How does injection moulding actually work?

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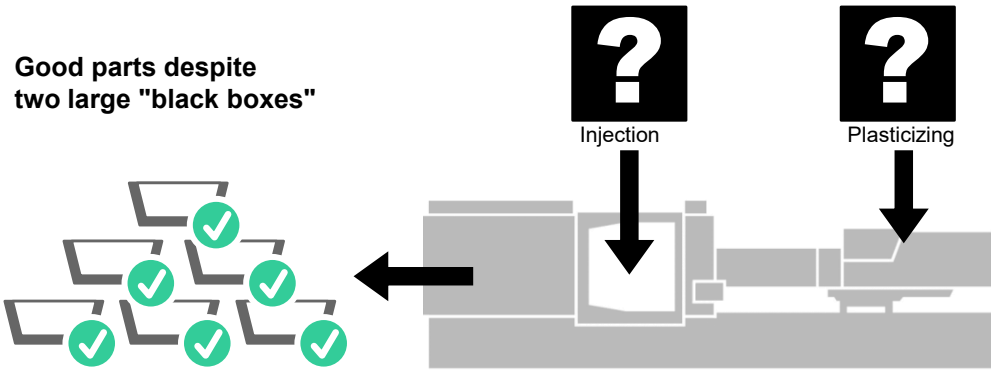
The challenge of injection moulding

Good parts despite
two large "black boxes"



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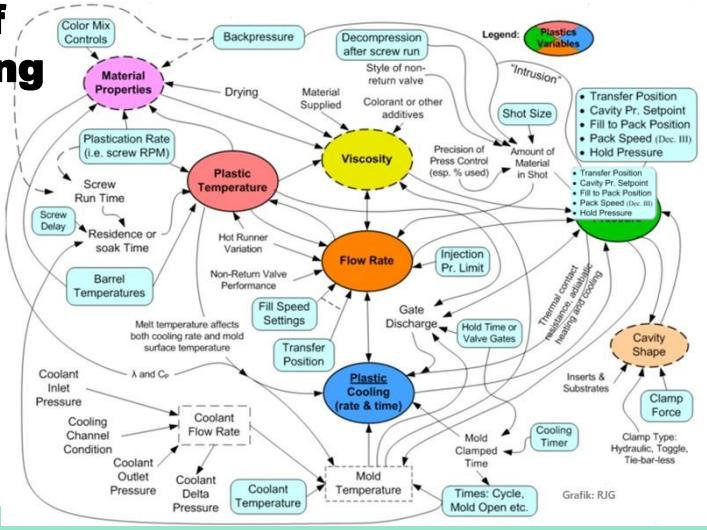
The challenge of injection moulding

x equations with
y unknown



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How does the operator adjust the machine?

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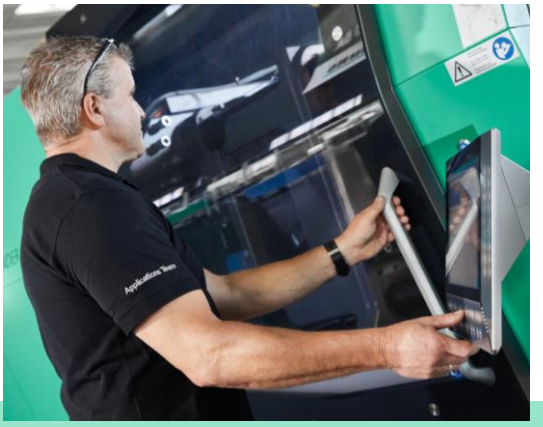
How does the operator adjust the machine? Pragmatic!

