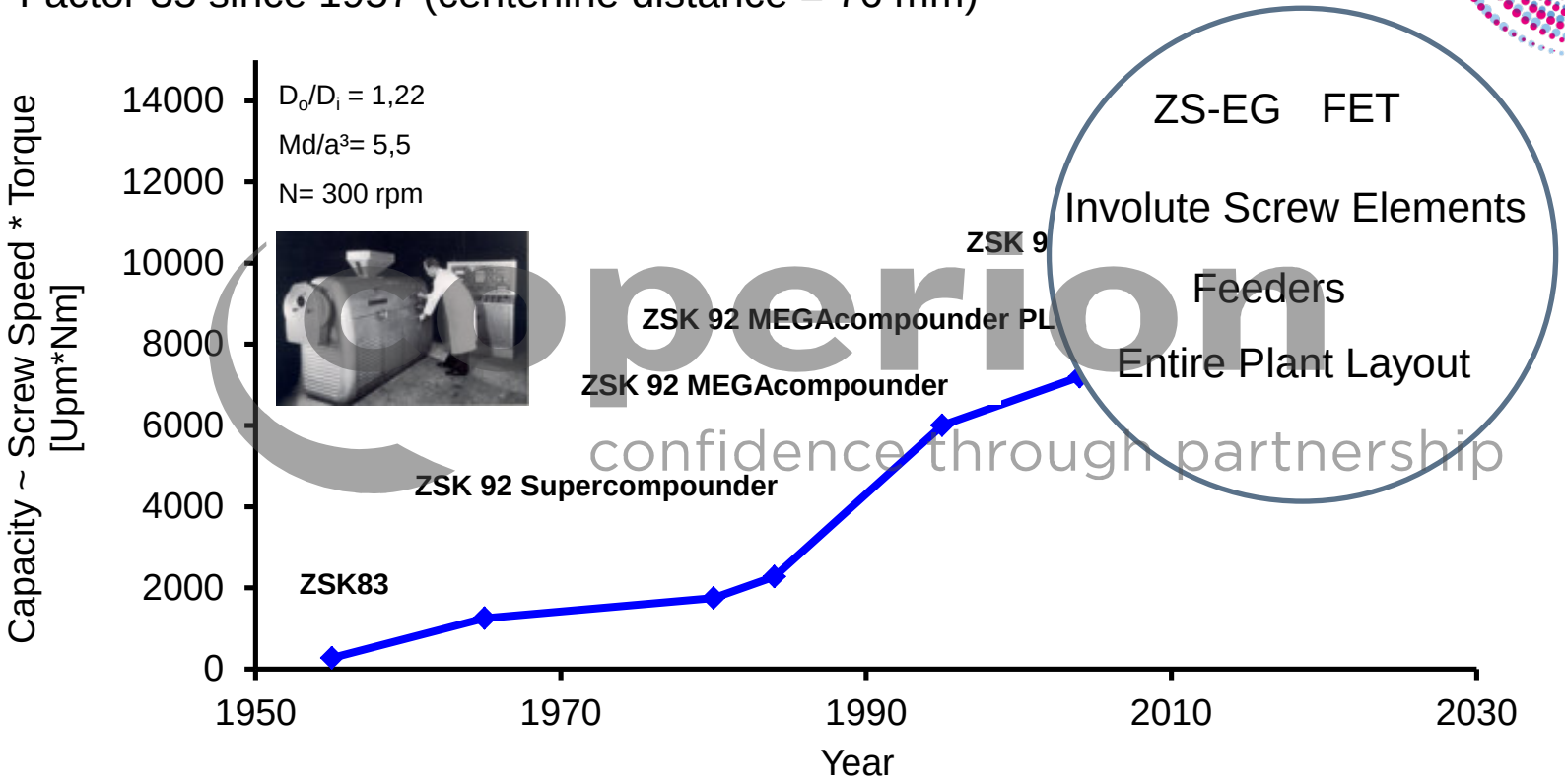
Throughput Increase 7% per Year

Factor 35 since 1957 (centerline distance = 76 mm)

