Supercritical Extraction of Binder from Metal Injection Moulded Components

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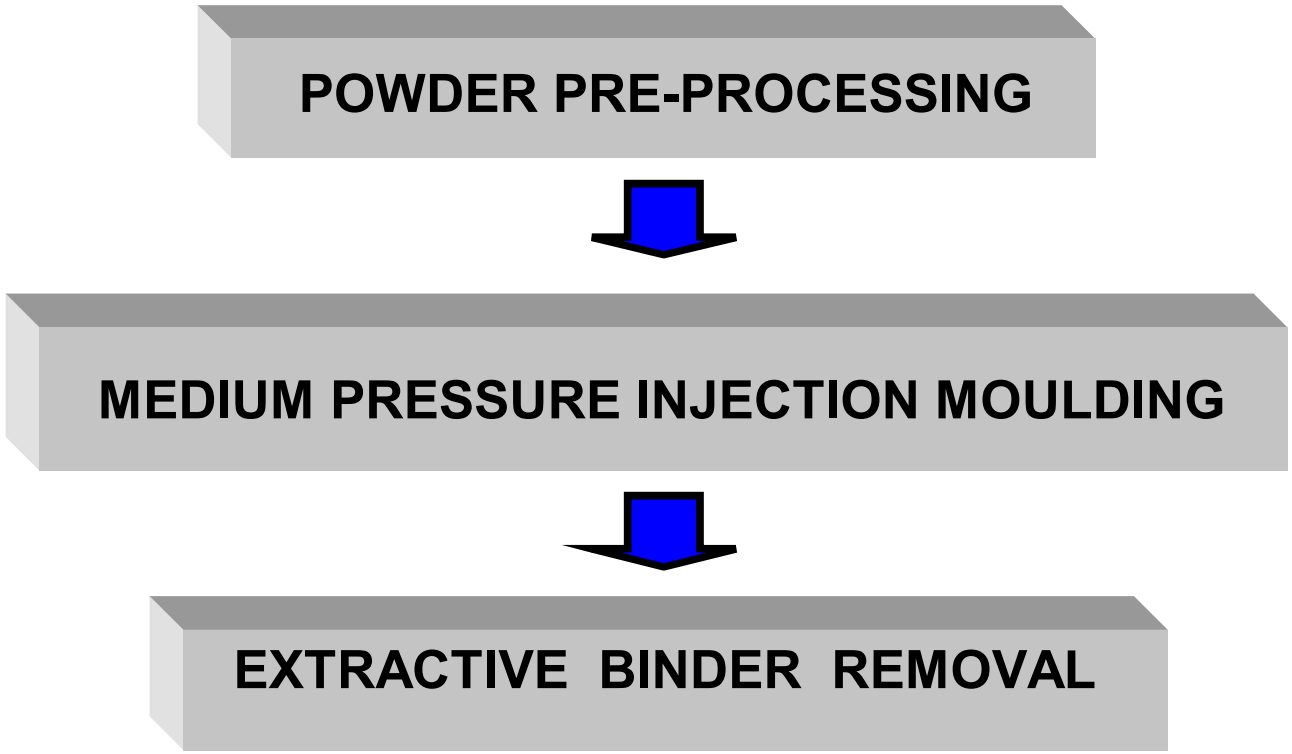
MEDPIMPOULD™

Medium Pressure Injection Moulding Technology by GOCERAM



Thermal (evaporative) ➡ **Supercritical CO_2 extraction**

BACKGROUND

- ✓ **Evaluate supercritical CO_2 extraction as a technologically/commercially competitive alternative to thermal (evaporative) binder removal**

- ✓ **design and build a low-cost production plant unit**

EXTRACTIVE BINDER REMOVAL

- **Water/non-aqueous liquid extraction**

  \+ technically uncomplicated & low plant investment

  \- environmental aspect: “chemical plant” needed for waste liquid treatment and binder recovery for large volume PIM production

  \- absorbed residual water/liquid in the debinded parts may require additional processing; transient “swelling” etc

