FOOTPRINT OF POLISHING PROCESSES

INSTITUT FÜR PRÄZISIONSBEARBEITUNG UND HOCH-FREQUENZTECHNIK

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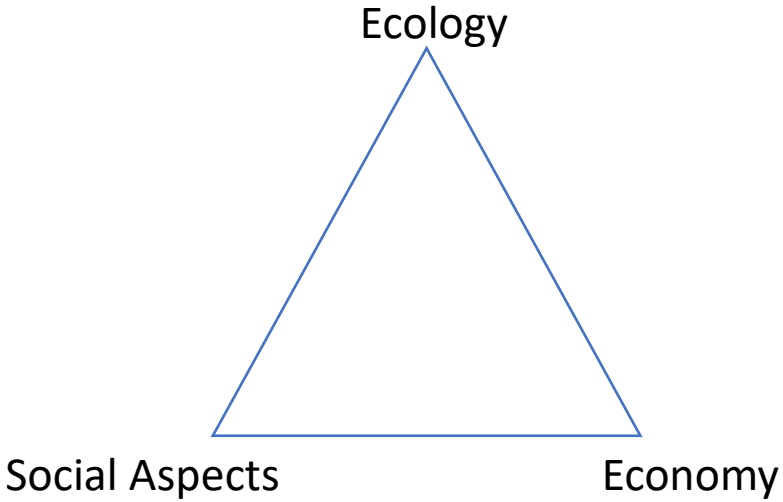
Agenda

1. Introduction to Sustainability
2. Motivation: Sustainable (Polishing) Processes
3. bbb
4. ccc
5. ddd

Sustainability

https://www.un.org/sustainabledevelopment/news/communications-material/

Sustainability triangle



Social aspects:
e.g. Generation Z

Sustainable (business) processes

Resources:

- Raw materials
- Energy consumption
- Water usage
- Usage of chemicals

https://www.nike.com/de/a/nachhaltigkeit-2025-ziele; 27.07.23)

Resources

Output:

- Customer product
- CO_2 emissions
- Waste
- Wastewater

https://www.nike.com/de/a/nachhaltigkeit-2025-ziele; 27.07.23)

Technology enabled sustainability

1) Protect resources and reduce cost, e.g via digitalisation

2) Improve time efficiency and optimize workflow

3) Make use of green energy and IT-infrastructure efficiently

4) Improve contentment and productivity of staff, e.g via more flexibility and family friendliness

5) Live sustainability and use it to create advantages in competition

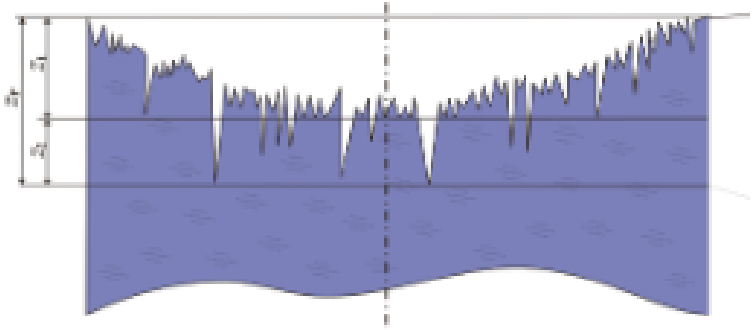
6) Improve your image

7) Get a pool position as future employer

https://www.pwc.de/de/nachhaltigkeit/sustainable-transformation.html; PwC: technology enabled sustainability

Polishing of precision optics

Polishing is the final step in surfacing of optics.



J.Bliedner: Optiktechnologie (2022)

Purposes of Polishing:

