



**Advanced  
Injection  
moulding,  
monitoring  
and control**

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

Duncan Webster

# Why Cavity Pressure?

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

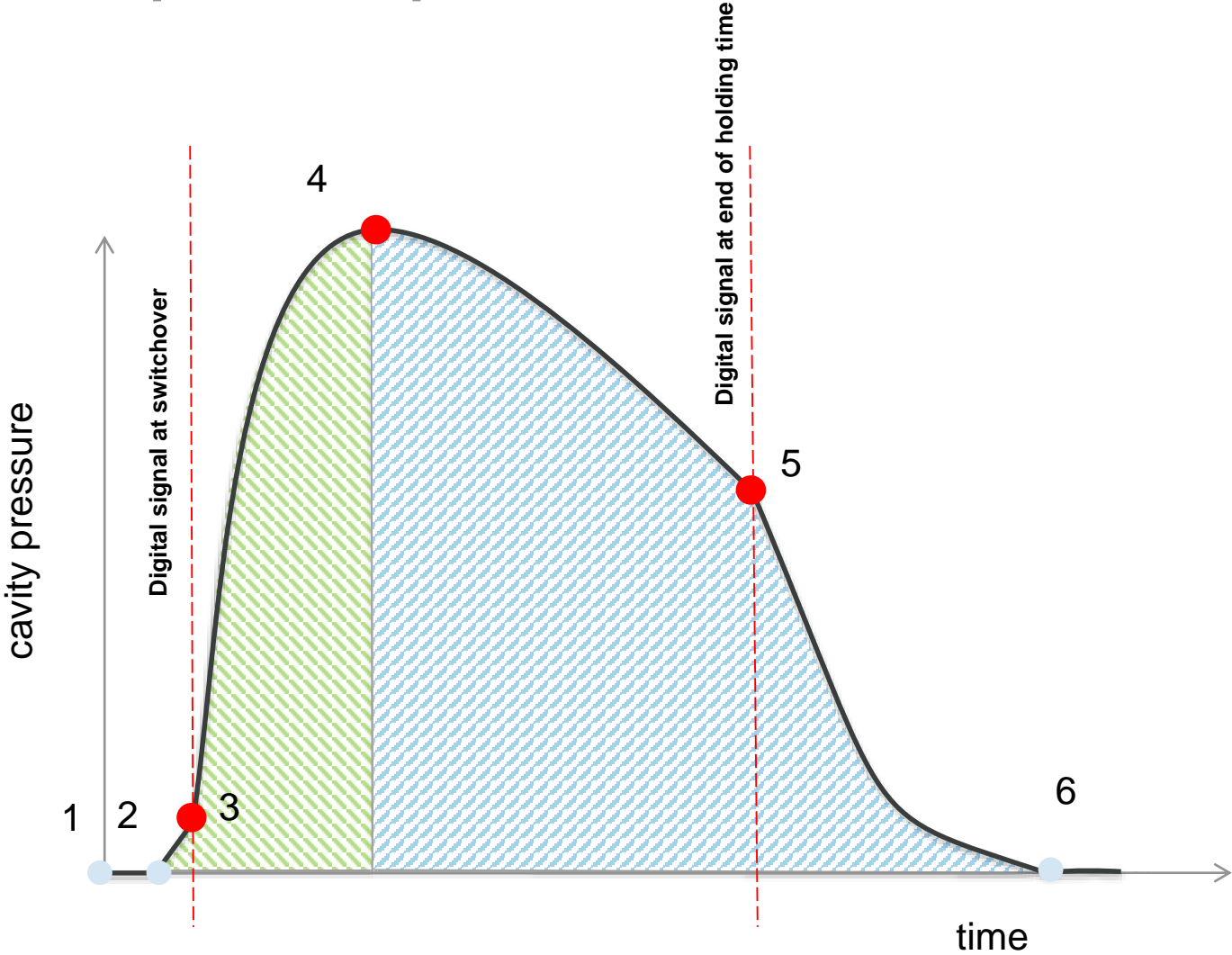
Automatic process tracking  
and documentation  
for PQ, with 100%  
confidence in a reliable  
process.

**Direct correlation  
between curve  
& component  
Dimensions and  
quality features**

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?

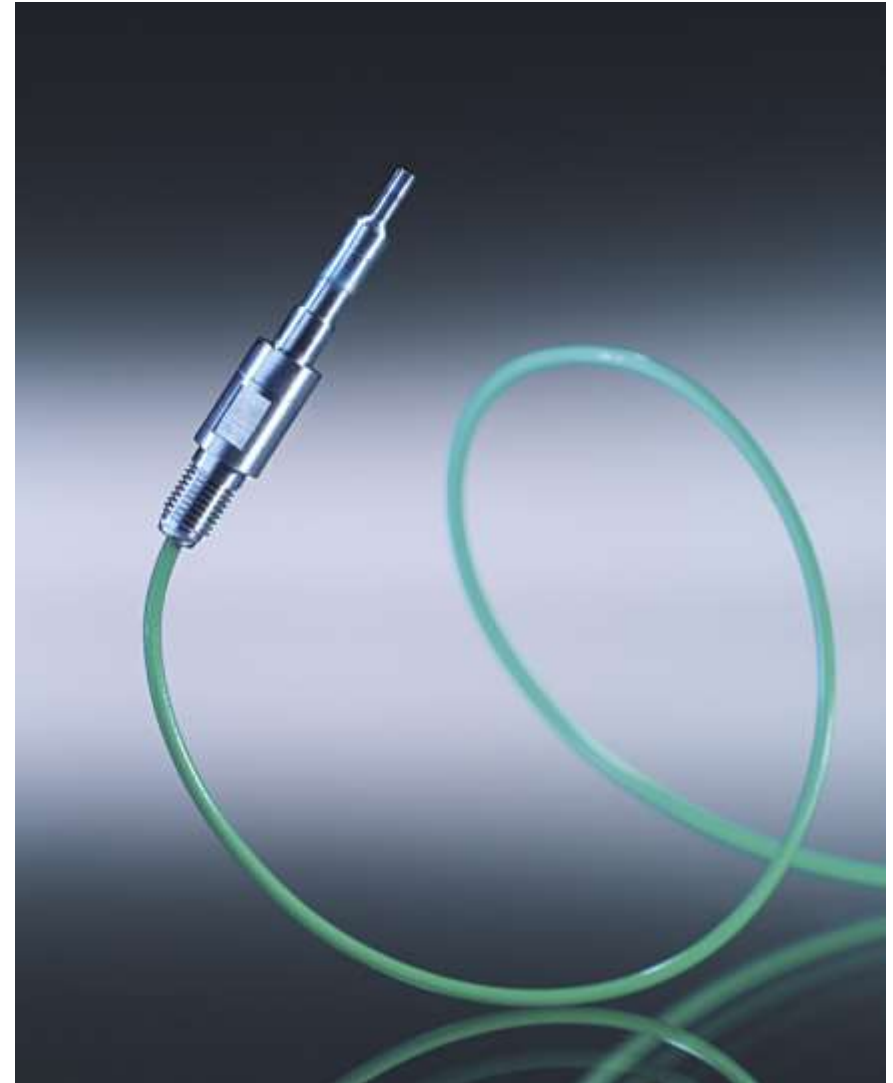


# How do we measure cavity pressure?

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



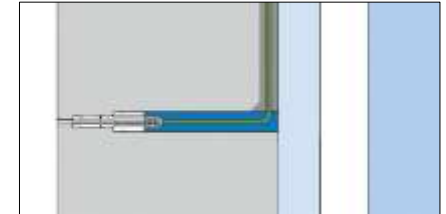
# What sensor options are available?