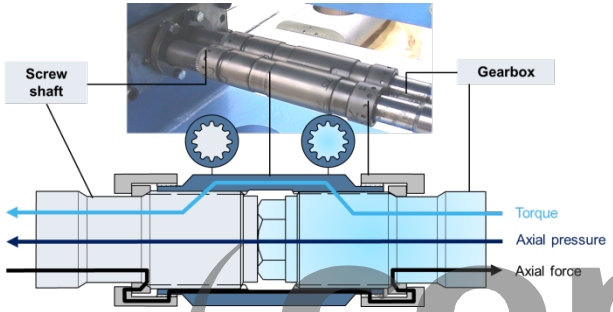


Throughput Increase 7% per year

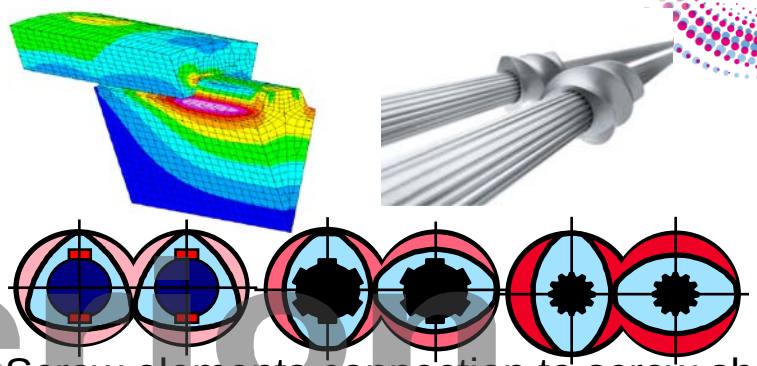
Factor 35 since 1957 (centerline distance = 76 mm)



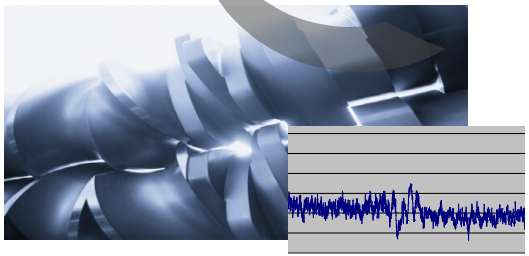
Development of Torque and Screw Speed



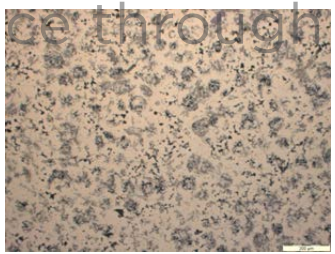
Screw shaft coupling

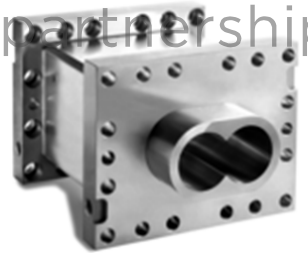


Screw elements connection to screw shaft



Low wear and pulsation optimized screw design

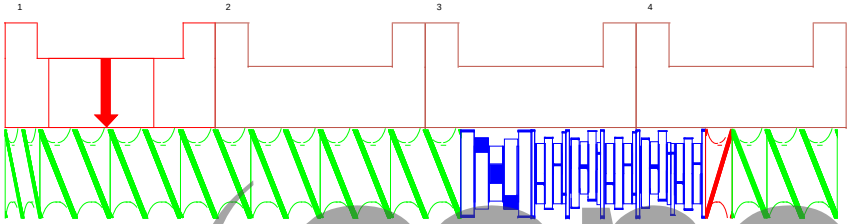


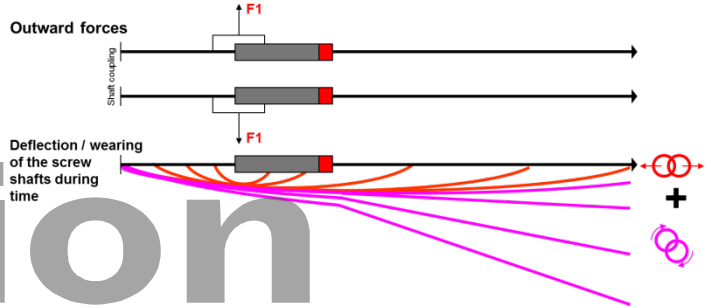


Materials of construction (…adhesive wear)