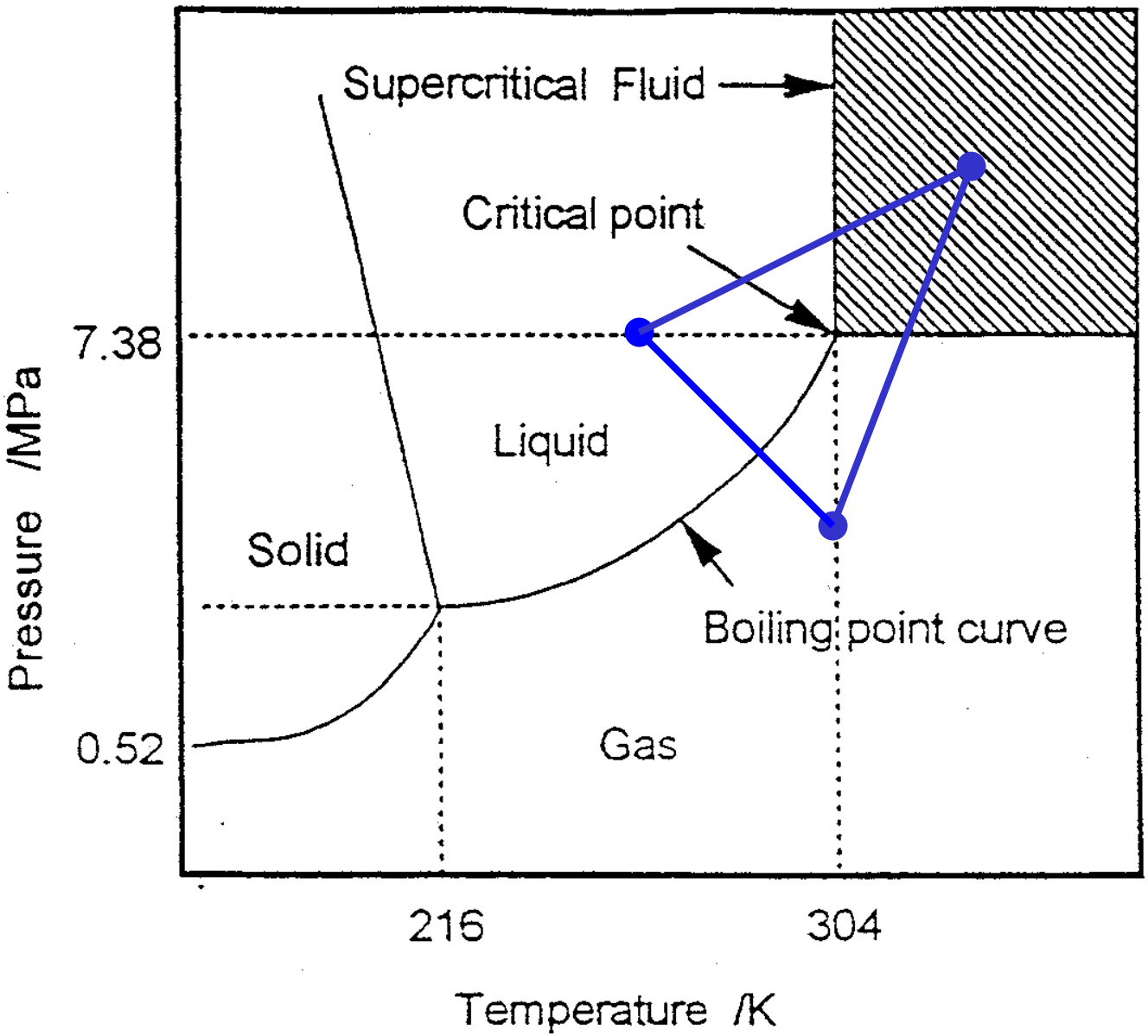
- **Supercritical liquid carbon dioxide extraction**

  \- investment & maintenance and service cost

  \+ clean closed-loop process & binder recovery

  \+ **rapid process & better parts due to supercritical liquid properties**

Phase diagram of CO_2



Physical parameters of CO_2

	Viscosity ($g\ cm^{-1}\ s^{-1}$)	Diffusion coeff. ($cm^2\ s^{-1}$)	Density ($g\ cm^{-3}$)
Gas	10^{-4}	10^{-1}	10^{-3}
S.C. Fluid	10^{-3}-10^{-4}	10^{-3}-10^{-4}	0.3-0.8
Liquid	10^{-2}	10^{-5}	1

