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EDURES EDUcation RESearch

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HOCHSCHULE FURTWANGEN UNIVERSITY HFU

Sc-CO2 Milling of Titanium

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KSF

Why change; challenges with hard-to-machine materials

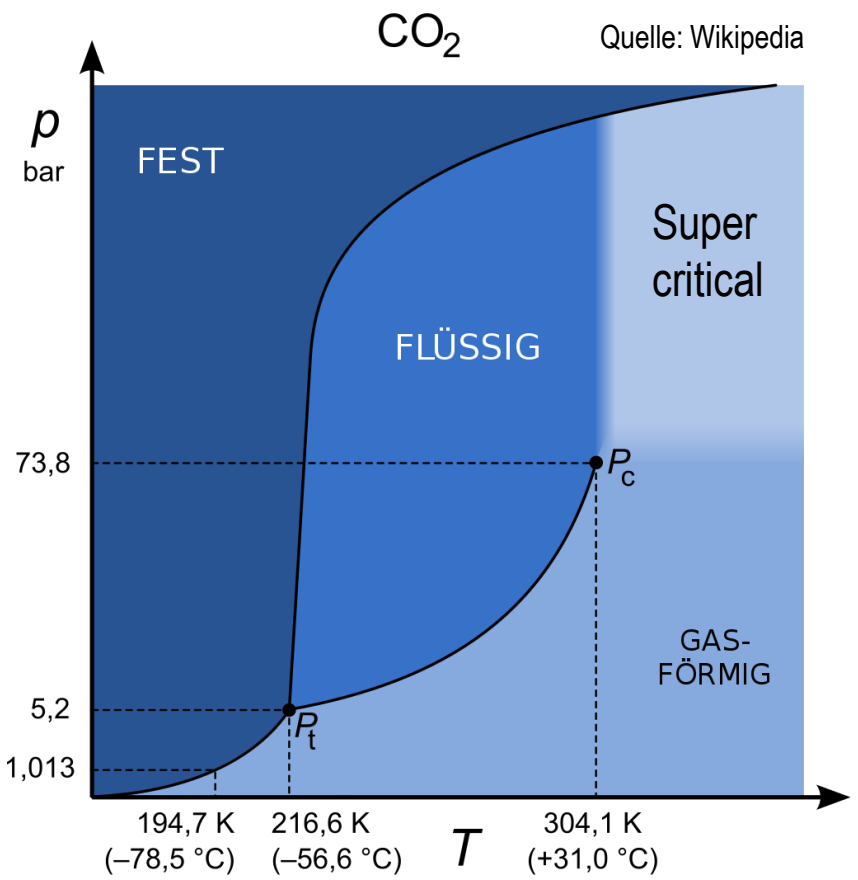
Costs associated with machining make approx. 80% of overall product manufacturing costs [Wein08, Azar11]

- High toughness
- High strength
- Low thermal conductivity
- Etc.

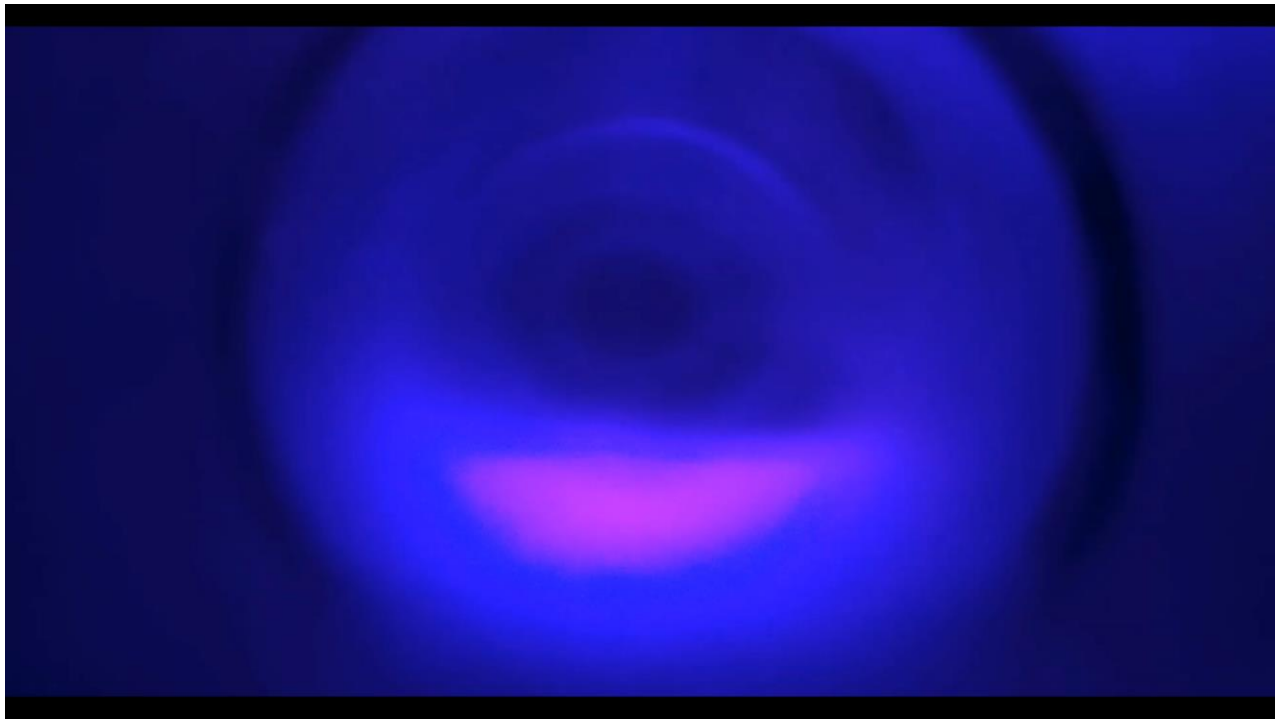
- High machining forces
- High machining temperatures
- Heat accumulation in the cutting area
- Difficult chip formation and evacuation
- Formation of burrs

