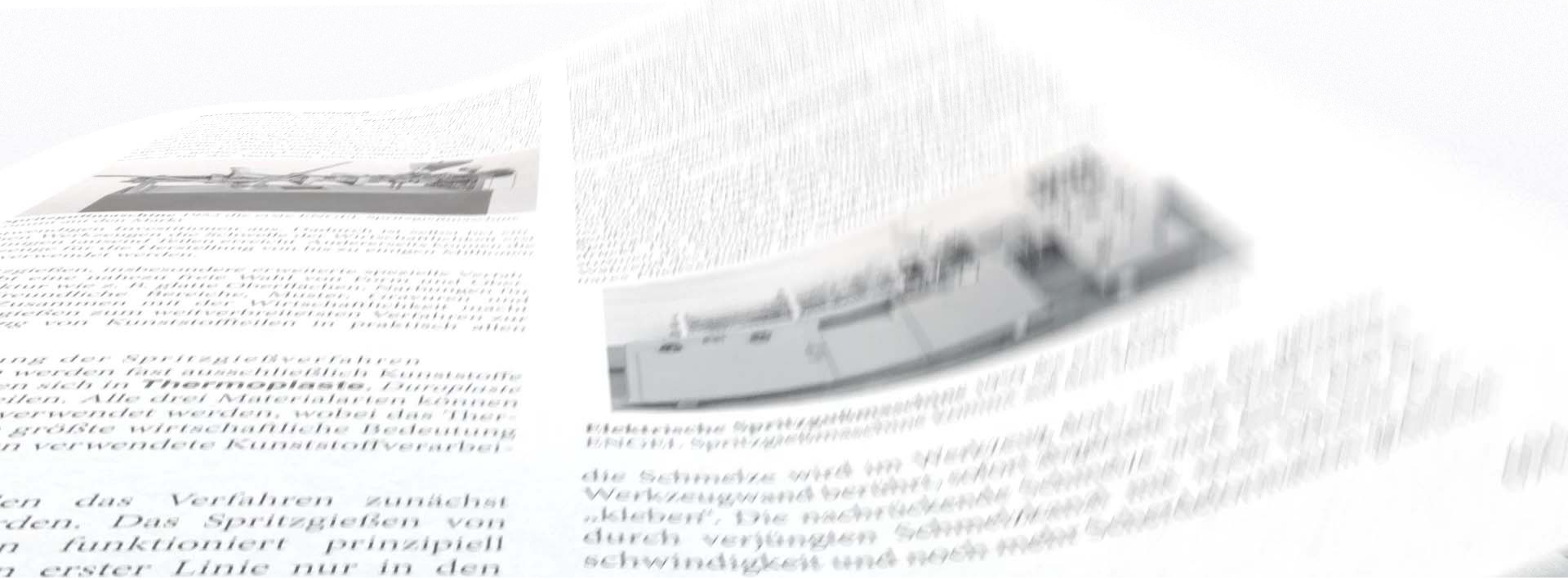
Inject 4.0:
Welcome to the Smart Factory

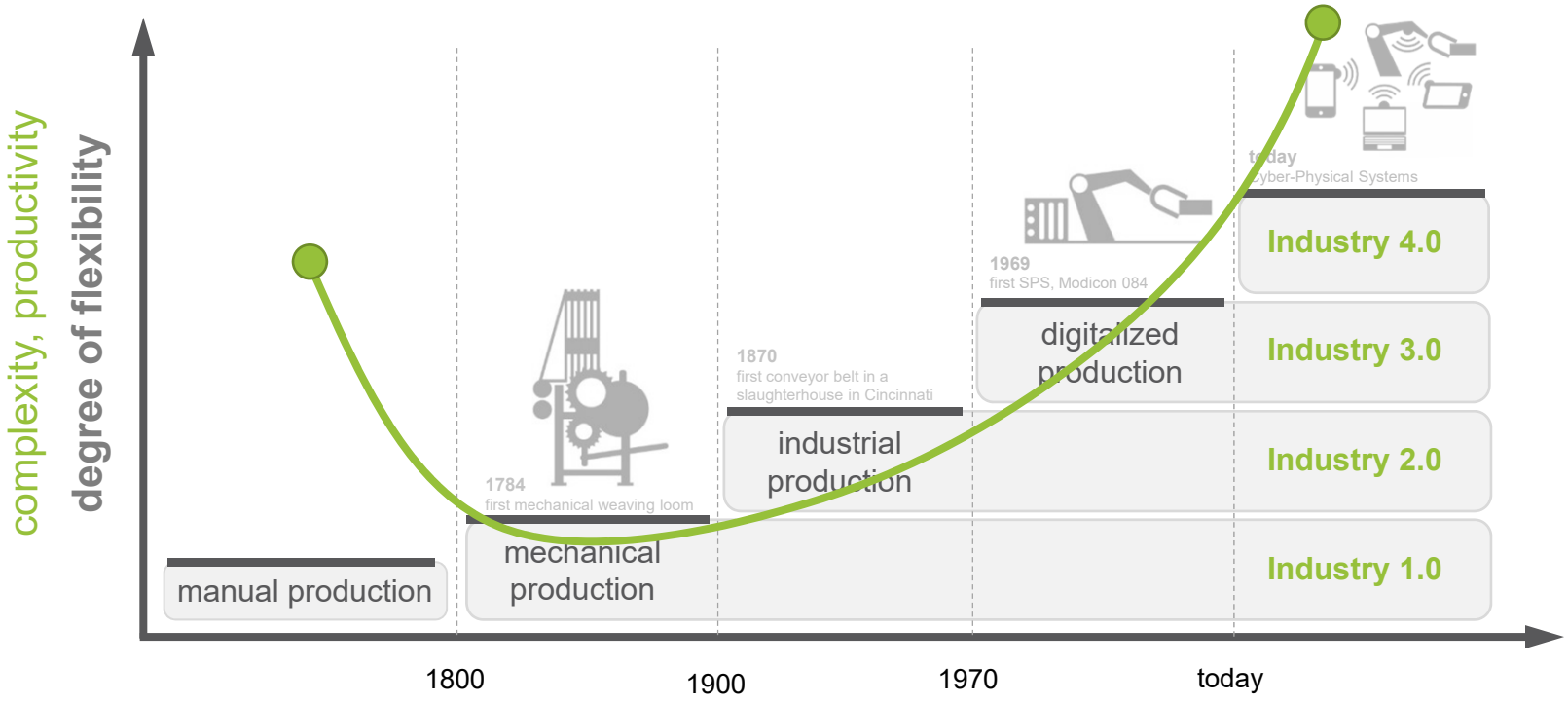
Presenter:

joachim kragl
ENGEL MACHINERY, INC.



Industrial revolutions

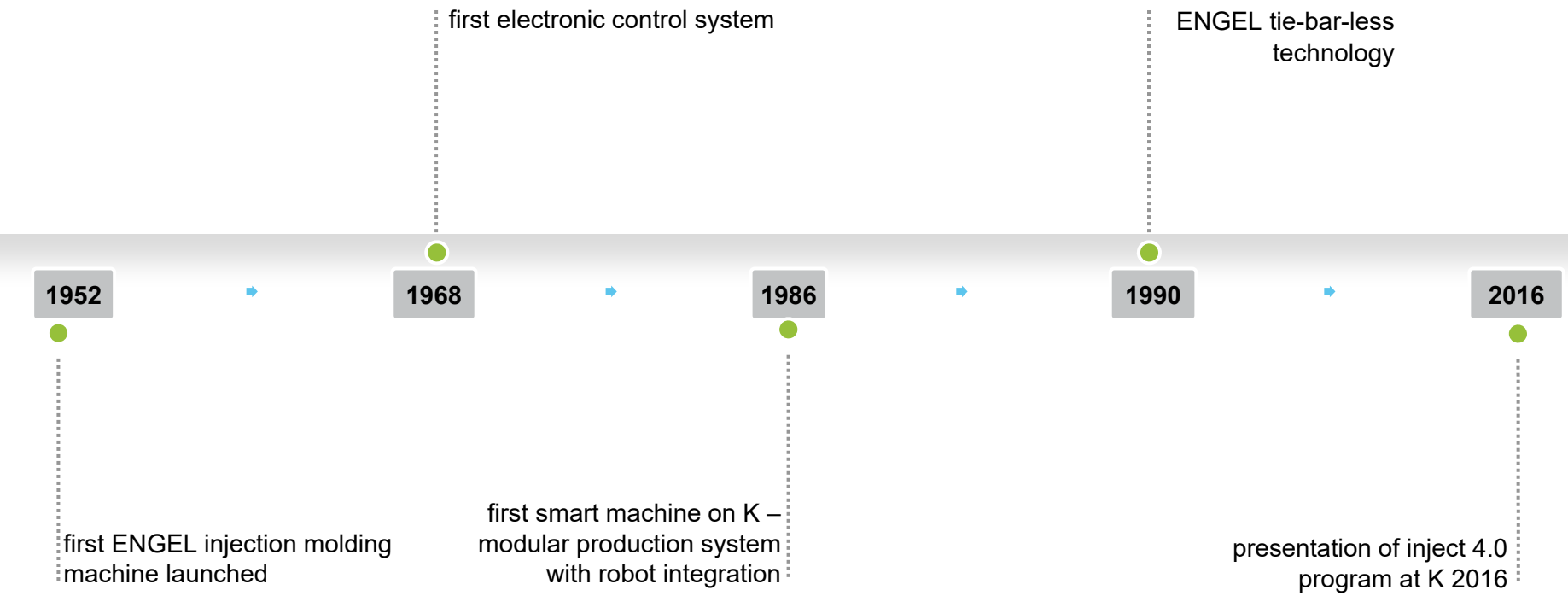
Industry 4.0 allows almost unlimited flexibility