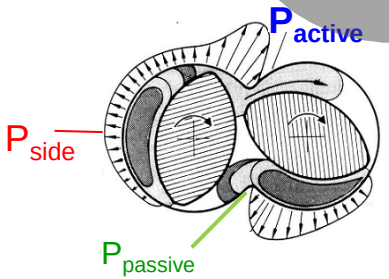
Development of Torque and Screw Speed

Outward forces along plastification

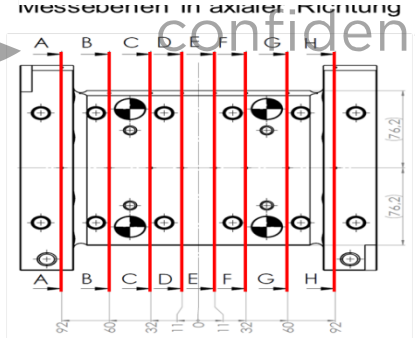




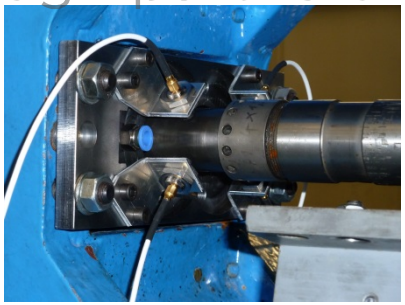
Pressures:Cross Section



Pressures:Axial Direction



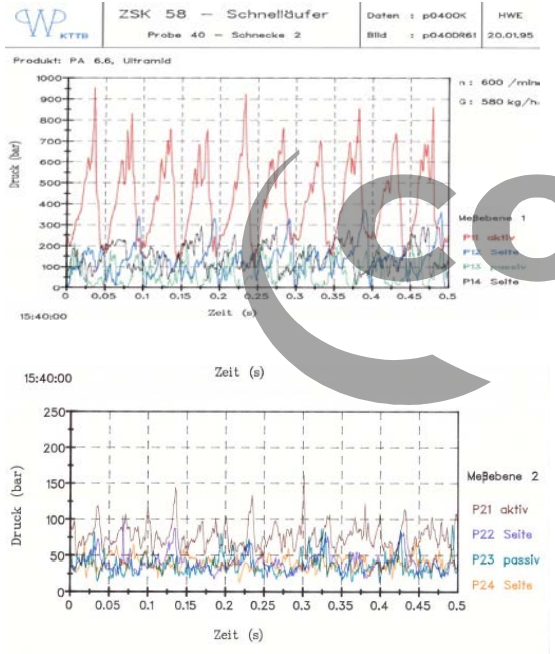
Measurement of mechanical deflection in vertical and horizontal direction



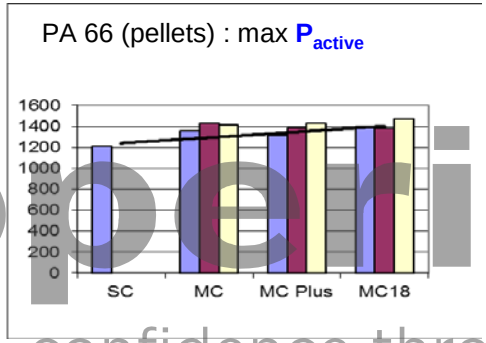
Development of Torque and Screw Speed

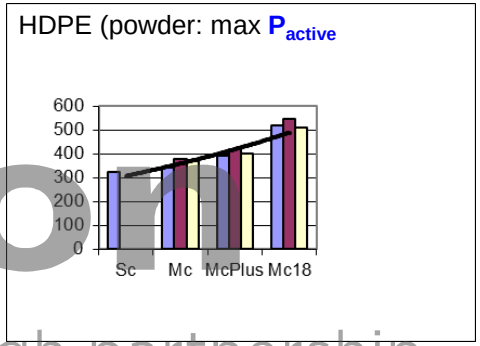
Fundamental development of machine series

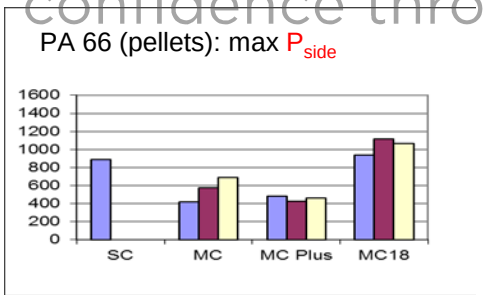
< 2000

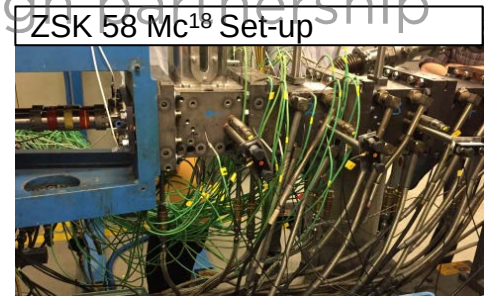


> 2000









600 Upm | 900 Upm | 1100 Upm | Expon. (600 Upm)

Main Factors Limiting the Capacity

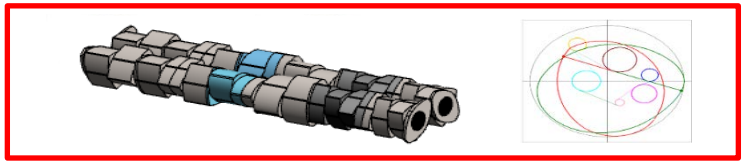
EXTRUSION DAYS
EFFICIENCY
IN COMPOUNDING