- Poor surface quality (rough)
- High tool wear
- Low cutting efficiency
- Long machining times
- High Machining costs

Supercritical CO2

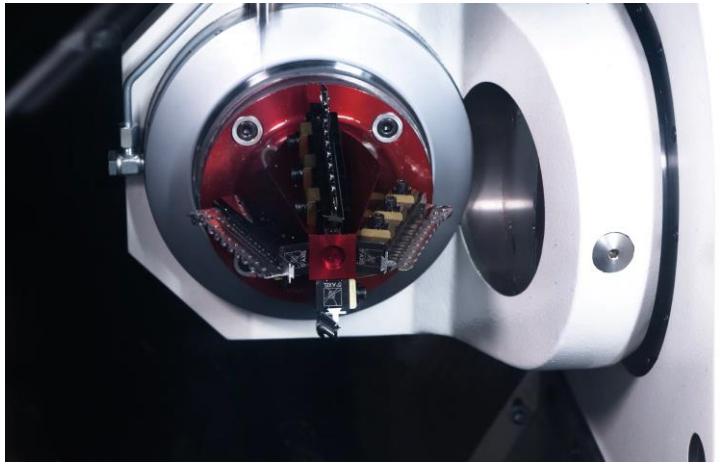


Supercritical CO_2 combined with nano-droplets of oil (MQL)