source: German Research Centre for Artificial Intelligence

ENGEL as active participant

Development of products over the years



The role of ENGEL

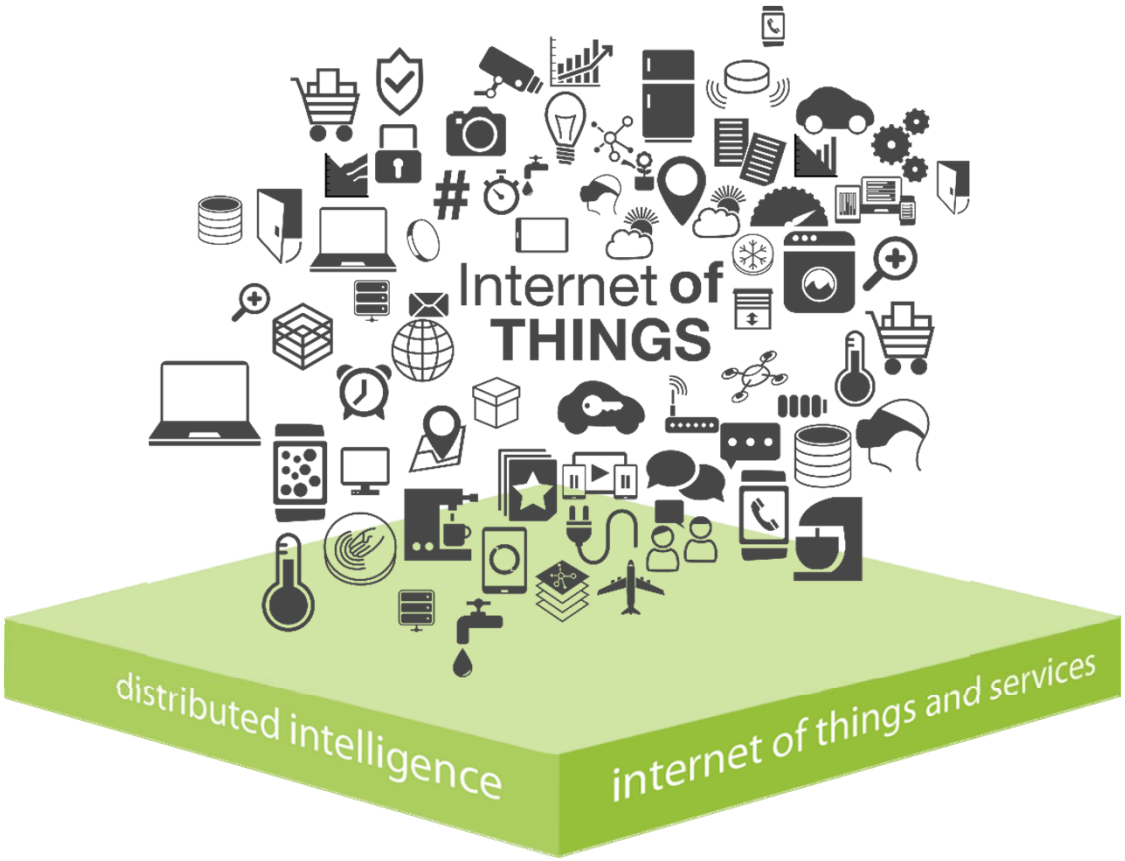
ENGEL as **user**

- transformation of machine production
  - engineer to order → configure to order
- Production of customized machines with the efficiency of mass products
- Increase competitiveness due to
  - Traceability over the complete supply chain
  - Paperless value chain
  - Higher level of automation
  - Higher productivity

ENGEL as **provider**

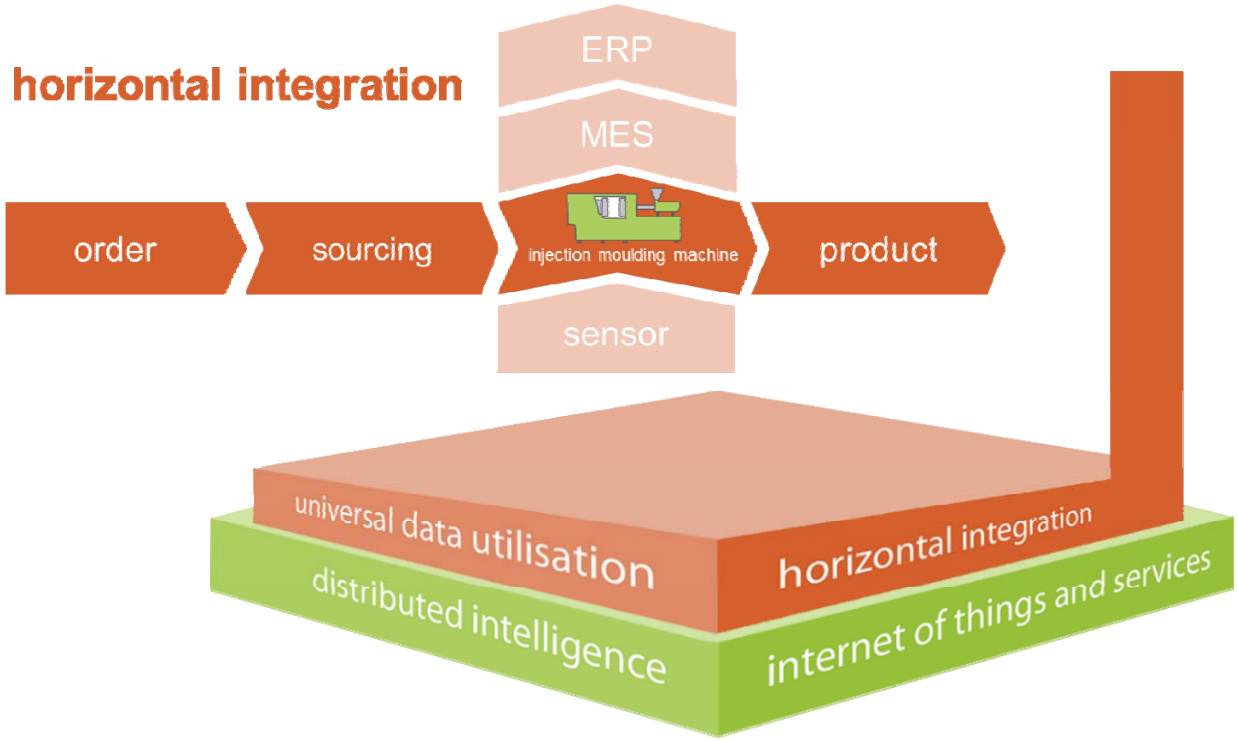
- Development of solutions
  - to support customers on the way to their smart factory
  - enabling new levels of flexibility
- Transformation of customer potential
  - Process stabilty
  - Availability
  - Productivity

