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measure. analyze. Innovate.

# Advanced Injection moulding, monitoring and control

**Cavity pressure monitoring, control and component quality prediction**

Duncan Webster

# Why Cavity Pressure?

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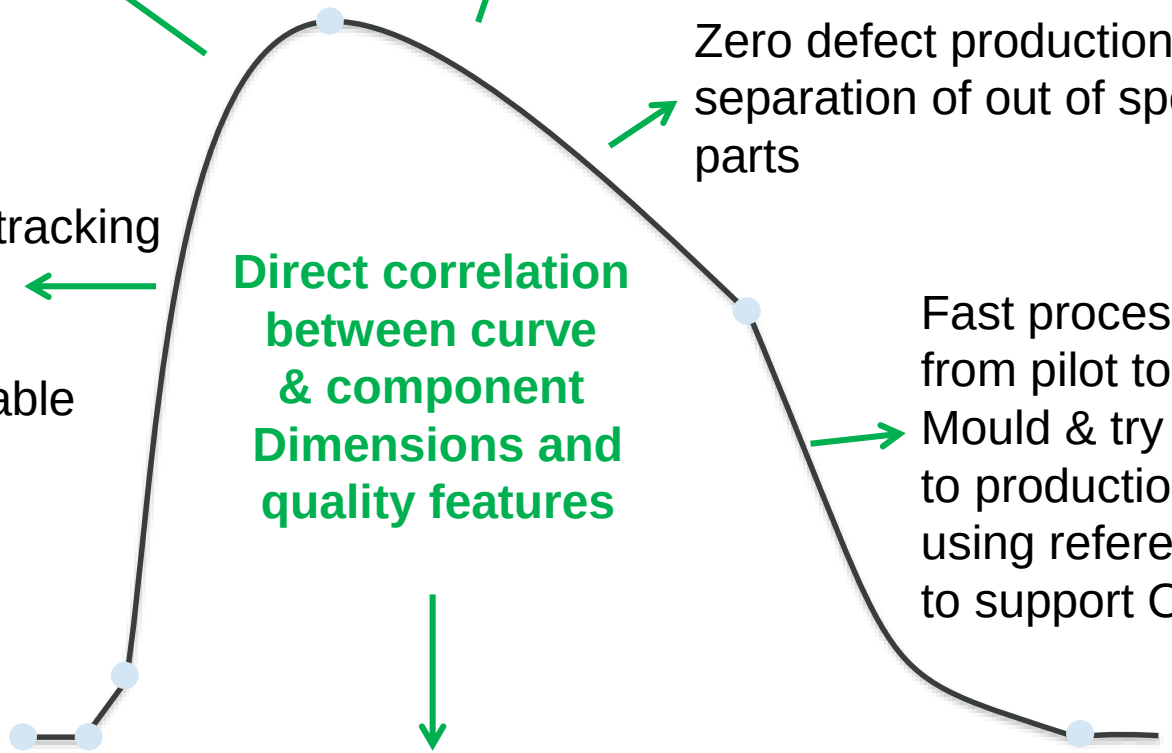
Reduced OQ validation time – due to fewer required runs

Monitor, track and control cavity fill balance

Zero defect production – automatic separation of out of specification parts

Automatic process tracking and documentation for PQ, with 100% confidence in a reliable process.




Fast process transfer from pilot to production Mould & try out machine to production machine using reference curve to support OQ & PQ

Real time quality feature and dimensional prediction – results in reduction of inspection and enables you to maintain the validated state.

# What can we measure & record by default in addition to the pressure profile?

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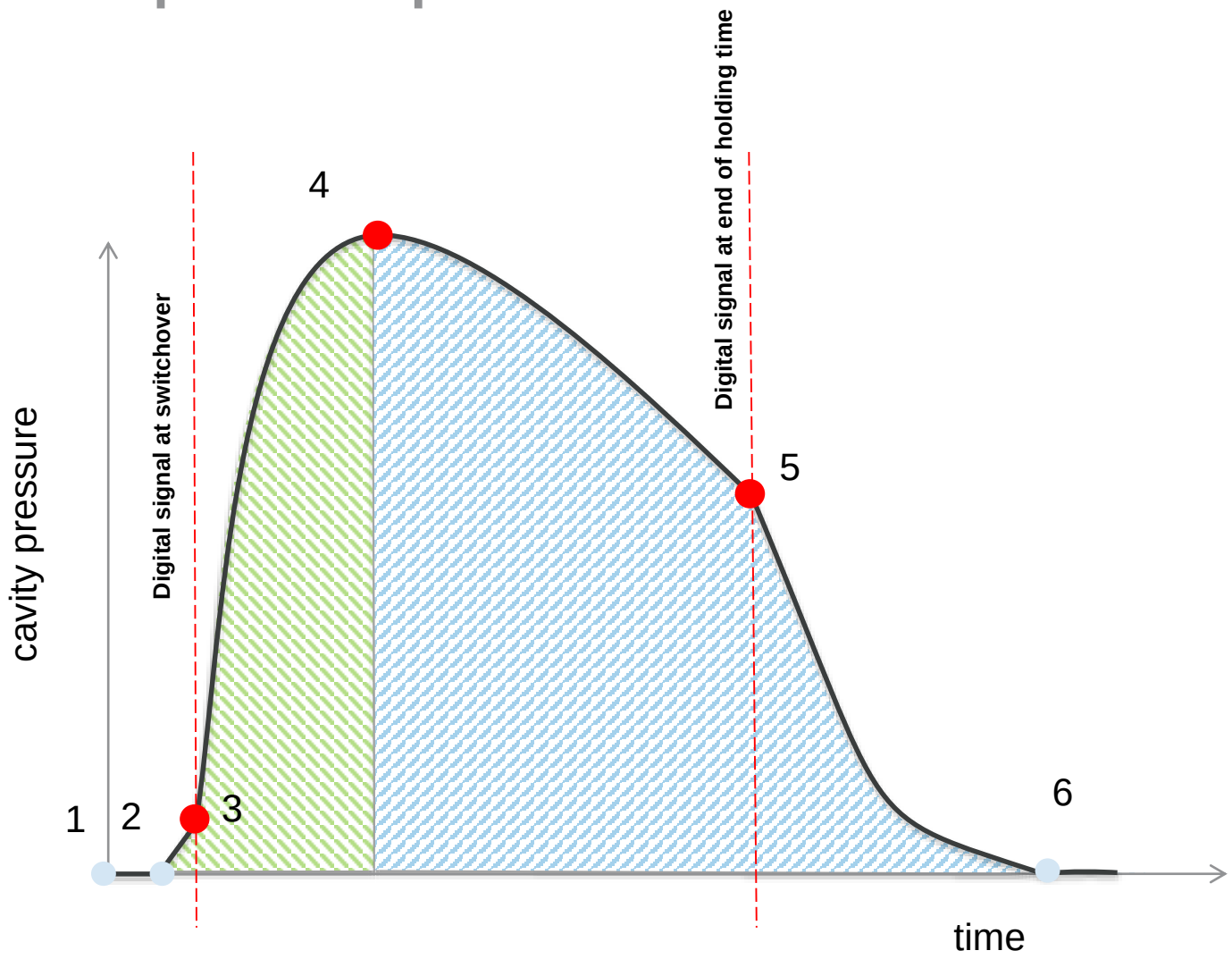