Quelle: Fusion Coolant Systems

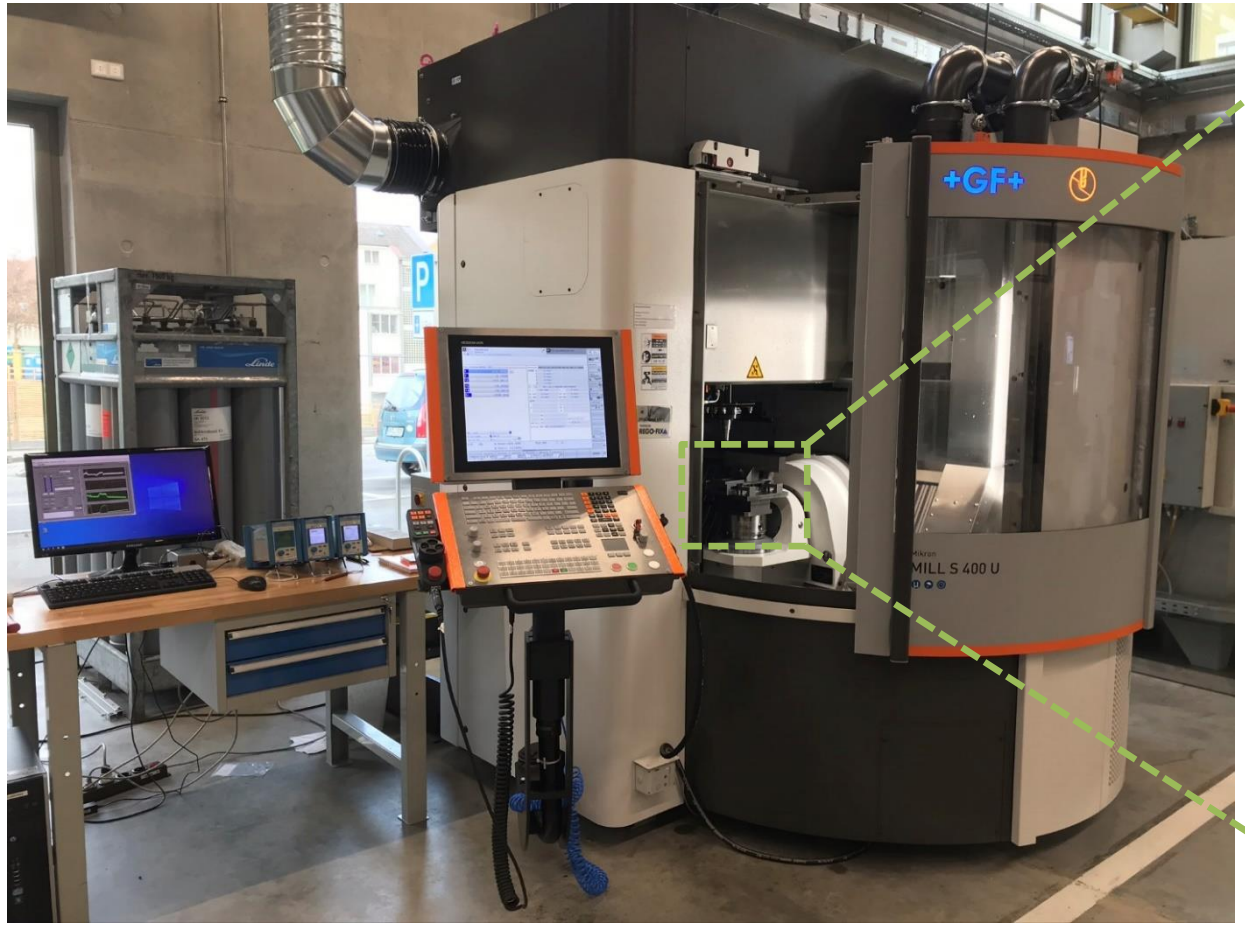
Supercritical CO2 as a coolant-lubricant

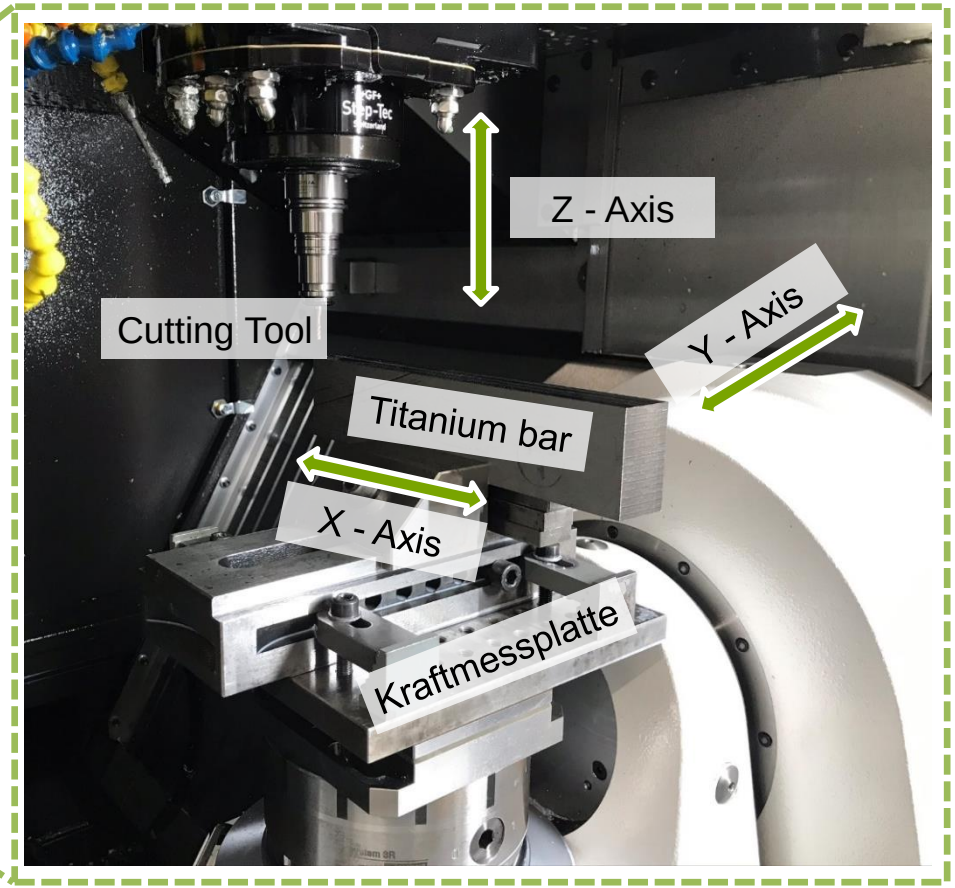


- Increase in material removal rate
- Reduction of tool wear
- Reduction of burr formation