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.



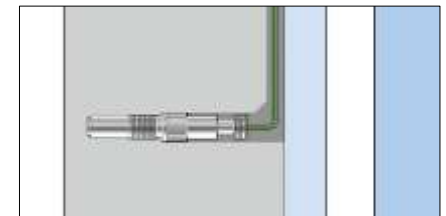
- **Indirect measurement**

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



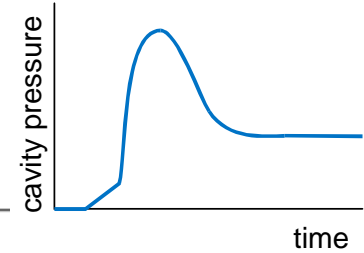
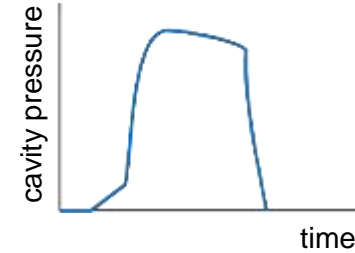
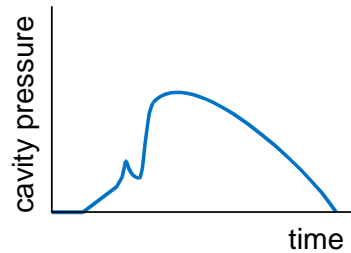
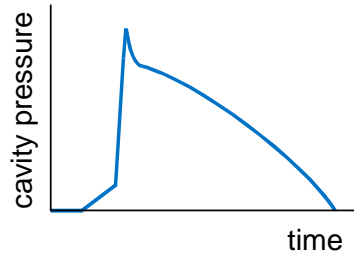
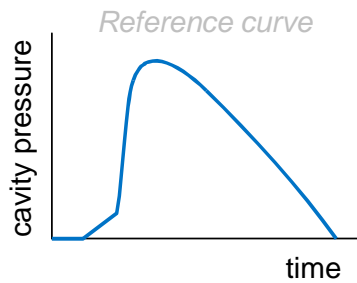
- **Contact-free measurement**

Measuring pins acquire the mould compression caused by the pressure – no witness marks on component.



# Why is CP so important?

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

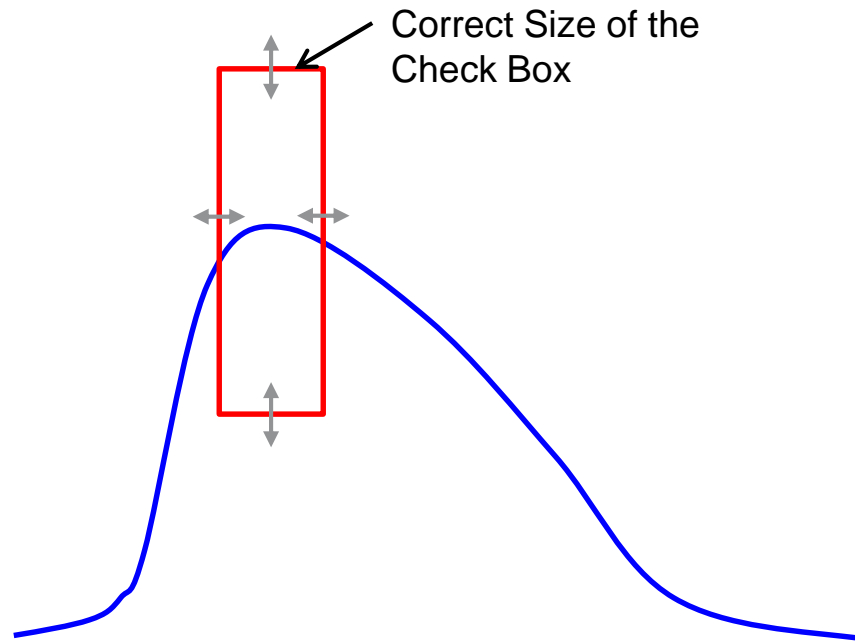
✗ Bad part

Mold opening or v-p switch over too late  
No relaxation of melt after solidification (cooling)

# What can we do with the curve data?

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**



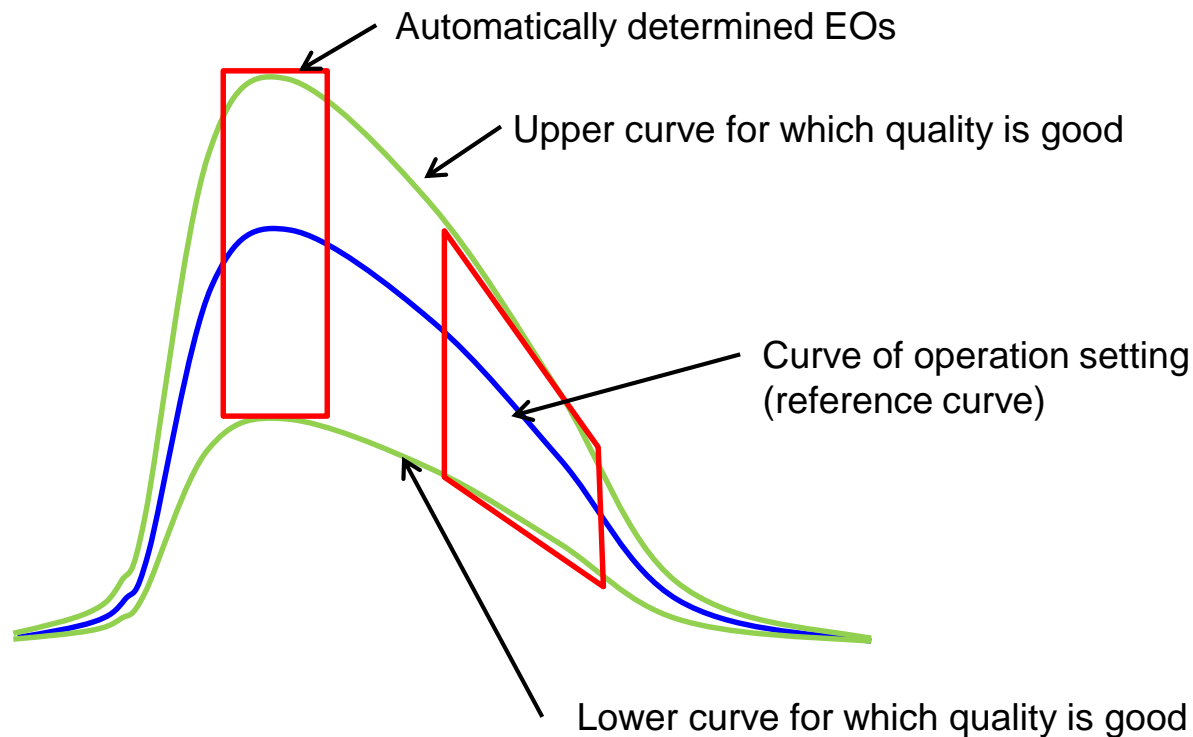
## Advantages of EO- Assistant:

- 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?

## 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.**





# What can we do with the curve data?

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

The screenshot displays the ComoNeo software interface for process monitoring. The main window is titled "Monitoring > EO Wizard Wizard mode". It features a sidebar with navigation options: Home, Analysis, Monitoring (selected), Sorting, EO Monitoring, EO Wizard, and Online prediction. The main content area includes:

- Process stability:** A scatter plot showing data points (red, green, blue) clustered around a mean value of approximately 1.02. A blue oval highlights the cluster.
- Current Measurement Cycle →:** A line graph showing pressure (bar) and temperature (°C) over time (s). The pressure starts at 0, rises to a peak of about 400 bar, and then gradually decreases to 0.
- Trend →:** A line graph showing pressure (bar) over time (s). The pressure remains relatively constant around 400 bar.

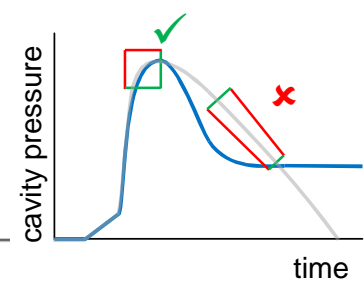
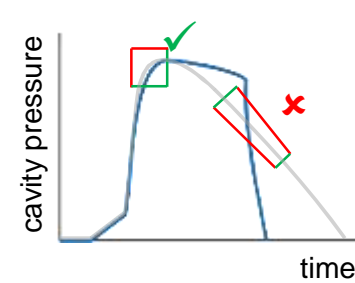
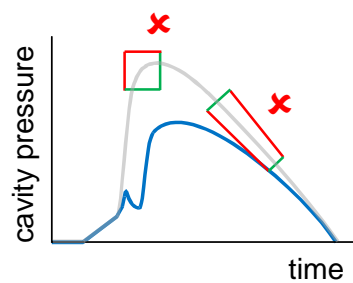
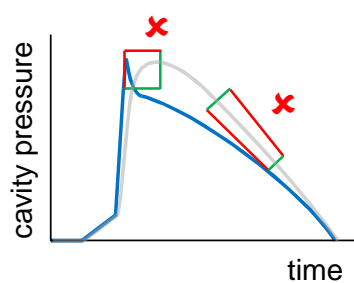
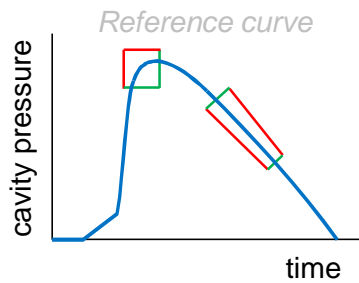
An "EO Wizard Management" dialog box is open, featuring a "Start EO Wizard" button. A red arrow points from this button to a secondary dialog box titled "EO Wizard - Enter Machine setting". This dialog box contains the following fields and controls:

- Injection speed:** A dropdown menu set to "100 mm/s".
- Holding pressure:** A text input field set to "500 bar".
- Process stability:** A small scatter plot showing data points (red, green, blue) clustered around a mean value of approximately 1.02.

At the bottom of the "EO Wizard - Enter Machine setting" dialog box, there are three buttons: "Cancel Wizard", "View Curves", and "Next".

# Why is CP so important?

CP represents correlation of process & parts properties



✓ Good part

✗ Bad part

✗ Bad part

✗ Bad part

✗ Bad part

Both EOs violated  
Signal «Sort»

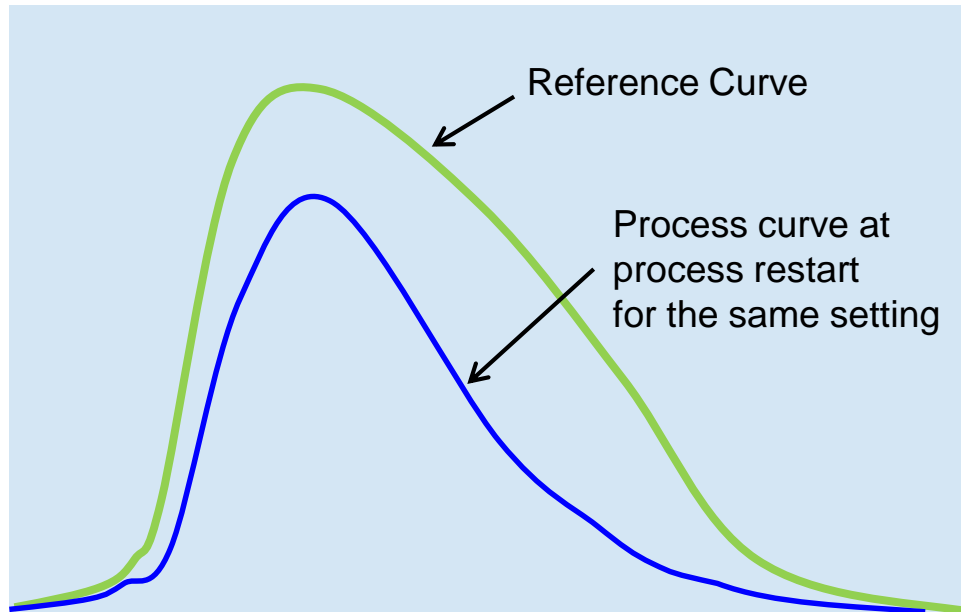
Entry box not activated  
Holding pressure EO  
violated  
Signal «Sort»

Holding pressure EO  
violated  
Signal «Sort»

Holding pressure EO  
violated  
Signal «Sort»

