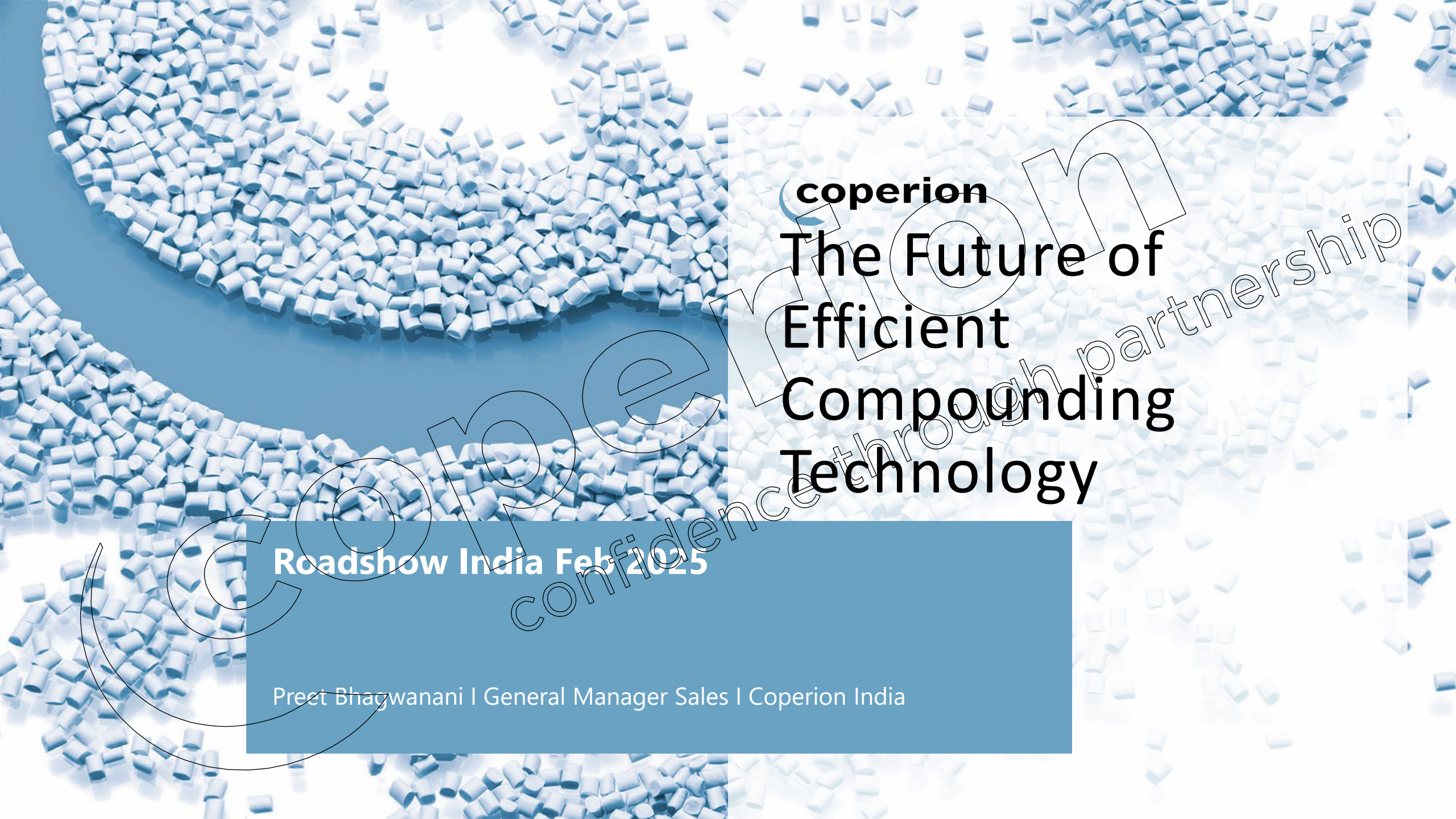


The Future of Efficient Compounding Technology

Roadshow India Feb 2025

Preet Bhagwanani I General Manager Sales I Coperion India

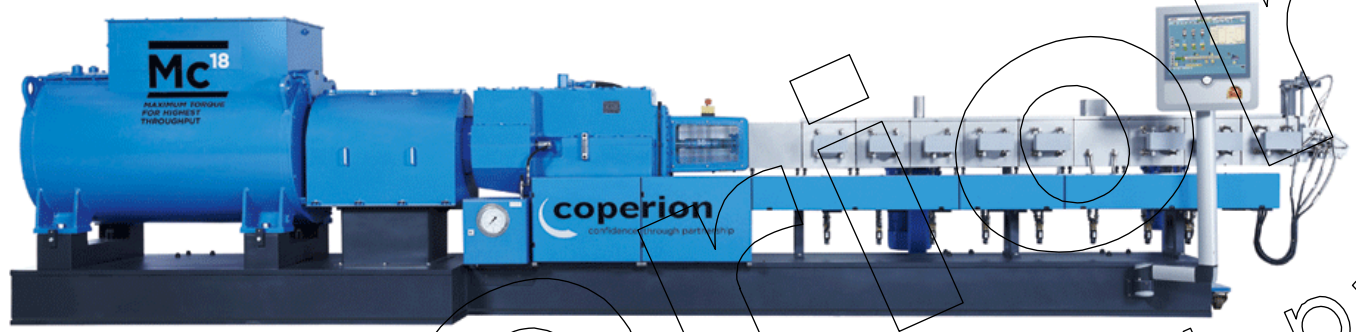
Agenda

1 Introduction ZSK Twin Screw Compounder | Functionality, Specific Torque, Specific Energy Input SEI

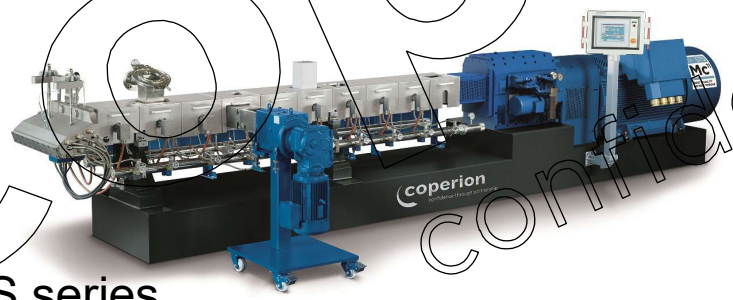
2 Efficient Examples | Specific torque, FET, ZS-EG, Bulk X-Change, C-Beyond