1. Plasticising must fit the process requirements

2. Align the injection process to the mould and to the moulded part



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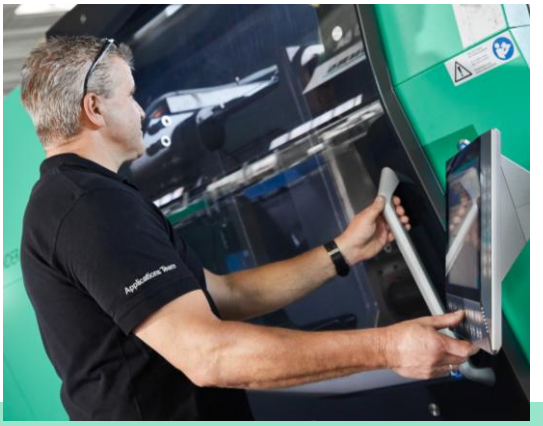

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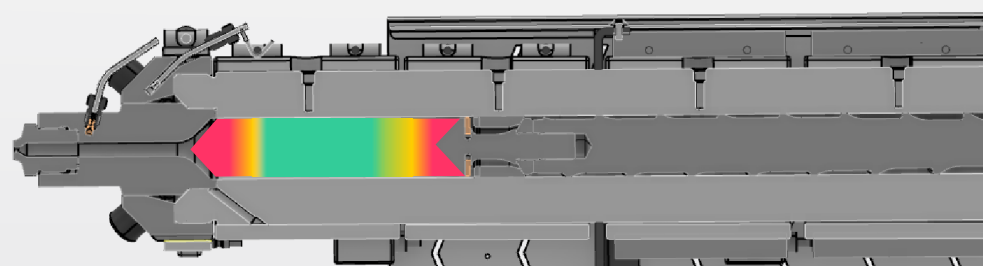
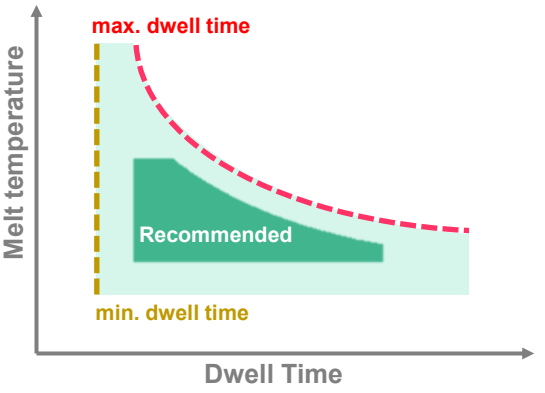
Does the injection unit fit the process requirements?



20 - 80 %	Optimal working area
10 - 20 % and 80 - 90 %	Conditionally suitable
< 10 % and > 90 %	not recommended

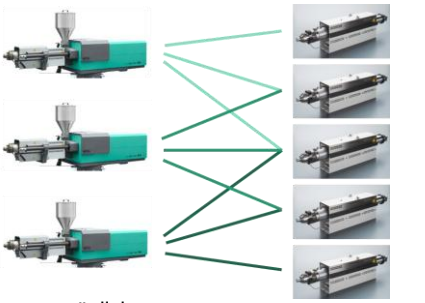
Important parameter: dwell time

- **Definition**
  Time from entry into cylinder to exit from nozzle
- **Minimal dwell time**
  Time to completely melt
- **Maximum dwell time**
  Limit to material degradation over time and temperature



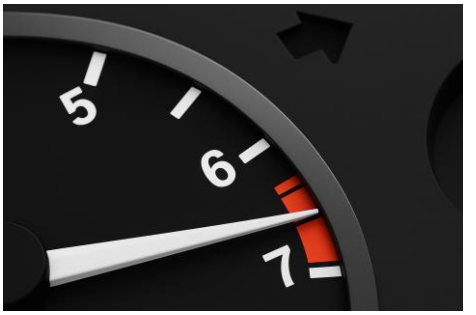
Adjusting plasticification

- Depending on machine size and process requirements
  - Injection unit extended or standard
  - Adapted wear protection
  - Special procedure
- All injection units from ARBURG are modular
- Goal: the right plasticization for **every** requirement



Important parameter: Dosing speed

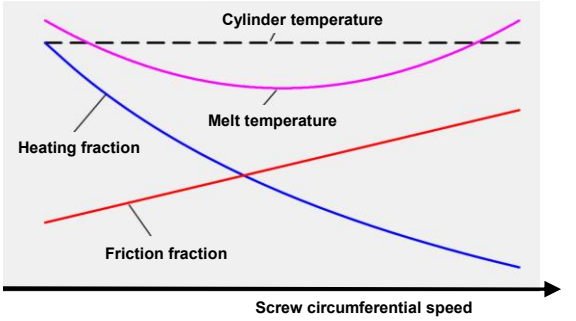
- Dose only as quickly as necessary
- Adjust dosing time to cooling time
  - Protects the material
  - Protects the pastifying unit
  - Saves energy (avoid unnecessary friction)
  - Dosing time never longer Select cooling time
- Use assistance functions such as DosingPilot



Faster is not always better!