Limit:
Motor power

Limit:
Feed intake

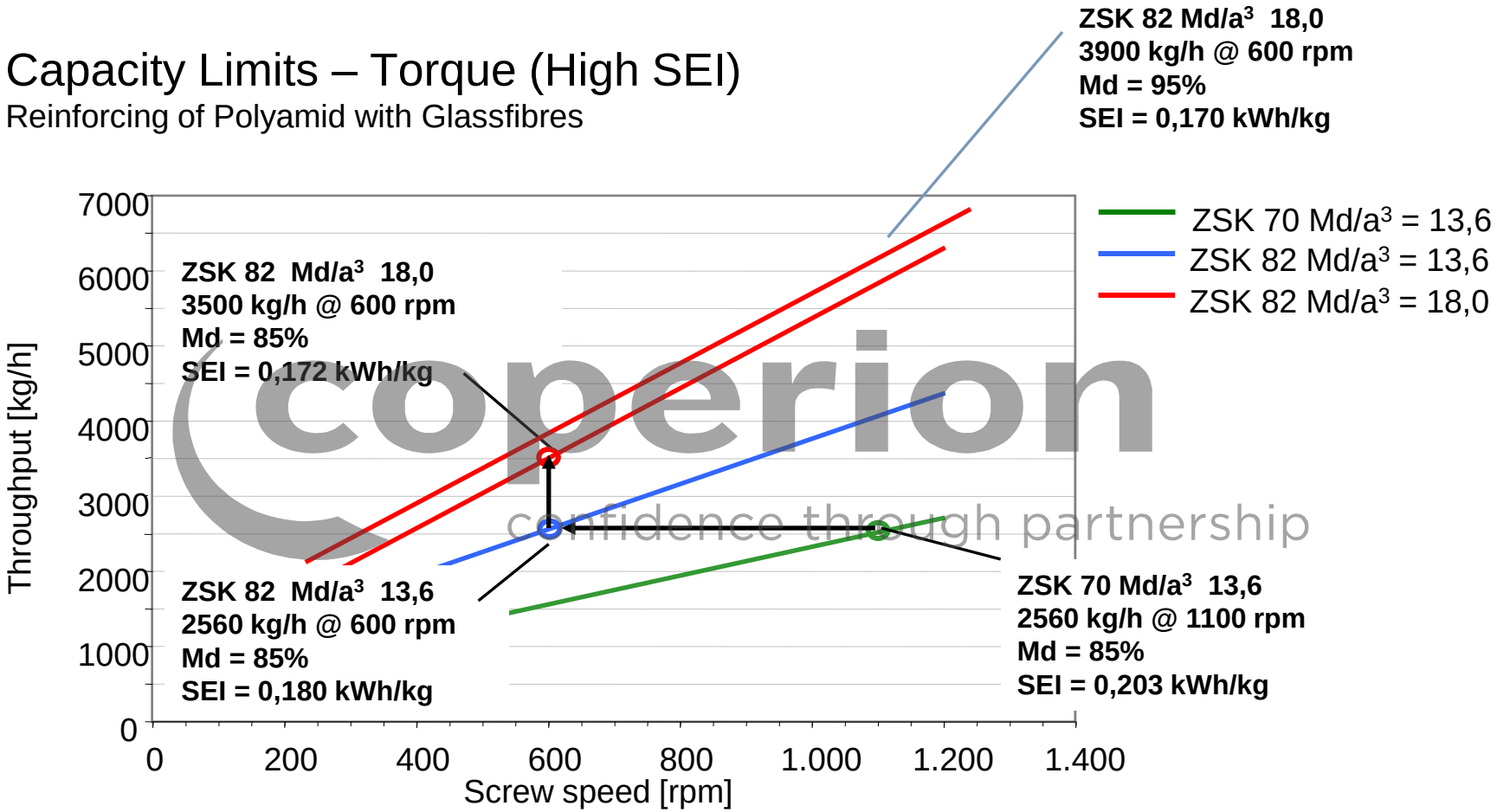
Limit:
Degassing

Limit:
Mixing/Quality

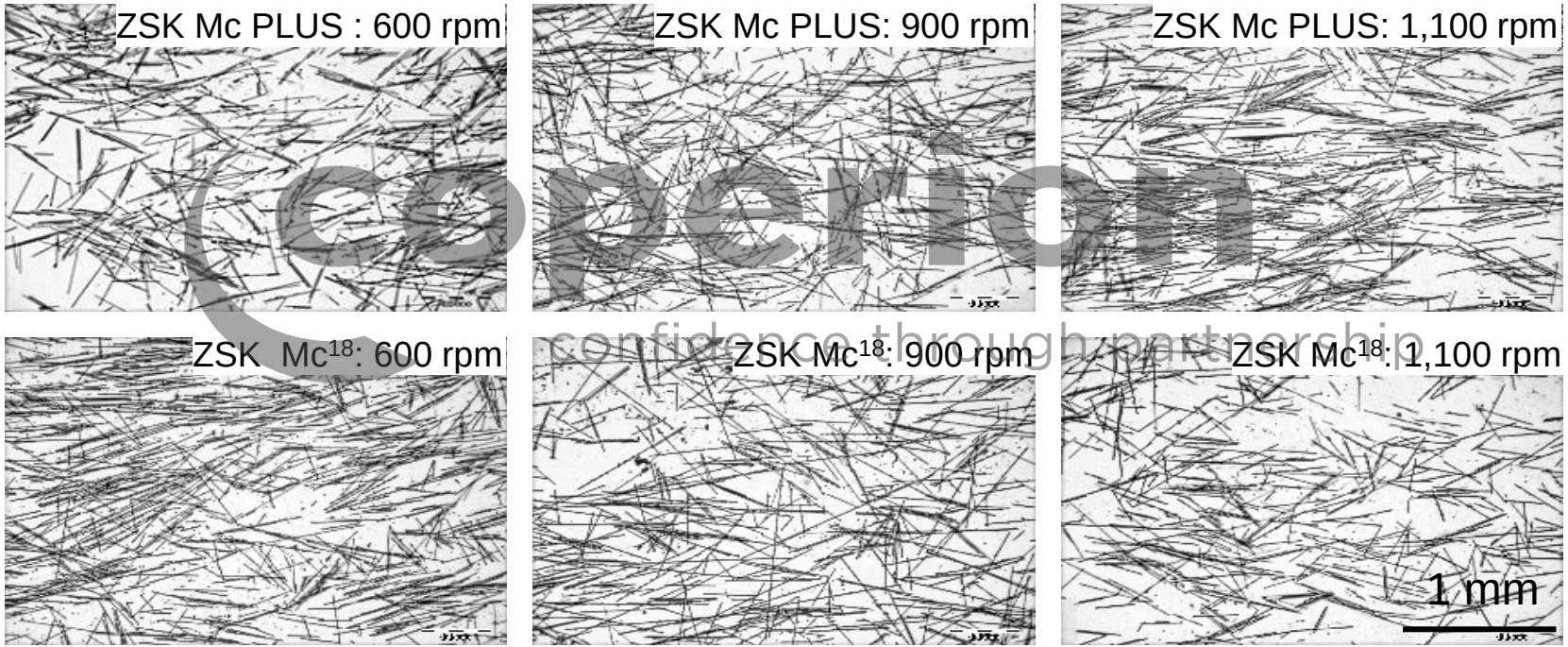


Capacity Limits – Torque (High SEI)