- CO_2 diffuses into a green body like a gas
- CO_2 dissolves the binder like a liquid
- The nonpolar CO_2 dissolves small- and medium-sized, nonpolar hydrocarbons like paraffin
- Solubility of paraffin in CO_2 is 0.5 wt% at 200 bar and 1.0 wt% at 300 bar

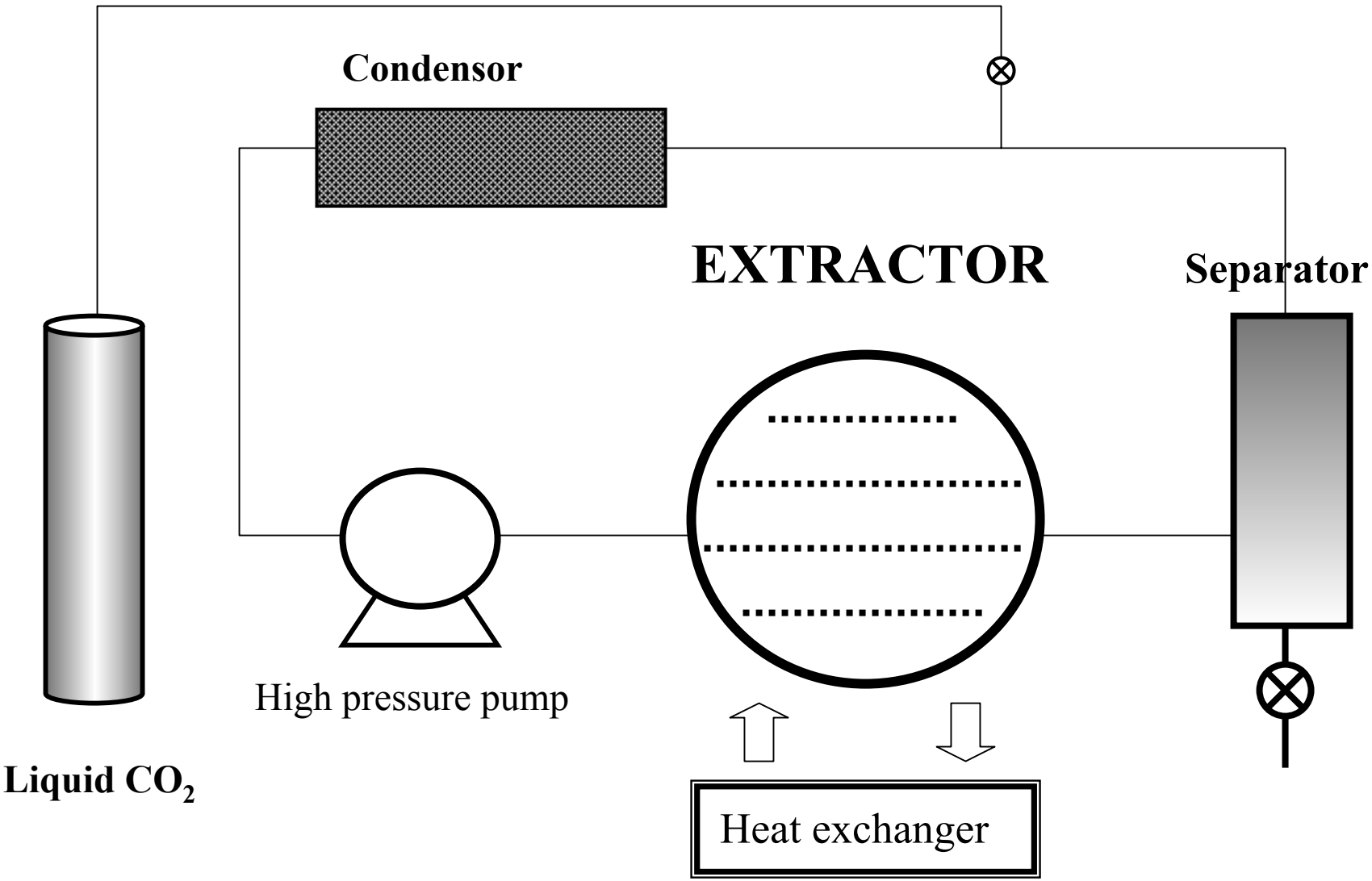
SUPERCRITICAL CO_2: gas + liquid properties:

☑ no capillary forces ⇨ no restructuring of particle packing

☑ zero surface tension ⇨ easy penetration of the pore system

☑ fast diffusion rate ⇨ rapid removal of the dissolved binder,
~ independently of concentration

Outline of the supercritical CO_2 extractor



Feedstock composition

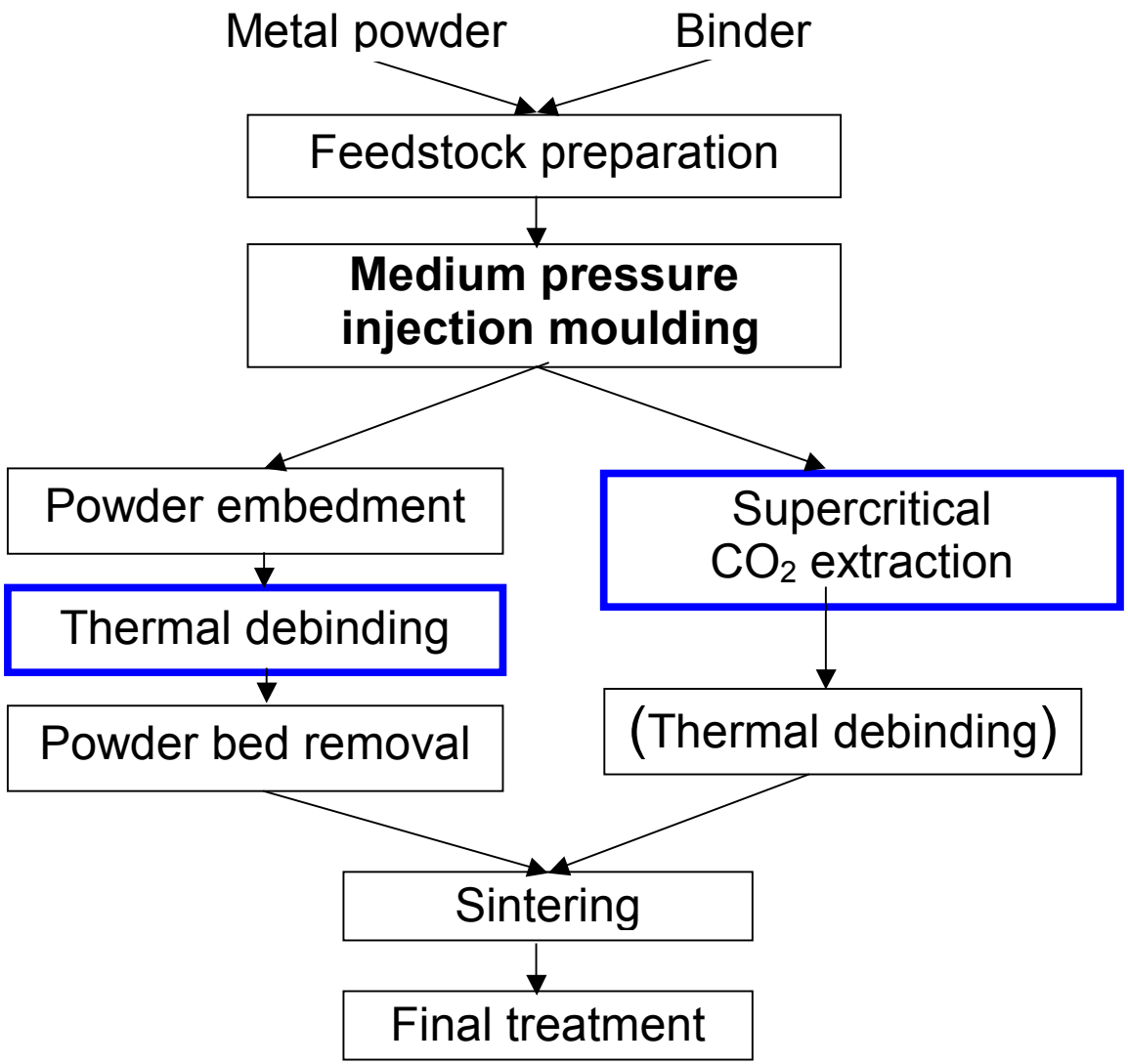
Powder loading **65 vol%**

OSPREY stainless 316L steel powder, - 20 μm

3-component binder **35 vol%**

Composition	*I*	*II*	
Paraffin wax	79	89	
Polymer	20	10	vol%
Stearic acid	1	1	

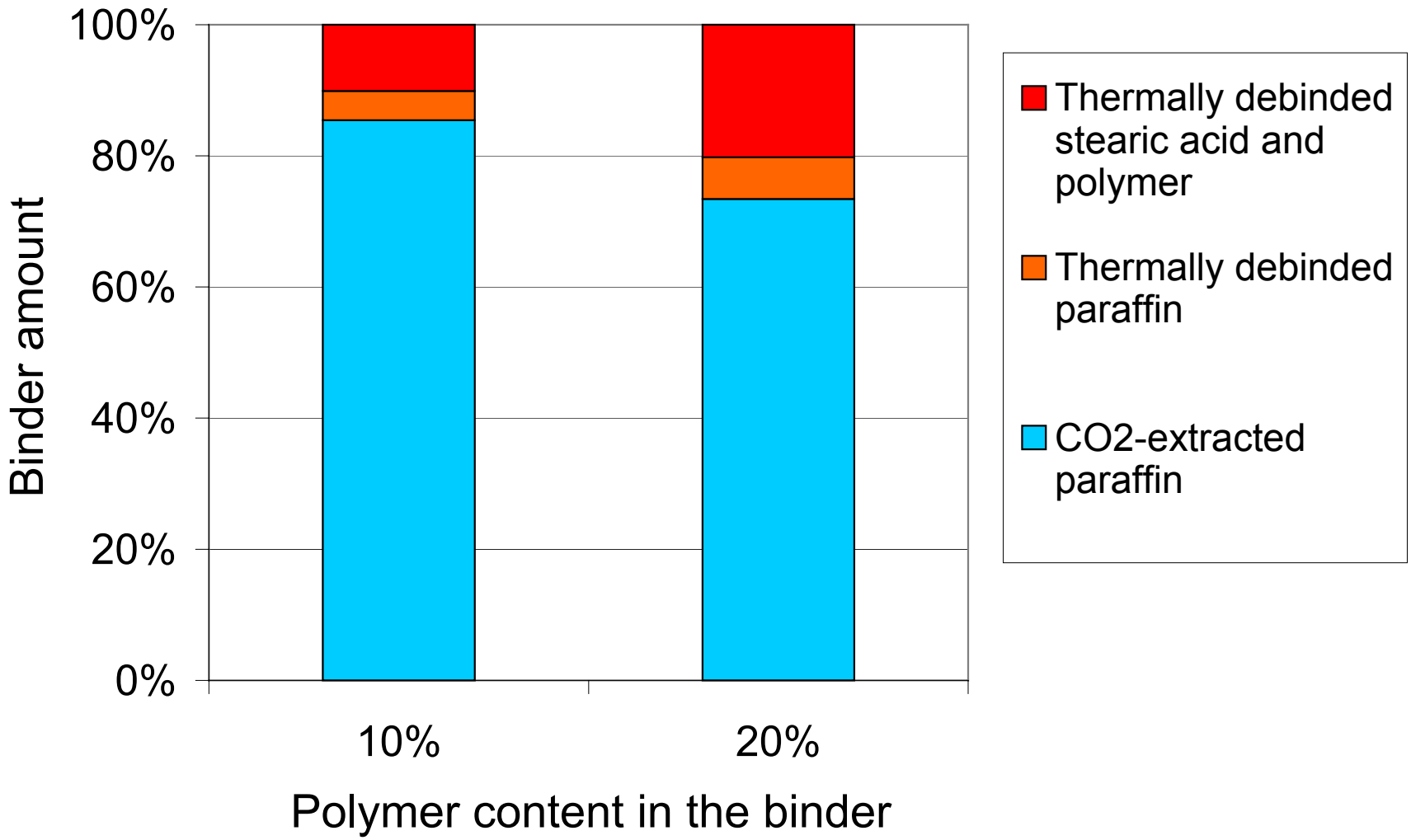
PROCESSING SCHEME