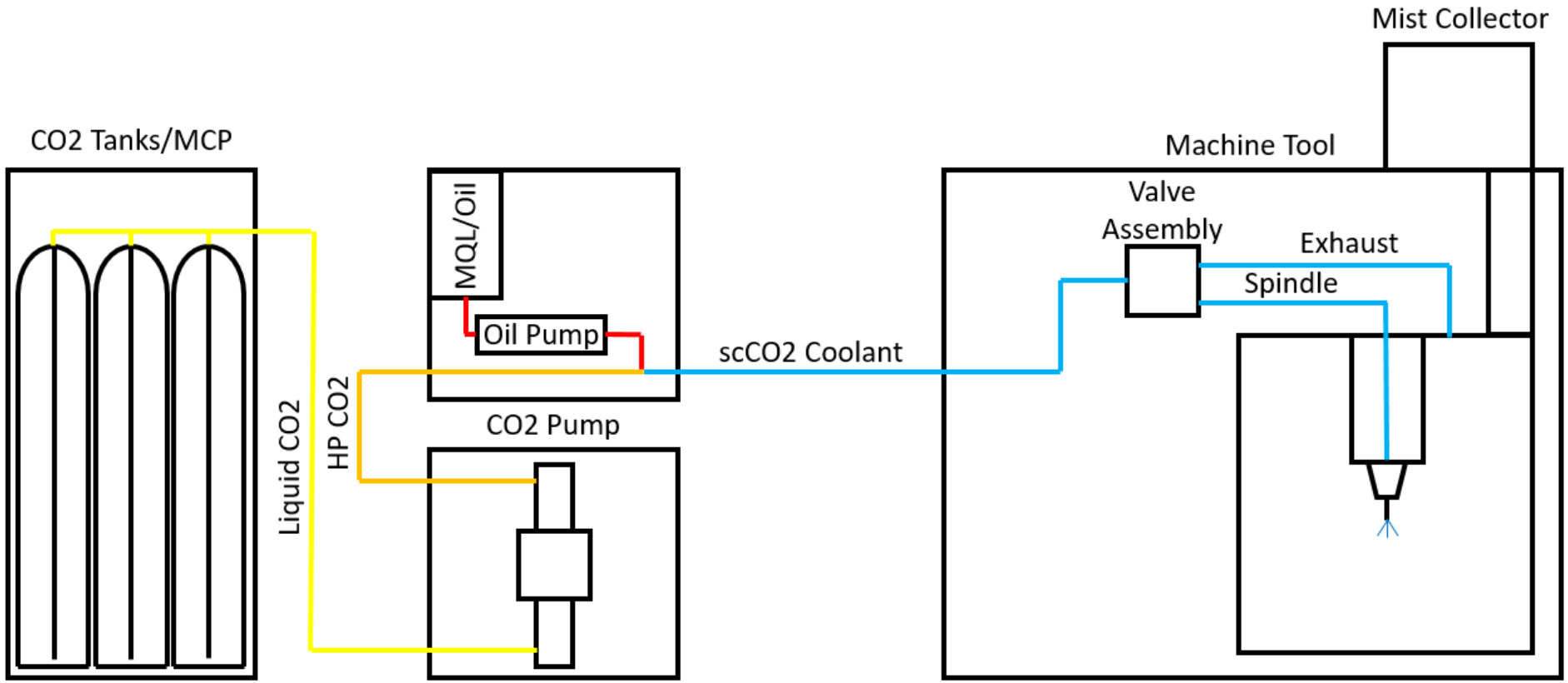
- Elimination of the need for additional cleaning equipment
- Machining without thermal damage
- Constant processing quality