3 Summary

Product range : Coperion's Compounders



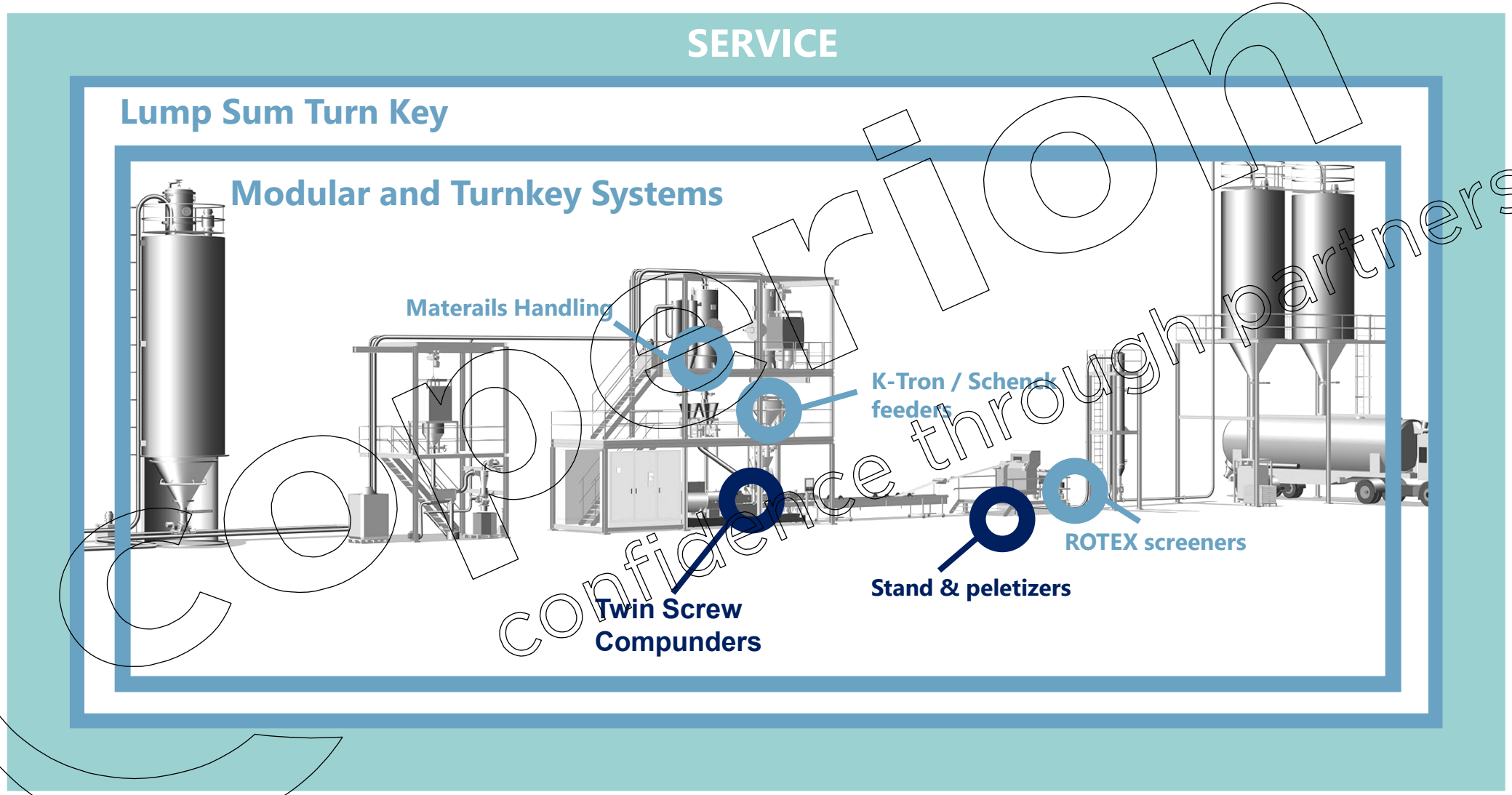
ZSK series



STS series

CTE series

Machines as Foundations for Product Ecosystems



Compounding tasks on Twin Screw Extruders

For high-quality end products: From single components to complete systems

Target Markets

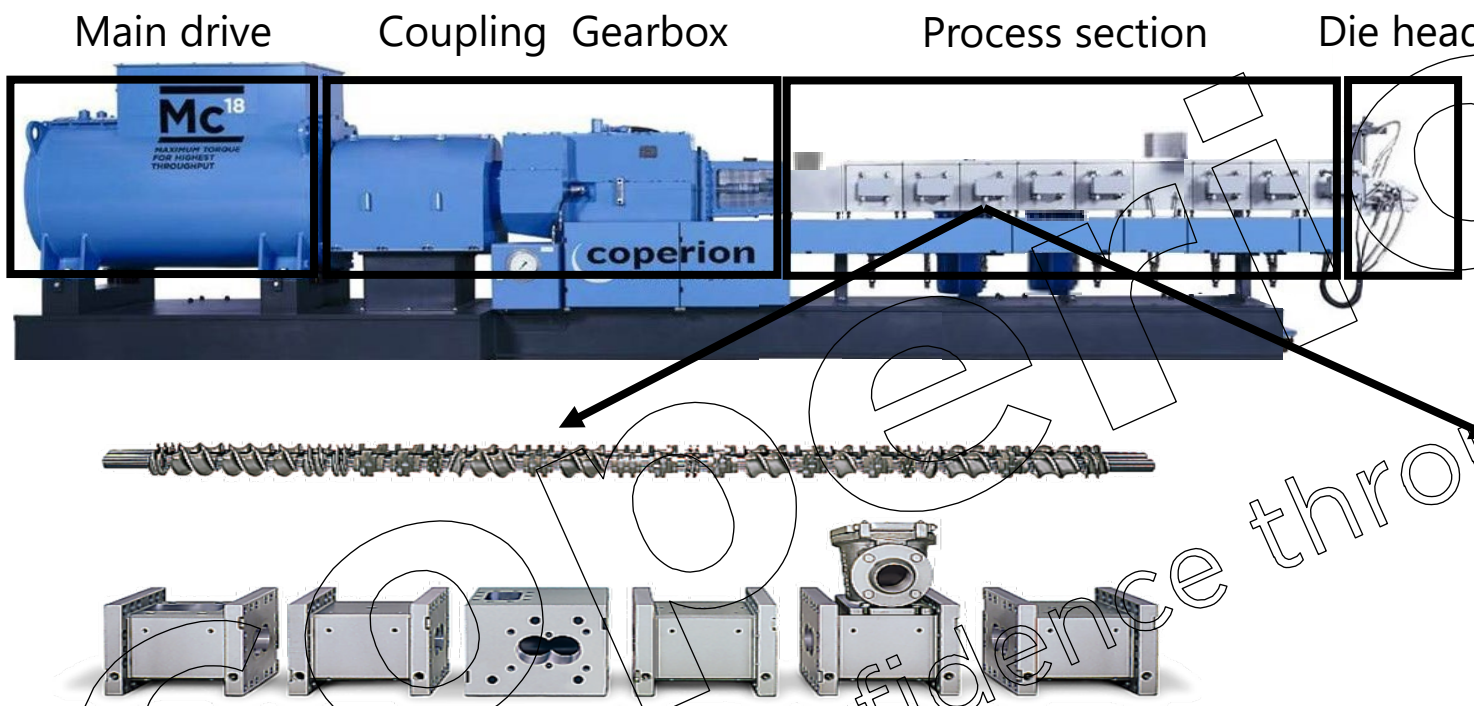
- Engineering Plastics
- Masterbatch
- PVC/HFFR
- Bio Plastics
- Direct Extrusion
- Battery Separator Films
- Chemical Applications
- Powder Coating
- Adhesives

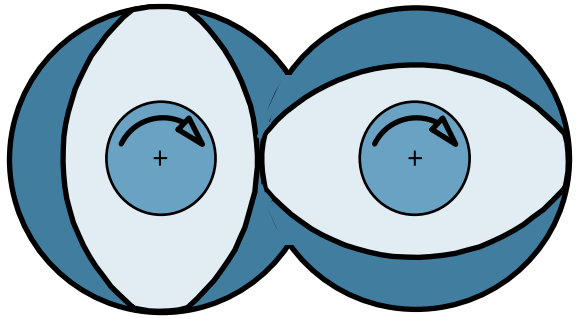
In other Business Units:

- Polyolefines
- Plastics Recycling
- Battery Masses
- Conveying of Minerals

The ZSK twin screw extruder

Modular design and => perfect fit to any process task



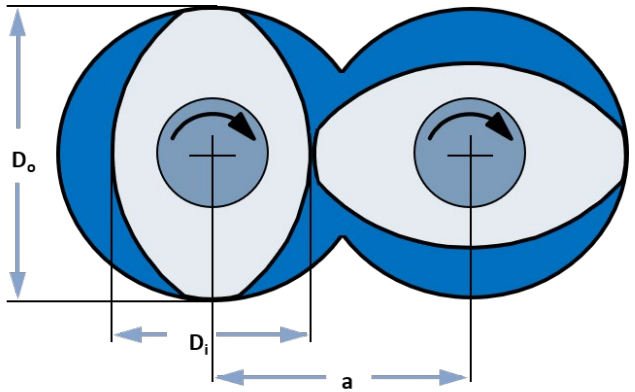


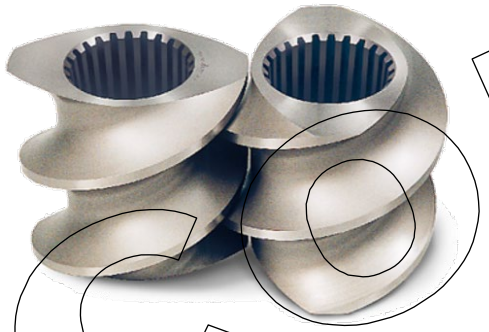
Benefits

- Modular design of barrels and screws
- Intermeshing and self-cleaning

ZSK development

Characteristic dimensions





D_0= Outer diameter
D_i = Inner diameter
a = Centerline distance
$\boldsymbol{D_0/D_i}$ = Diameter ratio
determines shear, degassing and powder intake

$\boldsymbol{M_d/a^3}$ = Specific torque
determines power density and filling degree

n = Screw speed
determines shear and mixing

Conclusion

- Specific parameters define a co-rotating twin-screw extruder ZSK
- The specific torque determines the power density of a co-rotating twin-screw

ZSK development

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

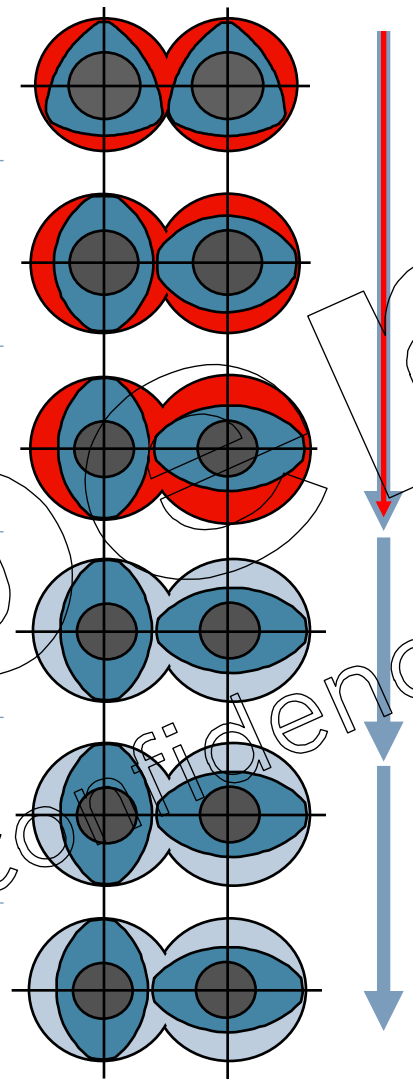
ZSK variable
$D_o / D_i = 1,44$
$M_d / a^3 = 5,0$ Nm/cm³
n = 300 min-1