# How do we measure cavity pressue?

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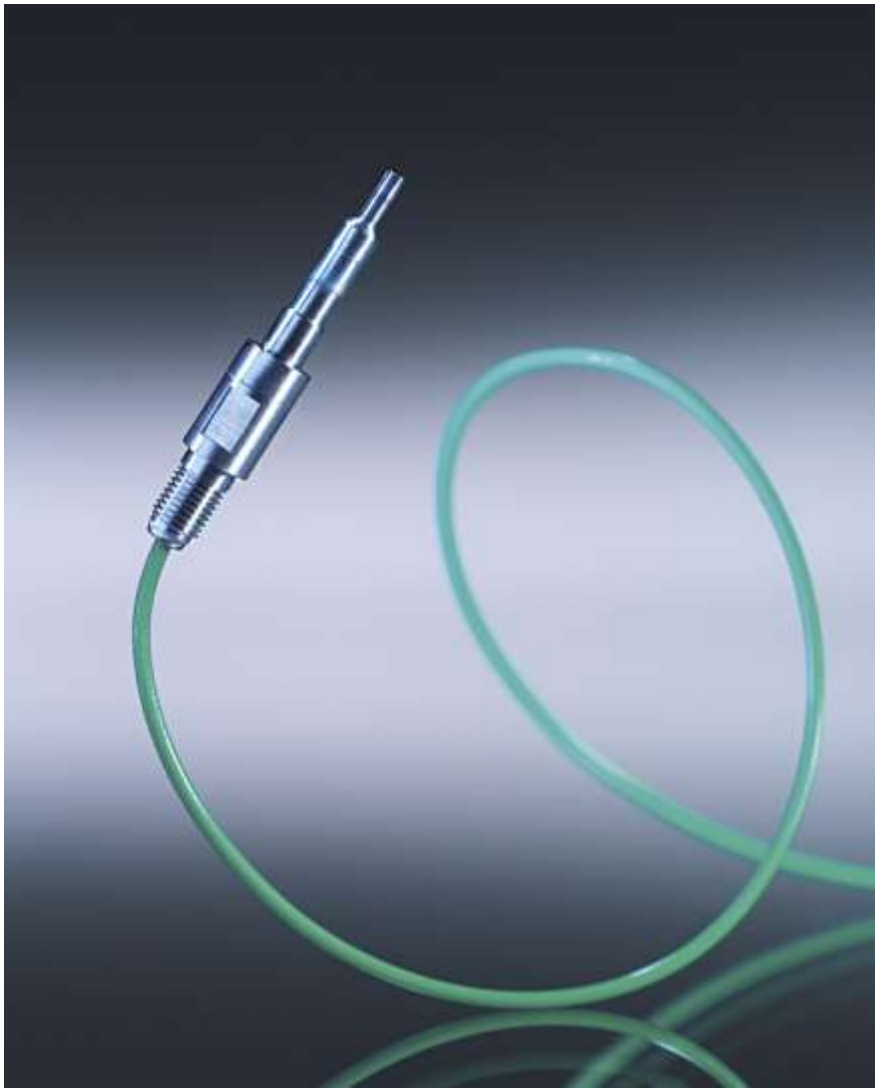
## High-precision piezoelectric sensors for higher process safety

Exact and reproducible pressure measuring values can only be obtained with reliable and accurately measuring sensors.

- High resolution, safe and durable measuring technology
- Acquisition of the smallest pressure variations
- Combined sensors for pressure and temperature
- Robust and maintenance-free



# What sensor options are available?

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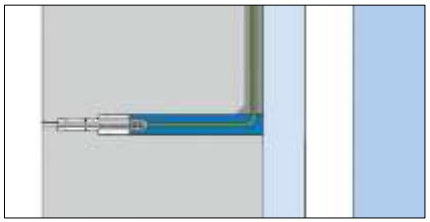
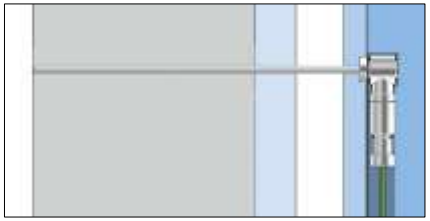
## Perfect solutions for any installation situation

Depending on the mounting situation, various sensors are available. The sensor enables an optimum cavity pressure measurement:

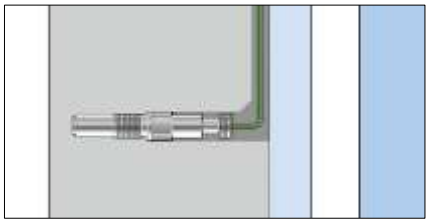
- **Direct measurement**
  The melt pressure acts directly on the front of the pressure sensor – sensors down to 1mm diameter in size.



- **Indirect measurement**
  The ejector pin transfers the pressure to a force sensor – no extra witness marks on component.



- **Contact-free measurement**
  Measuring pins acquire the mould compression caused by the pressure – no witness marks on component.



# Why is CP so important?

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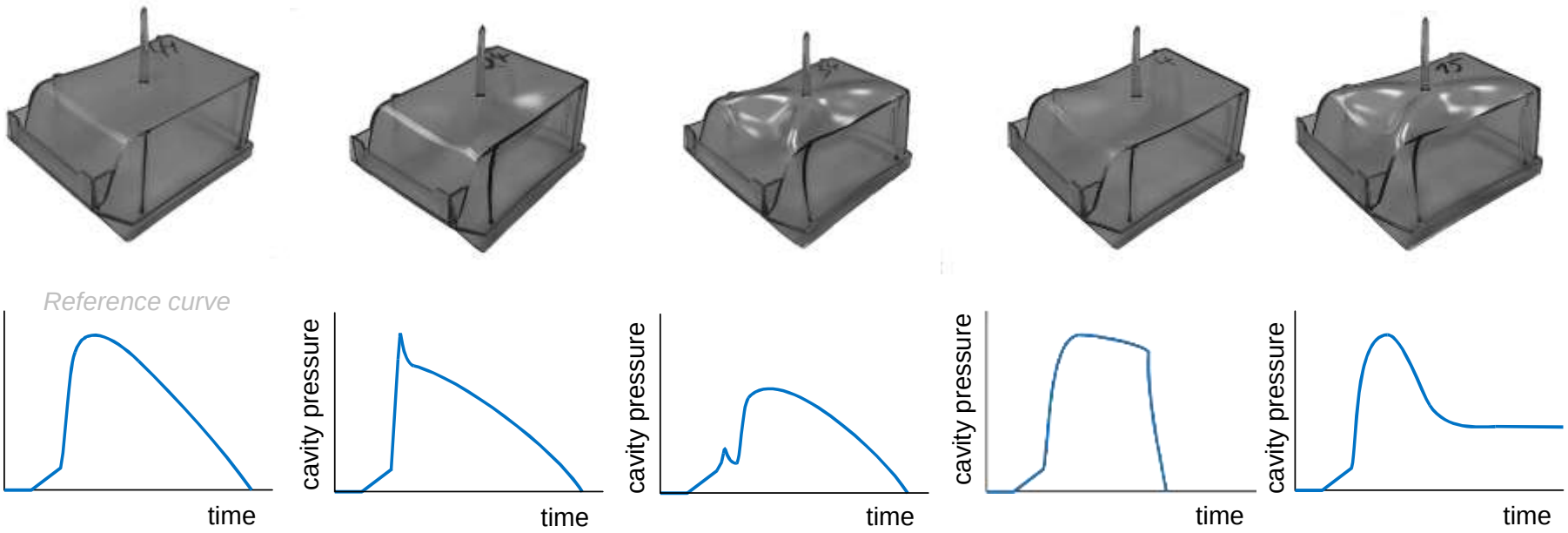
## CP represents correlation of process & parts properties




✓ Good part

× Bad part

v-p-switch over too late

No compensation of shrinkage through holding pressure

× Bad part

v-p-switch over too early

Uncontrolled filling, shrinkage

Short shots

× Bad part

Pressure drop

Too short holding pressure

Sink marks in the area of the gate

× Bad part

Mold opening or v-p switch over too late

No relaxation of melt after solification (cooling)