## 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**



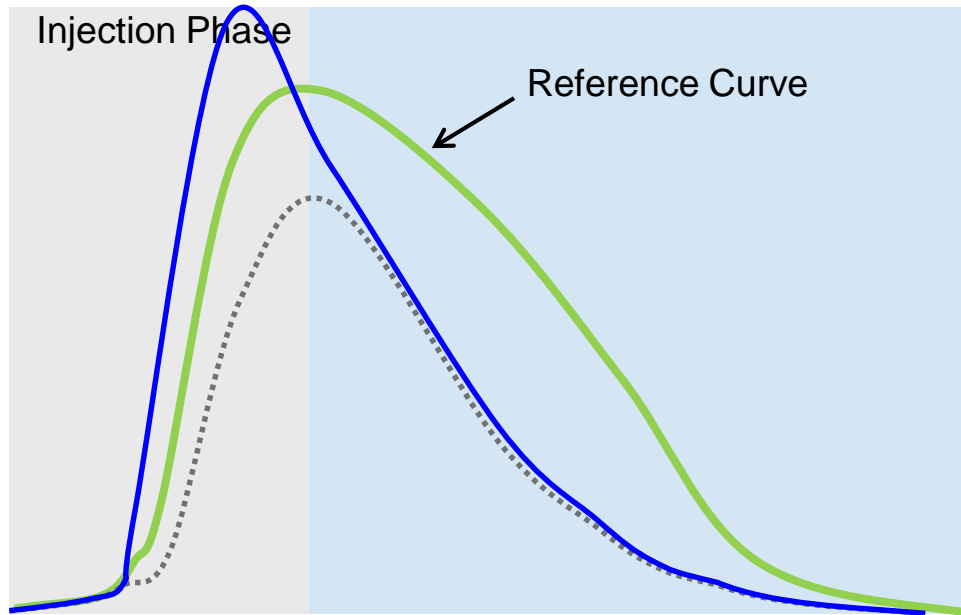
### **Advantages of Restart Assistant:**