Main elements of Industry 4.0

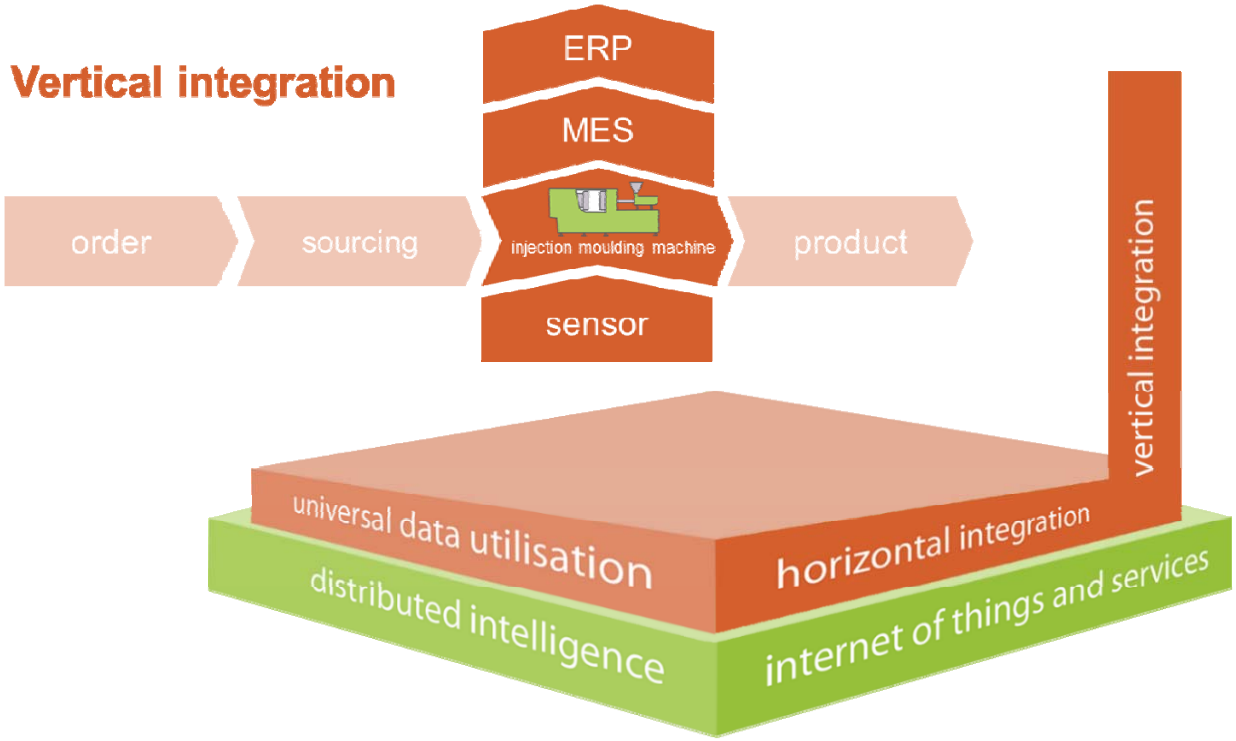


Main elements of Industry 4.0

Data Integration

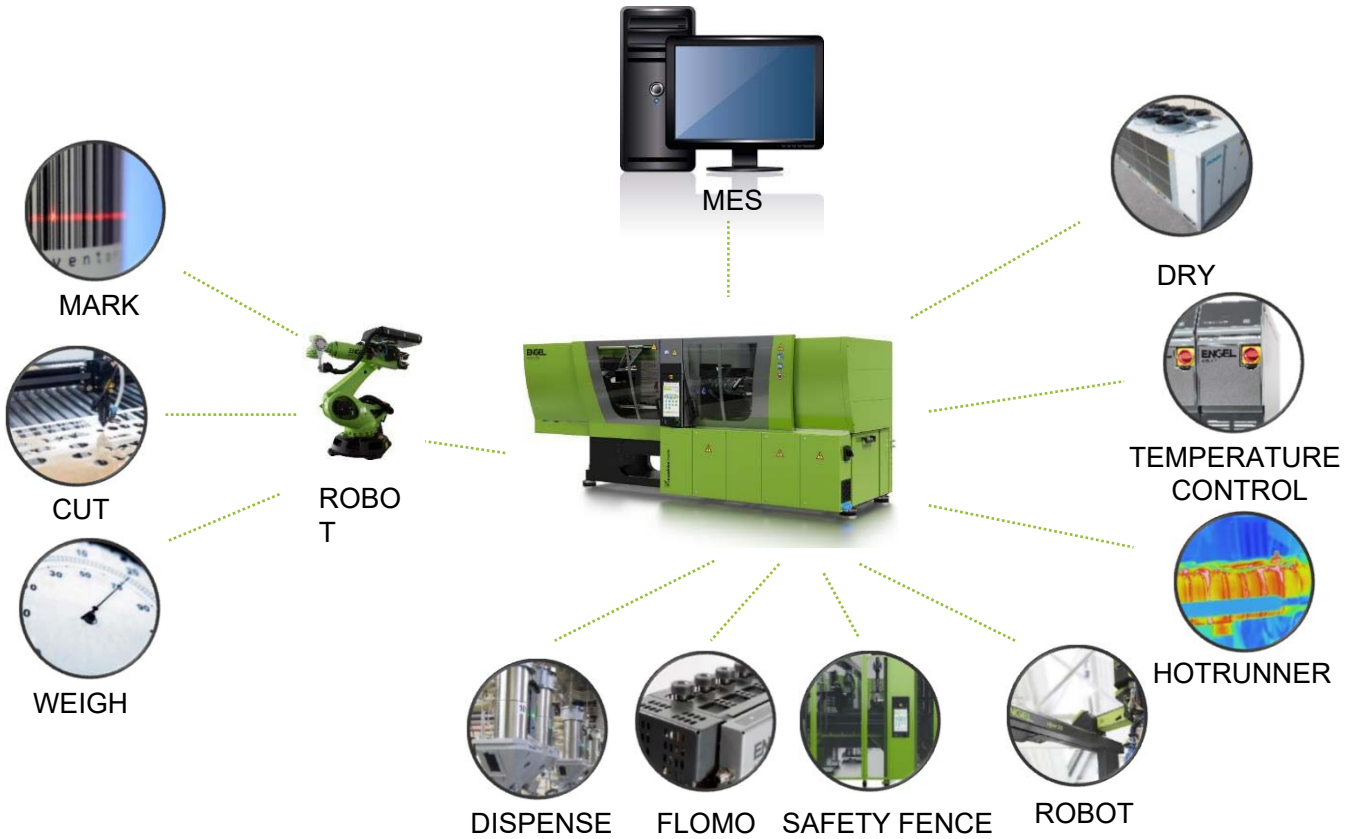


Main elements of Industry 4.0
Data Integration



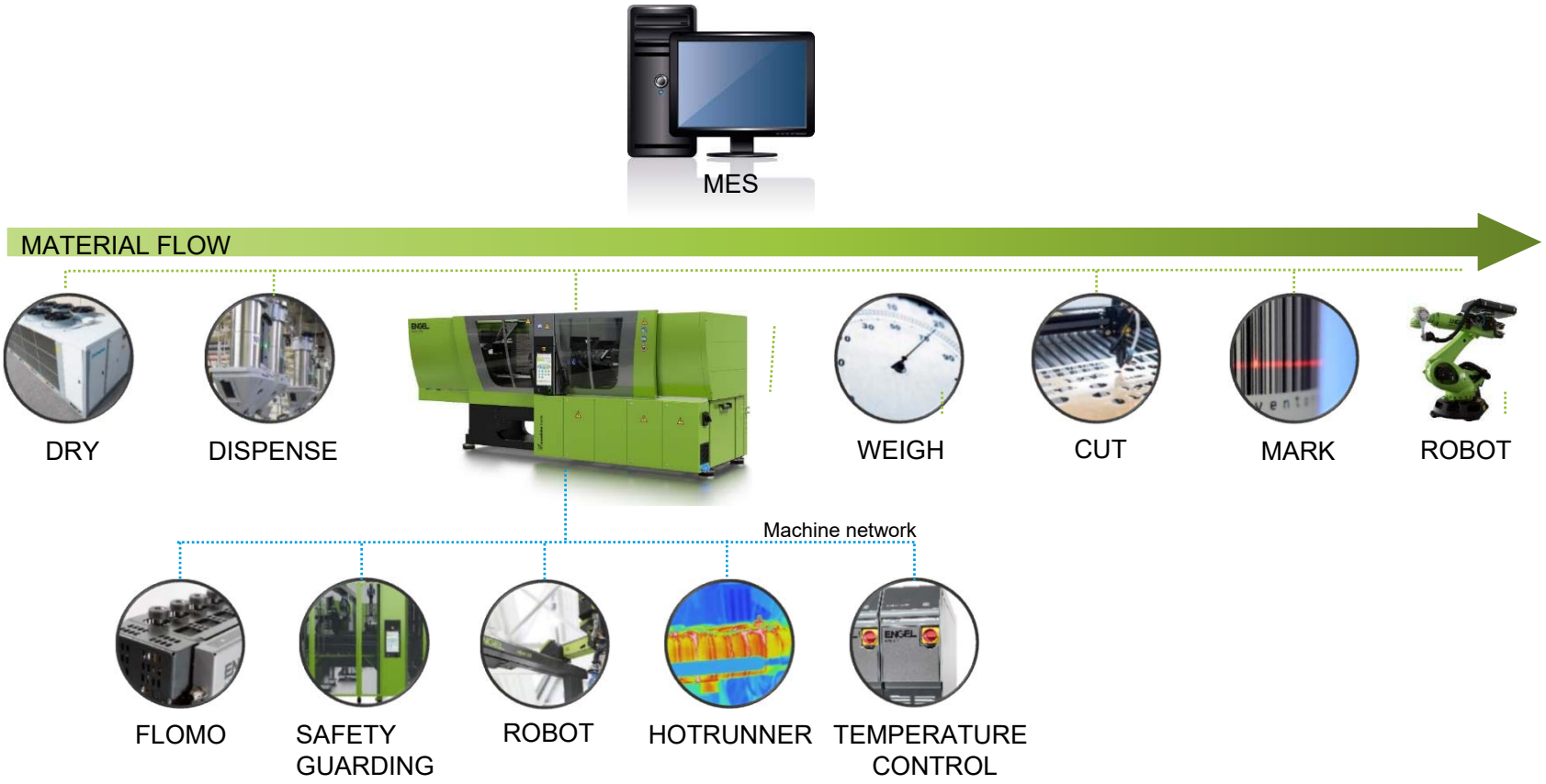
Data Flow - Today

point-to-point connection with specified hierarchy



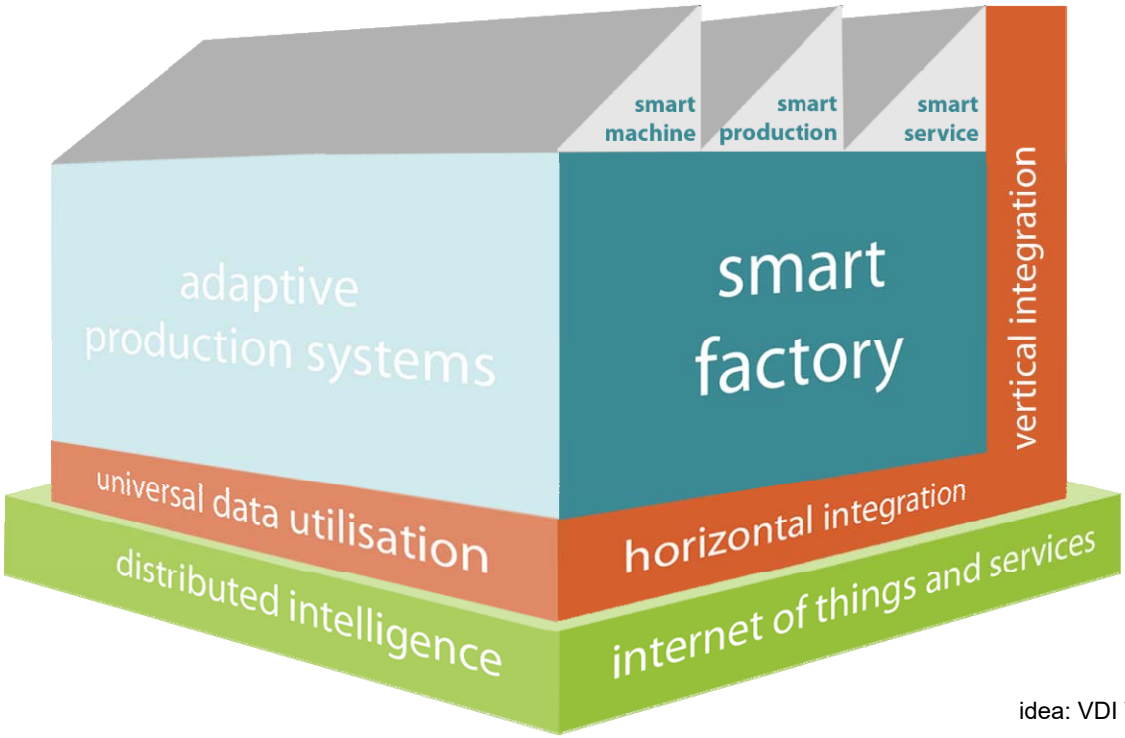
OPC-UA - Tomorrow

cross-platform service oriented architecture



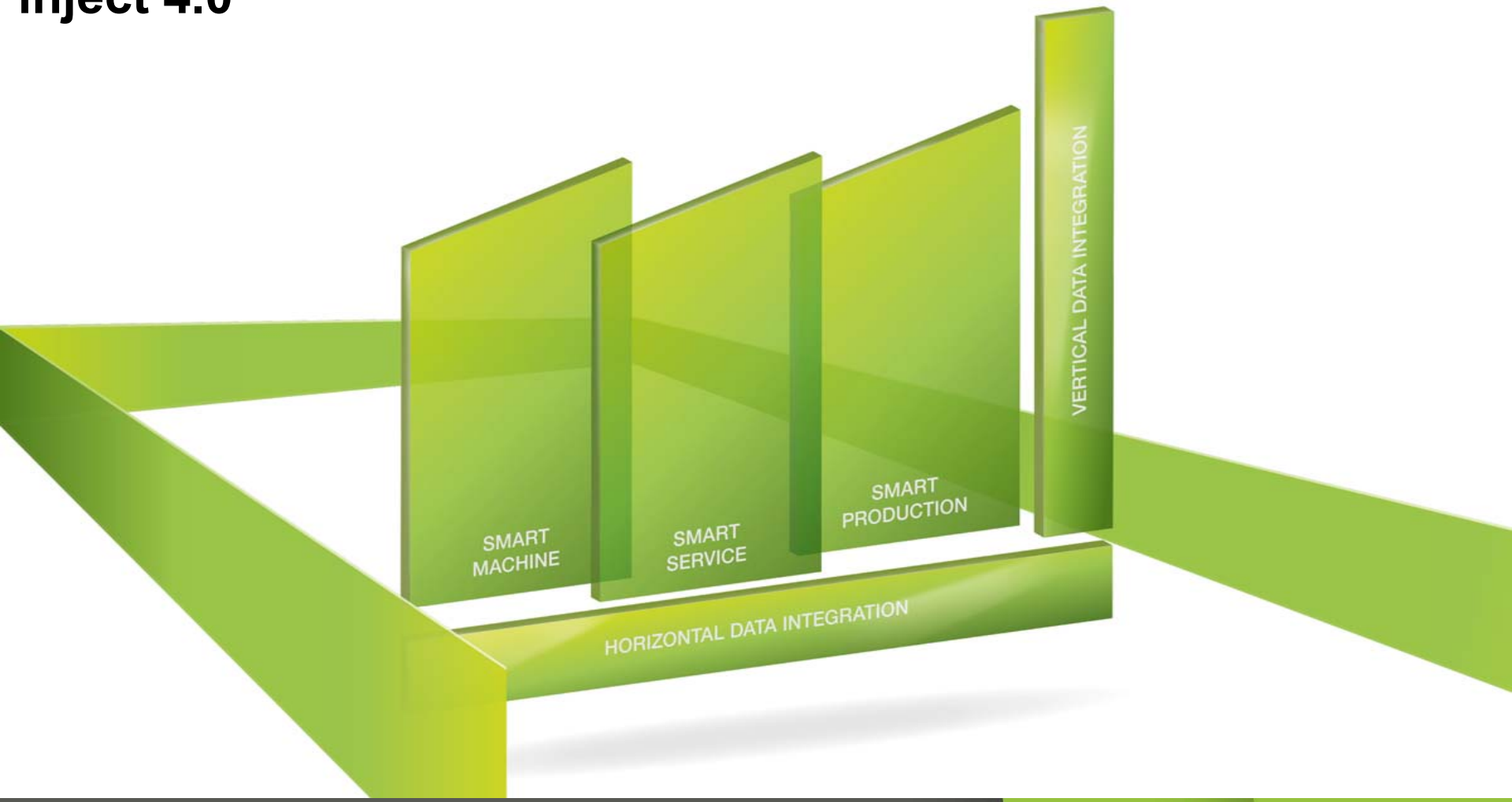
smart factory …

… The Heart of Industry 4.0



idea: VDI Wissensforum GmbH, VDI e.V

inject 4.0


SMART MACHINE
SMART SERVICE
SMART PRODUCTION
VERTICAL DATA INTEGRATION
HORIZONTAL DATA INTEGRATION

inject 4.0

Our target:

Leverage the full potential of injection molding

- **smart machine**
  Quality and process stability through adaptive production systems
- **smart service**
  Availability and maintenance through systematic data utilization
- **smart production**
  Productivity and flexibility through linking and integrating

smart machine

more stability, better quality

intelligent Quality solutions support the users for highest process stability

iQ weight control	iQ clamp control	iQ flow control	iQ vibration control
Intelligent compensation of process deviations	Determination of the ideal clamping force based on molding breathing	Automatic and intelligent molding temperature control process	Active compensation of external disturbances on robot movements