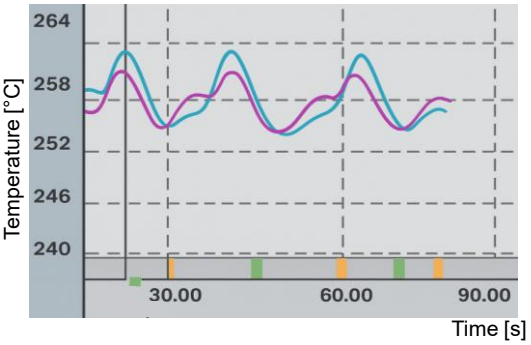
Parameters: Screw circumferential speed

- High levels increase dissipation
- Reduces energy input via the heating bands
- High speed for specified cycle time



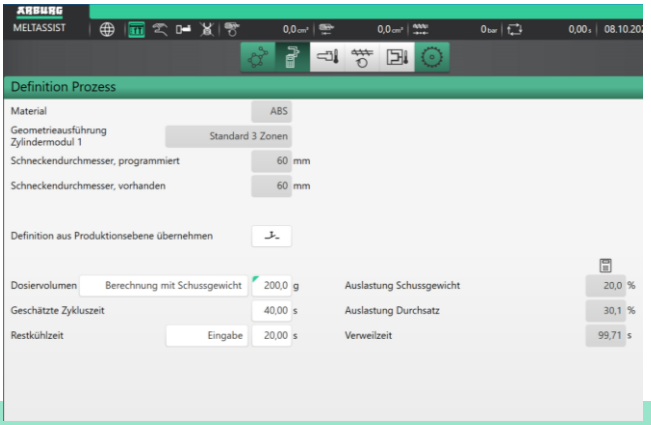
Other parameters

- Representation of cylinder temperatures
  - Overtemperature
  - programmed to max. 255 °C
- Injection speed
  - Additional peak due to shear



What does Arburg offer?

- aXw Control MeltAssist
- aXw Machine Finder
  - In the customer portal
- Key figures for
  - Processing temperatures
  - Accumulation pressures
  - Plasticization
  - Utilization
  - Dwell Time…



ROBUST PLASTICIZATION IS THE BASIS FOR THE NEXT STEP

How does the operator adjust the machine? Pragmatic!

1. Plasticization must match the material
2. **Align injection process with the mould and the moulded part**

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Determine injection parameters

- Process Requirement (Filling time classes):
  - <0,1 s High Performance
  - 0,1-0,3 s Thin-wall
  - >0,3 s Standard
- What is the goal?
  - Even, complete filling of the cavity
- Formula for injection flow $\mathbf{Q = \pi \cdot ¼ \cdot D^2 \cdot v}$
  - Supposedly simple
  - Coupled Dependencies of Pressure, Speed, Material Viscosity, and Temperature!

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Parameters of the injection unit determine:

- Component with sprue 75 g, one cavity, density 1 g/cm³, filling time: 0.35 s
- **Injection flow target**: 75 cm³ / 0,35 s ≈ **220 cm³/s**

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- ALLROUNDER 520 A 1500-290:

D	v	Calculation	Result Q
30 mm	280 mm/s (bei 1000 bar)	π x ¼ x 3² x 28	≈ 200 cm³/s
40 mm	280 mm/s (bei 1000 bar)	π x ¼ x 4² x 28	≈ 350 cm³/s

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- At **1000 bar**, a diameter of 30 mm with SPE 290 is **not sufficient**
- At **1000 bar**, diameter 40 mm with SPE 290 is **sufficient**