Reinforcing of Polyamid with Glassfibres

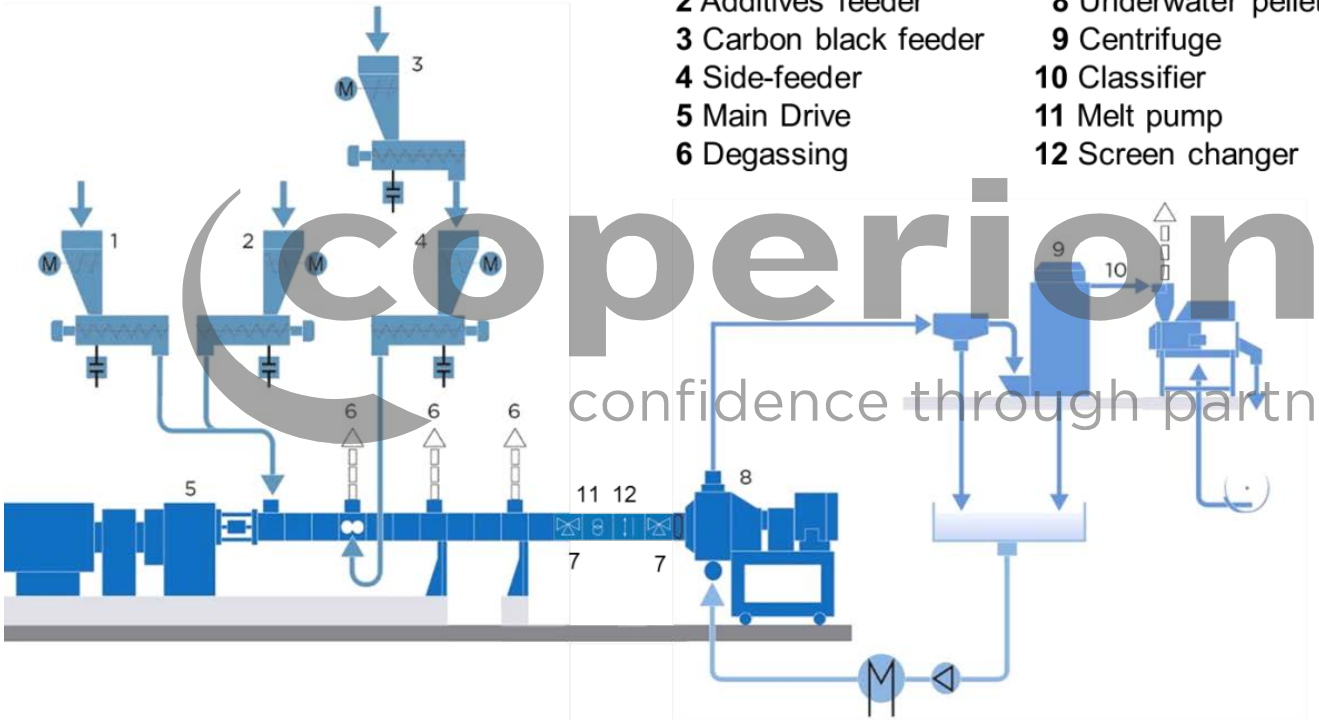


Microscopy of Glass Fibres for PA6 + 30% GF

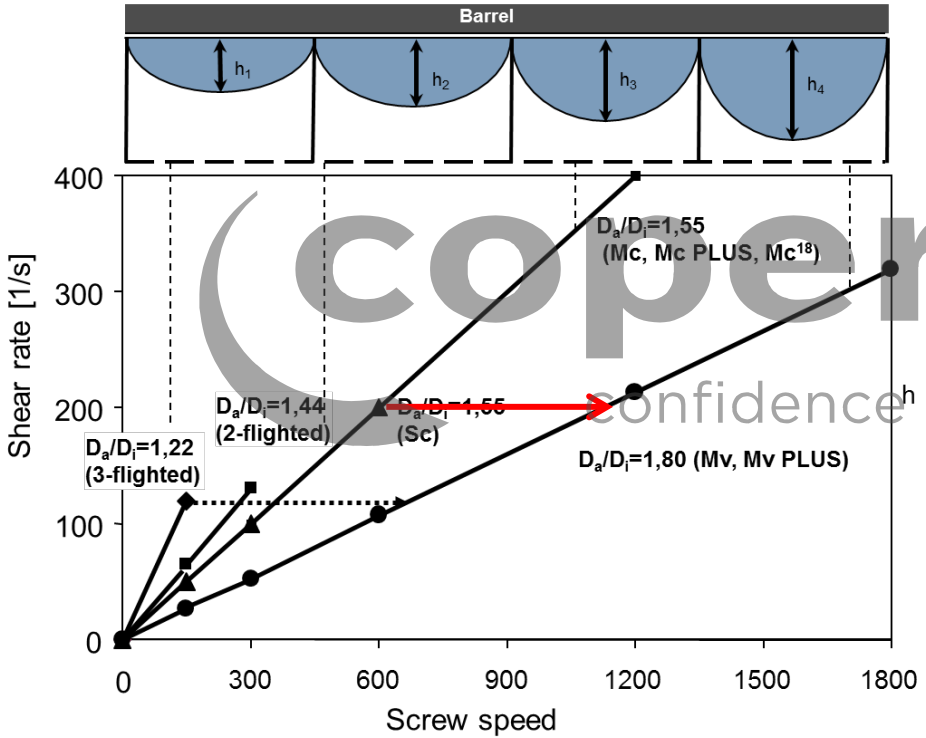


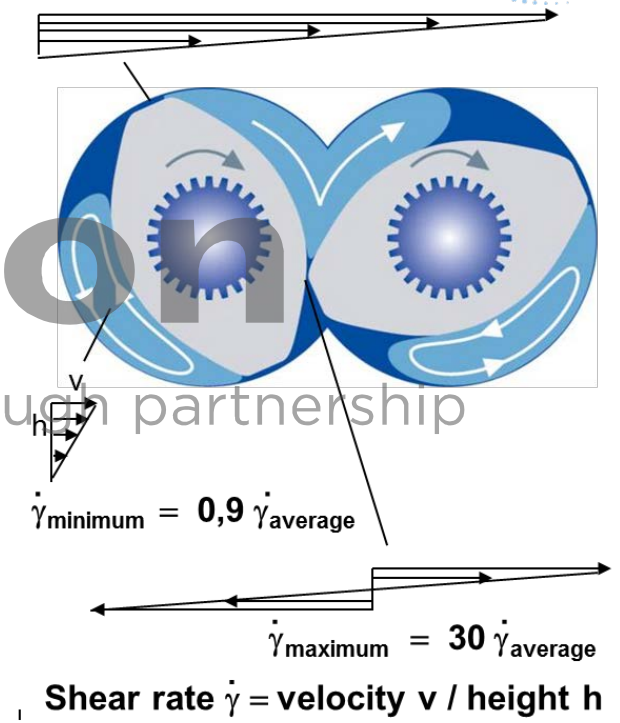
Capacity Limits – Torque and Volume

Carbon Black Masterbatch



Capacity Limits – Torque and Volume
Carbon Black Masterbatch



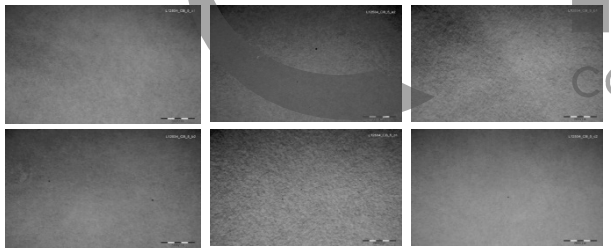


Capacity Limits – Torque and Volume
Carbon Black Masterbatch

ZSK 76 Mv PLUS
LLDPE + 40% carbon black pearls
1.500 kg/h @ 900 rpm

Evaluation according to ISO 18553*

ISO-Grade							
sample	a1	b1	c1	a2	b2	c2	Mean value
5	0,0	1,0	0,5	1,0	1,0	0,5	0,67