# What can we do with the curve data?

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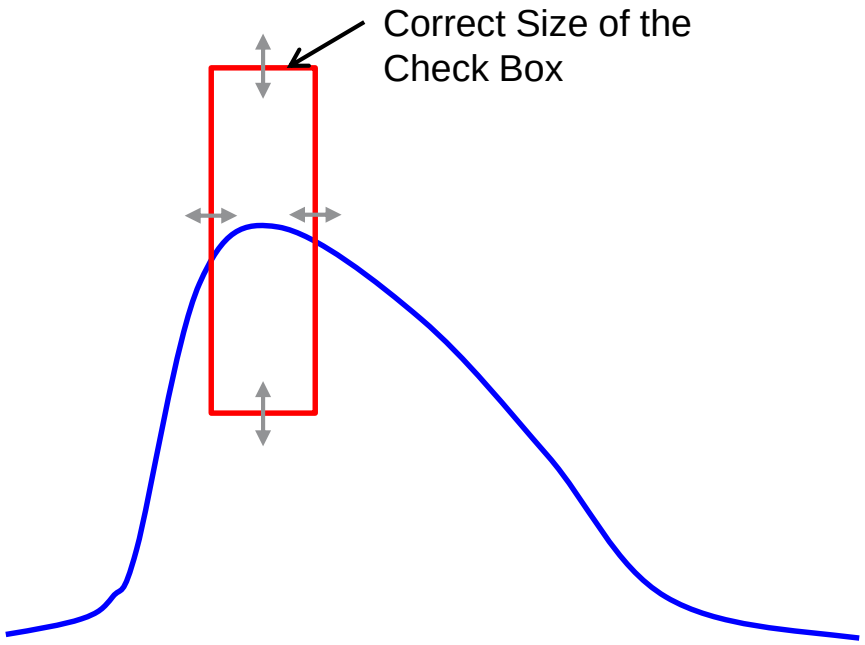
1. Automatically define limits for process / component quality control

**The process can be monitored by process values. Often is the question what is the correct Box types and what are meaningful limits**




**Advantages of EO- Assistant:**

- Internal Expert Know-How -> no specialist required
- Systematic approach
- User is guided
- Documented and repeatable process → independent from user
- Sharp setting of reject limits
- Reduction of “pseudo” scrap
- Repeated training possible

# What can we do with the curve data?

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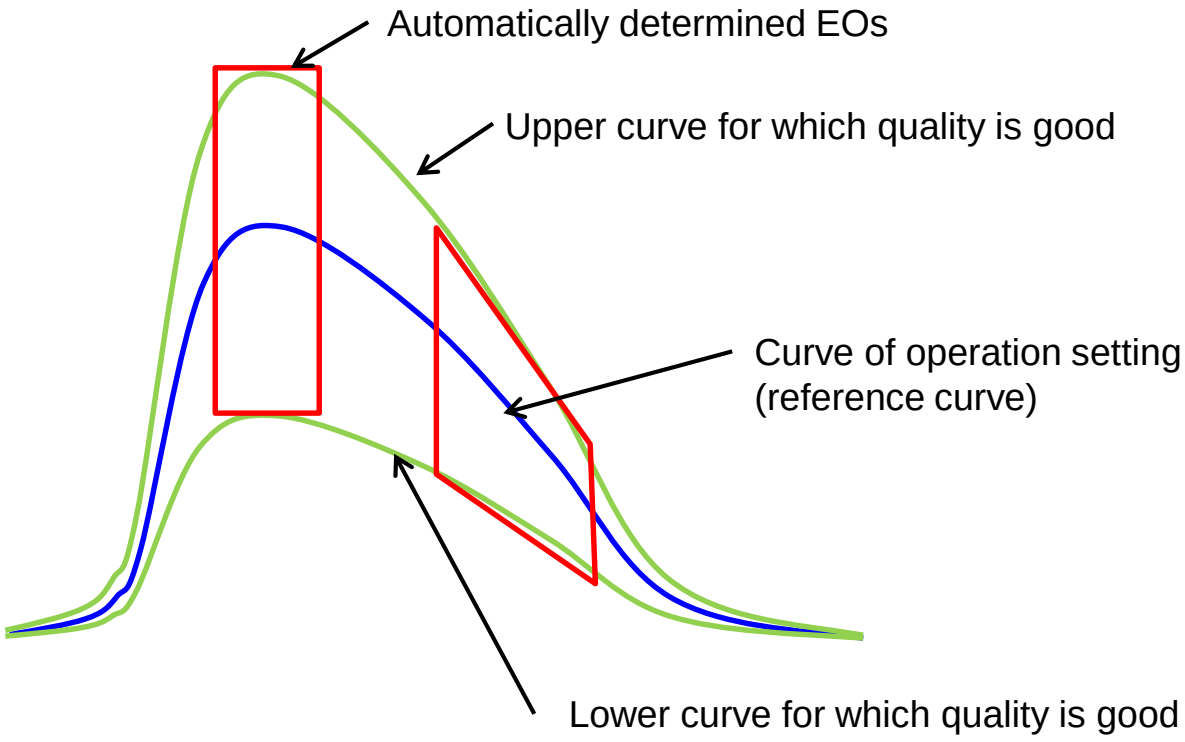
## 1. Automatically define limits for process / component quality control

**Basic idea is to find an upper and lower pressure curve for good quality. The check boxes are generated and fitted automatically according to these limiting curves.**



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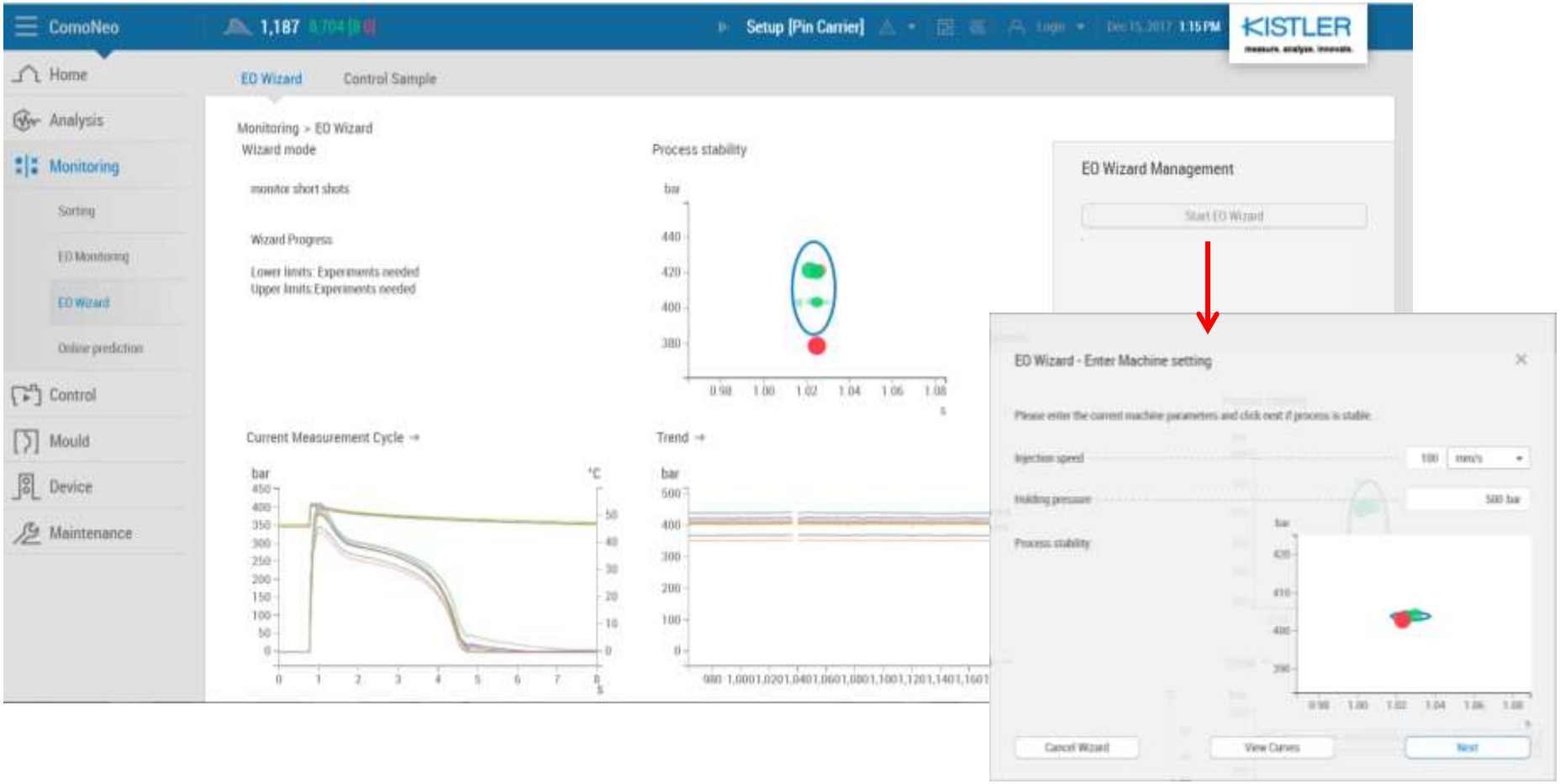

