FORGEfix® P

Pneumatic Cold Forging System

Machine-Hammer-Peening (MHP, according to VDI 3416)

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FORGEfix® P

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- How did FORGEfix come about
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- How economical is FORGEfix
- How is FORGEfix automated
- Who uses FORGEfix

MHP = FORGE$_{fix}$ + CNC

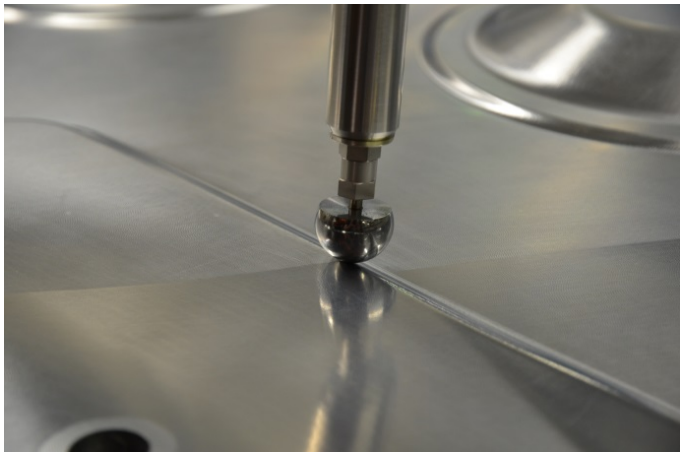

Photo: Mercedes-Benz

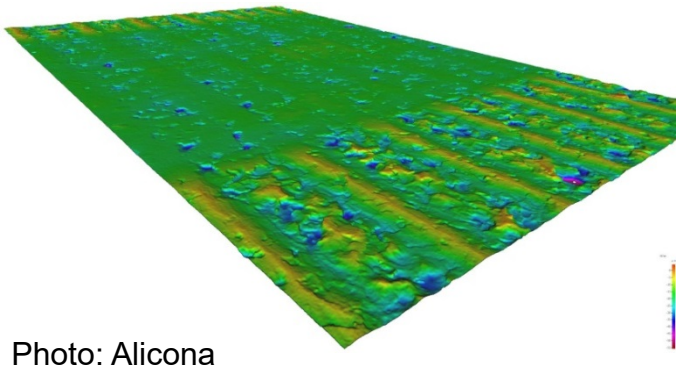

Photo: Alicona

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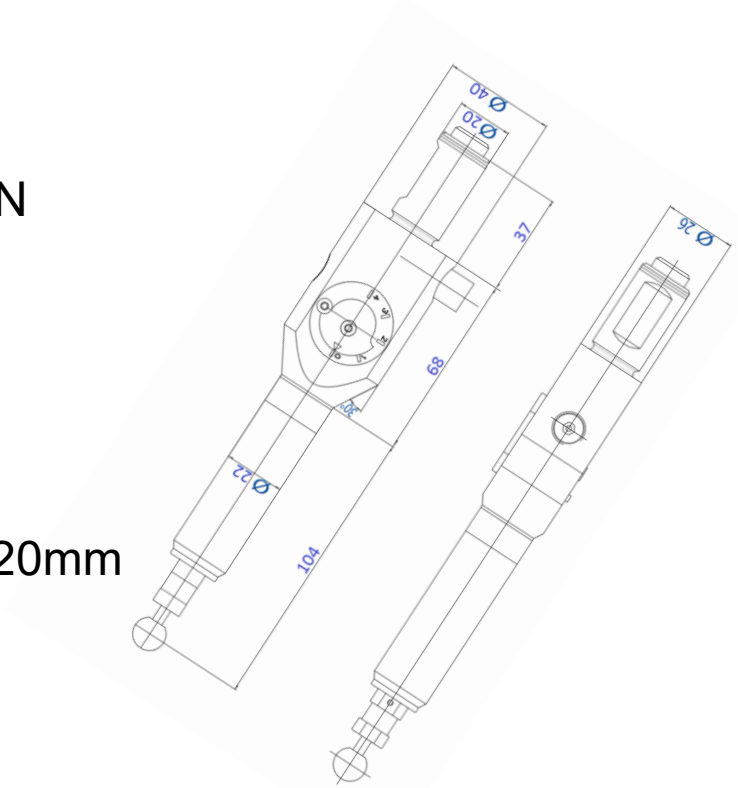
What is FORGEfix® P