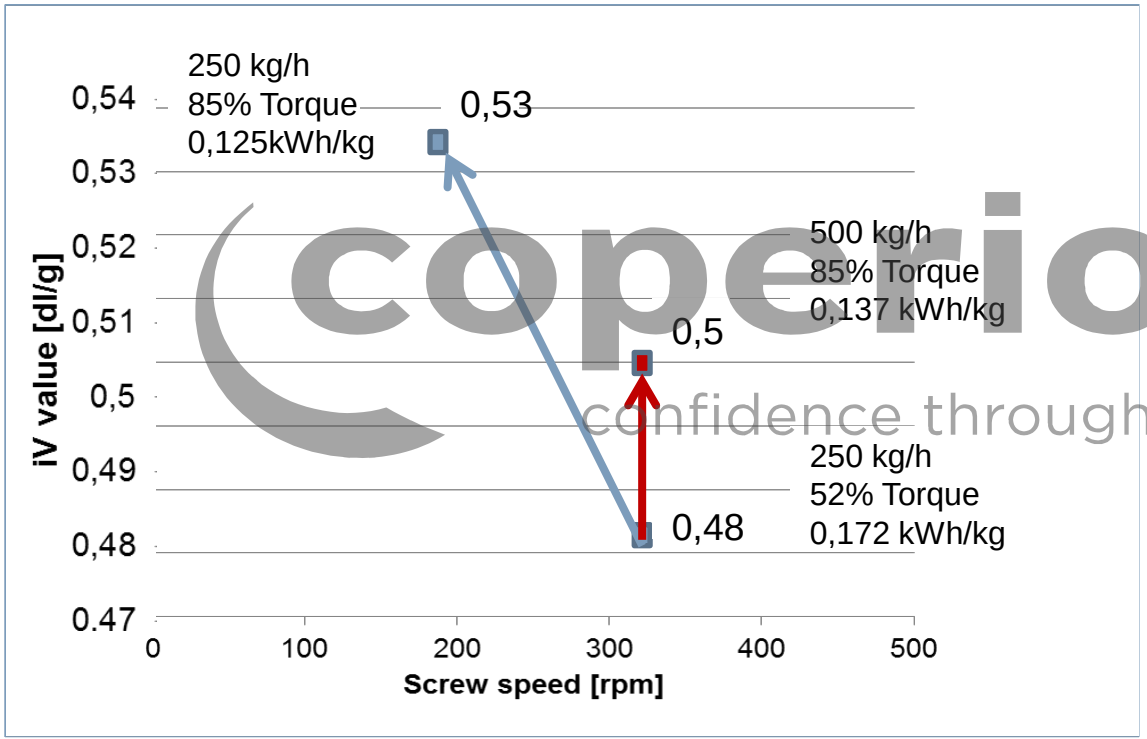
ZSK 76 Mv PLUS
HDPE + 40% carbon black pearls (P-type):
1.800 kg/h @ 900 rpm

ISO-Grade							
sample	a1	b1	c1	a2	b2	c2	Mean value
16	0,5	0,5	1,0	1,0	1,5	0,5	0,83

- Improved dispersion with large operation window at low and high screw speeds
- Developement of one universal screw design for different loadings, polymers and semi-conductive CB.