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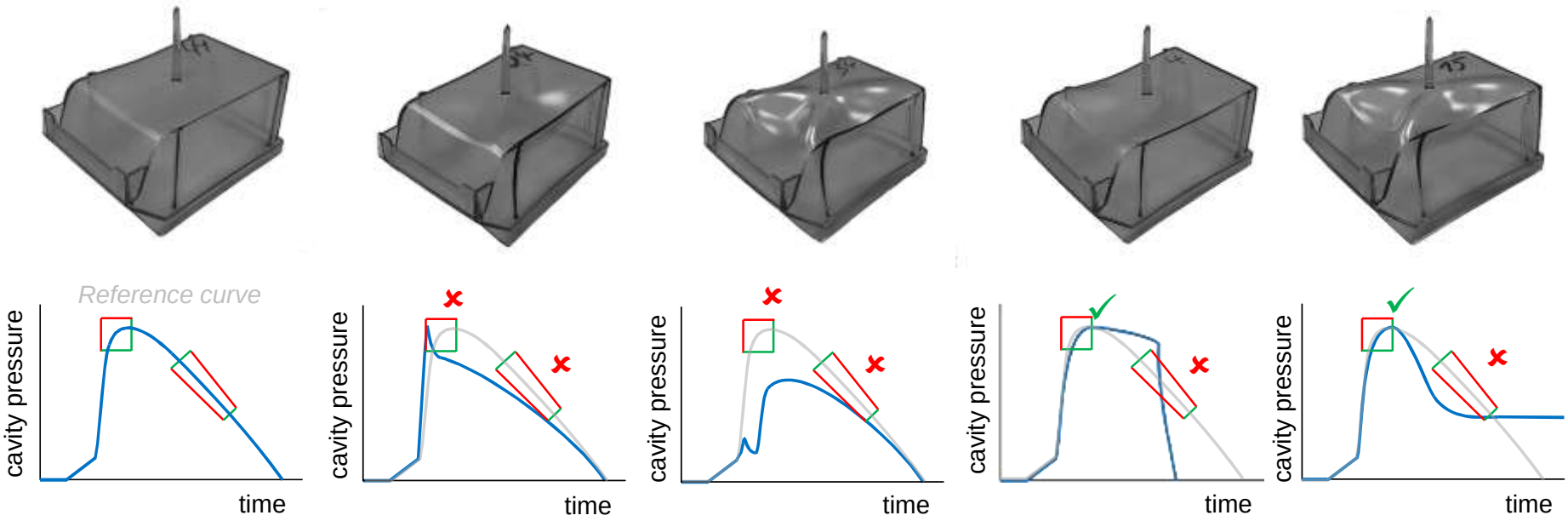


✓ Good part

× Bad part

Both EOs violeted

Signal «Sort»

× Bad part

Entry box not activated

Holding pressure EO violeted

Signal «Sort»

× Bad part

Holding pressure EO violeted

Signal «Sort»

× Bad part

Holding pressure EO violeted

Signal «Sort»

# What can we do with the curve data?

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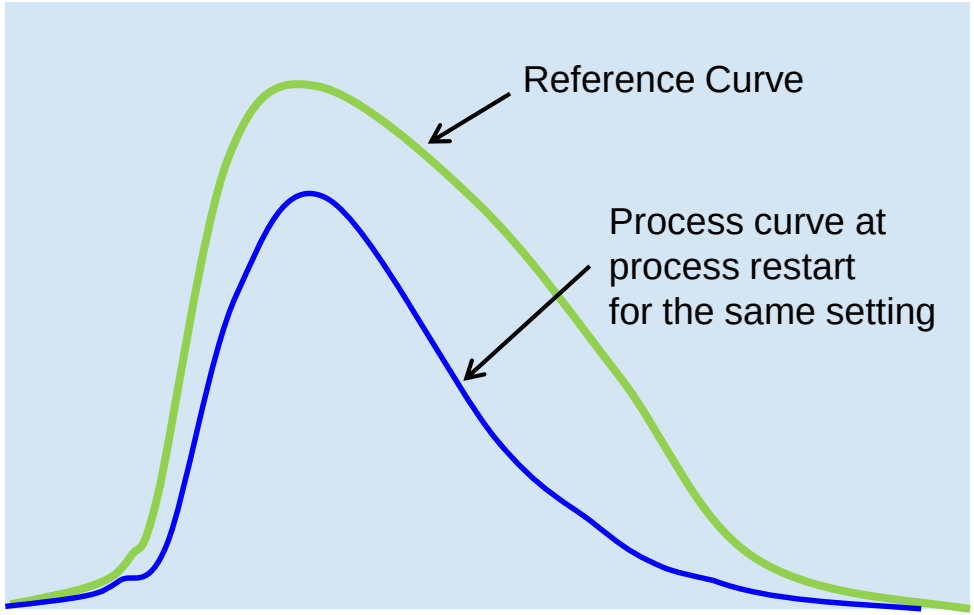
## 2. Transfer from pilot to production and machine to machine

**After restart of production or change of machine the process needs to be adjusted to reach the same quality**



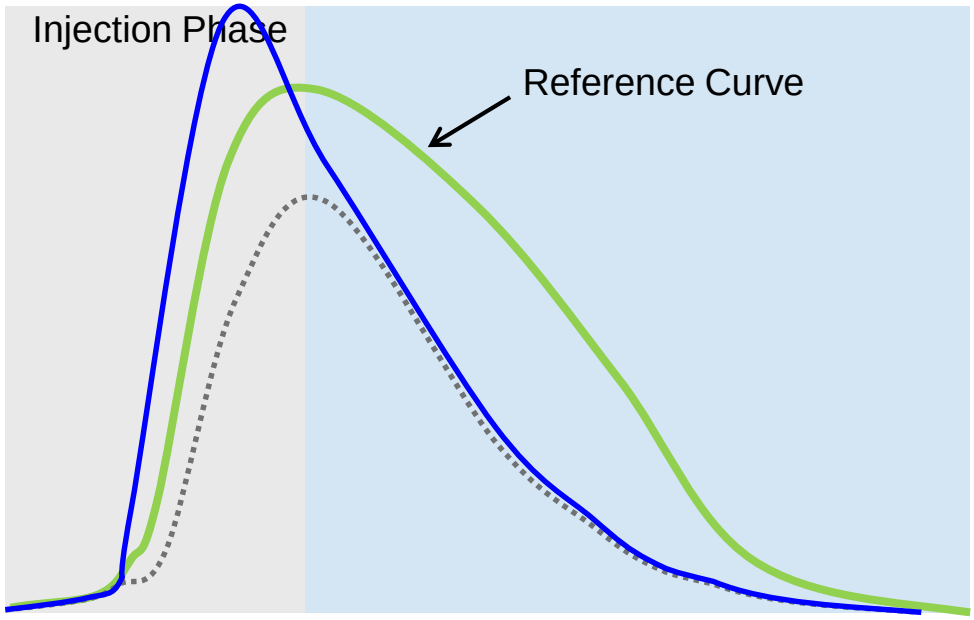

**Advantages of Restart Assistant:**

- Internal Expert Know-How -> no specialist required
- Systematic approach
- User is guided
- Documented and repeatable process → independent from user
- Time saving in Start Up and Mould transfer
- Reliable quality result