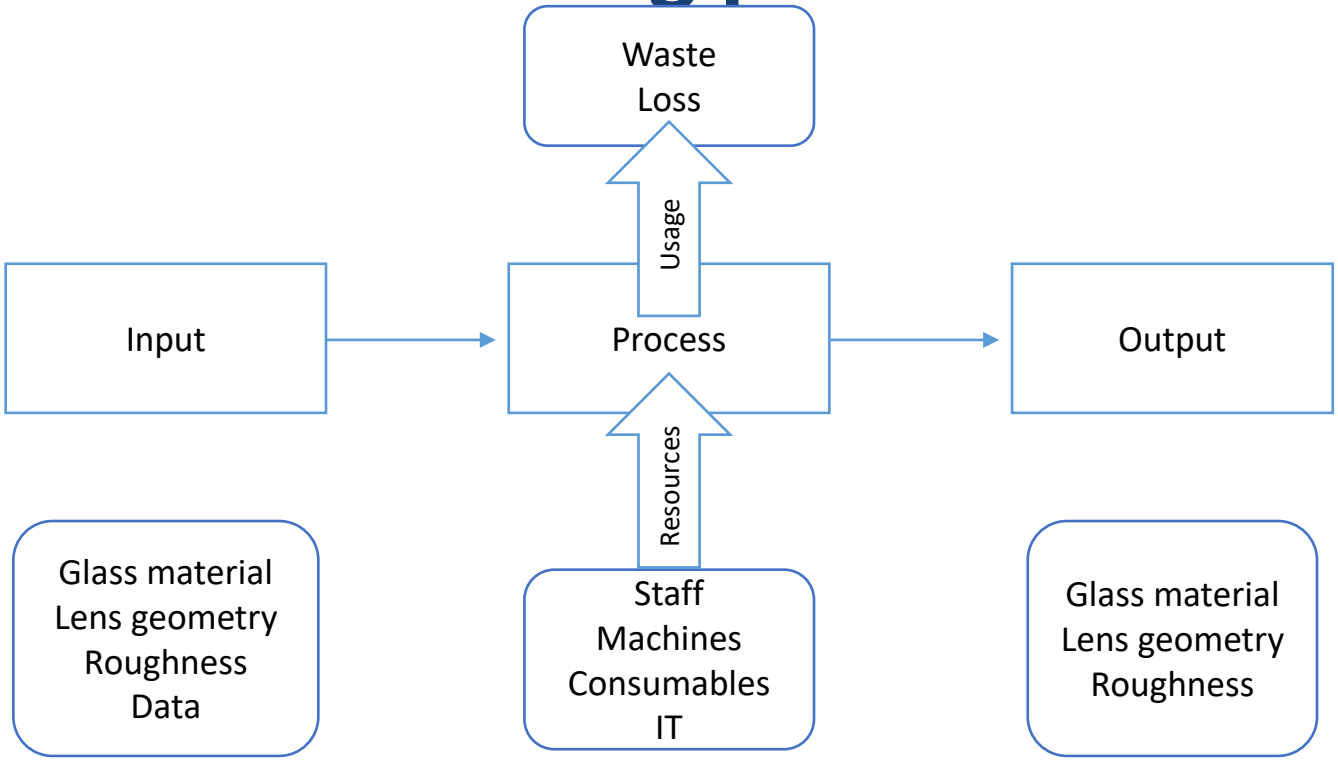
- **remove roughness**
- **remove subsurface damages(z2)**
- **Improve shape (z1)**

Challenges:

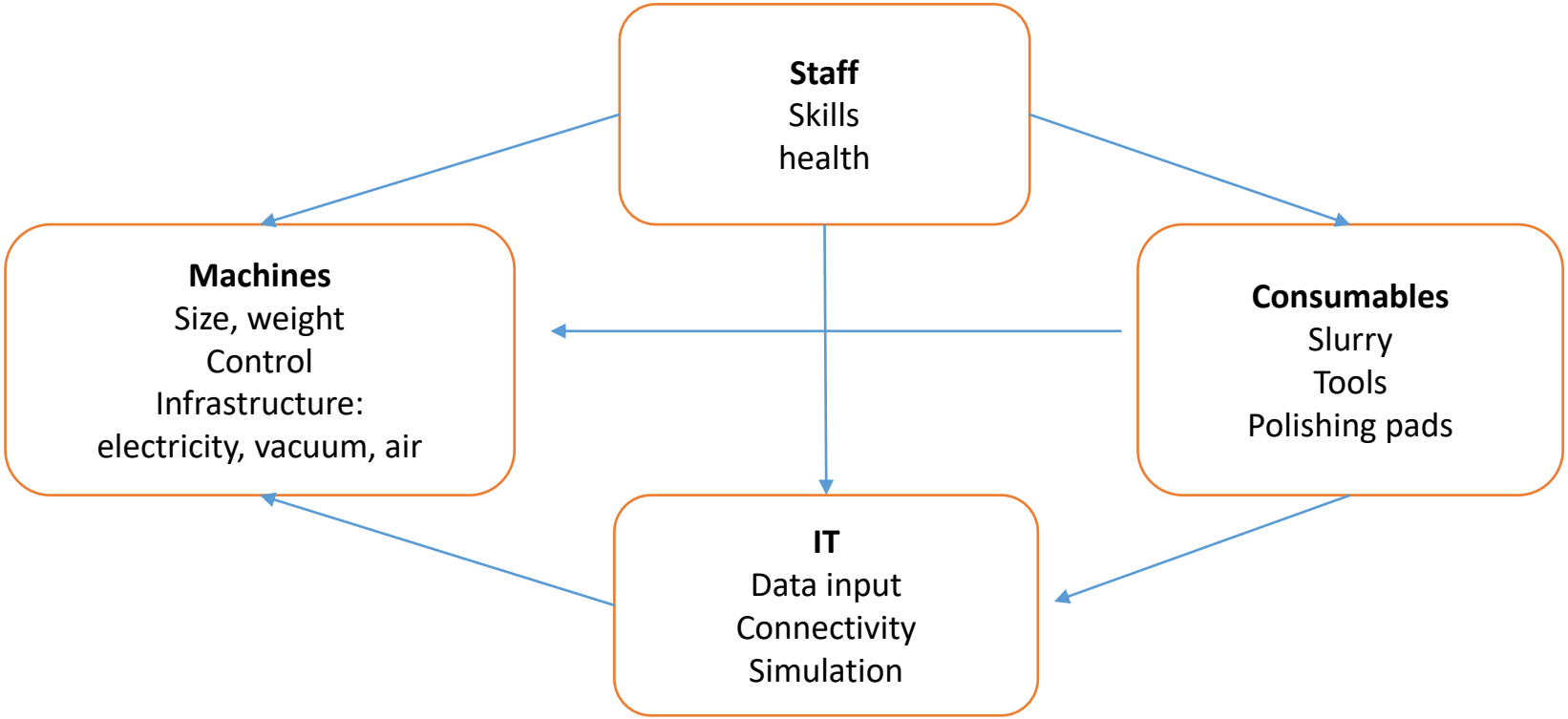
- **Wide variety of available processes**
- **Complex process**
- **Limited control of process**
- **Limited predictability of process**

How to rate “sustainability”?

Model of Polishing process



Resources



Polishing Processes at TC Teisnach

Overarm polishing
Leico (1995)

RPS40, (syncro-speed)
Stock (2018)

Syncro-speed
polishing, Loh (1989,)

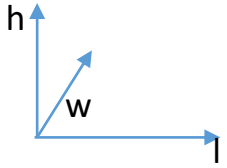
Polishing processes TC Teisnach cont.

MCP250, Optotech, 2010

MRF, QED, 2008

IBF, Opteg, 2015

Comparison of machines



Machine		year	Width [cm]	Length [cm]	Height [cm]	Weight (guess) [kg]	Additional remarks
Overarm 2-spindle	Leico	1985	75	75	170	325	
Syncro-speed	Loh	1989	110 100*	65 160*	165 210*	Ca. 1000 2290*	*latest model
RSP 40	Stock	2018	130	90	170	452	
MCP	Optotech	2010	220	280	270	Ca.5000	-0,7 bar; 6 bar
MRF	QED	2003	150 167*	140 137*	210 229*	 1588*	6 bar air *Q-flex100
IBF	Opteg	2015	340	270	280	Ca. 6000	Clean room advisable

Machine infrastructure

Machine	electricity	Vacuum	air	tool	control
Overarm 2-spindle	400V/ 50Hz	-	-	Shape depending tool	Manual
Syncro-speed	400V/ 50Hz	yes	-	Shape depending tool	manual
RSP 40	400V/50Hz/ 1,2 kW / 10 A	yes	no	Shape depending tool	CNC
MCP	400V/50Hz/52a /36kVA	-0,7 bar	6 bar	Ball bonnet	CNC
MRF	400V/50Hz/20 A		6 bar, 85l/min	Wheel	CNC
IBF		yes	Self-produced	Beam	CNC

Consumables

Machine	Tool	Slurry	Polishing pad	Preparation of tool	Waste
Overarm 2-spindle	Re-use	5/20 l	PU pitch	Cut to shape + glue + dressing Melting, shaping, cutting	Slurry, abrasion pad + glass, glue
Syncro-speed	Re-use	5/20l	PU	Cut to shape + glue + dressing	Slurry, abrasion pad + glass, glue
RSP 40	Re-use	5/20l	PU	Cut to shape + glue + dressing	Slurry, abrasion pad + glass, glue
MCP	Ball bonnet	5/20l	PU	Ready made Cut to shape + glue + dressing	Tool + Slurry, abrasion pad + glass, glue
MRF	wheel	1l	No	Choose wheel size	Abrasion glass, slurry
IBF	no	No	Graphite grills for beam shaping		Abrasion graphite grills