- 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



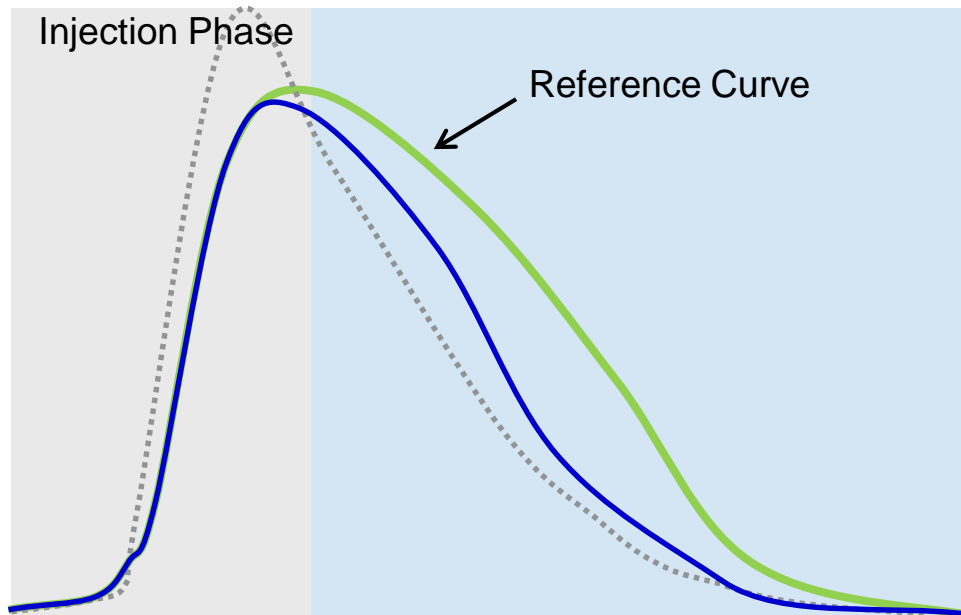
Adjust

- 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

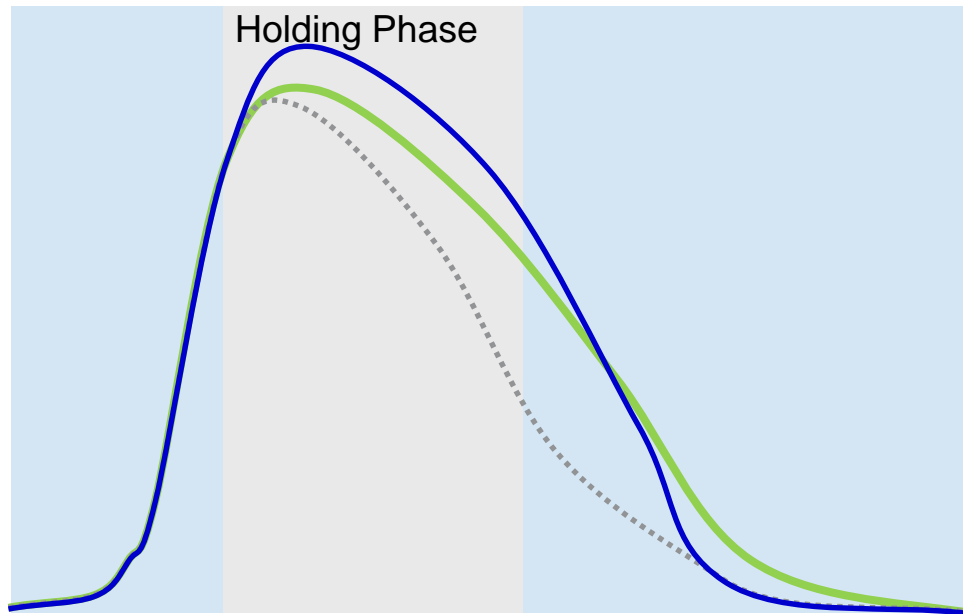


- Injection Speed
- Holding pressure
- Holding time

# What can we do with the curve data?

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

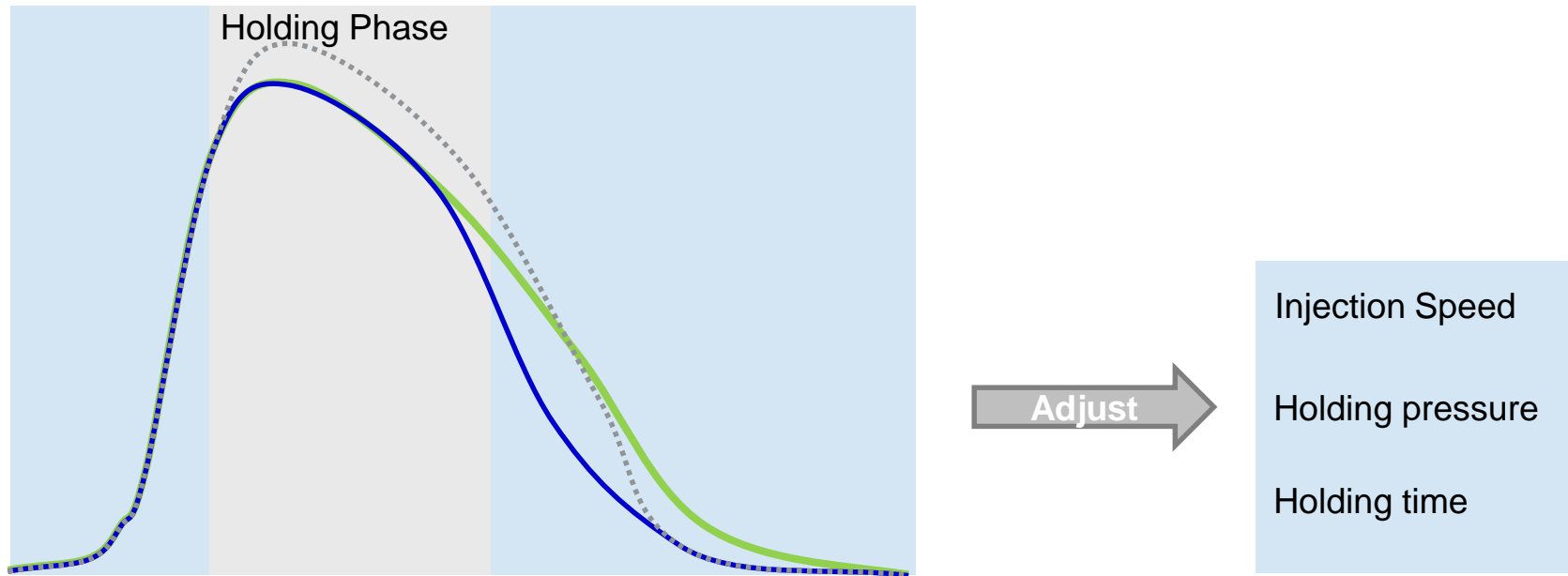
### Adjustment Holding Pressure 1



- Injection Speed
- Holding pressure
- Holding time

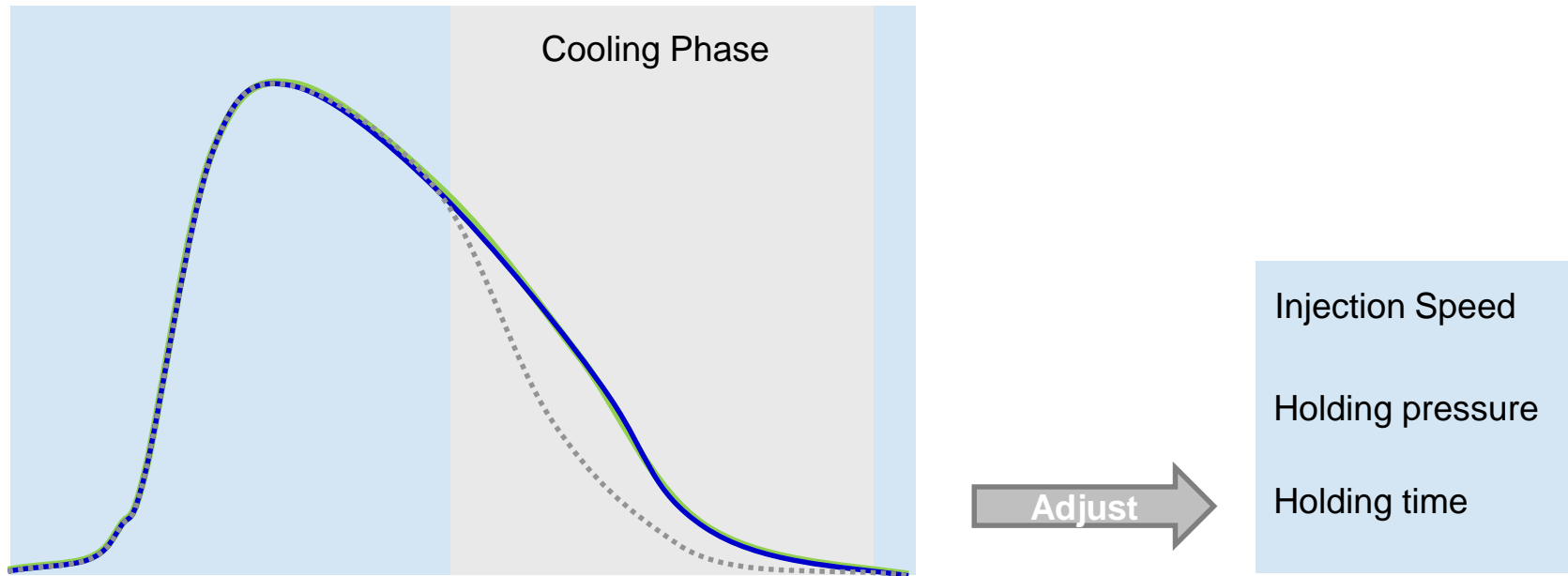
# What can we do with the curve data?