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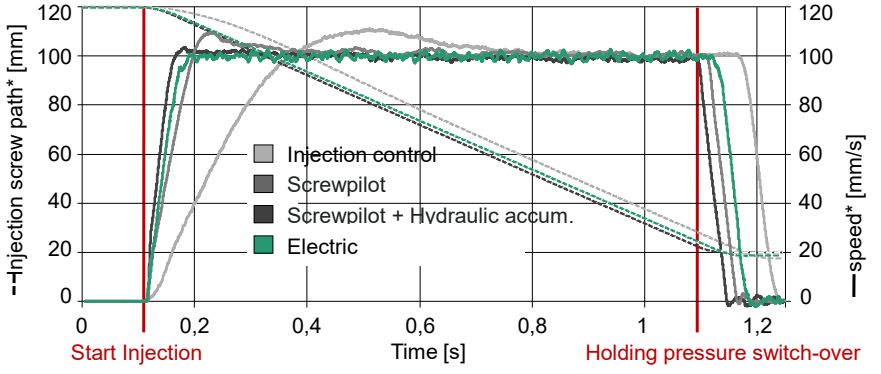
- ALLROUNDER 520 A 1500-290:

D	v	Calculation	Result Q	Q from machine data
30 mm	280 mm/s (bei 1000 bar)	π x ¼ x 3² x 28	≈ 200 cm³/s	**≈ 140 cm³/s (2500 bar)**
40 mm	280 mm/s (bei 1000 bar)	π x ¼ x 4² x 28	≈ 350 cm³/s	**≈ 250 cm³/s (1500 bar)**

- At **1500 bar**, diameter 40 mm with SPE 290 is **sufficient**
- At **2500 bar**, diameter 40 mm with SPE 290 is **not sufficient**

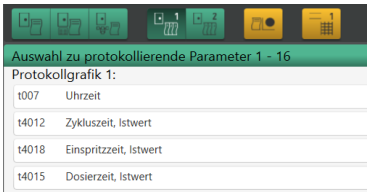
Injection dynamics



* for ALLROUNDER S and ALLDRIVE

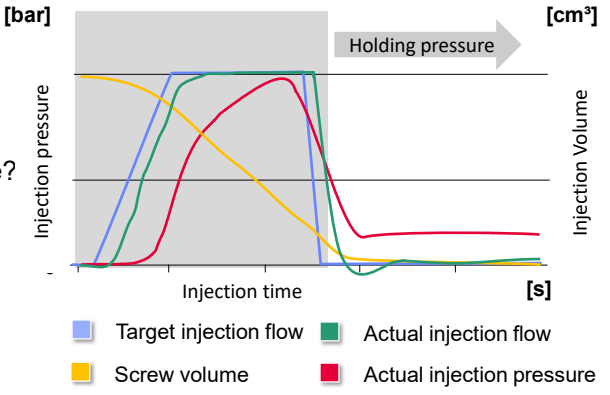
Process visualization over several cycles

- Define Production Log
  - Process times (injection time, dosing time, cycle time)
  - Pressures (max. injection pressure, changeover pressure)
  - Ways (mass pad, start dosing)
  - Temperatures (tool / cylinder)
  - Visualize trends with protocol graphics
- Measurement and monitoring graphics
  - Adjust recording duration Injection phase versus dosing phase
  - Monitor spray pressure (with integrals if necessary)



Visualization of the parameters

- Will pressure build-up succeed?
- Is speed throttled?
- Transition from spray pressure to holding pressure?



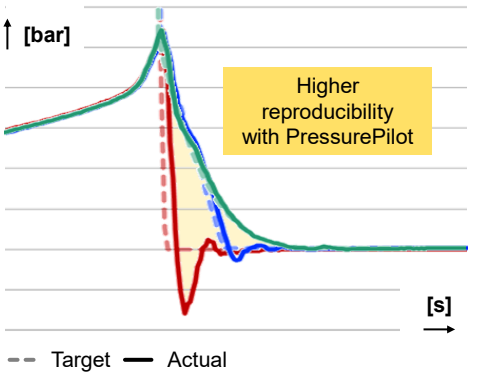
Customized Switching – Pressure Pilot

Ramp

- Linear specification of injection to holding pressure
- Active pressure control
- ARBURG Standard since 1987

aXw Control **PressurePilot**

- Non-linear specification of injection to holding pressure
- Bionically optimized pressure control – based on natural processes during pressure release