System set-up

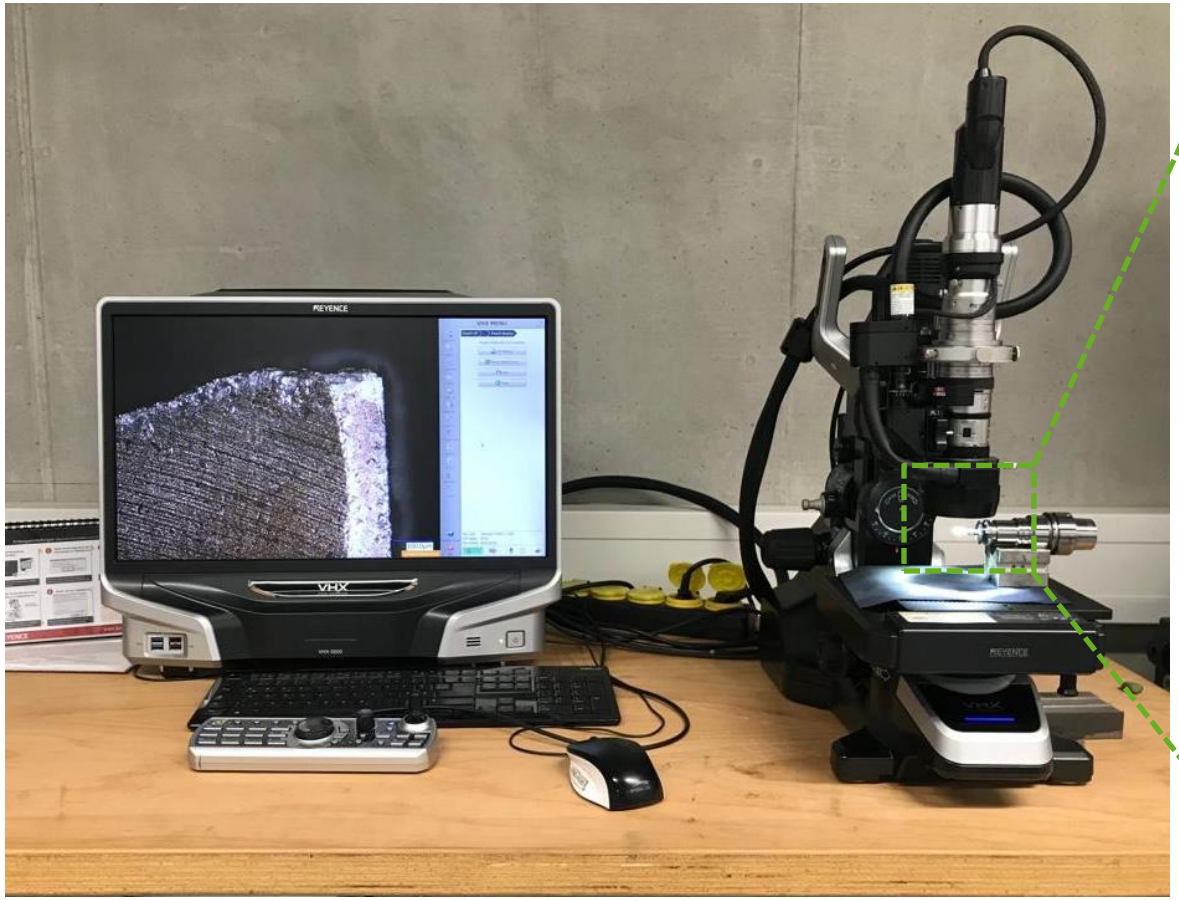




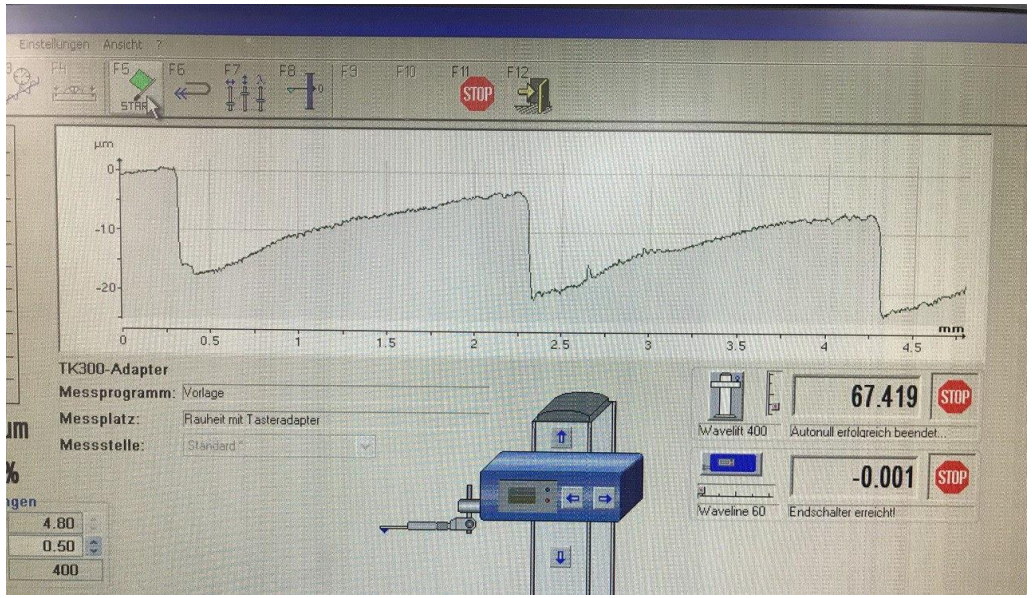
System set-up

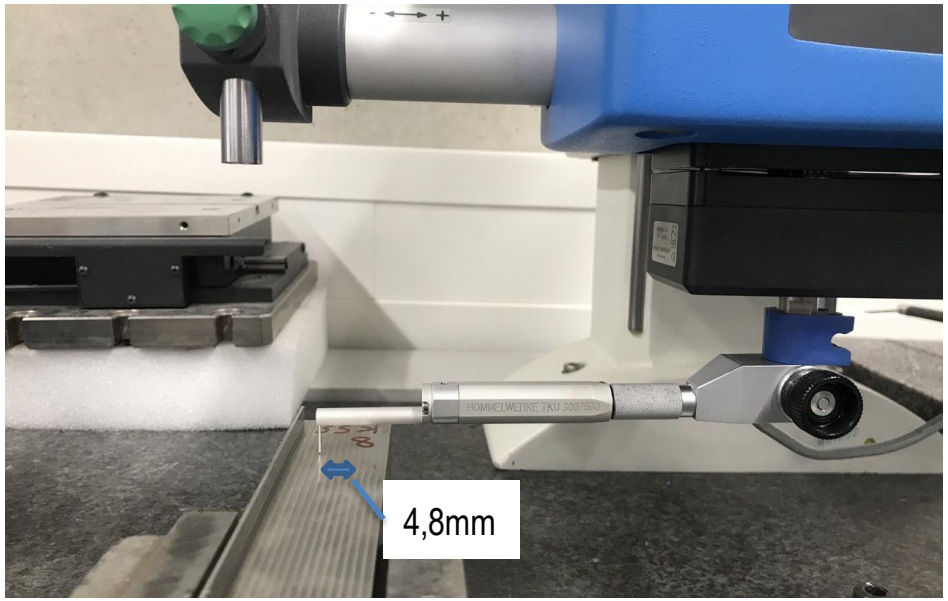


Tool wear measurement