smart machine

iQ weight control

Customer situation

- Raw material batch variations
- Moisture fluctuations
- Changes in ambient temperature

This results in

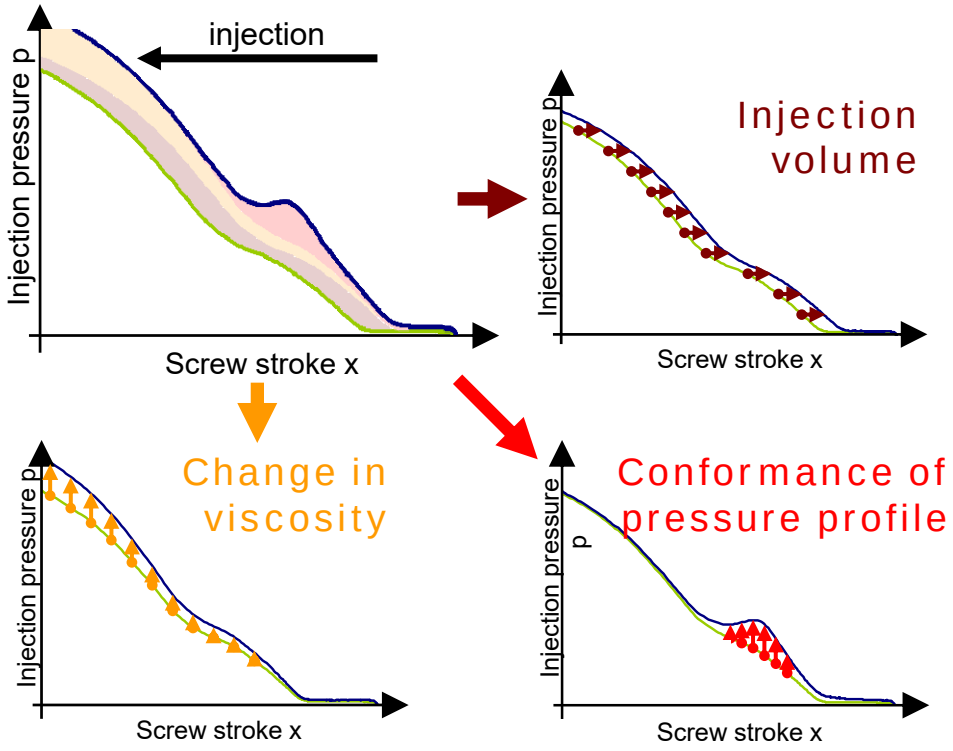
- Short shots
- Overloaded cavities

iQ weight control| injection

iQ weight control **compares** the **actual pressure curve** with a previously stored **reference curve**

The deviation from the reference curve is split up into **three contributions**

Each contribution forms one of the **new iQ weight control process parameters**



iQ weight control| injection

Objective of iQ weight control

- Compensate melt amount variations in the filling phase

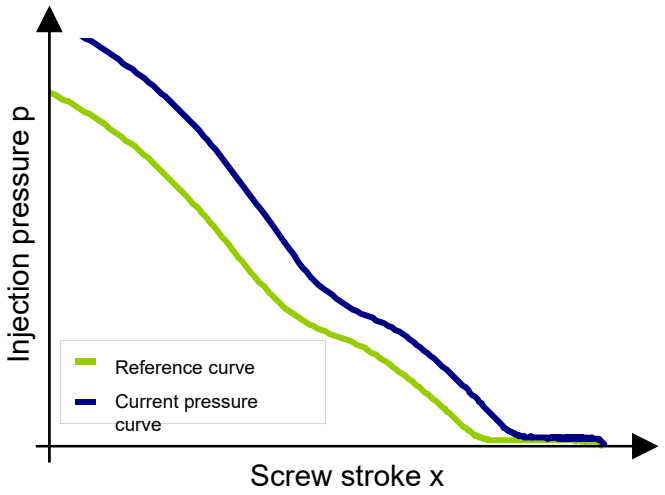
Deviations randomly change each cycle

- Adaptation needs to be done during injection in the same cycle

Example:

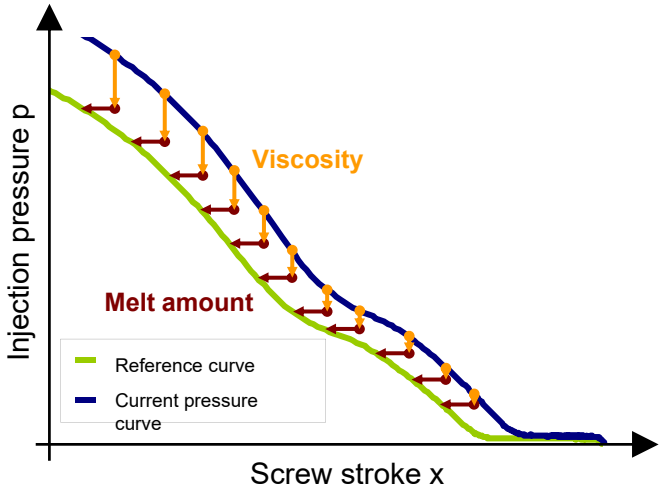
viscosity *and* ***melt amount*** *are* ***larger*** *than in reference cycle*

- ***Pressure*** *rises* ***earlier*** *and increases* ***more steeply***



iQ weight control| injection

The deviation from the reference curve is split up into contributions of **melt amount** and **viscosity**

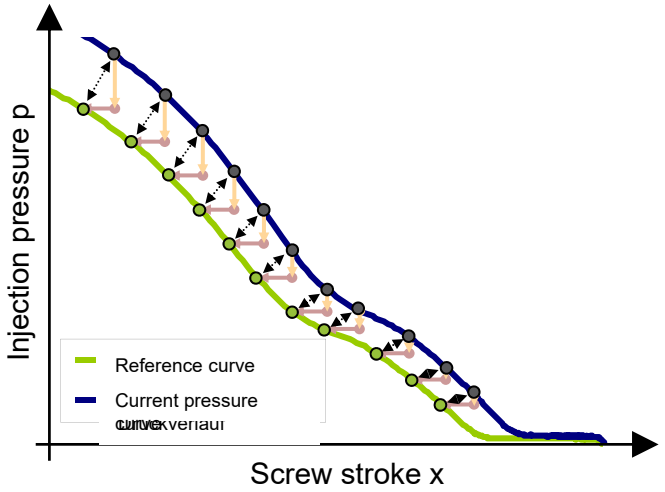


iQ weight control| injection

The deviation from the reference curve is split up into contributions of **melt amount** and **viscosity** online during injection