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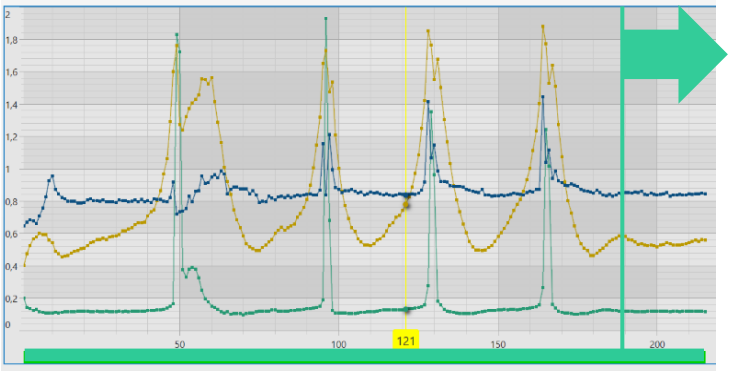
Process Visualization



Adaptation of the Dwell time when...

Material cushion is stable

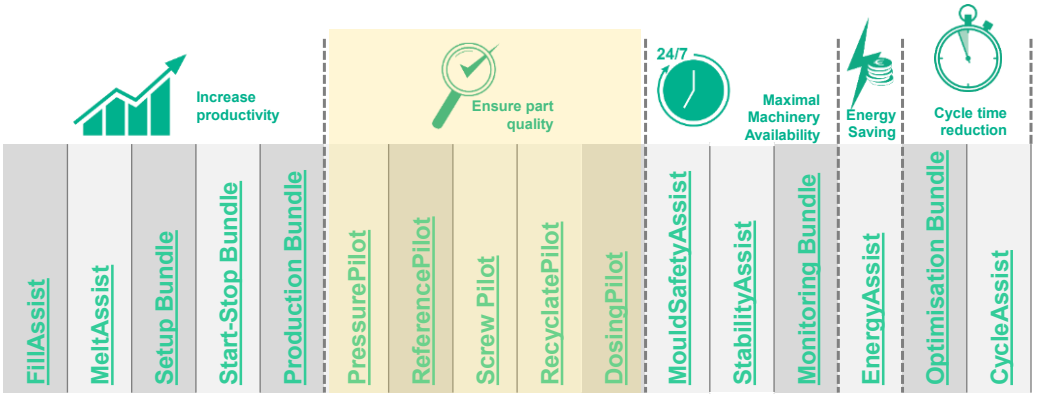
Torque is stable

Dosing time is stable

What to do if material fluctuates?

aXw Control **ScrewPilot**	aXw Control **RecyclatePilot**	aXw Control **ReferencePilot**
▪ High injection dynamics – uniform flow front ▪ Active braking – precise switching to holding pressure ▪ Stable injection process	▪ Quick control of the switching point based on reference in the same cycle ▪ Cross-cycle correction of the dosing volume ▪ Process control system without additional sensors	▪ Exact control of the holding pressure via pressure curve in the mould ▪ Consistently optimal moulded part quality ▪ Constant shot weights

What does ARBURG offer?



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PRECISE INJECTION IS THE BASIC BUILDING BLOCK FOR HIGH-QUALITY COMPONENTS

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Conclusion

Precisely match the machine and peripherals to the product and process

- Material feeding via safe material conditioning
- Hot runner: Compression of the melt
- Tool temperature control
  - Optimal flow adjustment
  - Setting the temperature optimally
- Automation vs. falling parts
- Optimize cycle time and/or energy

Basic rules

- **Robust** plasticizing and **precise** injection
  - If you know the basics,
    you can set parameters quickly and reliably
  - Core competencies important, even in the face of cost pressure, recyclates, new component design, shortage of skilled workers…
- Injection molding is physics and experience
  - Not Trial & Error
  - Consulting services from ARBURG

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WIR SIND DA.