Pneumatically operated tool with oscillating hammer head for mechanical surface treatment (MHP or “forging") of functional surfaces

- frequency range : cca. 250Hz
- power range: 250, 500 or 1000N
- Ball diameters: from 3 to 20mm
- Stroke compensation: 0 – 4mm
- Connection to the Machine: M16 / Weldon Ø 20mm (ATC possible)
- Compressed air connection: 6 bar (through spindle or external)



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How did FORGEfix® P come about

Developed in cooperation with MERCEDES-BENZ (MB) Production Equipment

- Manual grinding and polishing of the thermoforming tool surface until 2011 (spending up to 17days of manual labor)
- Development of the process (MB)
- Development of the FORGEfix based on the GRAVfix (3S-Engineering GmbH)
- Patenting (Patent Nr. 10 2010 019 547A1)
- 2010 Serial production of FORGEfix
- Mai 2011 Implementation in the first Robot-Finishing cell (MB)
- April 2013 Implementation in the second Robot-Finishing cell (MB)
- 2013 worldwide sales of FORGEfix
- 2018 Pokolm acquires product FORGEfix and all patents - intensify sales on German and international market

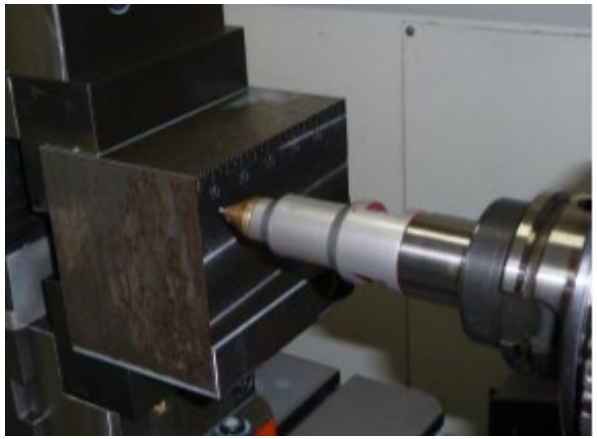


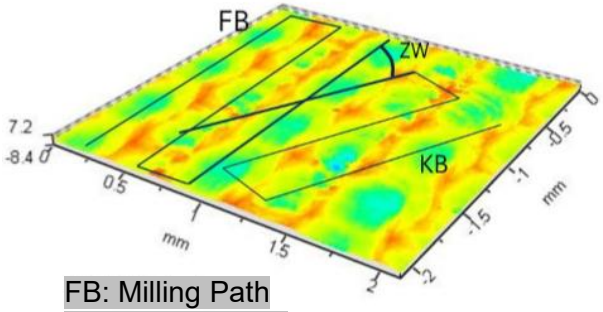
Foto: Mercedes-Benz

How FORGEfix® P work

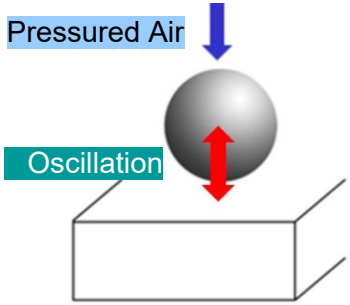
Cold forging head (ball) is guided with a corresponding CNC program over the surface (forging path).