Thus each point on the pressure curve can be associated with the corresponding point on the reference curve

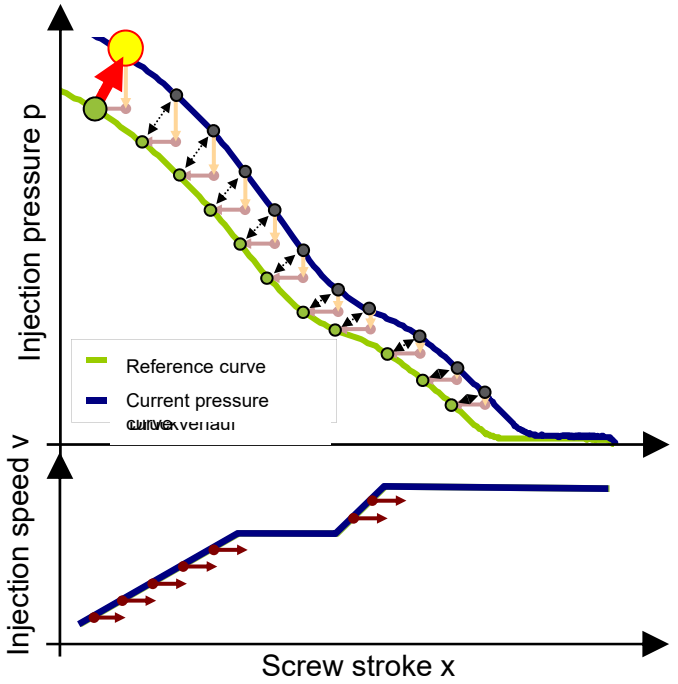
The resulting point pairs have the **same fill state of the cavity**



iQ weight control| injection

How does iQ weight control react?

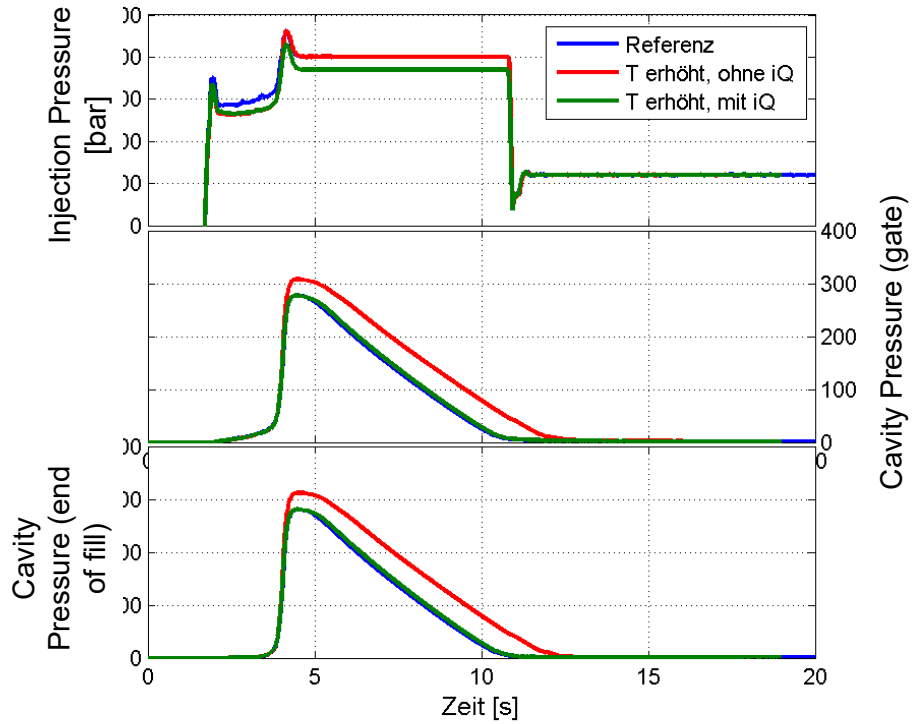
- The **injection speed profile is shifted** according to the detected melt amount
- Likewise the **cut-over point** is adapted to the actual fill state of the cavity
- These **corrections** are done **in the same cycle – in realtime**
- Outcome: **Consistent fill state** at switch-over to holding pressure



iQ weight control| hold pressure

Hold pressure profile is automatically adapted when the viscosity changes

- Simulated **viscosity change** by increasing barrel temperature
- **Automatic adaptation of hold pressure profile** based on viscosity change
- **Cavity pressure curves** return to their **original state**



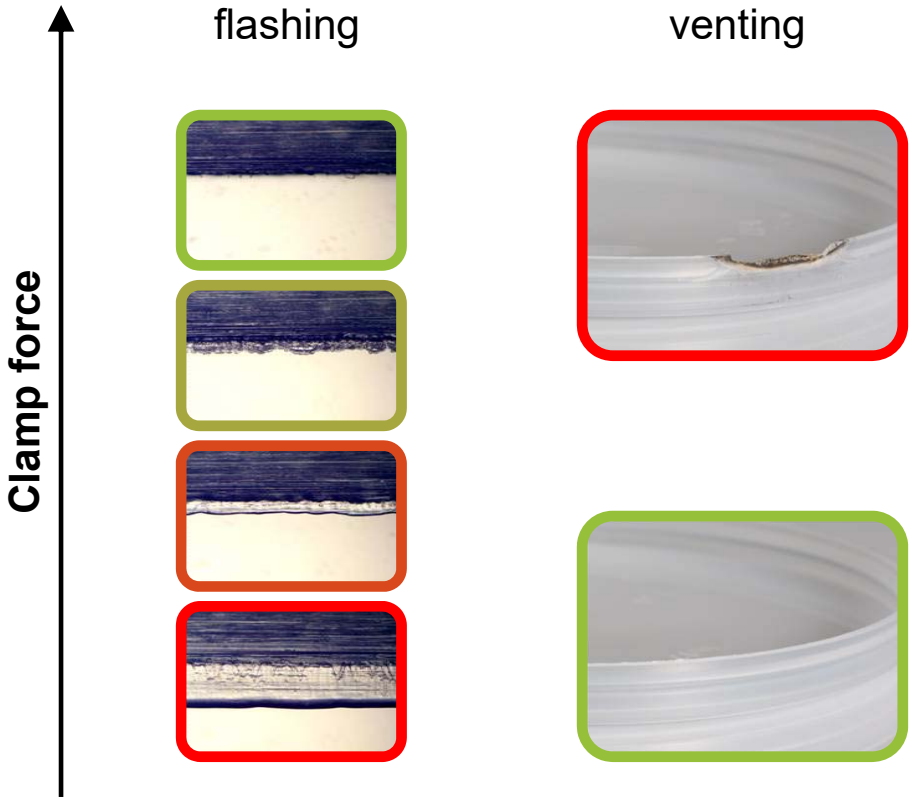
smart machine
iQ clamp control

Customer situation

- Different users set different clamp forces
- Too little or too high clamping force

This results in

- Burrs
- Bad venting → burn marks
- Unnecessary wear and tear of the molding and machine



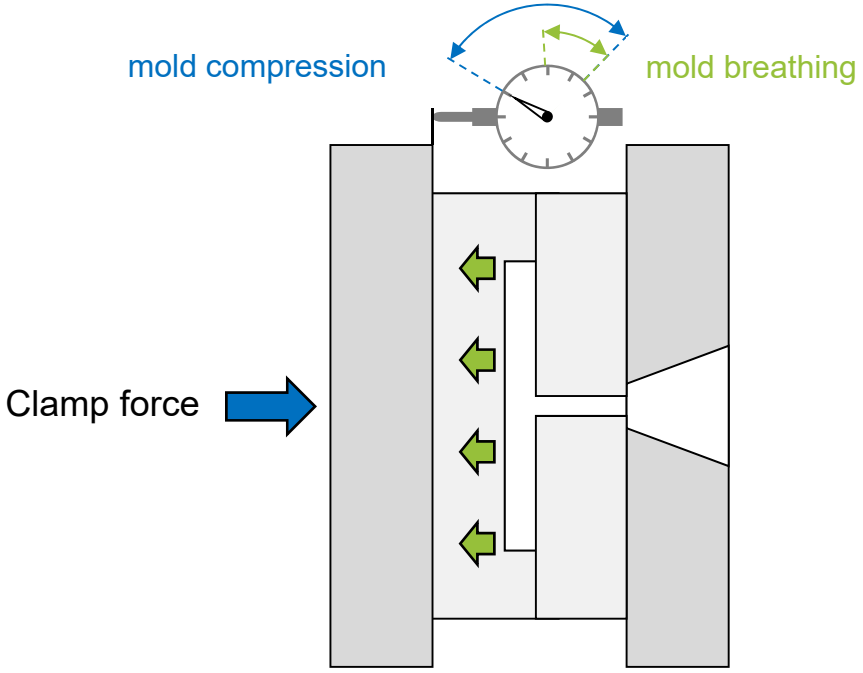
smart machine
iQ clamp control

The ENGEL solution

- Automatically determines the ideal clamping force based on mold breathing
- Provides and monitors process relevant information about each shot

Results

- Objective and optimal setting of a critical process parameter
- Fewer rejects and high reproducibility
- Lower wear and tear of molding and machine