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

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

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

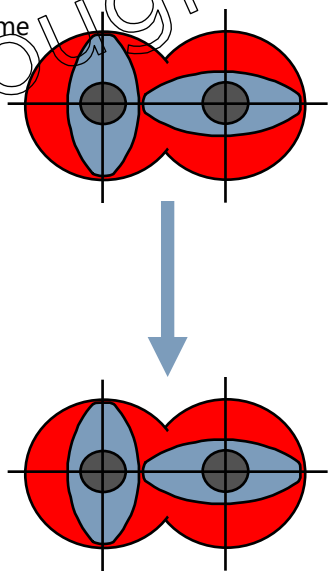
ZSK Mc¹⁸
$D_o / D_i = 1,55$
$M_d / a^3 = 18$ Nm/cm³
n = 1200 min-1



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

Increase of free volume
(additional 40%)

Increase of torque

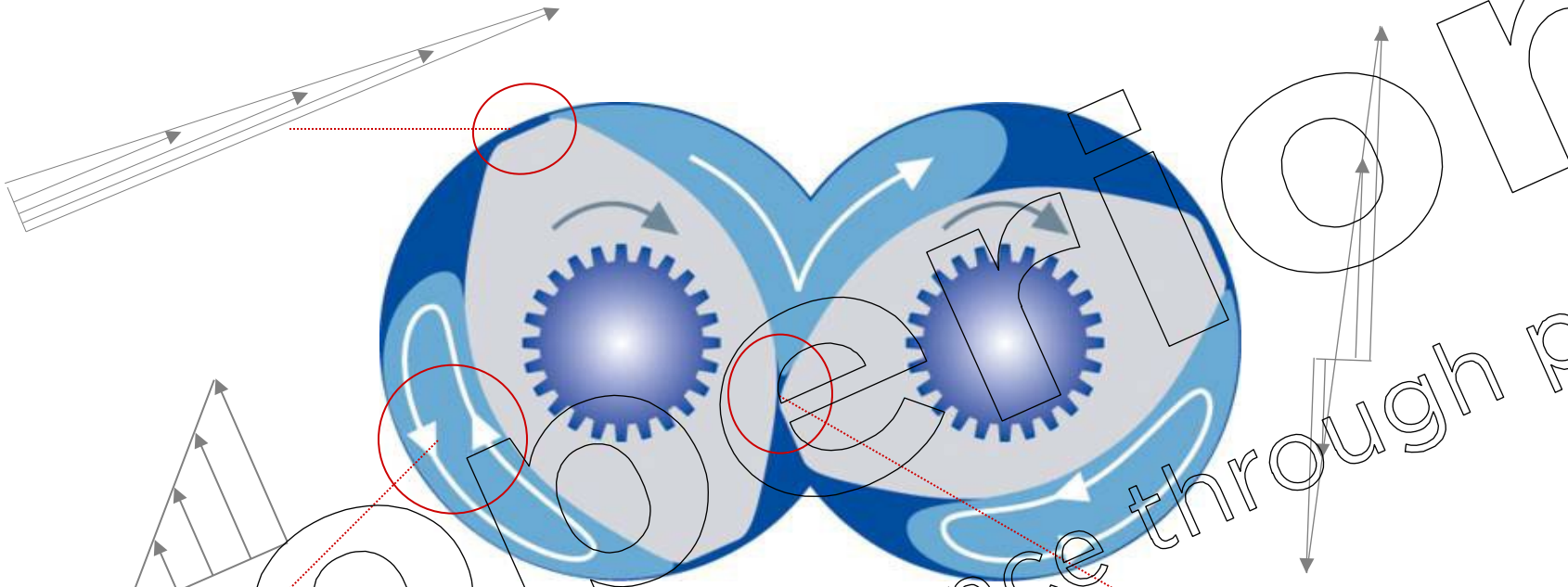


ZSK MEGAvolume
$D_o / D_i = 1,80$
$M_d / a^3 = 8,7$ Nm/cm³
n = 1800 min-1

ZSK Mv PLUS
$D_o / D_i = 1,80$
$M_d / a^3 = 11,3$ Nm/cm³
n = 1800 min-1

ZSK development

Shear rate distribution in screw channel



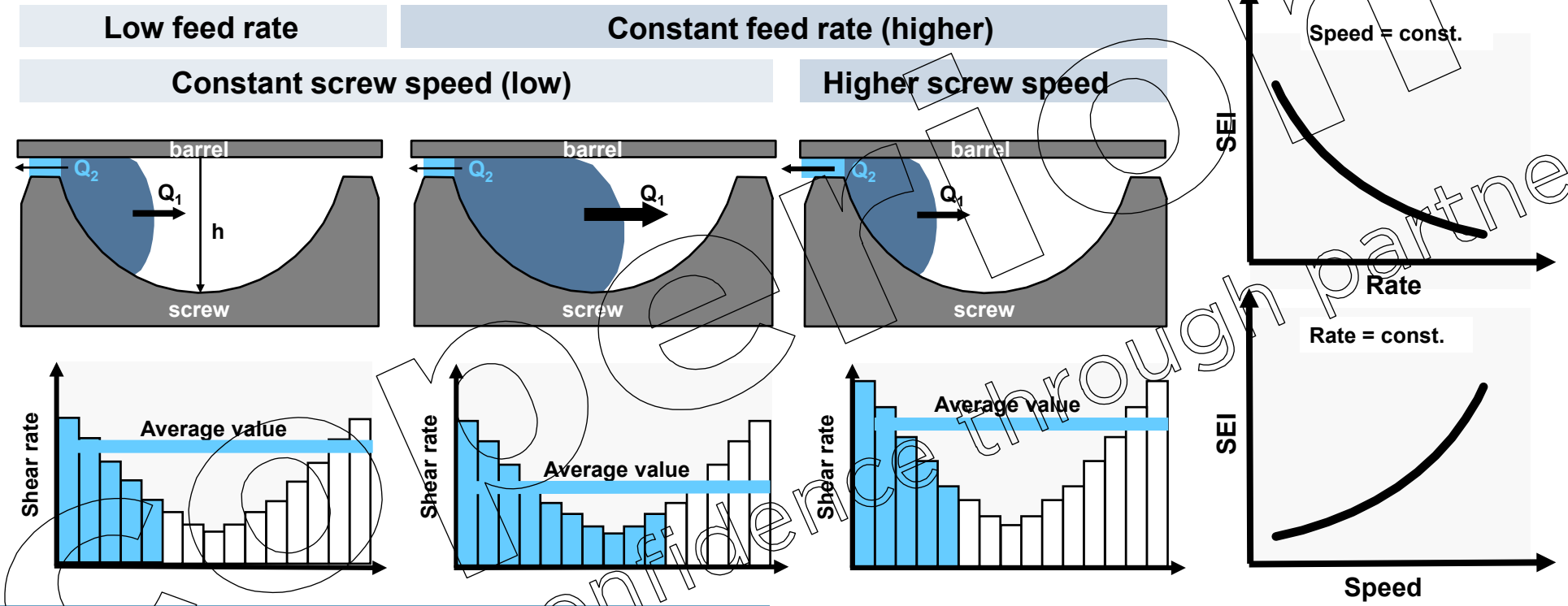
$\dot{\gamma}_{minimum} = 0{,}9\ \dot{\gamma}_{average}$

$\dot{\gamma}_{maximum} = 30\ \dot{\gamma}_{average}$

$$\text{Shear rate } \dot{\gamma} = \frac{\text{circumferential speed v}}{\text{channel depth}}$$

Process parameters

Specific energy (SEI): Influence of rate and screw speed



Why is high torque saving energy?