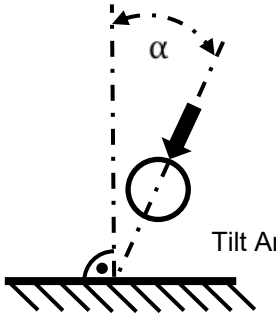
Variable setting parameters:

- Ball diameter
- Feed rate
- Stepover
- Feed angle (between forging path and milling path)
- Tilt angle α



FB: Milling Path
KB: Forging Path
ZW: Feed Angle between forging path and milling path (0 to 90°, recommended 90°)





Tilt Angle α = 0 to 30°, recommended 0°

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What is FORGEfix® P for

Creation of functional surfaces

1. **Smoothing milled surfaces**
2. **Surface hardnening (cold)**
3. **Targeted, local introduction of residual compressive stresses**

Advantages/ Benefits

⇨ Elimination / reduction of manual processing times

⇨ Prolonged service life of machined components

⇨ Increasing economic efficiency with maximum reproducibility

Photo: Hermle

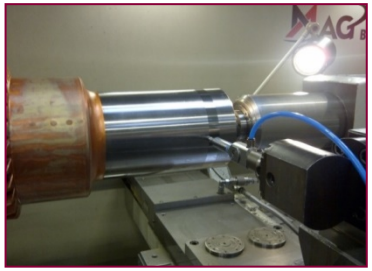
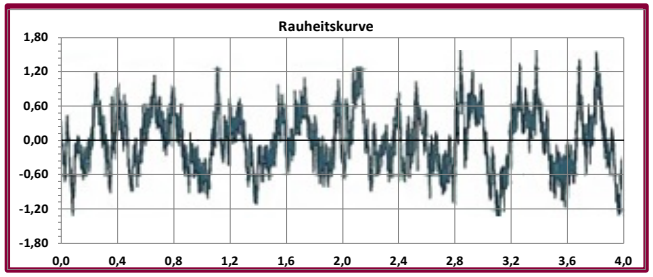


Photo: Voith Turbo

What does FORGEfix® P do

Smoothing the surface

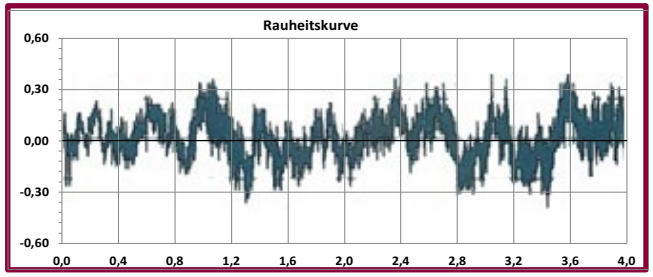
- Roughness Ra improves by 2 - 20 times (Ra <0,05µm)
- Homogeneous surface quality
- Repeatable surface quality
- No offset (machining allowance) required, since µ-deformation



Material St 52

Before:
Rz = 2,534µm
Ra = 0,405µm

MHP



After:
Rz = 0,864µm
Ra = 0,129µm

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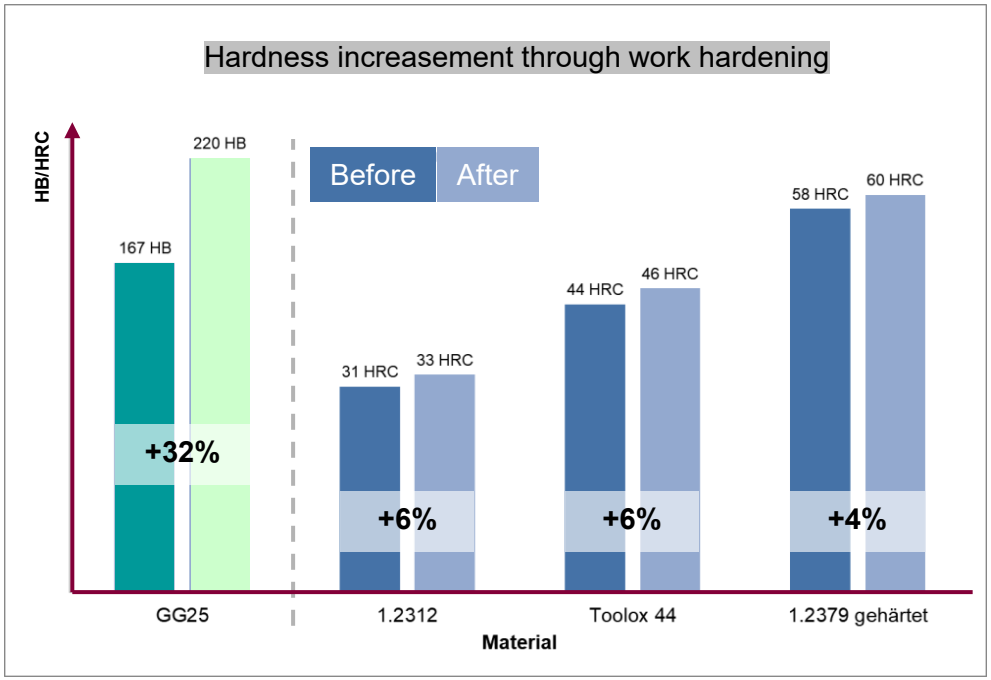
What does FORGEfix® P do