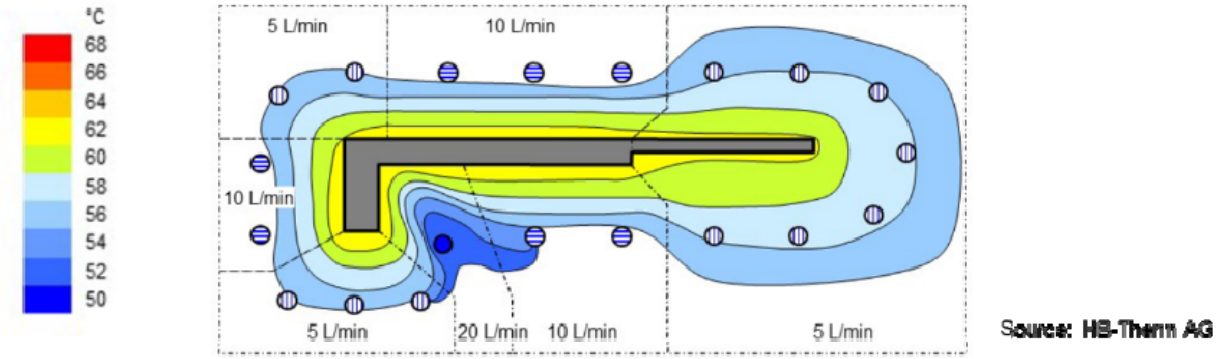
The mold is compressed by the clamp force
Cavity pressure during filling causes **mold breathing**

Available for electric clamping units of e-mac and e-motion series
Available for duo machine series: June 2017

smart machine
iQ flow control

Customer situation

- Different flow rates around a mold's cavity are necessary
- No knowledge about optimal flow rate, no process reliability
- Trial and error approach to optimize the flow rate
- High energy consumption and costs
- High mold surface temperatures require longer cooling times and therefore influence productivity



Source: HB-Therm AG

smart machine
iQ flow control

The ENGEL solution

- iQ flow control communicates via OPC-UA interface with mold temperature control unit
- The speed-controlled pump provides the system with only required water quantity
- e-flomo monitors and controls the process
- Full integration in CC300

e-flomo

Process control and monitoring to avoid rejects

iQ flow control

All temperature control components at a glance

e-temp

Reduction of energy costs with speed controlled pump

Available for new machine orders starting in April 2017

smart machine
iQ vibration control

Customer situation

- external disturbances influence the robot movement
  - ejector movement, machine vibration, movements of auxiliaries
  - strokes on the gripper, complex EOAT on long axes

The ENGEL solution

- detection and reduction of vibrations for an optimal movement
- active compensation of external disturbances

Results

- improved positioning and repeatability
- shortest molding open times
- maximum lifetime

Available in standard for viper 40/60 by December 2016 and viper 20/90/120 by April 2017

smart machine
iQ vibration control

smart service

higher availability, better maintenance

smart service

e-connect | e-connect.monitor | e-connect.24 | e-connect App

More support, improved availability

e-connect

- Online customer portal
- Plant overview
- Service ticket details

e-connect.monitor

- Condition monitoring
- Analysis at ENGEL
- Data exchange via e-connect portal

e-connect.24

- 24/7 online support
- Service Requests
- Remote View
- Conference center
- Data exchange

e-connect App

- Machine & production status
- Machine alarms
- Service Requests

smart service
e-connect

Customer situation

- Various communication and information channels with supplier
- High effort to collect necessary information on current service cases
- Unplanned downtimes

Preview: October 2016
Market launch: October 2017

smart service
e-connect

How does it work?

- Portal as main point of communication and information
- Overview of equipment including status, alarms and warnings
- See condition of machine components
- Details on service cases (tickets, spare parts orders, etc.)
- Check price & availability of spare parts
- Send service requests

Results

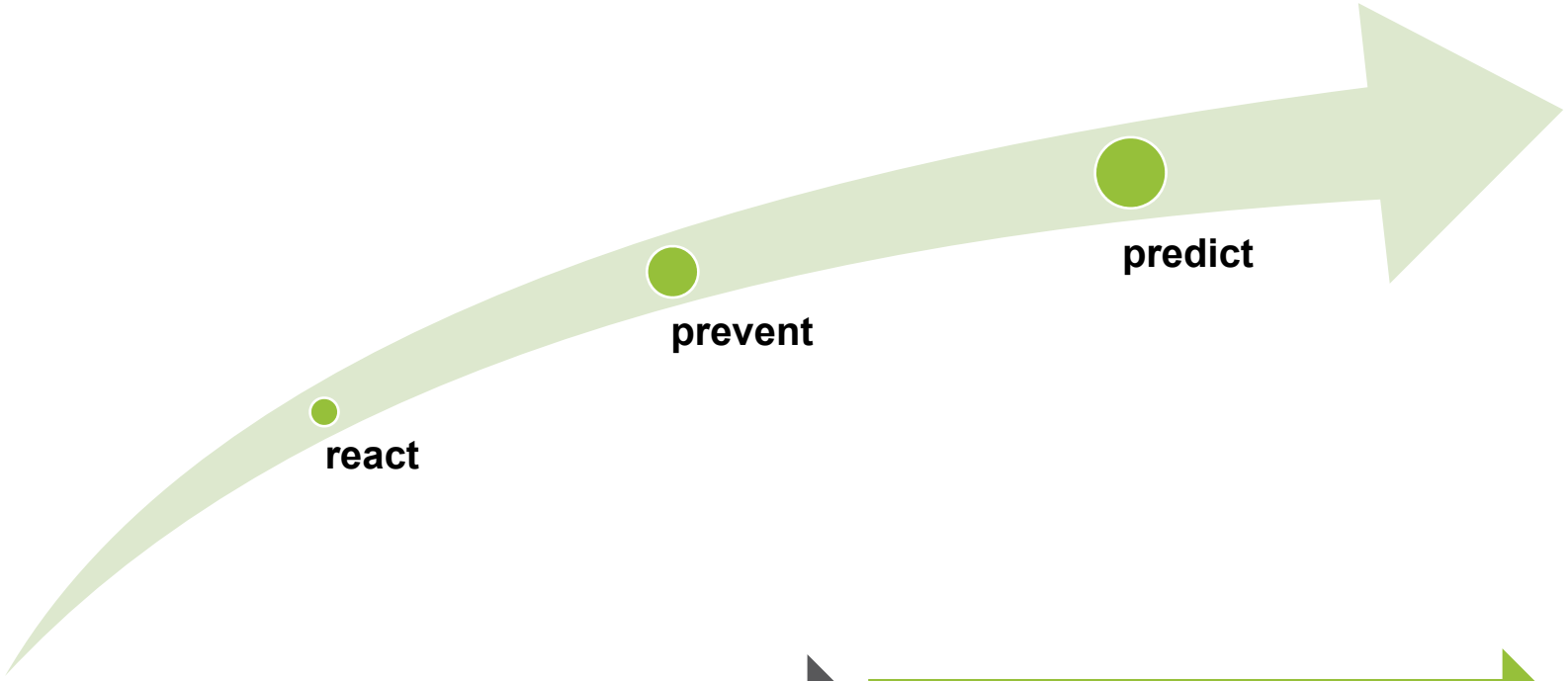
- Customer and ENGEL have the same state of knowledge
- Minimized downtimes

http://engel-econnect-prototype.azurewebsites.net/en/dashboard.html

Preview: October 2016
Market launch: October 2017

smart service

The evolution of maintenance



- react to problems on the machine
- set regular intervals for maintenance

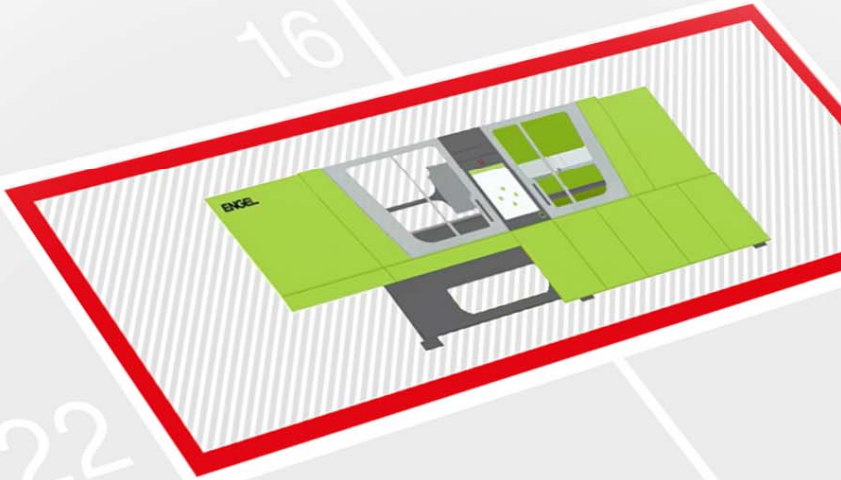
- analysis of machine data
- predict condition of the machine
- plan maintenance accordingly

smart service

e-connect.monitor

Customer situation

- Unexpected downtimes
- High preventive maintenance efforts
- Stocking costs for spare parts
- Varying technician and spare parts availability and delivery times
- Time-consuming root cause analysis



smart service

e-connect.monitor

Monitor

- process-critical components
- during operation
- via collected data from additional sensors

Analyze

- secure transfer of data to ENGEL
- interpretation with ENGEL algorithms
- evaluation of condition and remaining lifetime

Act

- customer feedback via ENGEL e-connect
- maintenance recommendations
- service requests and spare part orders

e-connect.monitor

Online screw monitoring

plasticizing screws

- Evaluation of screw condition
- without machine downtime
- within a few minutes
- using latest ultrasonic technology

- ENGEL service technician equipment
- All measurement results in e-connect

Available October 2017

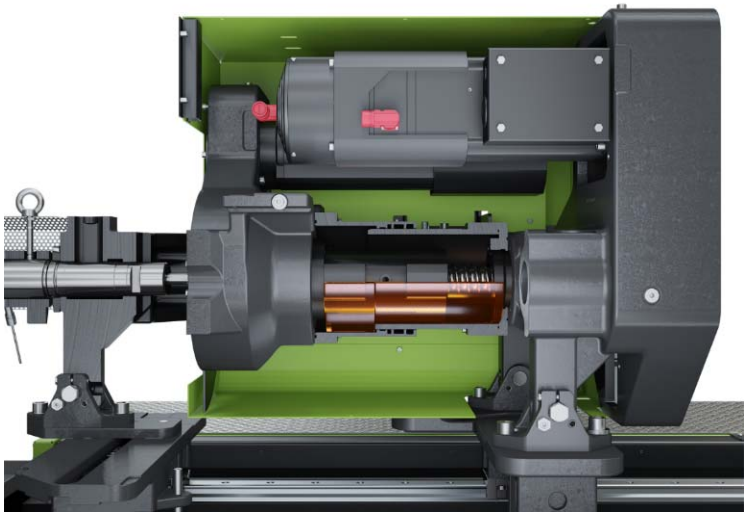
e-connect.monitor

Predict the condition of the machine‘s main drives

ball screws

- online monitoring of clamping and injection unit ball screws
- full integration of various sensor signals
- automatic transfer of measurement data to ENGEL
- automatic analysis via ENGEL algorithms
- all measurement results in e-connect

Available April 2018



smart service

e-connect.24

Customer situation

- Unplanned downtime (nights, weekends)
- High travel costs for service technicians

Available for all machines down to CC100 A03

smart service

e-connect.24

How does it work?