# What can we do with the curve data?

## 2. Transfer from pilot to production and machine to machine

### Adjustment Injection Speed 1



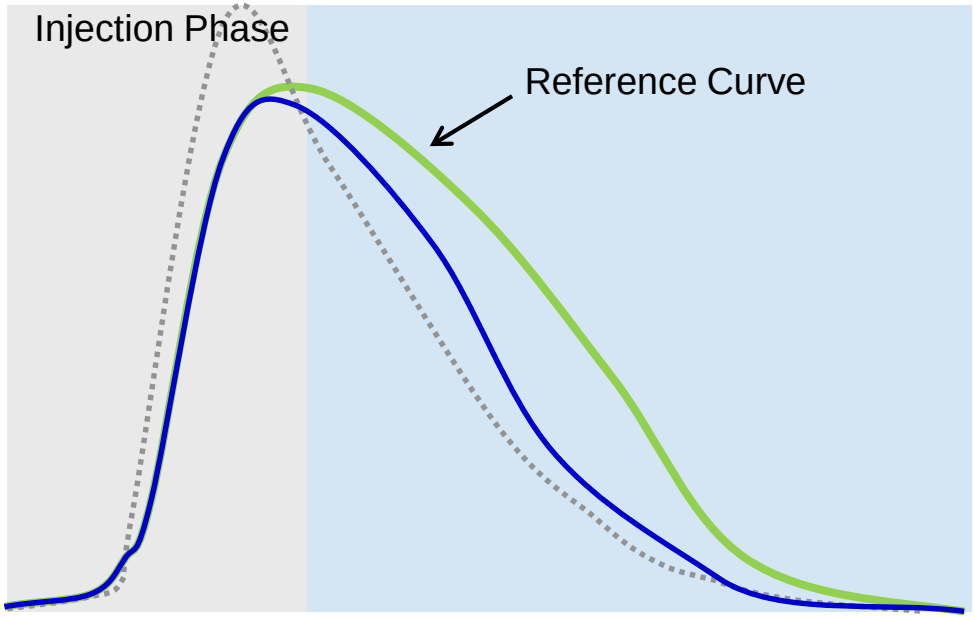

Adjust

- Injection Speed
- Holding pressure
- Holding time

# What can we do with the curve data?

## 2. Transfer from pilot to production and machine to machine

### Adjustment Injection Speed 2




Adjust

- Injection Speed
- Holding pressure
- Holding time

# What can we do with the curve data?

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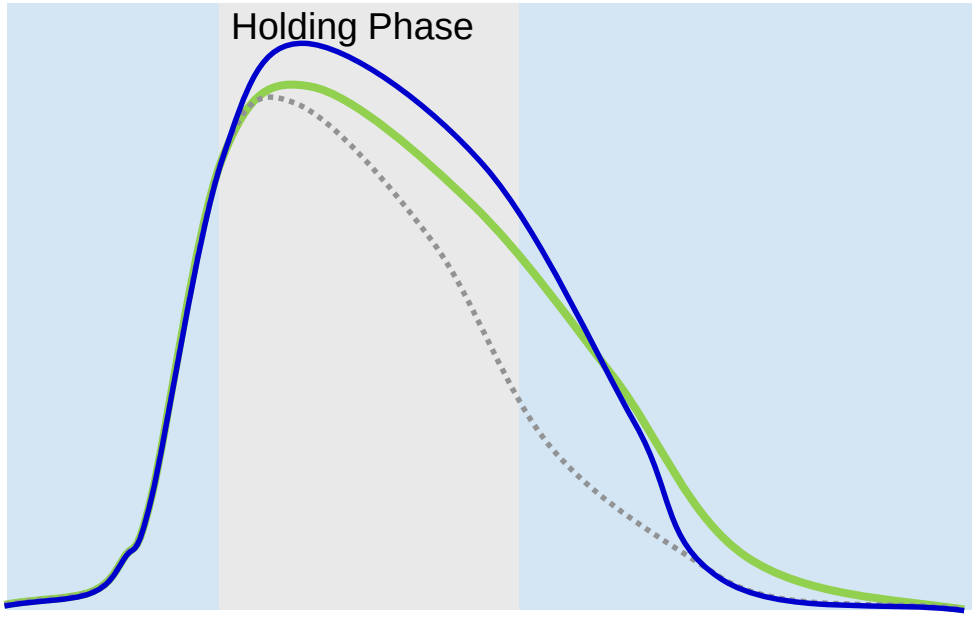
## 2. Transfer from pilot to production and machine to machine