Cold Hardening of the surfaces

- Up to more than 30% increasement of the surface hardness due to work hardening (depending on the material)
- Partial waiver of additional aftertreatment of the surface

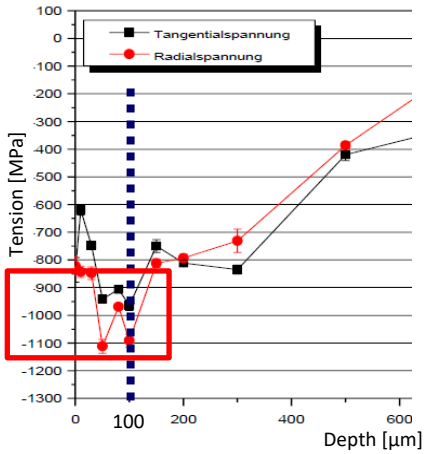


What does FORGEfix® P do

Introduction of residual stresses in the surface

- Compressive stresses up to 1.000 MPa up to 0,5mm deep
- Hardness increase over 10% possible
- Targeted, local introduction of residual compressive stresses
- Increasing the service life by avoiding cracking
- Milling + local MHP on the same machine (no re-clamping of the working part)

Piston rod processed with MHP



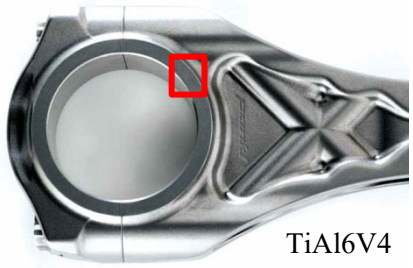


Photo: Pankl Racing

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What does FORGEfix® P do

Results from the field | Smoothen + hardness

Material		process parameters			Status	Results			
Designation	Tensile strength	Ball diameter	Feed rate	Sidestep		Roughness		Hardness	
	N/mm²	mm	m/min	mm		Ra [µm]	Factor	HRC/HRB	%
GG25	300	20	3,5	0,3	Before	1,700	5,00	167,0 HRB	31,7%
					After	0,340		220,0 HRB	
Al 3.7075	500	20	3	0,2	Before	1,500	12,82	61,2 HRB	5,23%
					After	0,117		64,4 HRB	
St 52	500	12	2	0,2	Before	2,700	12,22		
					After	0,221			
1.2312	1000	12	1	0,1	Before	1,461	20,29	31,20 HRC	5,77%
					After	0,072		33,00 HRC	
Toolox 44	1400	8	1	0,1	Before	0,497	4,36	43,70 HRC	5,49%
					After	0,114		46,10 HRC	
1.2379 hardened	2100	8	1	0,1	Before	0,100	2,08	58,20 HRC	3,61%
					After	0,048		60,30 HRC	

What does FORGEfix® P do?