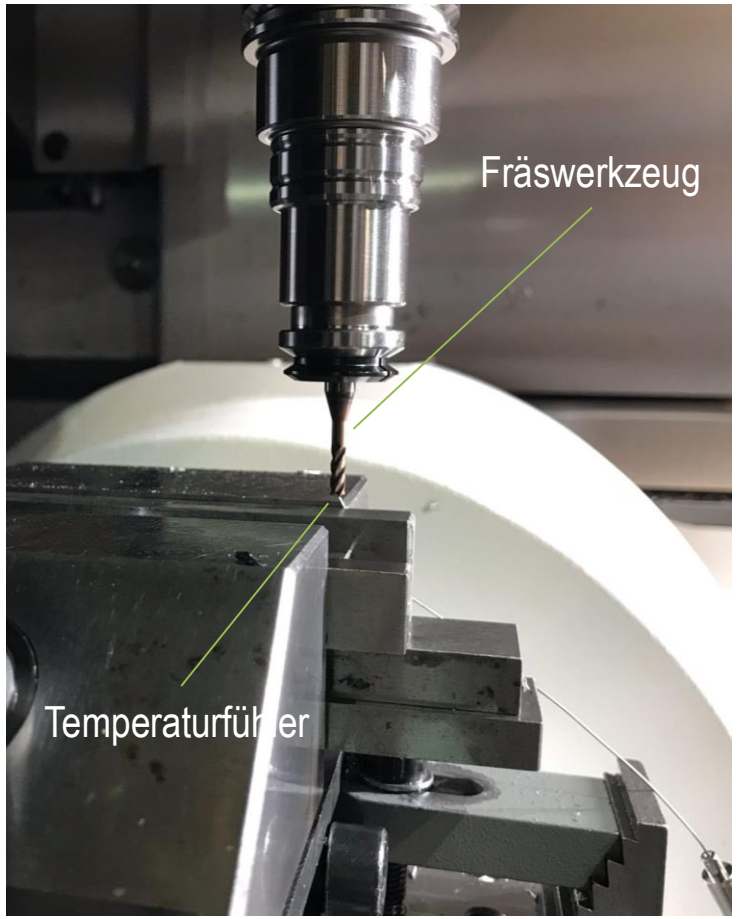


Surface roughness measurement



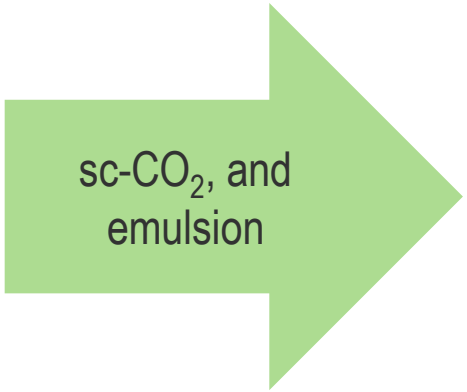


Temperature



Milling of titanium - Supercritical CO2 combined with nano-droplets of oil (MQL)