### Adjustment Holding Pressure 1

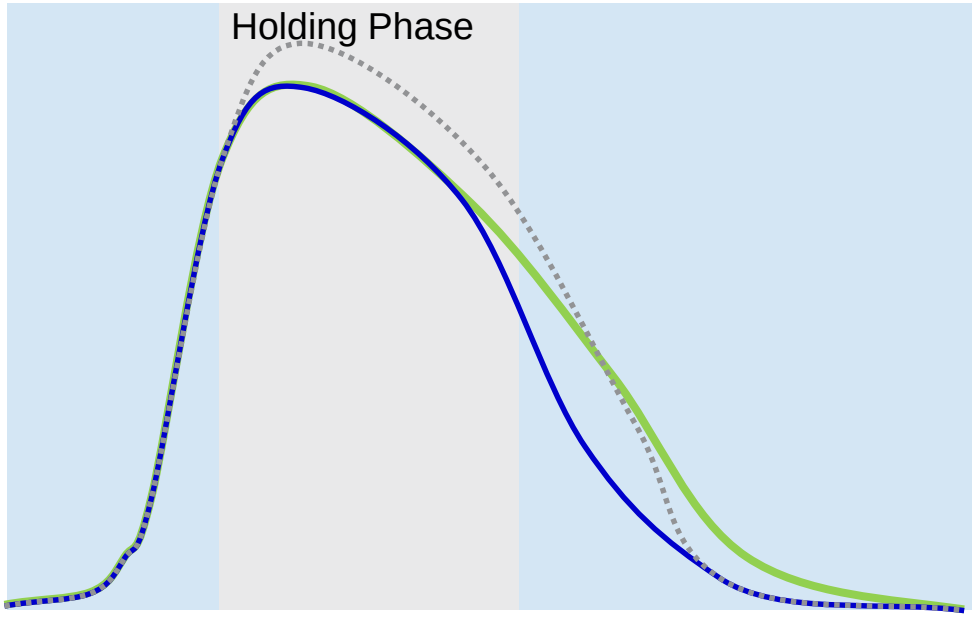



Adjust

- Injection Speed
- Holding pressure
- Holding time

# What can we do with the curve data?

## 2. Transfer from pilot to production and machine to machine

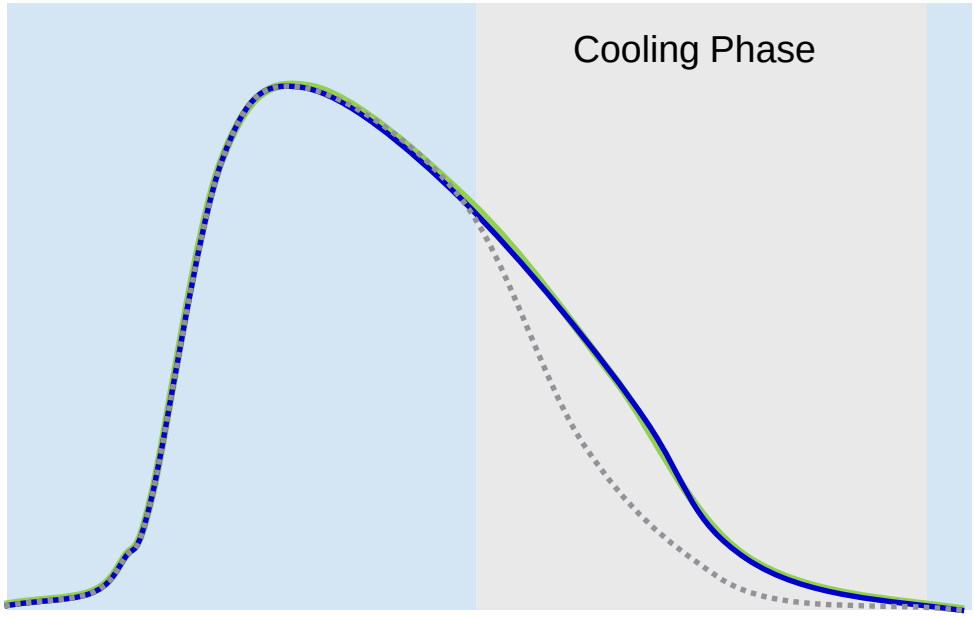



Adjust

- Injection Speed
- Holding pressure
- Holding time

# What can we do with the curve data?

## 2. Transfer from pilot to production and machine to machine




Adjust

- Injection Speed
- Holding pressure
- Holding time

After a few steps the original reference curve can be reproduced

# What can we do with the curve data?

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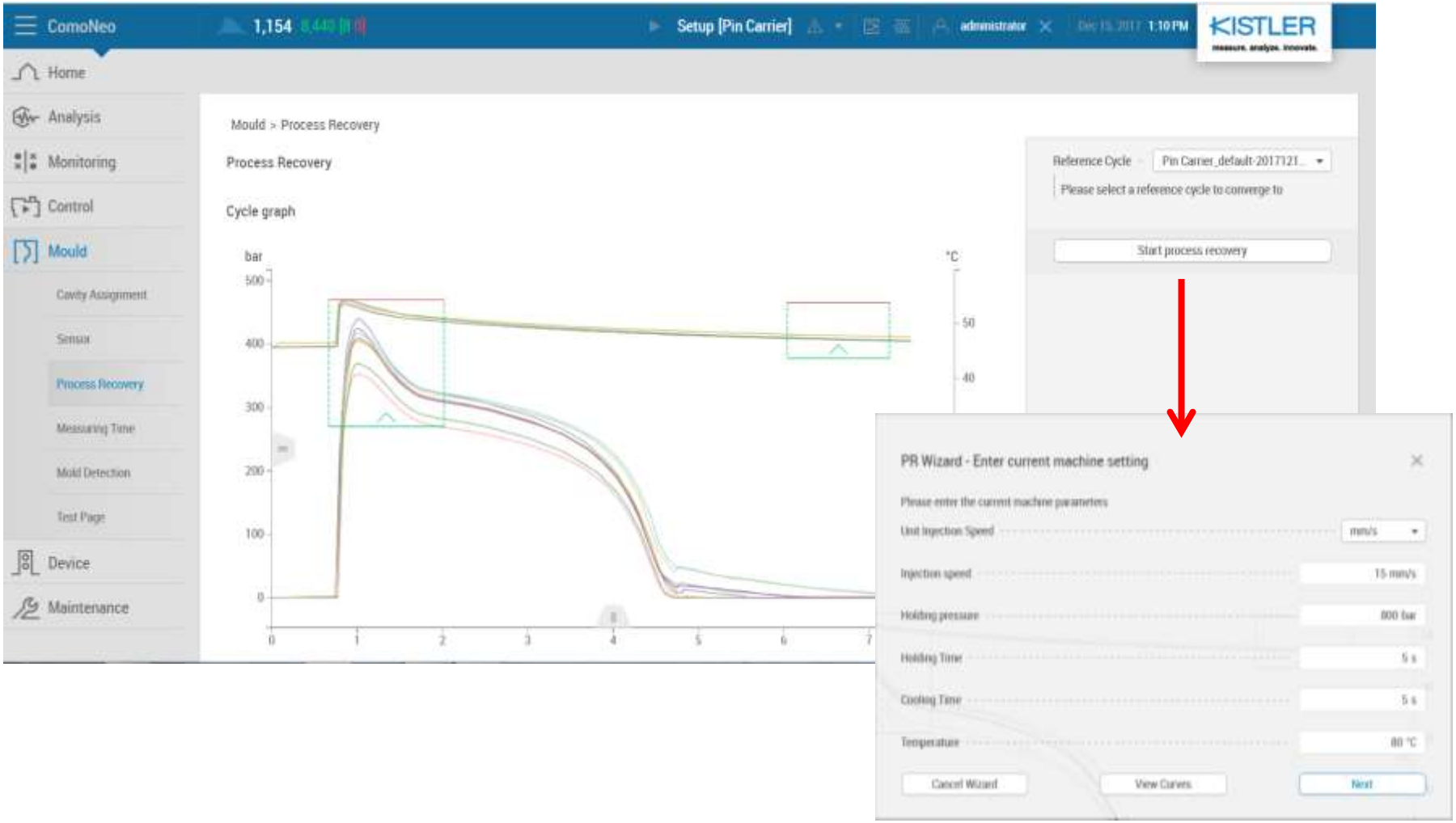
## 2. Transfer from pilot to production and machine to machine



# What can we do with the curve data?

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What do you think about predicting the dimentions while part is still in the cavity?

# What can we do with the curve data?

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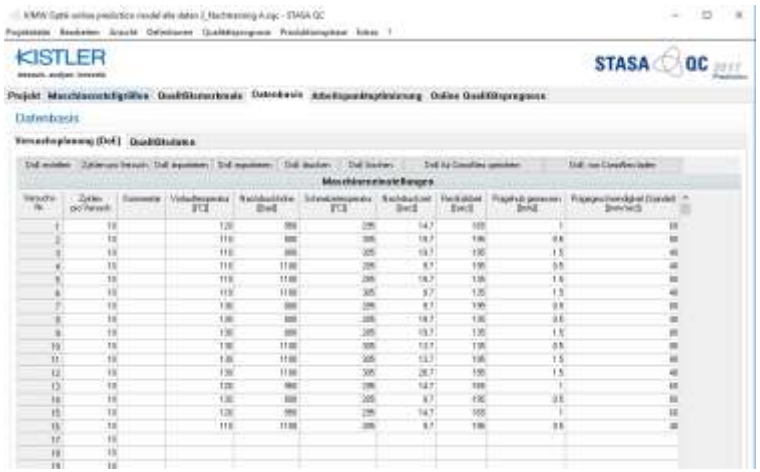
## 3. Online quality and dimentional prediction based on DoE Model

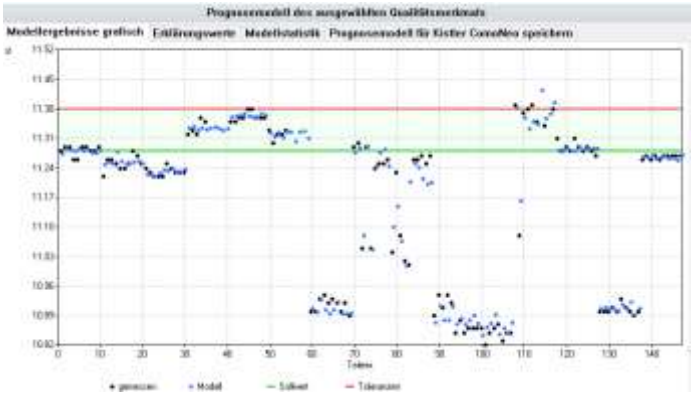
### 1. Creation of Design of Experiment (DoE)