- Fixed package price per machine
- 24/7 online support
- Fast response time if problem occurs
- Access to top ENGEL experts worldwide

Results

- Minimized downtimes
- Saving of time and money

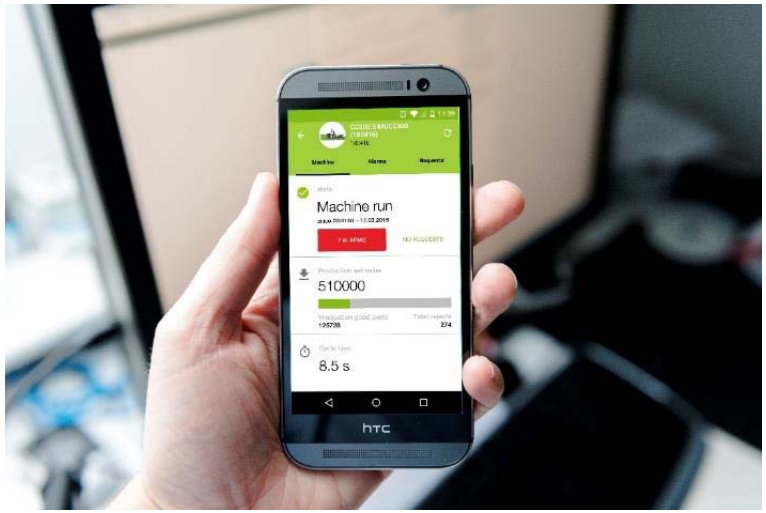
Available for all machines down to CC100 A03

smart service

e-connect App

Up-to-date wherever you are

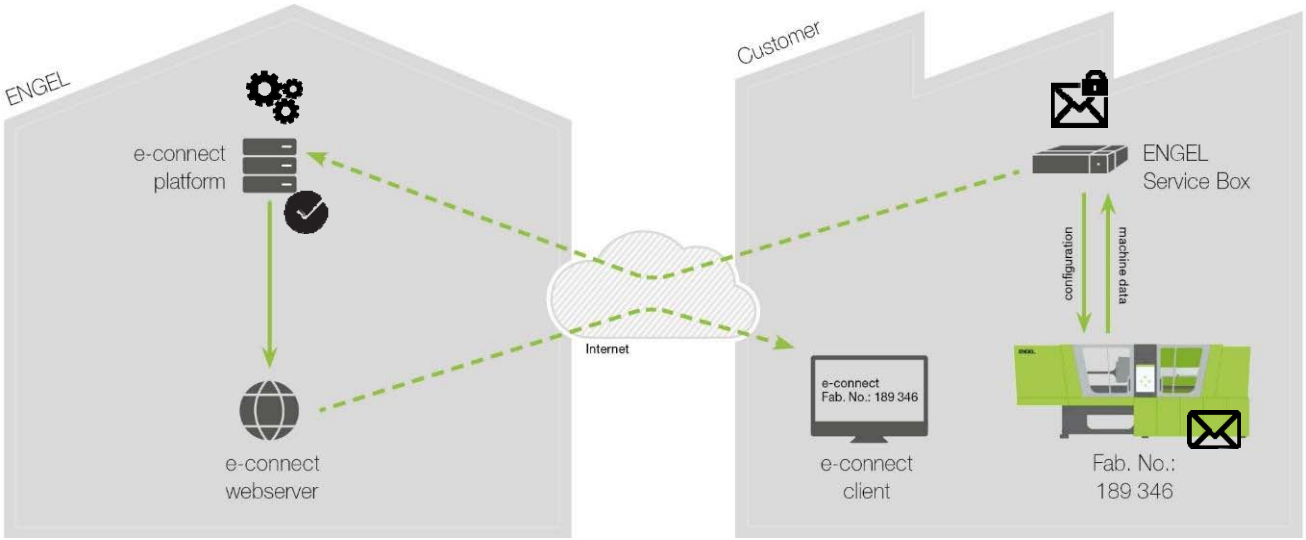
- Available for e-connect.24 users
- Free of charge
- Overview of equipment including status, current alarms and warnings
- Overview of production status
- Possibility to send service requests



e-connect App besides iOS and Android also available for Windows 10 October 2016

smart service

Infrastructure



e-connect platform
- ensuring integrity of machine data
- combining measurement results with customer data
- backend for e-connect portal
- special algorithms developed by ENGEL engineers

Webserver
- frontend for e-connect portal
- visualization of data and information

Connection
- Secure end-to-end connection
- VPN tunnel with SSL/TLS data transfer
- Authentification via public key infrastructure (PKI) certificates

ENGEL Service Box
- communication gateway between ENGEL data center and machines
- hardened device with integrated firewall
- runs virtualized or on dedicated hardware
- collects and aggregates data according to configuration

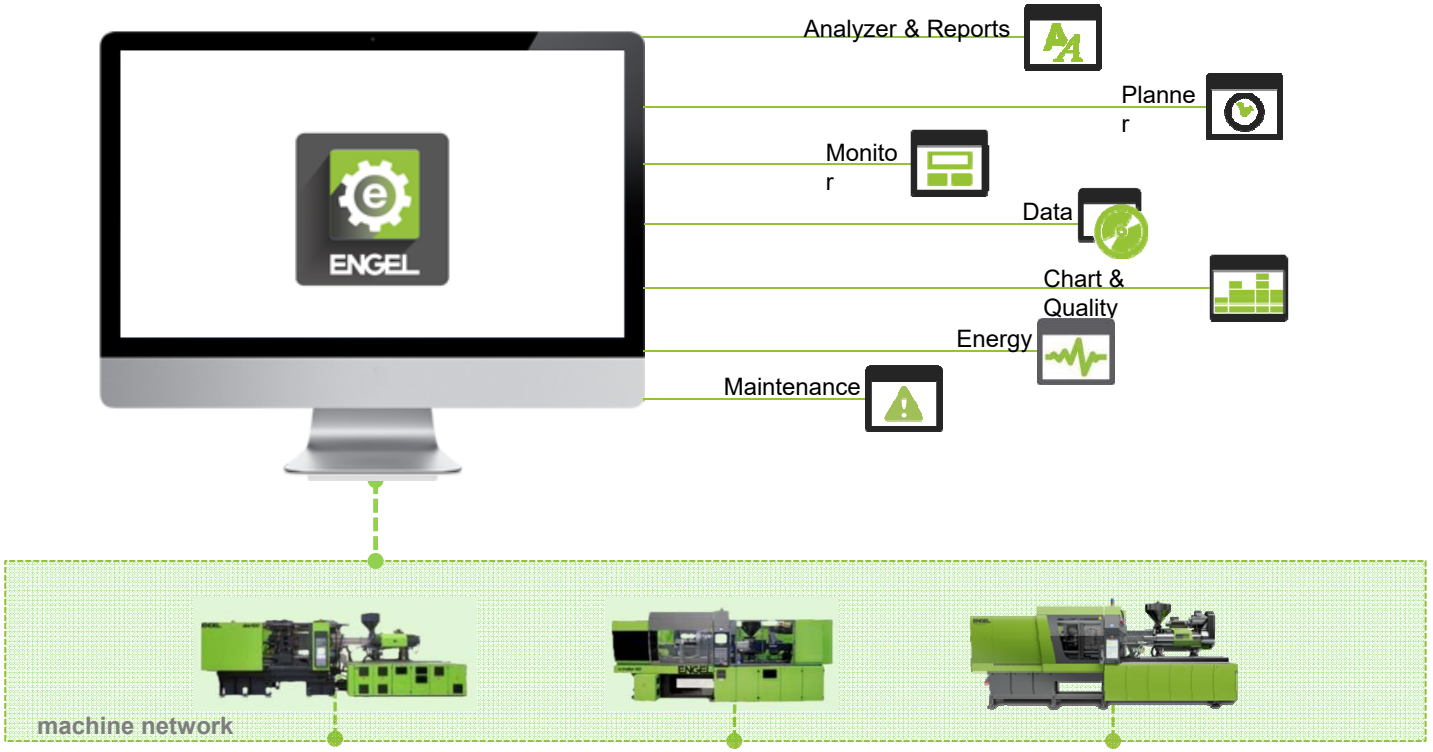
e-connect client
- access to customer portal via authentification and an encrypted connection