Supercritical extraction

MIMed parts:	watch cases, tensile bars, blocks (thickness: - 10 mm (0.4 “))
Extractor:	500 ml chamber volume Re-circulating fluid system Separator removing the paraffin wax
Medium:	Pure CO_2
Pressure:	200, 300 bar
Temperature:	40-70°C
Cycle time:	6 hours
Result:	**90-95 wt% of the paraffin is removed**

Summary: extraction results

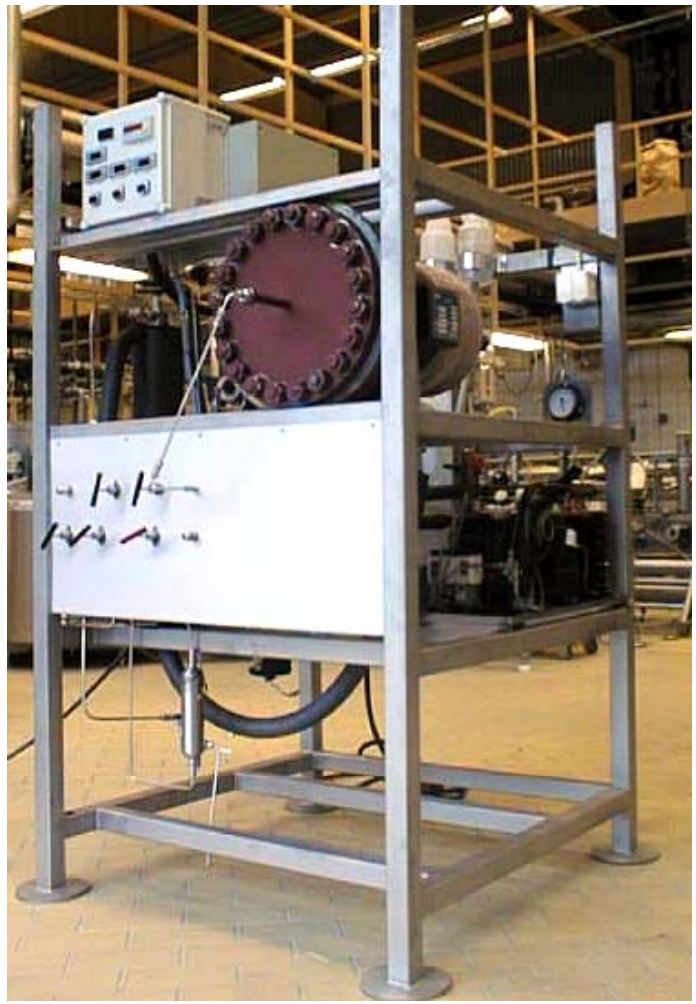


Efficiency of the process

Extractor volume:	20 litres
Setting density:	650 pieces of injection moulded watch cases
Cycle time:	5-6 hours
➡ Yearly output:	~ 1.000.000 pieces
Investment cost:	~ 80.000 US$
More information:	www.goceram.com

Advantages of supercritical extraction

- Reduced debinding time
- No powder embedment
- Better shape stability
- Improved surface finish
- Thick-walled components
- Recovery of paraffin wax



Ongoing work

Extraction of thick-walled components:

- Blocks with 65 vol% stainless 316L steel; thickness 20-25 mm
  55 vol% alumina thickness 15- 20 mm

  Thickness limit?

- CO_2 with 5 % ethanol (co-solvent extraction) + catalyst additive to different wax types

  Extraction time?

  5 x 5 x 60 mm bars showed > 90 % extraction/2 hours