### 2. Execution & recording of process cavity data

### 3. (geometrical) measurement of parts

### 4. Creation of prognosis model



### 5. Transfer & intregration into ComoNeo

# What can we do with the curve data?

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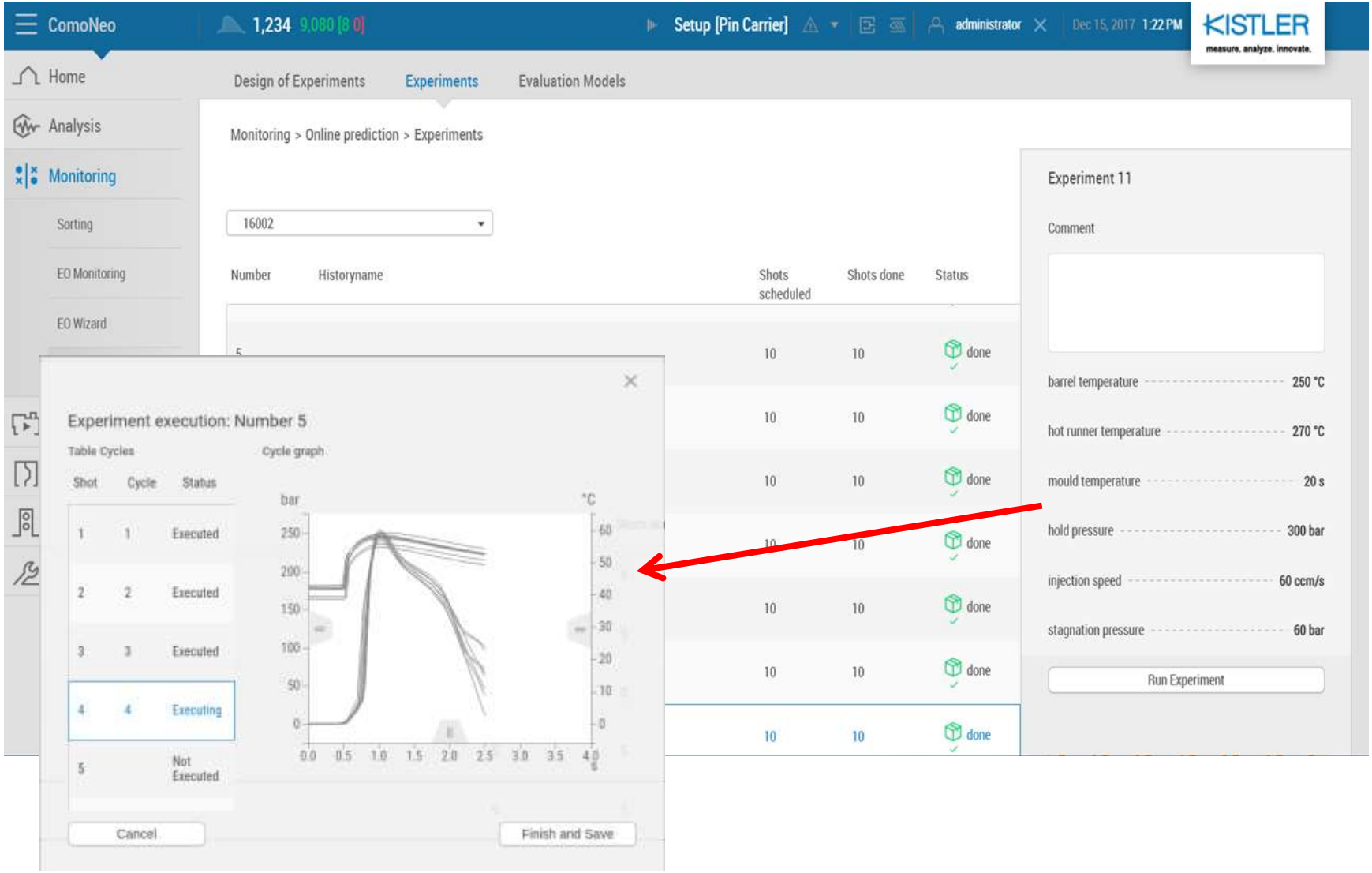
## 3. Online quality and dimentional prediction based on DoE Model



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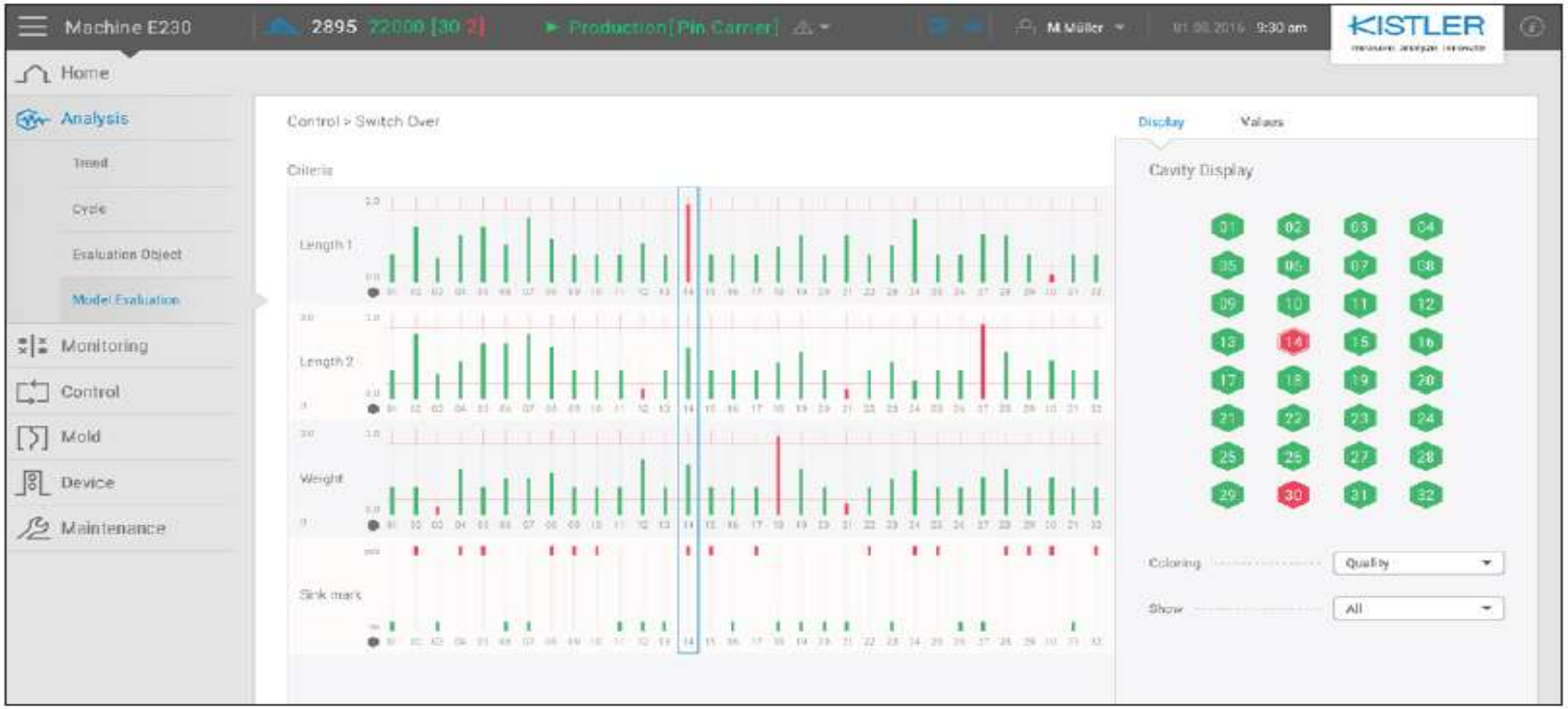


Online quality prediction: high-end process monitoring – ComoNeo directly predicts the components characteristics and evaluates quality on the basis of the present tolerance values.

# What can we do with the curve data?

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Documenation and offline analysis using
CoMo DataCenter 3.3

The CoMo DataCenter 3.3 connects all ComoNeo devices and centrally stores all the trial and production data.

- Fast detection of process variations
- Recording and comparison of production efficiency across different batches, machines, and locations
- Possibility of filtering by production order
- Quick and easy search
- OPC-UA interface for Factory 4.0

# Can we use the cavity pressure curve to control the process and avoid making bad parts?

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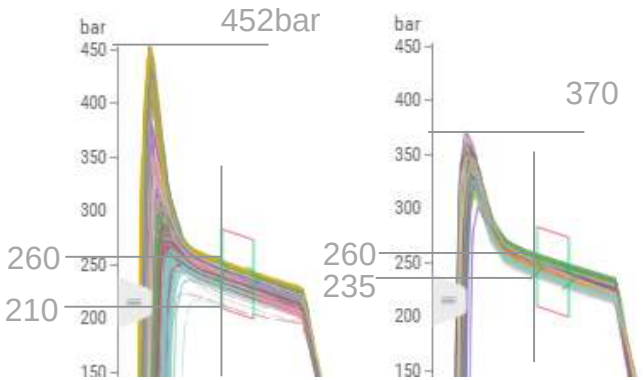
## Automatic cavity balancing closed loop control:




Benefit:

- Decreased peak pressure of 18%
- Decreased holding pressure difference50%
- Homogenious pressure distribution