At constant screw speed, the specific energy SEI is reduced with higher throughput rate.
High degree of fill leads to higher energy efficiency and lower melt temperature

Agenda

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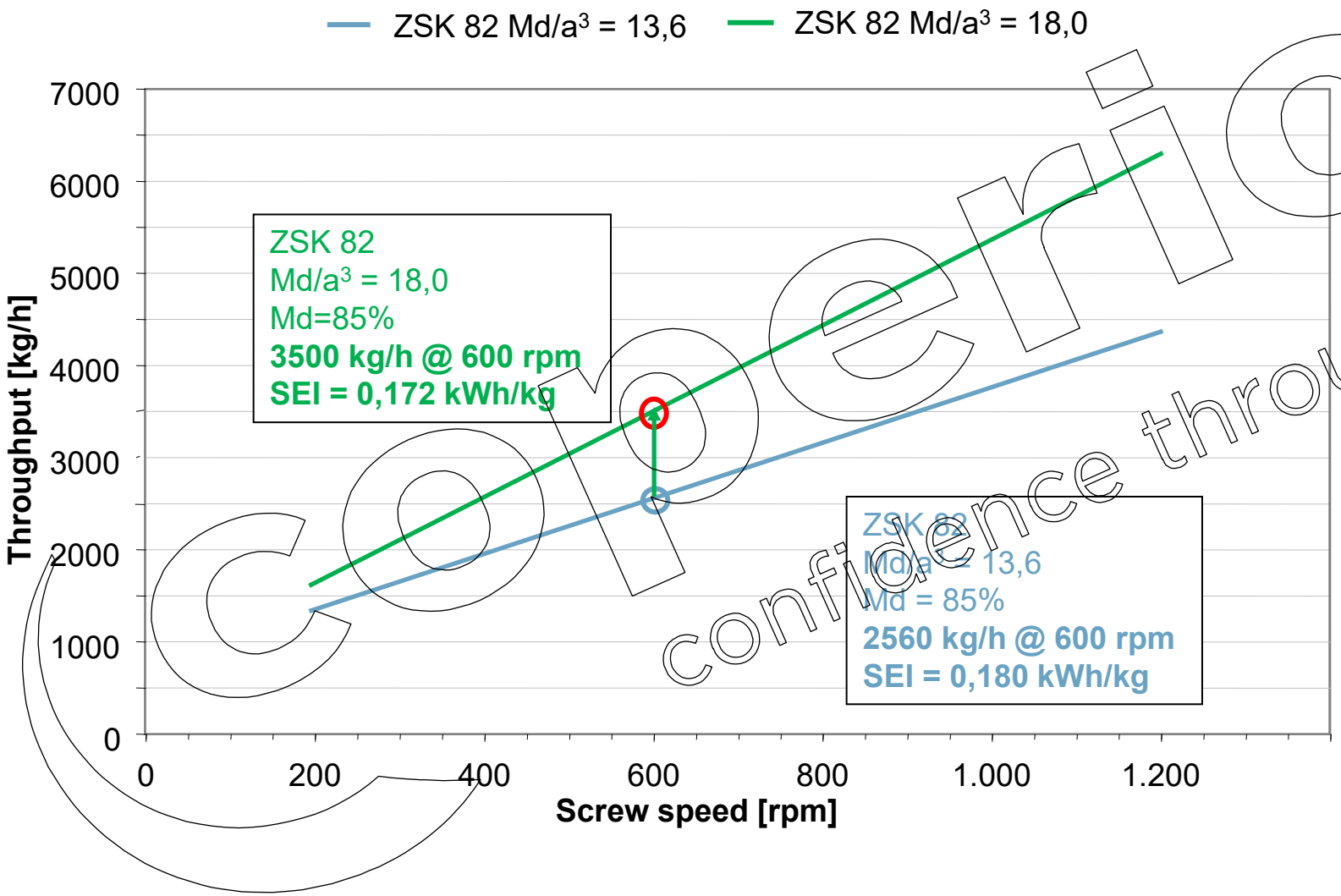
2 Efficient Examples | Specific torque, FET, ZS-B MEGAfeed, ZS-EG, Bulk X-Change, Motor selection, C-Beyond

3 Summary

Example 1: Increasing Specific Torque

Fiber reinforced PA6 + 30% GF, higher degree of fill with higher specific torque



Conclusion

Higher specific torque leads to lower specific energy input SEI (and higher profitability)

3,5 t/h PA, runtime 6000h:

- **Energy saved:** 0.008kWh/kg * 21,000,000kg = **168.0kWh**
- **Output increase:** 940kg/h * 6000h = **5640t/year**

→ **Use highest possible torque**

→ **Check for modernization**

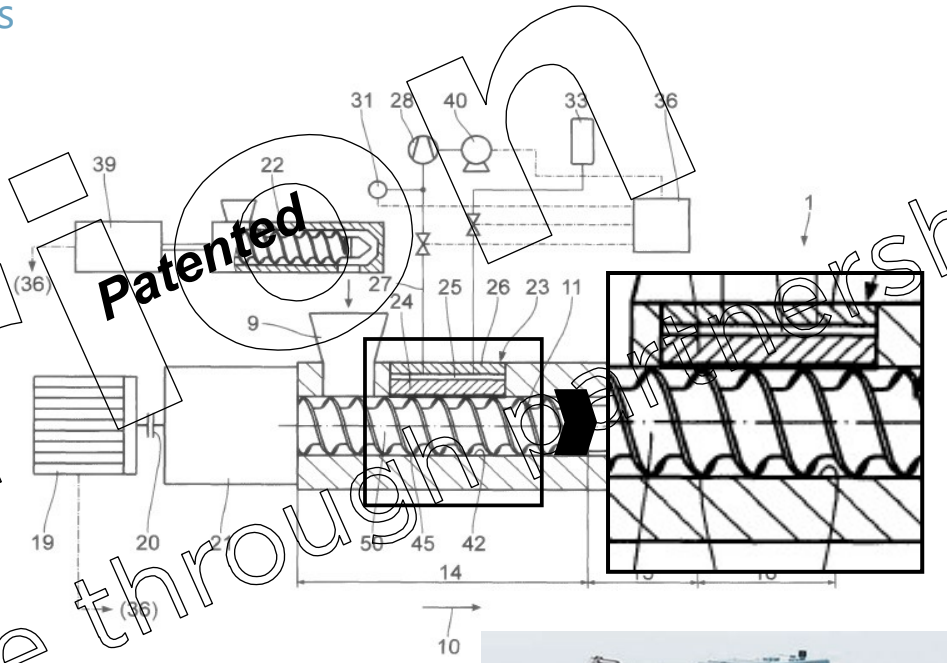
Example 2: Feed Enhancement Technology

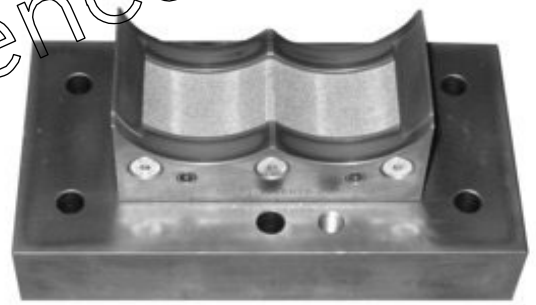
FET: Technology to increase the throughput of feed limited products

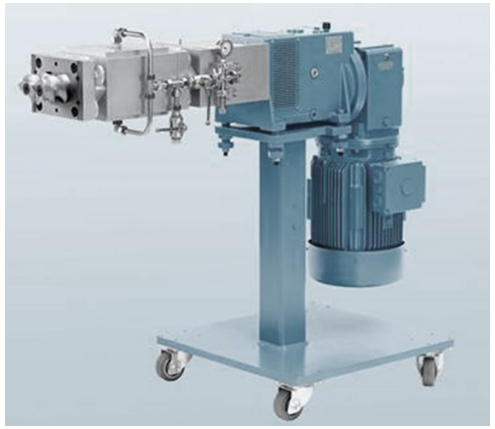
Features:
Solids conveying is improved by applying vacuum in the feed zone to a wall section which is porous and permeable to gas.

This wall section is realized by an insert with a filter membrane installed in an open barrel.