Fully automated smoothing of the surface | practical example

Task

- Complete processing of thermoforming mould (mould+die)
- CNC-Milling + MHP on Hermle C42
  ⇨ no re-clamping of the working part
- Material Steel 1.2379 60HRC (D2)

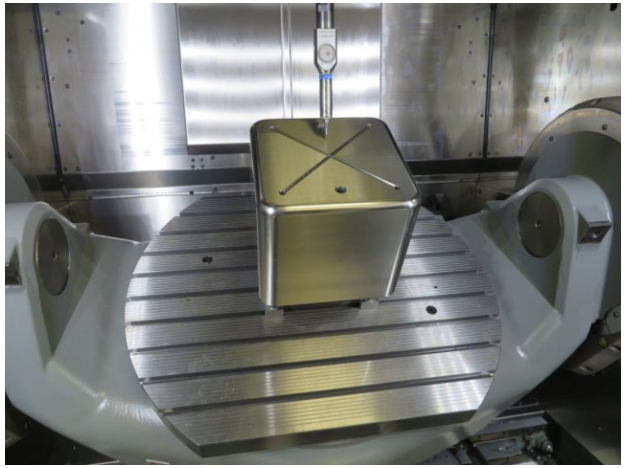
MHP

Result

- Ra 0,08 µm
- Hardness increased from 60 HRC to 62 HRC | +3,3%

Advantages / Benefits

- ➔ Saving 3.600.- €/Mould
- ➔ Payback period 2 months



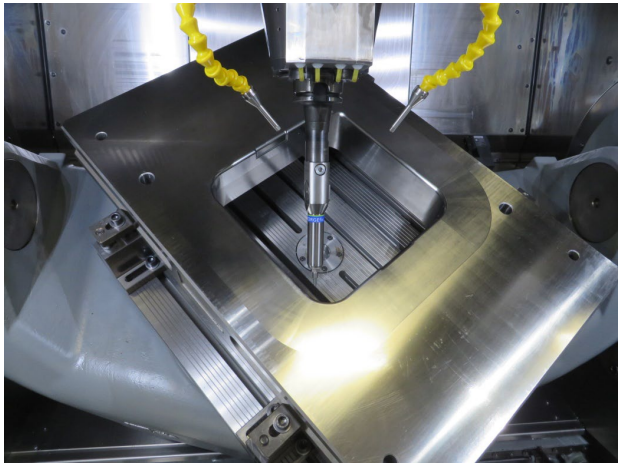


Photo: AESCULAP

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What does FORGEfix® P do?

Local introduction of residual stresses in tools | practical example

Task

- Complete machining dies (aluminium hot forgings)
- CNC Milling + MHP on Hermle C30
  ⇨ no re-clamping of the working part
- Material Steel 1.2343 (H11)

MHP

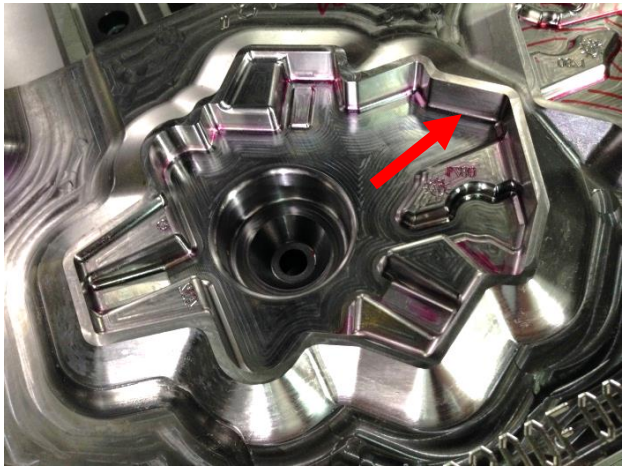
Result

- Increasing tool life by avoiding cracking

Advantages / Benefits

➔ Increase of the tool life quantities

4.300pcs | +36 % (mittel)