⇒ Balanced cavity filling

⇒ Increased process capability

⇒ Decreased scrap rate

# Can we use the cavity pressure curve to control the process and avoid making bad parts?

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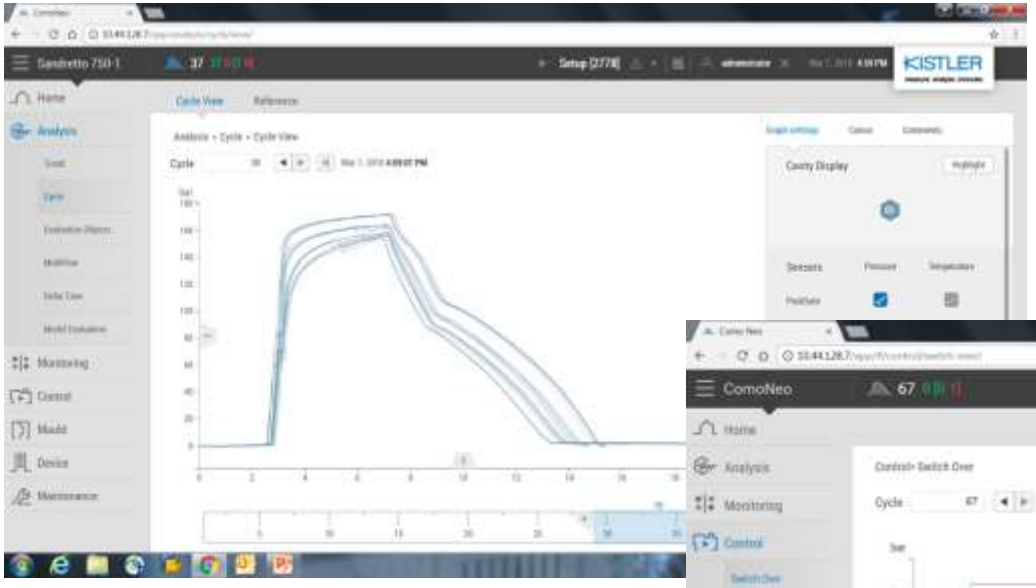
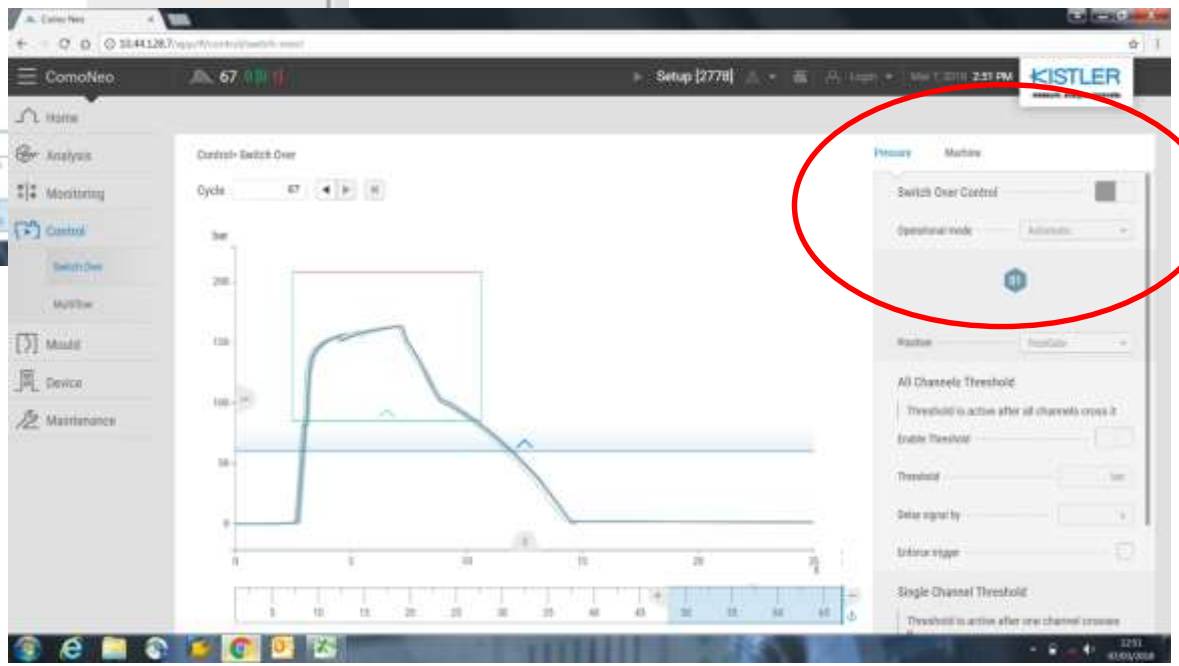
## SLP – Automatic switchover control:



# Global Kistler network

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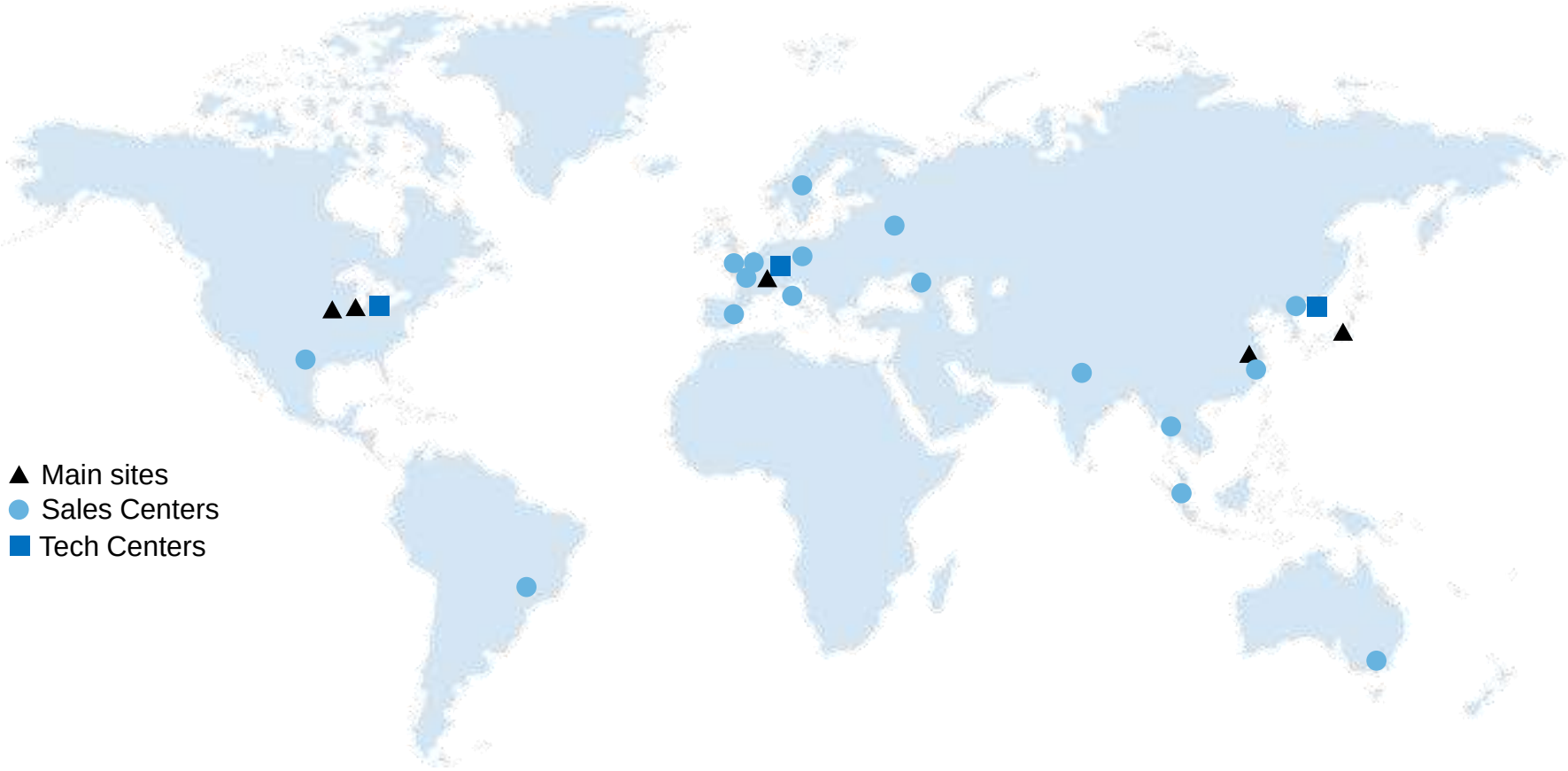
## 61 Locations worldwide with 1,860 employees

Kistler provides sales and service wherever our customers have production facilities. For even increased technical support, Kistler is building Tech Centers around the globe for a tailored service.



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# Ballpark figures just aren't good enough