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



# What can we do with the curve data?

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

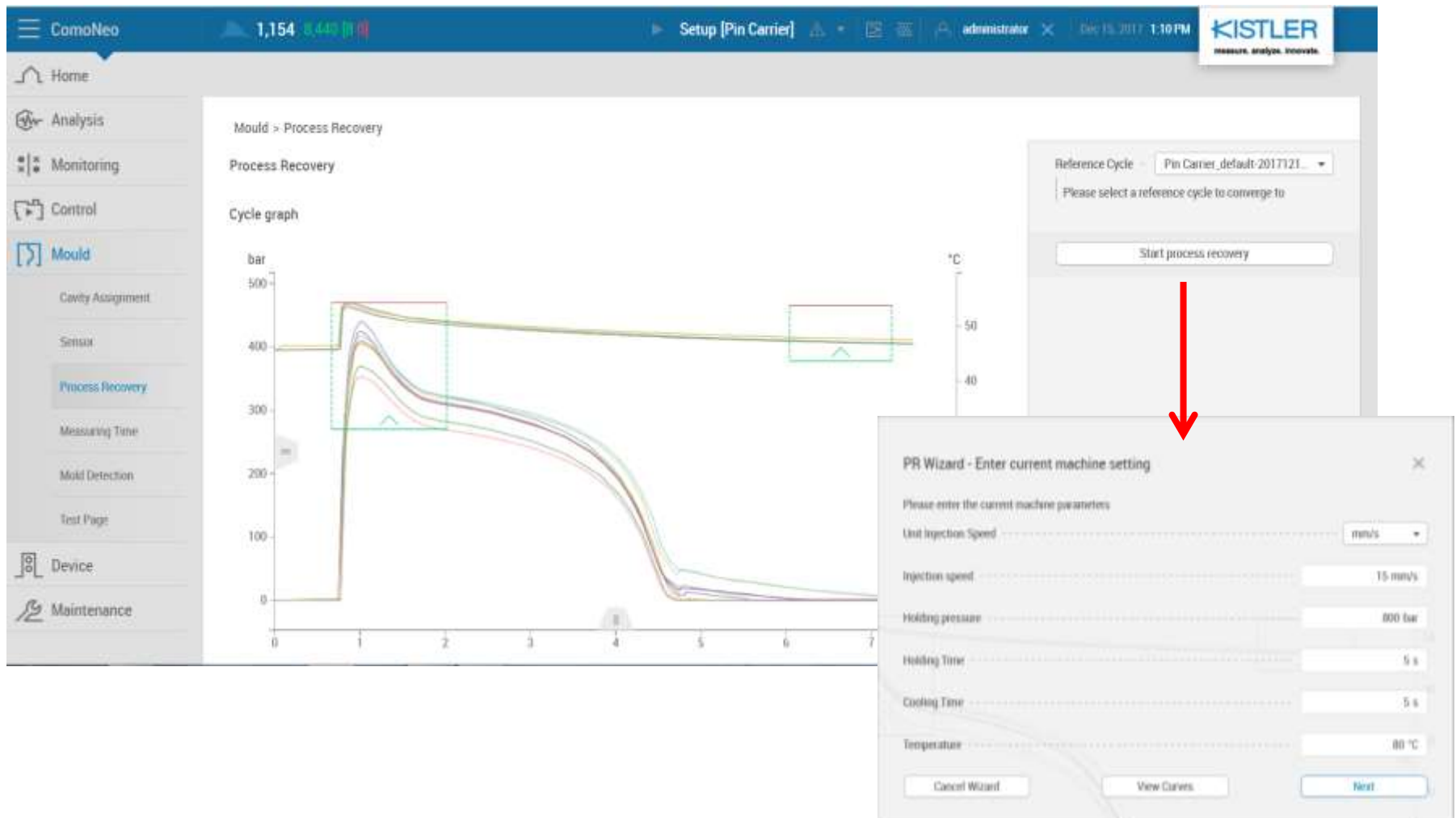


After a few steps the original reference curve can be reproduced



# What can we do with the curve data?

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



# What can we do with the curve data?

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



# What can we do with the curve data?

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

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

KISTLER STASA QC

Projekt: Mischmaschine - Qualitätskontrolle - ÜMittelwert - Aufbaugestaltung - Online Qualitätsregression

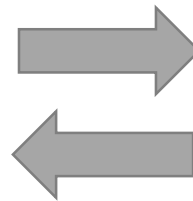
Datenbasis

Versuchsplanung (DoE) Qualitätsdaten

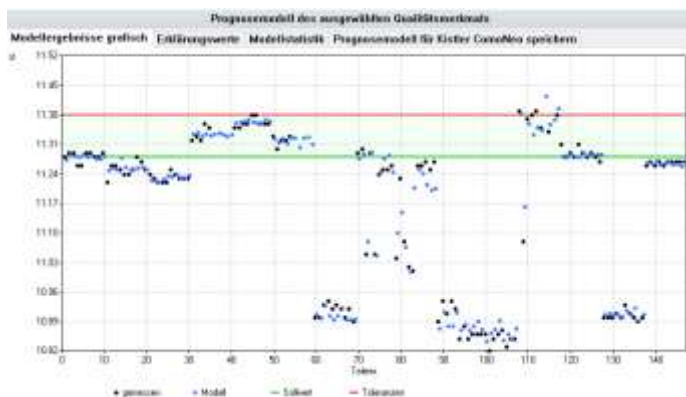
Mischmaschine

Versuchs-Nr.	Zyklus (ppm/min)	Parameter	Vibrationspegel F1 [G]	Winkelgeschwindigkeit [U/min]	Schwingungspegel F2 [G]	Schwingungspegel F3 [G]	Verstellzeit [s]	Profilwert gemessen [mm]	Profilwertmodell (Trend) [mm]
1	10	100	1.20	800	200	14.7	100	1	10
2	10	110	1.10	800	200	14.7	100	0.8	10
3	10	110	1.10	800	200	14.7	100	1.5	10
4	10	110	1.10	1100	200	14.7	100	0.5	10
5	10	110	1.10	1100	200	14.7	100	1.4	10
6	10	110	1.10	1100	300	14.7	100	1.3	10
7	10	130	1.30	800	200	14.7	100	0.8	10
8	10	130	1.30	800	200	14.7	100	0.6	10
9	10	130	1.30	800	200	14.7	100	1.5	10
10	10	130	1.30	1100	200	14.7	100	0.5	10
11	10	130	1.30	1100	200	14.7	100	1.4	10
12	10	130	1.30	1100	300	14.7	100	1.3	10
13	10	130	1.30	800	300	14.7	100	1	10
14	10	130	1.30	800	300	14.7	100	0.6	10
15	10	130	1.30	800	300	14.7	100	1	10
16	10	130	1.30	1100	300	14.7	100	0.5	10
17	10	130	1.30	1100	300	14.7	100	1.4	10
18	10	130	1.30	1100	300	14.7	100	1.3	10
19	10	130	1.30	1100	300	14.7	100	0.8	10