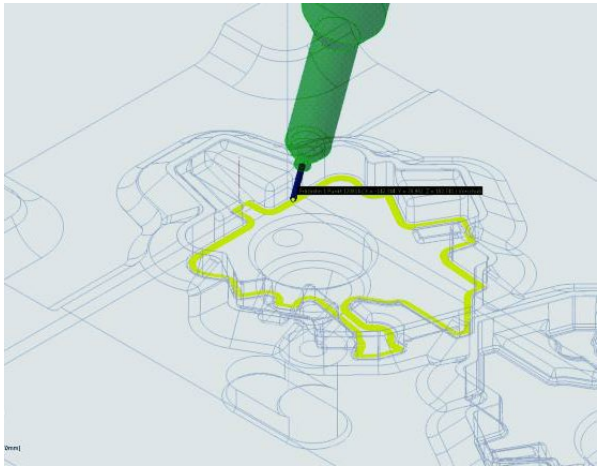


Foto: Leiber

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What does FORGEfix® P do

Local introduction of residual stresses in components | practical example

Task

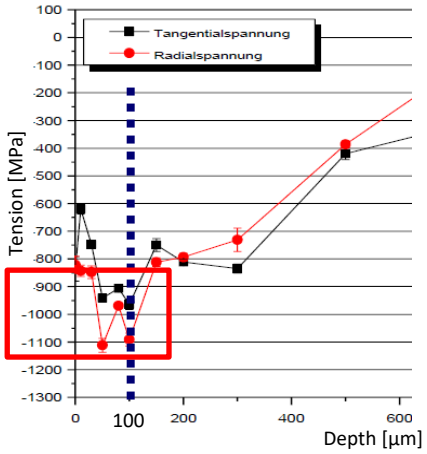
- Complete machining piston rod (Formula 1 / racing)
- CNC Milling + MHP on Hermle C30
  ⇨ MHP replaces shot blasting
  ⇨ no re-clamping of the working part

MHP

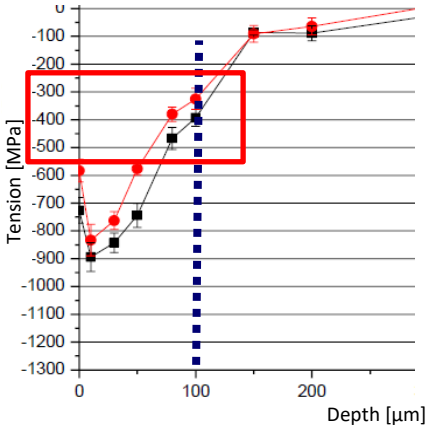
Result

- Increasing the service life by avoiding cracking
- Factor 2 higher residual stress in depth 100µm
- Hardness increase from 356HV1 to 402HV1 | + 13%

Piston rods processed with MHP



Piston rods processed with shot blasting



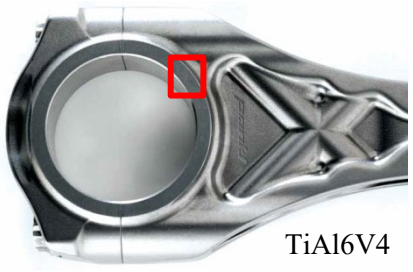


Photo: Pankl Racing

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What does FORGEfix® P do

Conditions to be observed | Summary

- When forging, the tilt angle should be α <30 °
  - ⇨ Positioning of the tool (depending on component geometry)
  - ⇨ 5-axis machining required (depending on component geometry)
- FORGEfix (main Spindle) must not rotate during processing (especially with external air supply)
  - ⇨ Processing of the corresponding CNC program with S = 0 rpm
- In the processing area of casting, material should have no porosity.
  - ⇨ Forging over the porosity area leads to uneven surface level
- Corresponding finishing quality / flatness is necessary
  - ⇨ Waveness of the surface will not be smoothed by forging

How economical is FORGEfix® P

Increased cost-effectiveness through process shortening and automation

- 80 - 100% reduction of manual work such as grinding and polishing
- Up to 100 hours of manual process are fully automated
- Finishing process and overall process of manufacture is shortened
- Lower requirements on finishing process reduce machine running time
- Repeatability of the process
- Complete machining in one clamping is possible