Already more than 150 ZSK equipped with FET

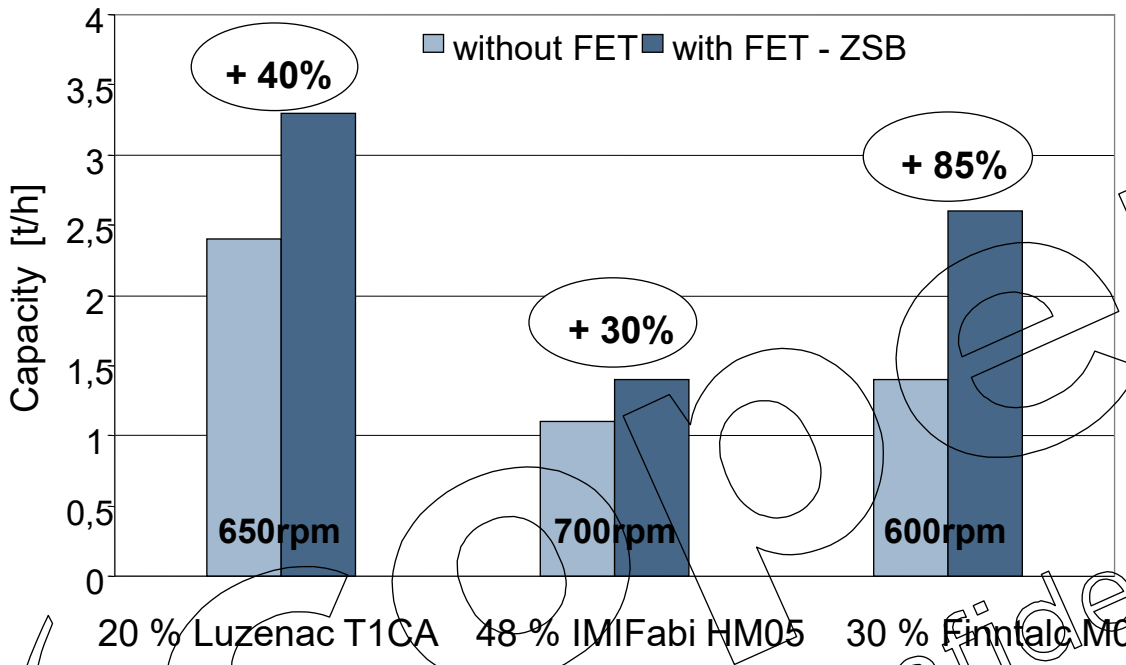


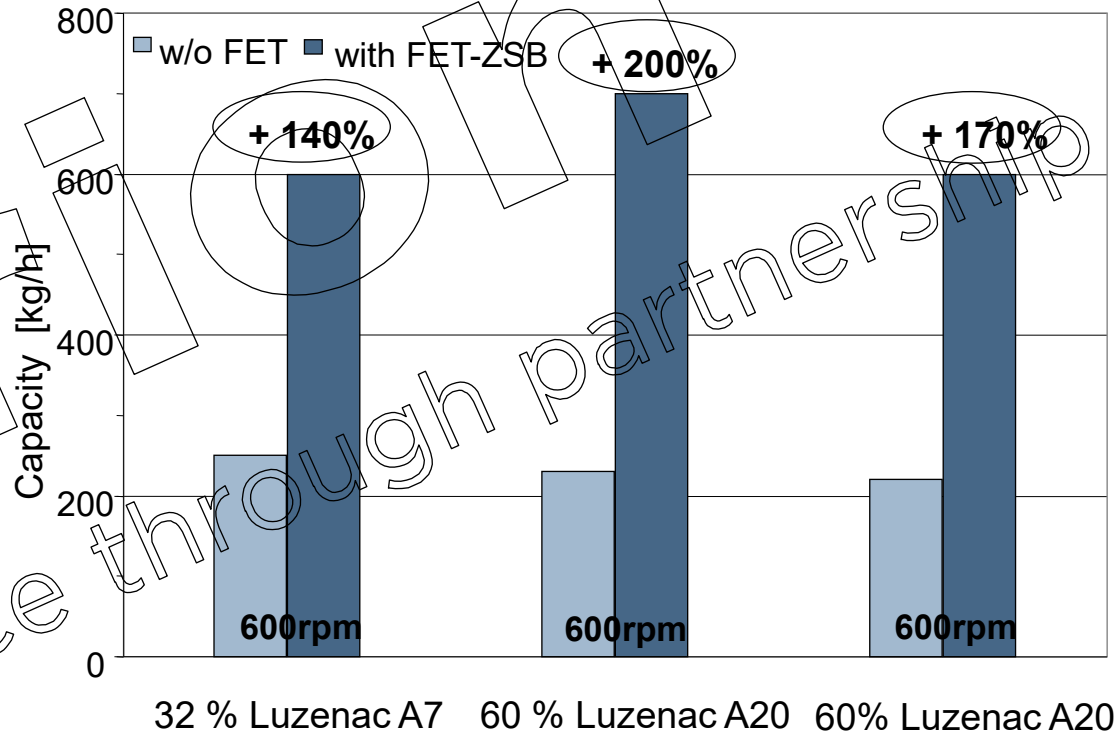




Example 2: Feed Enhancement Technology

FET: Examples from production ZSK92 and trials ZSK50





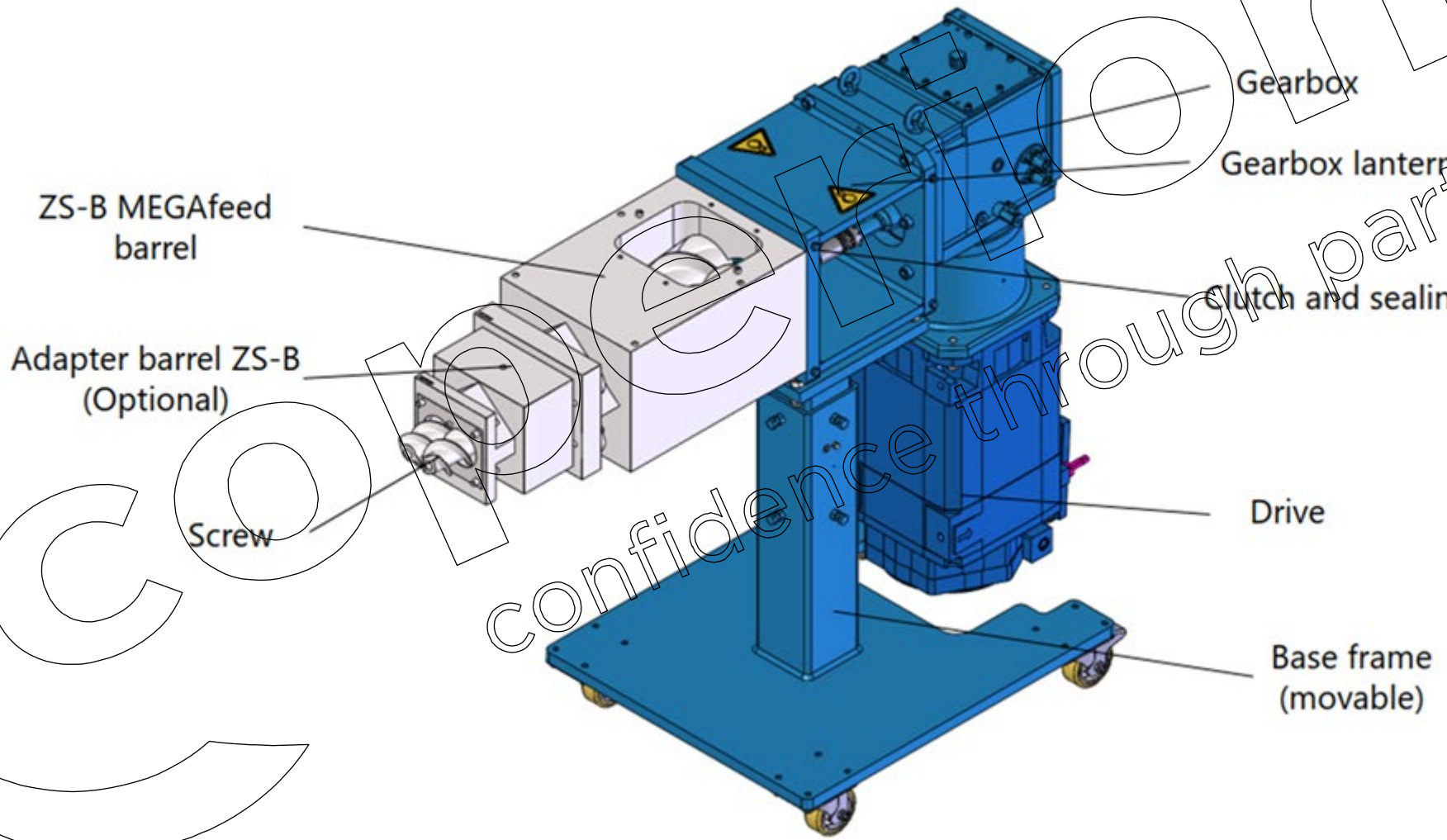
Conclusion

- Increase of throughput for fine powders at constant screw speed of ZSK
- Decrease of SEI in relation to throughput increase and energy savings at same footprint