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



### 4. Creation of prognosis model



### 3. (geometrical) measurement of parts



### 5. Transfer & integration into ComoNeo

# What can we do with the curve data?

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

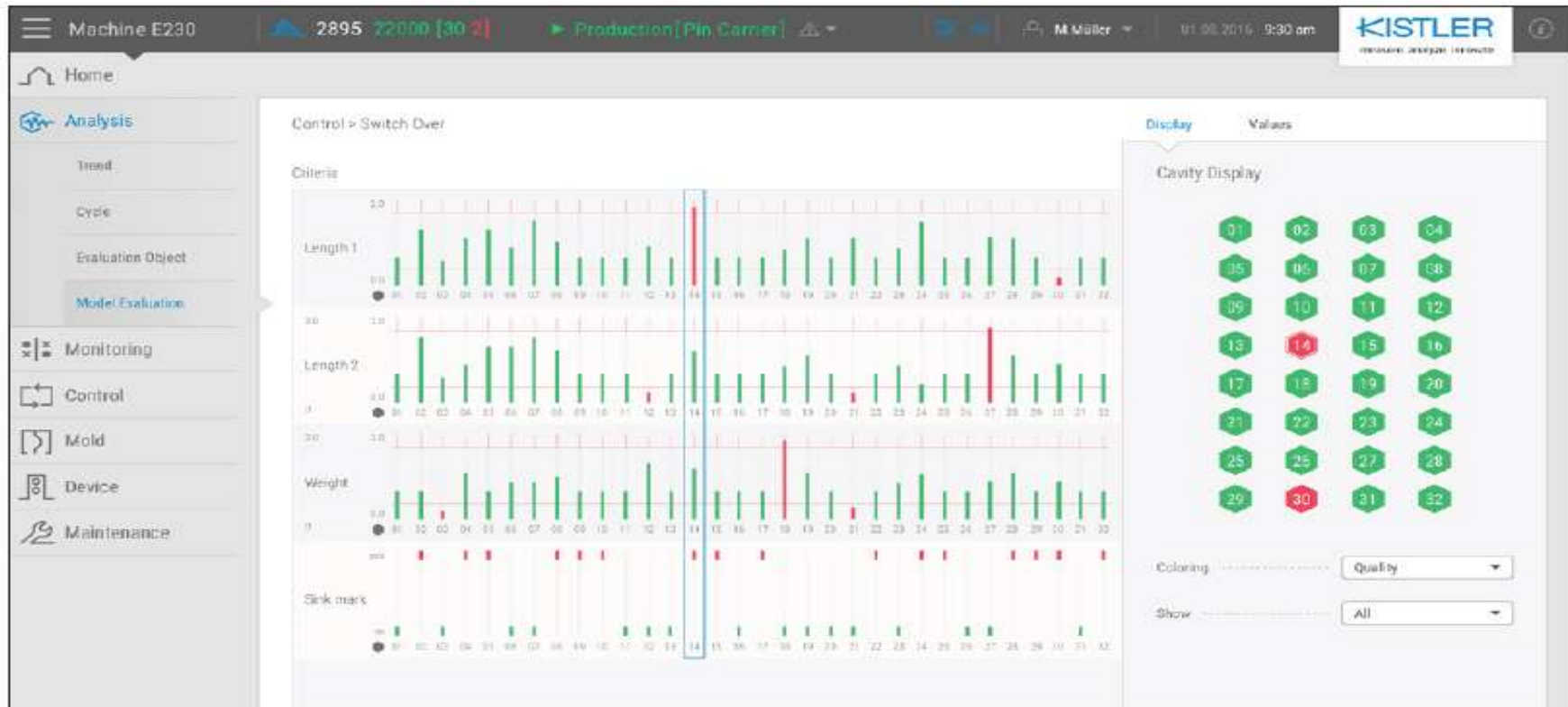
The screenshot displays the ComoNeo software interface. The top navigation bar includes 'ComoNeo', user statistics (1,234, 9,080 [8 0]), 'Setup [Pin Carrier]', user 'administrator', and date/time 'Dec 15, 2017 1:22 PM'. The main menu on the left includes 'Home', 'Analysis', 'Monitoring', 'EO Monitoring', and 'EO Wizard'. The central area shows 'Monitoring > Online prediction > Experiments' with a dropdown menu set to '16002'. A table lists experiment details:

Number	Historyname	Shots scheduled	Shots done	Status
5		10	10	done
		10	10	done
		10	10	done
		10	10	done
		10	10	done
		10	10	done
		10	10	done

An 'Experiment execution: Number 5' dialog box is open, showing a 'Table Cycles' and a 'Cycle graph'. The table lists cycles 1-5 with statuses: Executed, Executed, Executed, Executing, and Not Executed. The cycle graph plots pressure (bar) and temperature (°C) over time (0.0 to 4.0). A red arrow points from the 'Executing' status in the table to the graph. The right sidebar shows 'Experiment 11' parameters: barrel temperature (250 °C), hot runner temperature (270 °C), mould temperature (20 s), hold pressure (300 bar), injection speed (60 ccm/s), and stagnation pressure (60 bar). A 'Run Experiment' button is at the bottom.

# What can we do with the curve data?

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



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?

Documentation 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.

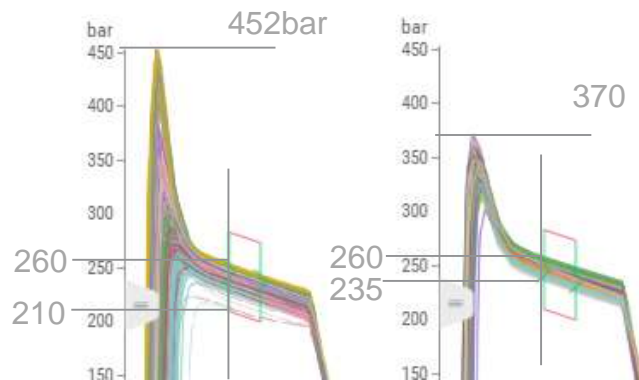
- Fast detection of process variations
- Recording and comparison of production efficiency across different batches, machines, and locations
- Possibility of filtering by production order
- Quick and easy search
- OPC-UA interface for Factory 4.0