- Milling cuts: constant depth, constant speed
- Cutting tool: 3 flutes / Φ = 6 mm
- Material: Grade 5 Titanium
- Parameters:
  - v_c = 51 - 200 m/min
  - a_e = 2 mm
  - a_p = 5 mm
  - f_z = 0,0128 - 0,025 mm
  - v_f = 225 - 796 mm/min

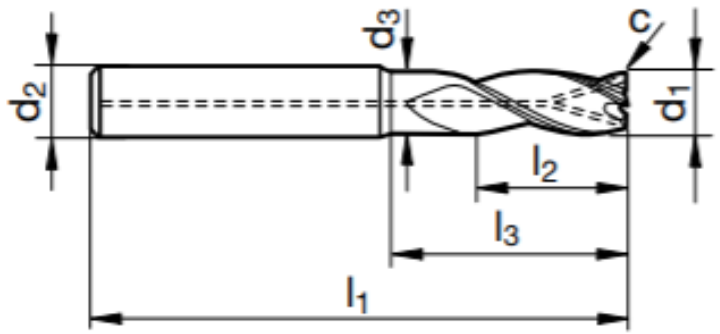


- Tool Wear
- Surface condition (topography)
- Cutting Forces
- Surface roughness
- Chip size and form
- Development of burrs
- Surface micro-hardness

Milling tool

GUHRING

Ratiofräser RF 100 DIVER Series **6799**

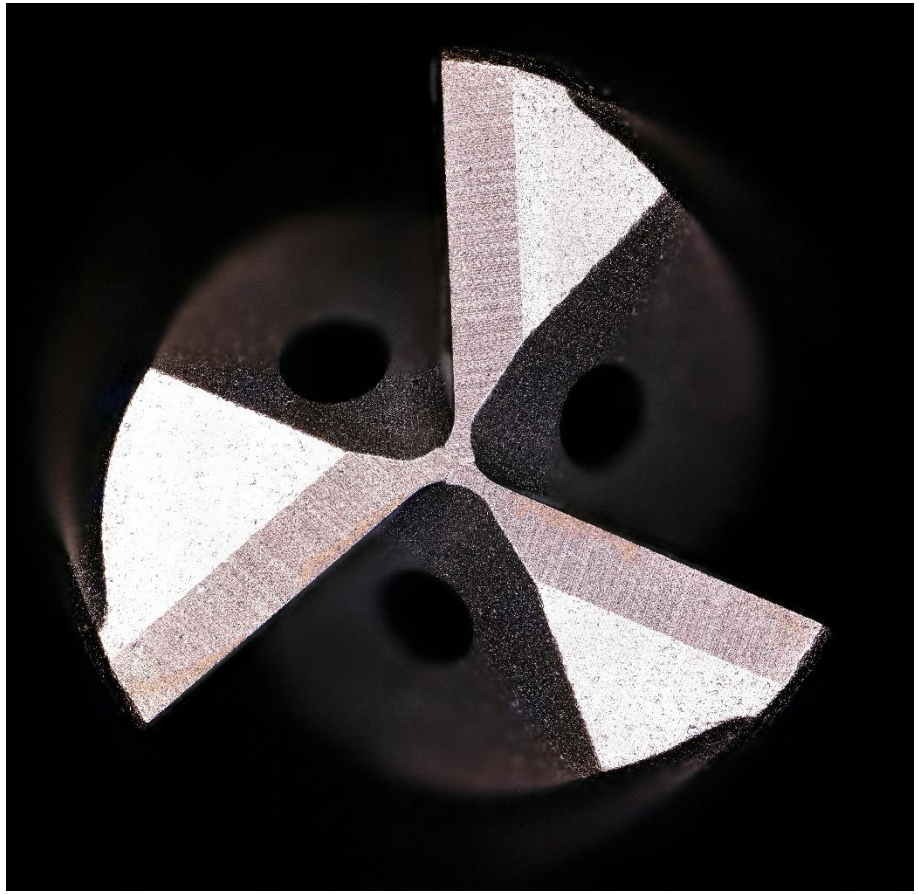


d1 h10	d2 h6	d3	l1	l2	l3	c	No. of Flutes	Code no.	EDP Number
mm	mm	mm	mm	mm	mm	mm x 45°			
6.00	6.00	5.70	57	13.0	20.0	0.09	3	6.000	9067990060000 9068000060000