Example 3: ZS-B MEGAfeed side feeder

ZS-B MF Design

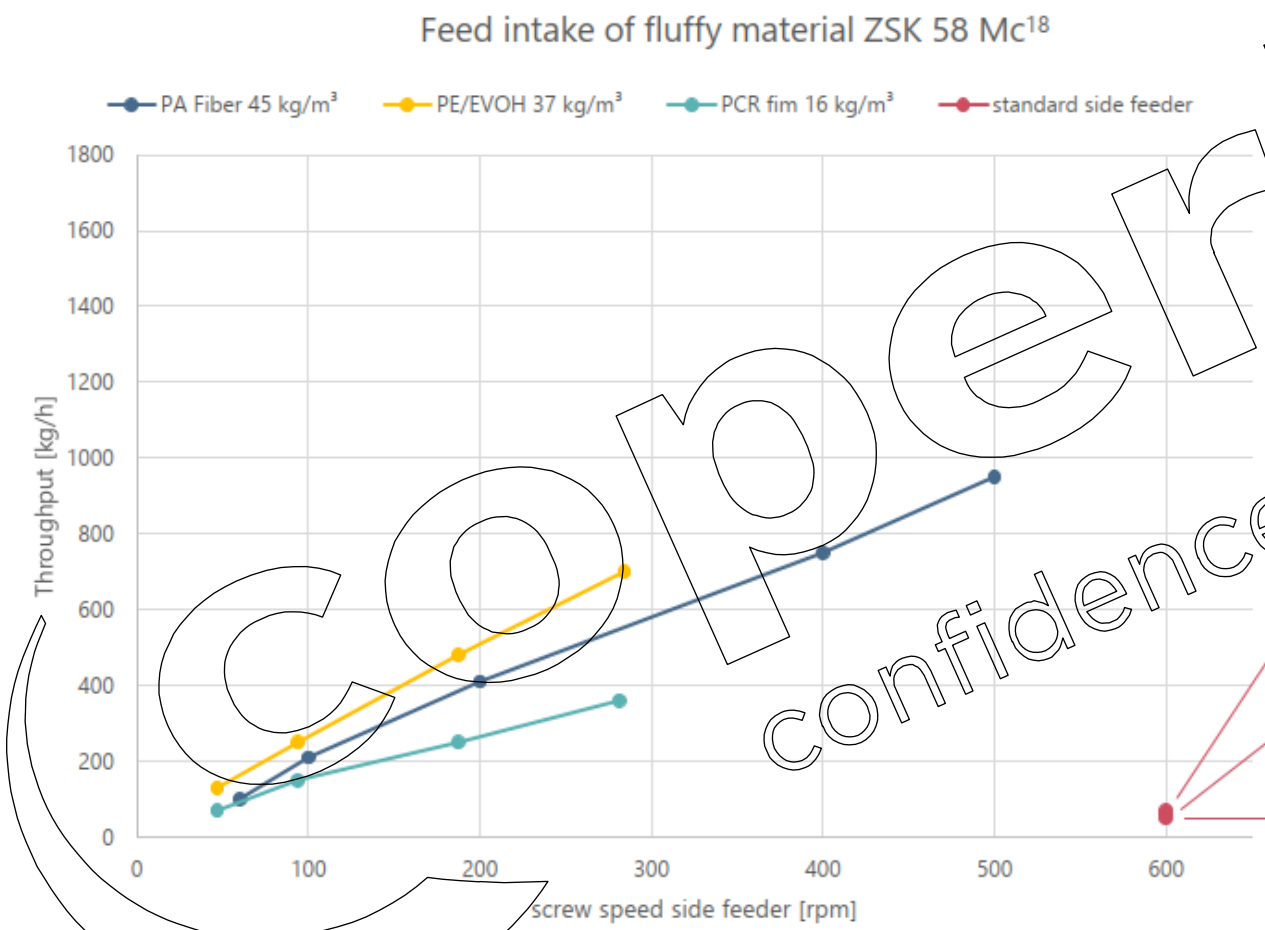
Design



Example 3: ZS-B MEGAfeed side feeder

Challenges for the handling of recyclates

Feed intake



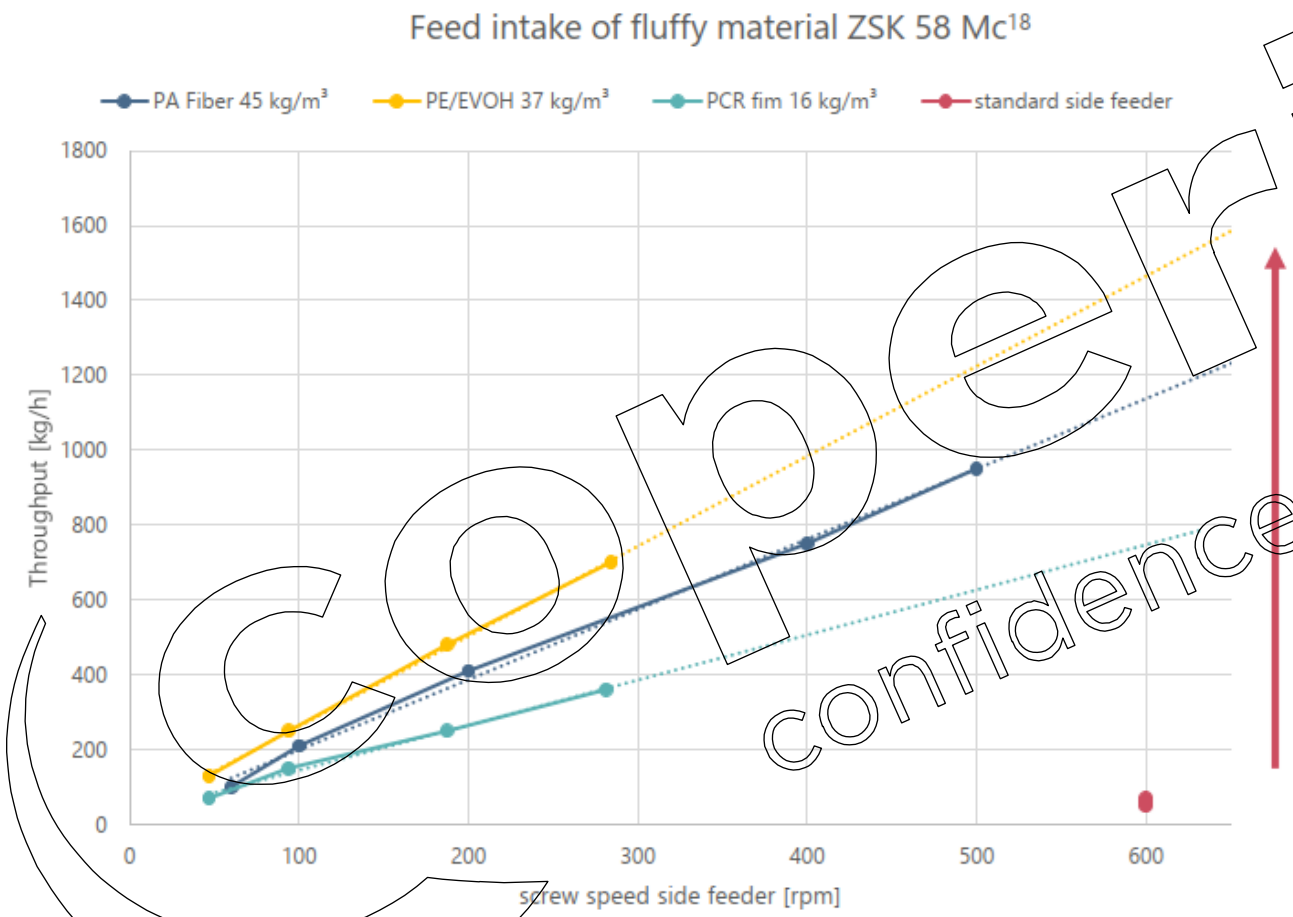
New innovative feeding device

Even with very low screw speeds at the **NEW side feeder**, higher throughputs can be achieved with very fluffy materials