smart production

higher productivity, greater networking

smart production

e-factory



ENGEL e-factory

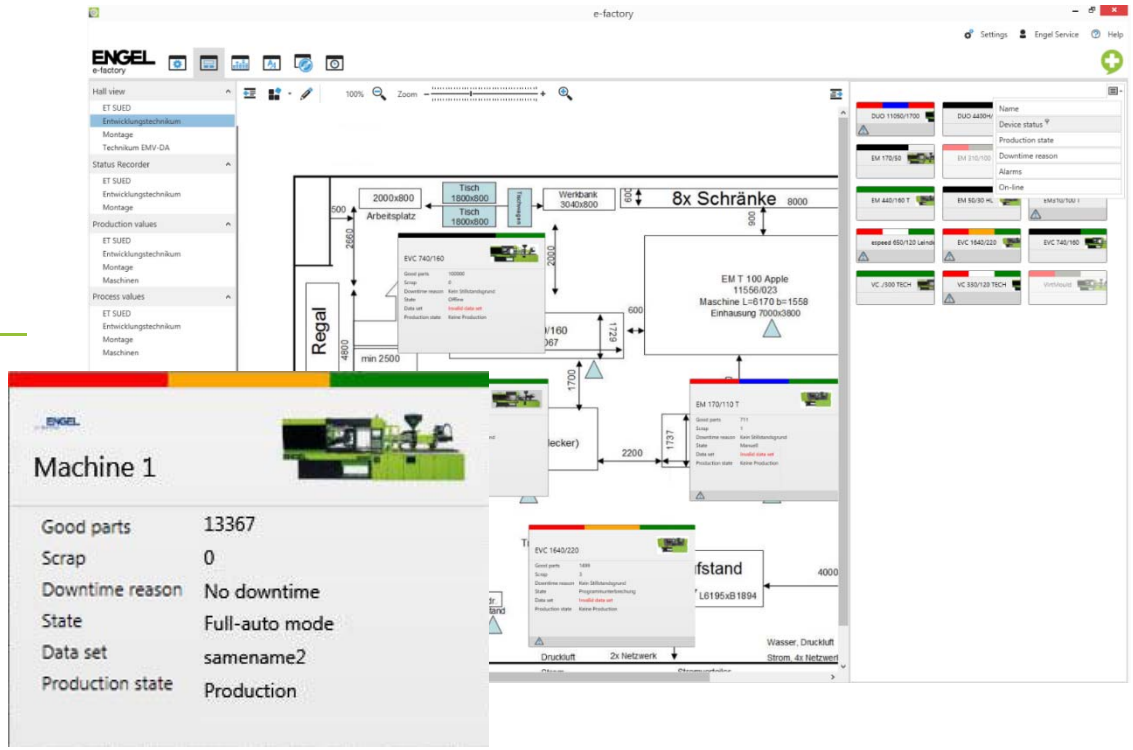
Monitor – transparent production

e-factory Monitor

- ✓ less downtime
- ✓ stable quality levels
- ✓ increase production efficiency

Enhancements

- status recorder
- min/max surveillance
- alarm package by email
- online ENGEL screen view
- production monitor

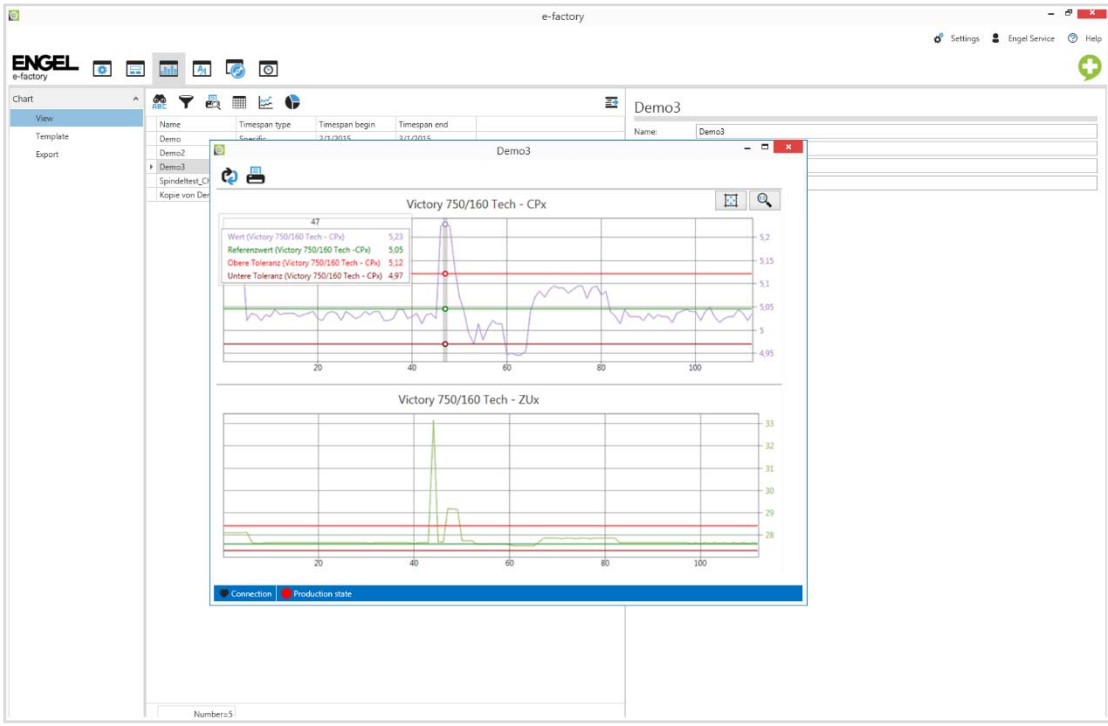


ENGEL e-factory

Chart – documented quality

e-factory Chart

- ✓ user related representation of data
- ✓ significant variables for process evaluation
- ✓ real time and historical data
- ✓ continuous production monitoring



Enhancements

- ✦min/max monitoring
- ✦alarm package by email

ENGEL e-factory

Planner – intelligent planning

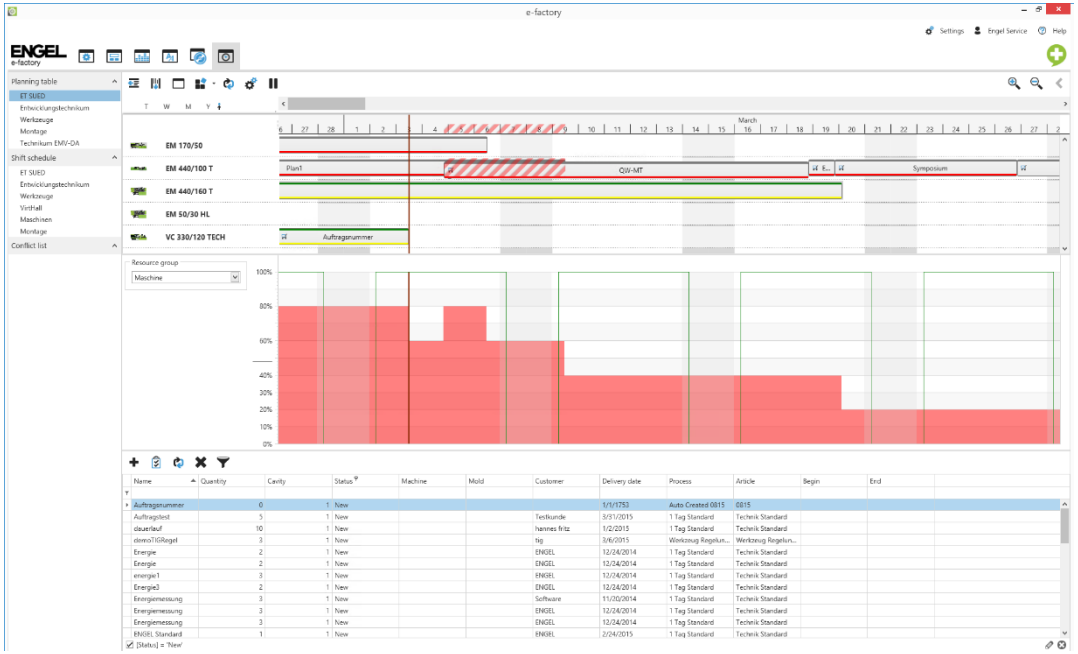
e-factory Planner

✓ depiction of the production steps

- combining of different steps in one process
- depiction of multi-stage and related operations

✓ multiple component orders with multiple moulds

- overview of different articles



Enhancements

- ERP interface

ENGEL e-factory

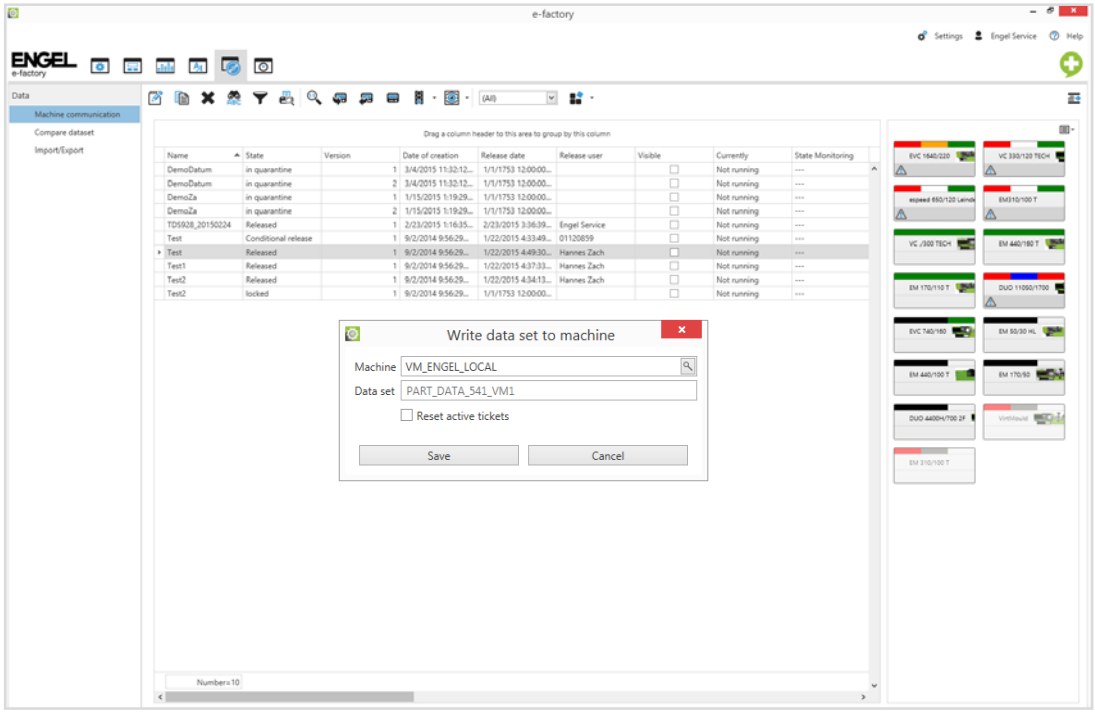
Data – premium set-up

e-factory Data

- ✓ centrally managed part data sets
- ✓ templates for data set print-out
- ✓ quick set-up (online transfer of part data set)
- ✓ data security

Enhancements

- ✦ set value modification logging
- ✦ tabular display of part data sets
- ✦ offline ENGEL screen view



Thank you!