Capacity Limits – Torque and Volume

PET + 60 TiO_2



Improve iV by
reduction of speed at
Same throughput

Improve iV by
increase of throughput
at same screw speed

Capacity Limits - Quality
Influence on dispersion quality

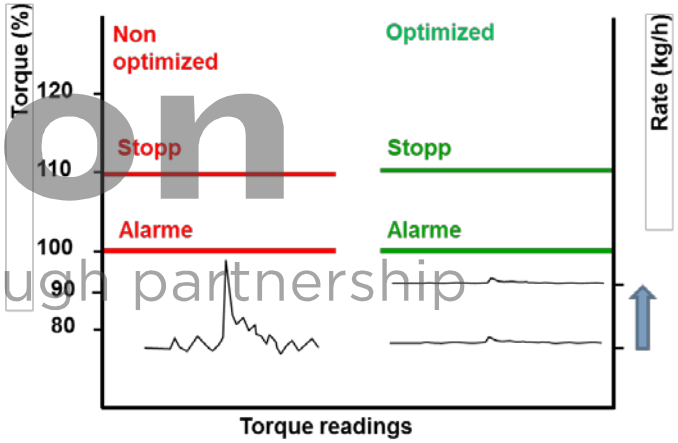
Not optimized screw configuration

Optimized screw configuration – **standard** elements

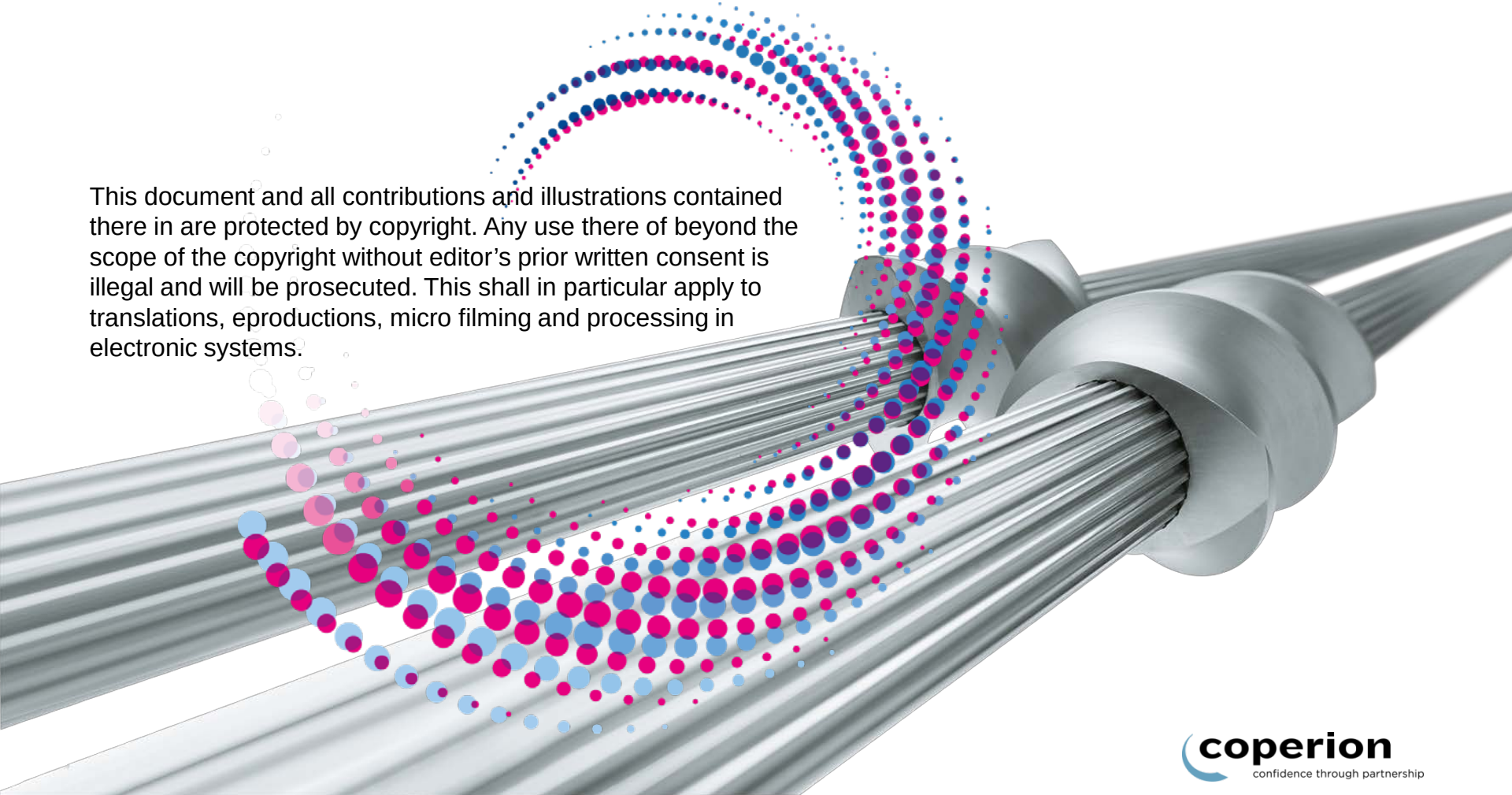
Optimized screw configuration – **new involute** elements

Over 60 Years of ZSK: Process-related Modularity and Flexibility Meets High Quality and Efficiency

- Torque and volume as well as the screw speed have been developed over the last 69 years.
- Technical features such as side-feeding, feed enhancement technology, twin screw side degassing, materials of constructions have ensured to use the available torque and volume.
- Upstream and downstream equipment have been optimized to ensure the high efficiency of the ZSK (feeders, die head and pelletizing systems).




Thank you very much
for your attention!
coperion
confidence through partnership



coperion
confidence through partnership