Example 3: ZS-B MEGAfeed side feeder

Challenges for the handling of recyclates

Feed intake



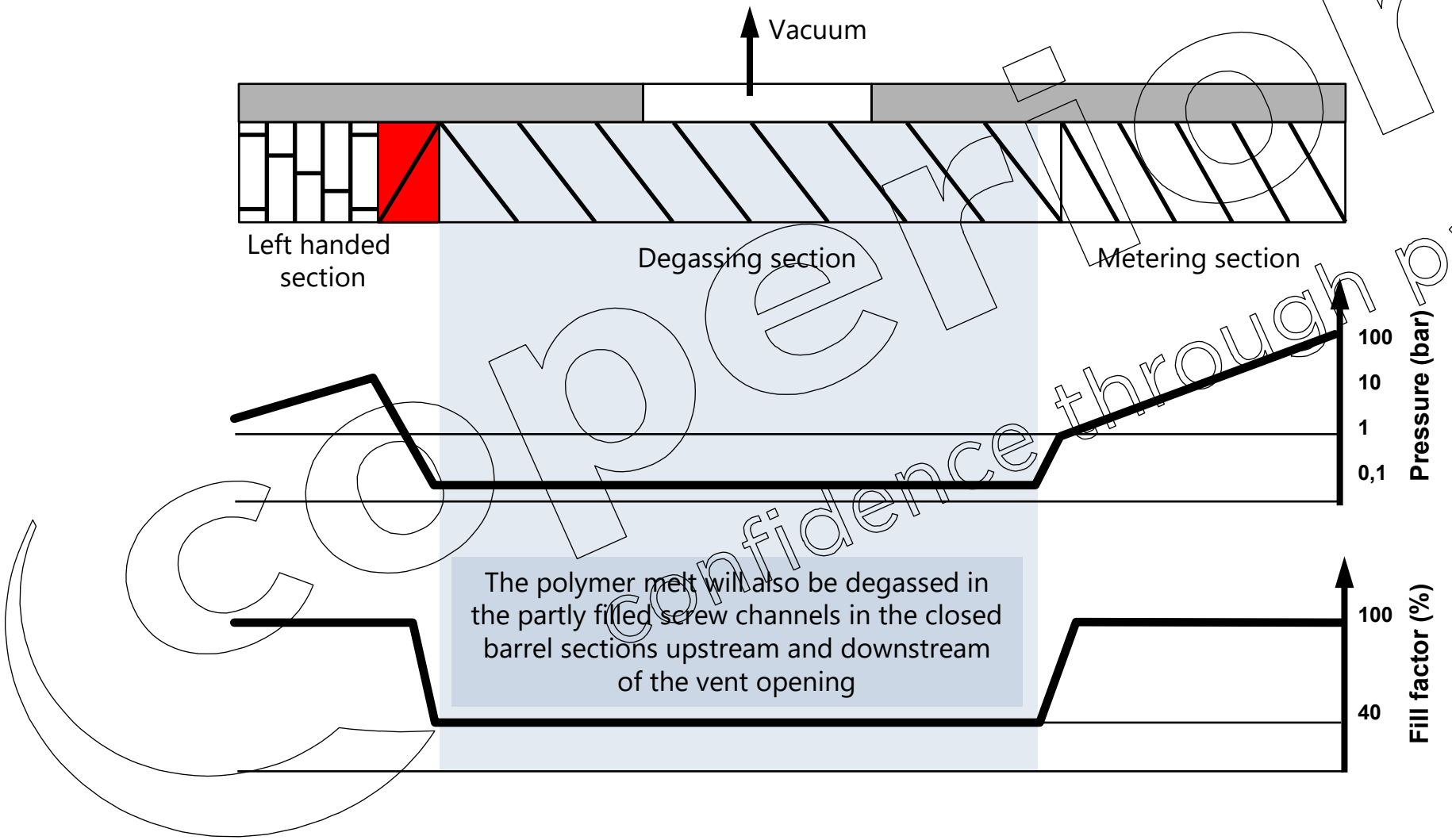
New innovative feeding device

By fully utilizing the screw speed of the ZS-B MEGAfeed the throughput for very fluffy materials can be increase by factor 10-15!!!

Throughput x 10 -15

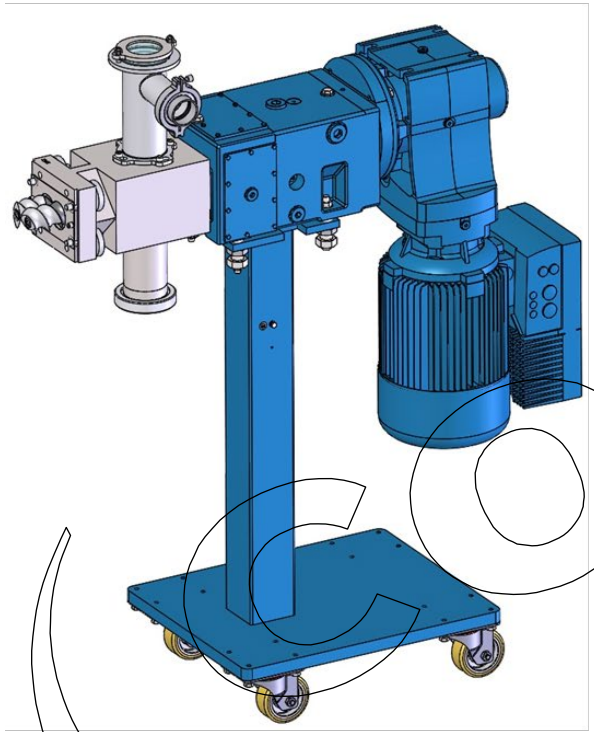
Example 4: Side degassing ZS-EG

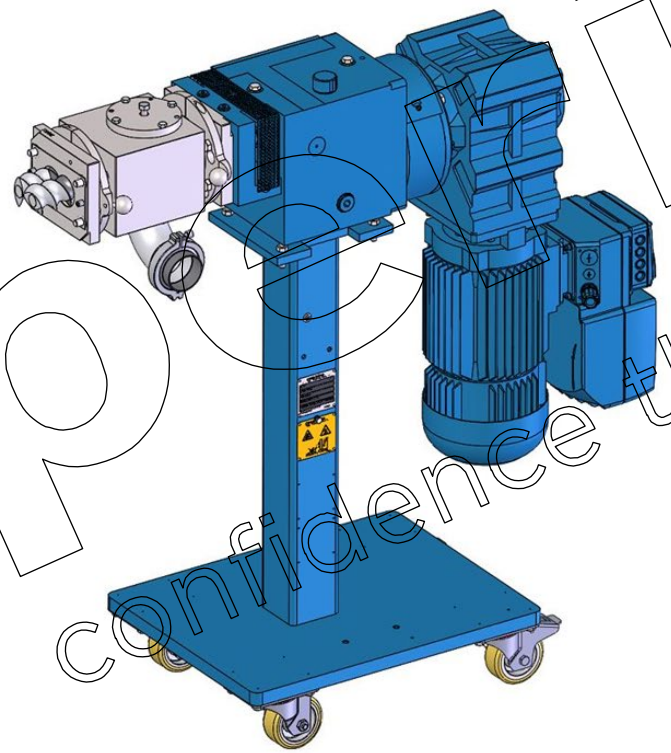
Principle of degassing



Example 4: Side degassing ZS-EG

Side-Degassing ZS-EG for stable production



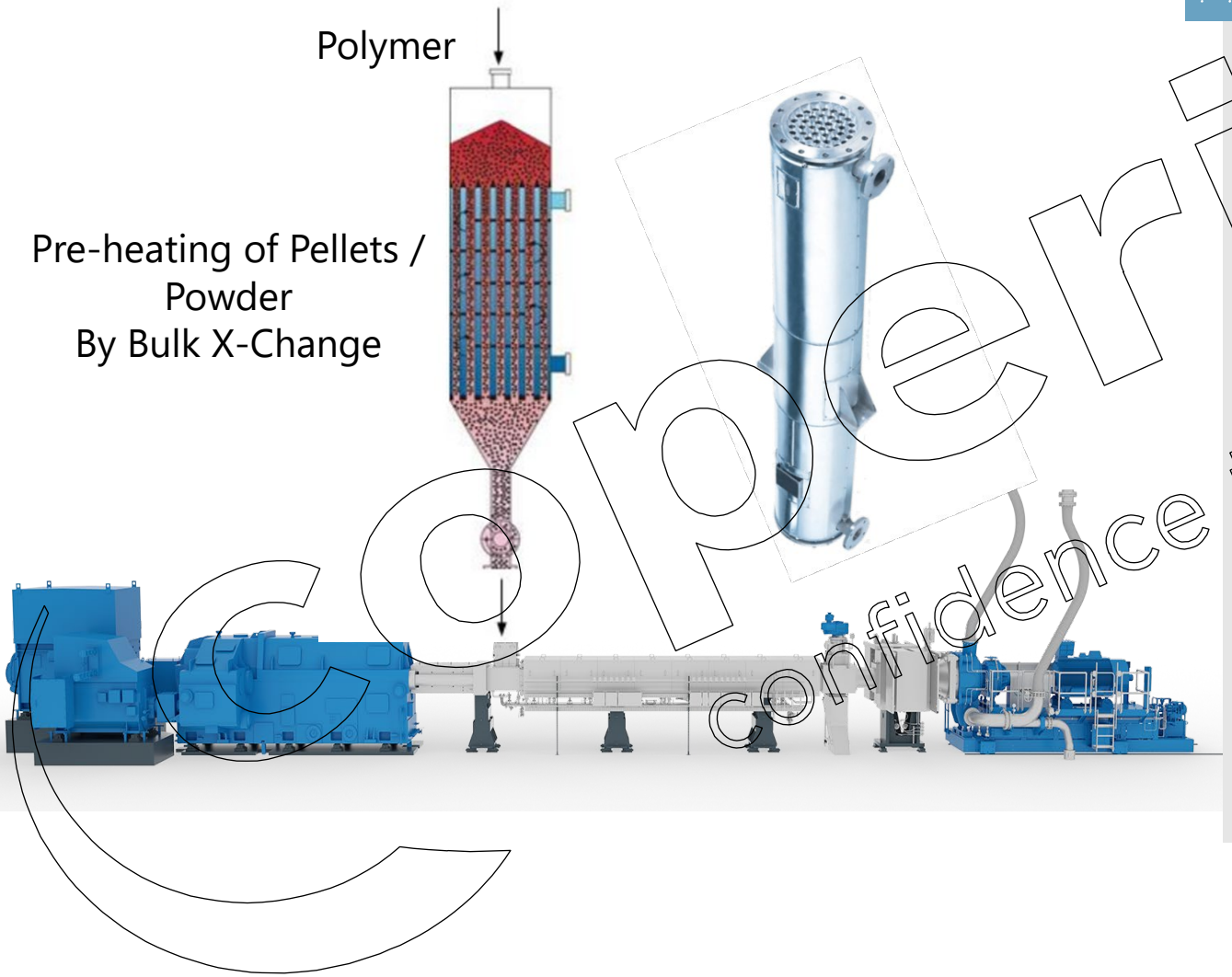


Side-Degassing ZS-EG

- Safe degassing for higher degree of fill
- Higher throughput due to higher filling degree (up to 30 %)
- Higher output rates for processes with higher moisture content e.g. recycling or WPC
- Less downtime, less scrap because of higher production safety

Example 5: Preheating of polymer

Reduction of energy consumption with Bulk X-change



Savings

Bulk X-Change use to lift the feedstock temperature by using „secondary or waste" energy sources available on a petrochemical plant.