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

## Automatic cavity balancing closed loop control:

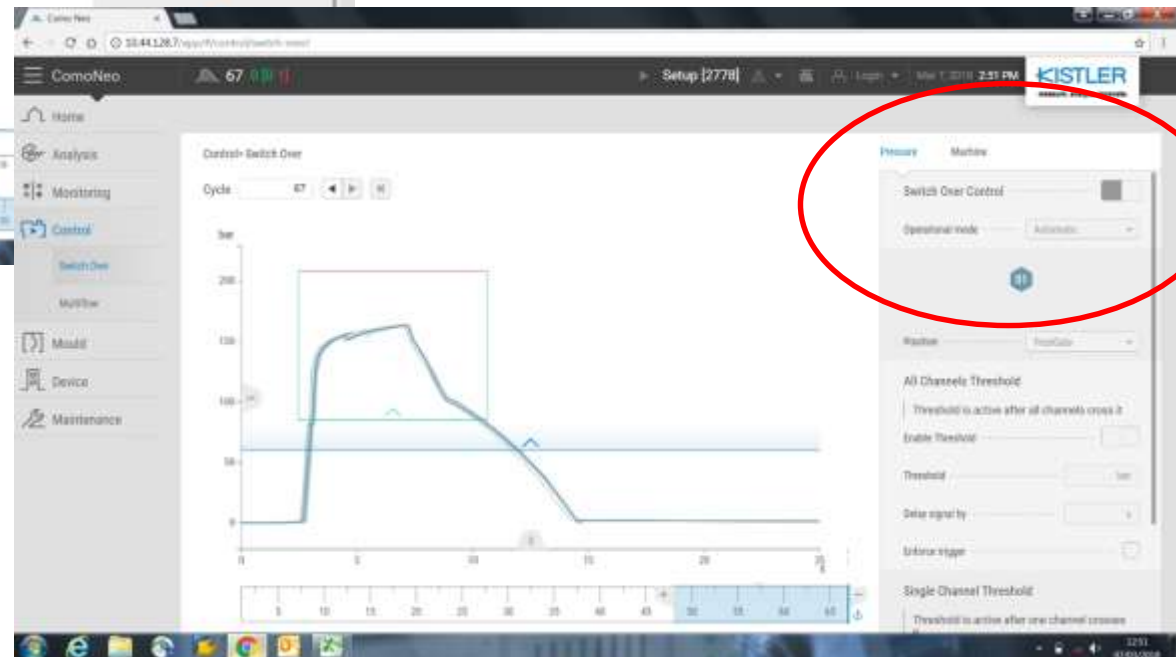
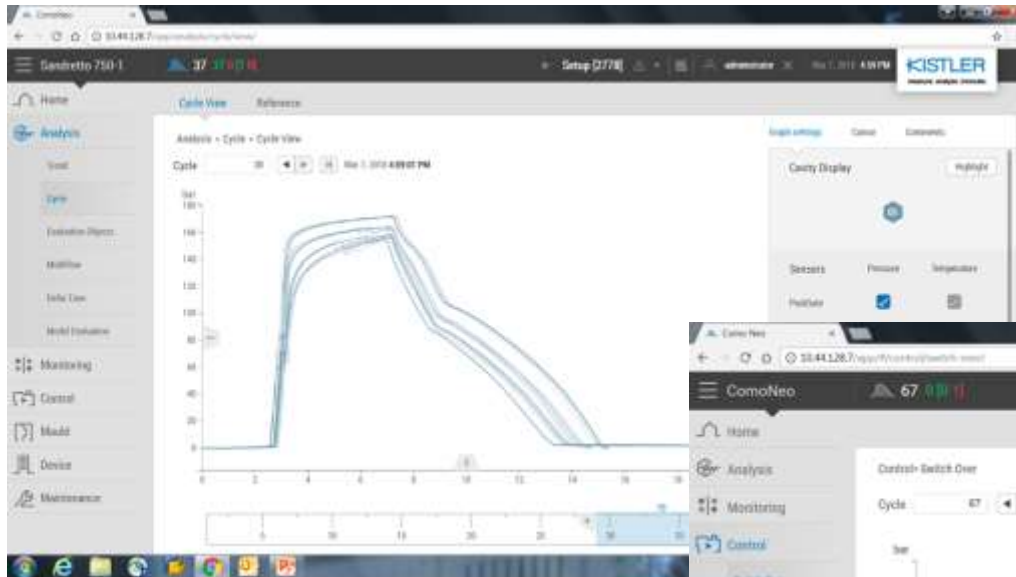


### Benefit:

- Decreased peak pressure of 18%
- Decreased holding pressure difference 50%
- Homogenous 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?

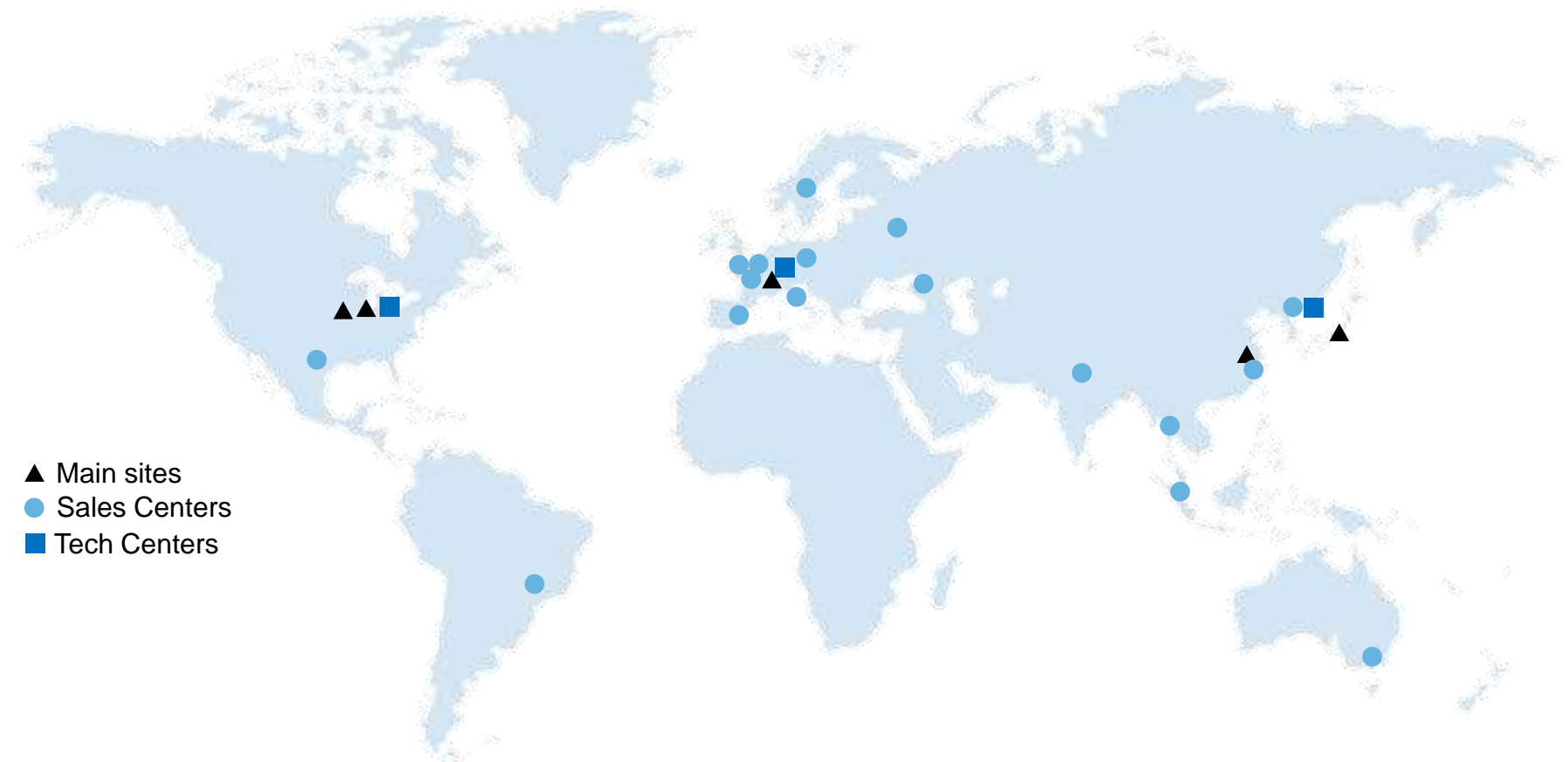
## SLP – Automatic switchover control:





## 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.



**Ballpark  
figures just  
aren't good  
enough**



instead  
of