Economics

Machine	Price	MRR/10min	Skills of staff	Expected quality
Overarm 2-spindle	500€ (second hand)	P:2,0 µm PU: 1,3 µm	Experience, manual adjustments	λ/10
Syncro-speed	3500€ (second hand)	4,9µm	Experience, manual adjustments	λ/10
RSP 40	25.000€	30µm	Numerical control	λ/10
MCP **	250.000€		CNC, programming offline possible *	λ/10
MRF **	250.000€		CNC, Simulation*	λ/40
IBF **	600.000€		CNC, Simulation*	λ/60

*highly qualified staff / engineer required
**freeforms possible

Quality of lenses, reliability

Test run on several machines: overarm polisher, RSP, Synchro, MCP

Material: N-BK7, 40 mm diameter, plano, 3 samples per test

Input: grinded on SPM, tool D18, 80 mm diameter

→ was comparable for all samples used

Consumables:

tool as necessary: if PU then LD66

for overarm polishing: pitch and PU LD66,

slurry: based on Ceria, density 1,025; if possible 5l

Measurements

roughness: New View 7200, whitelight interferometer

shape: SSI Interferometer

Process time 10 minutes

The process was not optimized for each machine.

Results of test run

Overarm pitch
MRR: 7 mg / 2,2µm
Roughness Ra 5,6 nm
Shape (in fringes)(SAG/IRR) 2,1/5

OverarmPU
MRR: 4 mg, 1,3µm
Roughness Ra 260 nm
Shape (in fringes)(SAG/IRR) 7/5

RSP
MRR: 96mg / 30µm
Roughness Ra 0,34 nm
Shape (in fringes)(SAG/IRR) 7,6/0,6

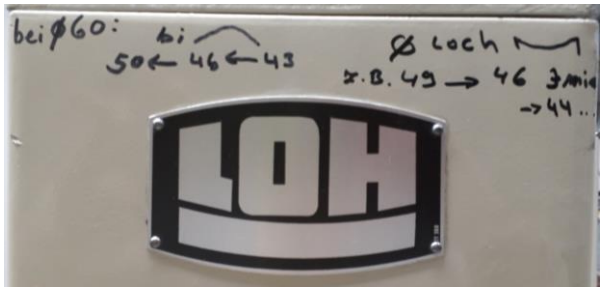
Synchro
MRR: 15mg / 4,5µm
Roughness Ra 0,37 nm
Shape (in fringes)(SAG/IRR) 7,3 /2,2

MCP
MRR: 12 mg / 3,8µm
Roughness Ra 0,95nm*
Shape (in fringes)(SAG/IRR) not available
*(0,35 nm after 10 minutes more)

Social

Skills
Precisions optics
CNC usage
Measuring
Apply simulation
develop simulation

Health
Dust from dry ceria
Weight of lenses
Cleaning
Air-conditioning



Technology enabled sustainability

Shape of surface	Freeforms: less material, less weight	Iterative polishing processes: Measurement - deviation analysis – removal function - corrective polishing
predictability	Process time, output quality	
simulation	Deterministic processes	
optimization	Efficiency of machine usage	

Waste in bonnet polishing

First generation Bonnet:
Membrane + polishing pad glued
→ dismount polishing pad with solvent
Quality and reliability limited
→less amount of waste

Second generation Bonnet:
Membrane + polishing pad as one premounted unit
Good quality, high reliability
→ huge amount of waste

Third generation Bonnet:
No membrane, dressed “moos-gummi” support, polishing pad clamped
→ polishing pad used for days; moos-gummi for months / years
Good quality, high reliability
→ No solvents, little volume and weight of waste

Slurry supply

Slurry supply 20 l, Leico

Slurry supply 5 l, homemade

Slurry supply 1 l, QED

Summary

- Economy, Ecology, Social Aspects: First collection of facts
- Rating? Up to your priorities
- Shareholders focus on “sustainable investments”.
- Sustainability starts in your head, with your values and convictions.
- Optics is one of the so-called enabling technologies. Integrators are keen to prove they act responsible with regards to sustainability. That builds up pressure for suppliers to prove they act responsible as well.
- Optics and therefor glass are hidden in many products.

Let’s get started.

Summary - Sustainability

Influenced by optics

Impact of Optics production

https://www.un.org/sustainabledevelopment/news/communications-material/