1) 45t/h HDPE plant (USA); 90°C feed, 95% availability:

- electricity cost (assumed): 0.0845$/kWh
- **Energy saved:** 0.020kWh/kg * 360.000.000kg = **7.200.000kWh**
- **Money saved:** 0.0845$/kWh * 7.200.000kWh = **600.000$/year**

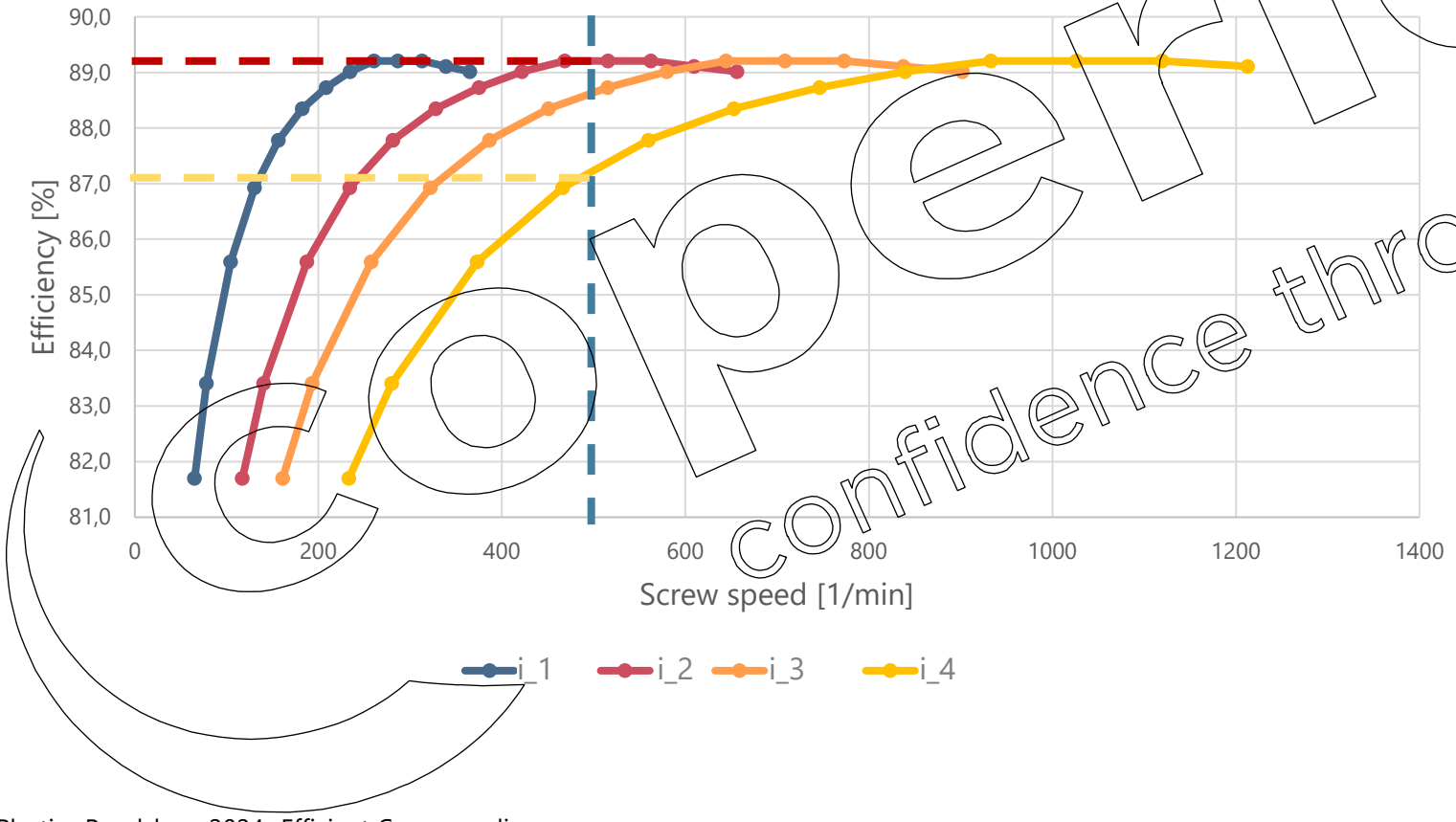
2) 2.0 t/h PA plant (Germany); 60°C feed, 95% availability:

- electricity cost (assumed): 0.17€/kWh
- **Energy saved:** 0.025kWh/kg * 16.000.000kg = **400.000kWh**
- **Money saved:** 0.17€/kWh * 400.000kWh = **68.000€/year**

Example 6: Motor efficiency

Reduction of energy consumption by choosing right motor range

Motor and frequency converter do not have a constant efficiency over the speed range.



Energy Savings

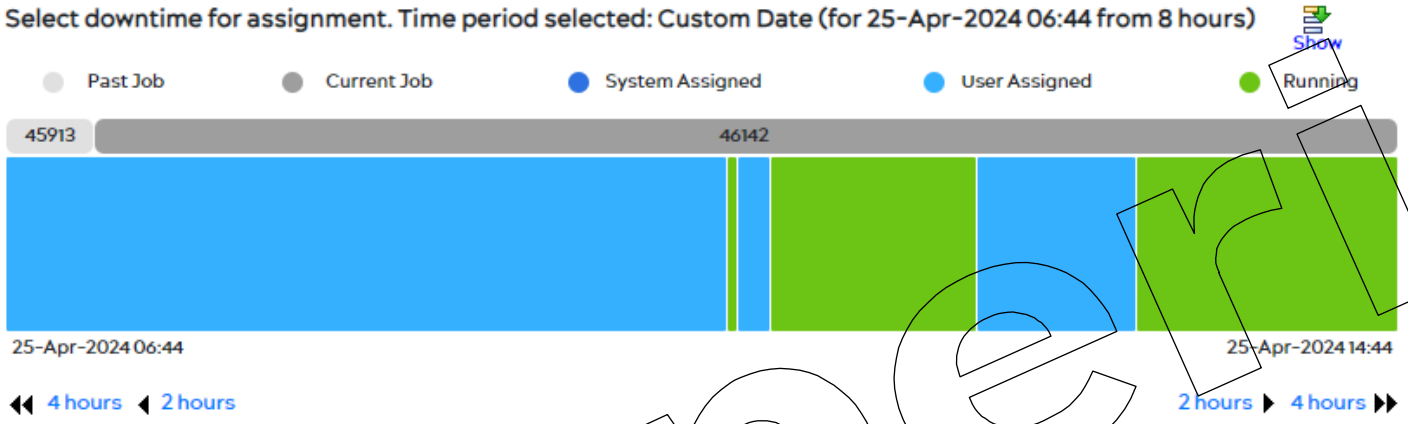
ZSK70Mc[18]
Design screw speed 600 vs. 1200rpm

- 2% difference in efficiency at 500rpm
- 8,8kW higher efficiency at 4000h

→ 35000kWh savings

Example 7: C-Beyond, Downtime-Tracking and OEE

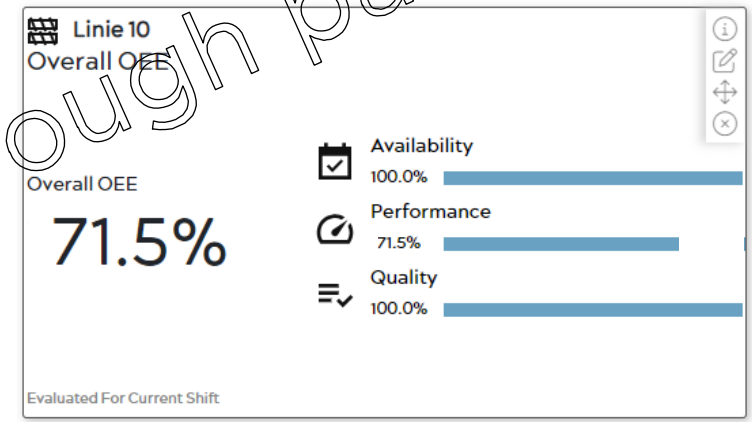
Reduction of energy consumption by evaluation of unnecessary downtime



unassigned

0 current shift

0 previous shift



Conclusion

By identifying OEE and the most common causes of downtime, situational awareness can be gained to achieve improvements in operations and energy consumption

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3 Summary

Summary

How to increase energy efficiency

- Automatic Strand conveying can make pelletizing much easier and safer
- Using highest installed specific torque by using high degree of fill can save energy
- Feed Enhancement Technology FET can increase output and degree of fill for formulations with feed limited fine powders
- Side-degassing ZS-EG allows for higher degree of fill and to reduce scrap
- Pre-heating of material with Bulk X-change safes motor power and energy
- The right design of the motor can save energy
- C-beyond assist to determine downtime and increases awareness of energy waste
- Think about modernization by changing drive unit or adding features for increasing torque

Final Conlcusion

Increasing energy efficiency is possible by using higher torque with several features, methods or combination of these. Additionally, also profitability can be increased!

Optional Chapter Navigation

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You're very welcome to follow us.