Advantages / Benefits

⇨ Saving on shorter processing time

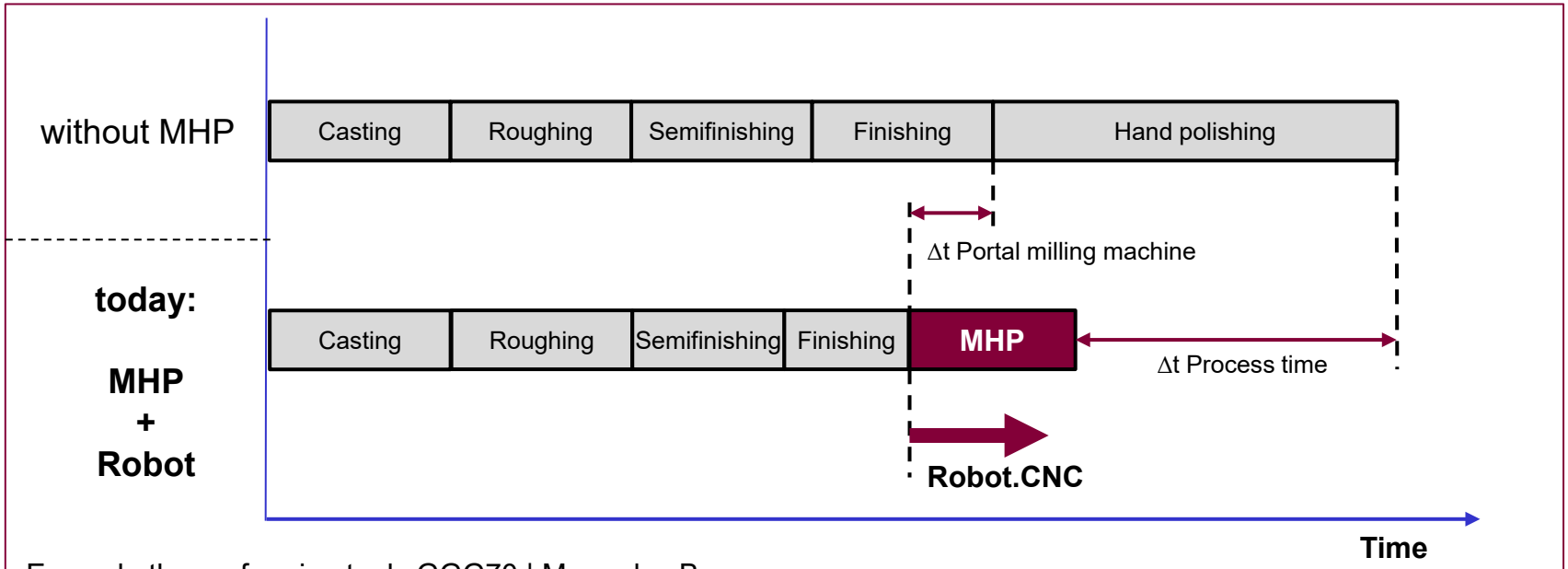
⇨ Optimized machine utilization and occupancy

⇨ Reduction of human resources

⇨ Increasement of the quality

How economical is FORGEfix® P

Process Reductions and Automation | practical example



Example thermoforming tools GGG70 | Mercedes Benz

	Hand polishing	Automated finishing (MHP)
Mercedes-Benz	cca. 50 h/m²	cca. 20 h/m²
		Reduction by up to60 %

How is FORGEfix® P automated

Processing of large and / or complex free-form surfaces

- Existing CNC milling machine / lathe according to NC data set
- Applied inside standard tool holder with M16 or Weldon Ø 20mm
- Tool change from magazine (ATC) possible
- Compressed air connection 6 bar

Alternative:

- Robot machine tool according to NC data set (for example KUKA.CNC)

Photo: Hermle

Photo: Mercedes-Benz

Photo: Sematek

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Who uses FORGEfix® P

Area of aplication

- AUTOMOTIV
- AEROSPACE
- MEDICAL
- MOLD & DIE (Thermoforming etc.)
- MOLDS (CFK, GFK, Castings etc.)
- AND MUCH MORE...