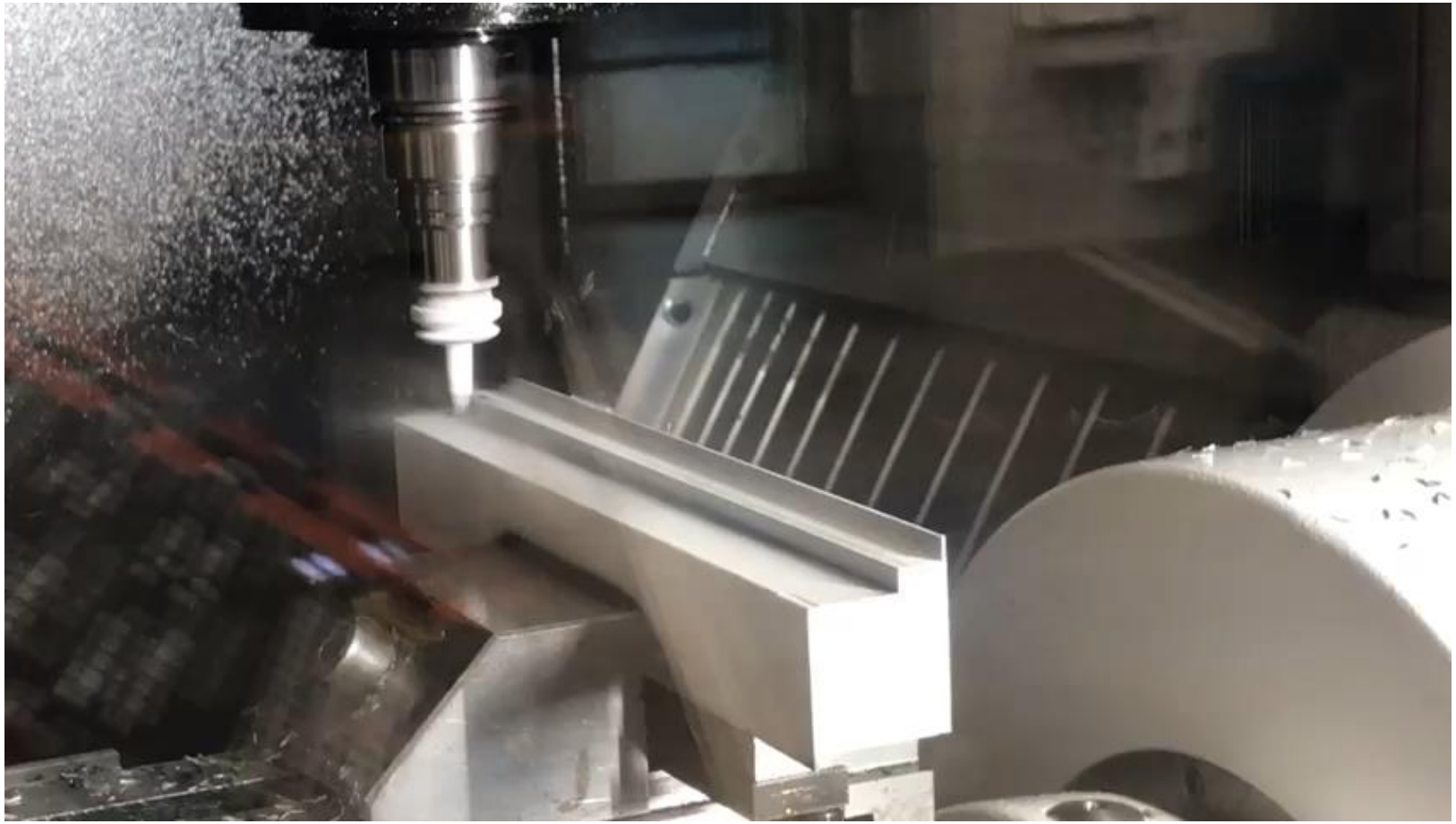
Solid carbide: DK460UF (K20-K40) Coating: Signum (TIALN)

Suggested Parameter: v_c: 51 m/min, n: 2706U/min, v_f: 127 mm/min, f_z =0,0155 mm/tooth , a_p = 10 mm; a_e = 3 mm;

Milling tool



Sc-CO2 milling



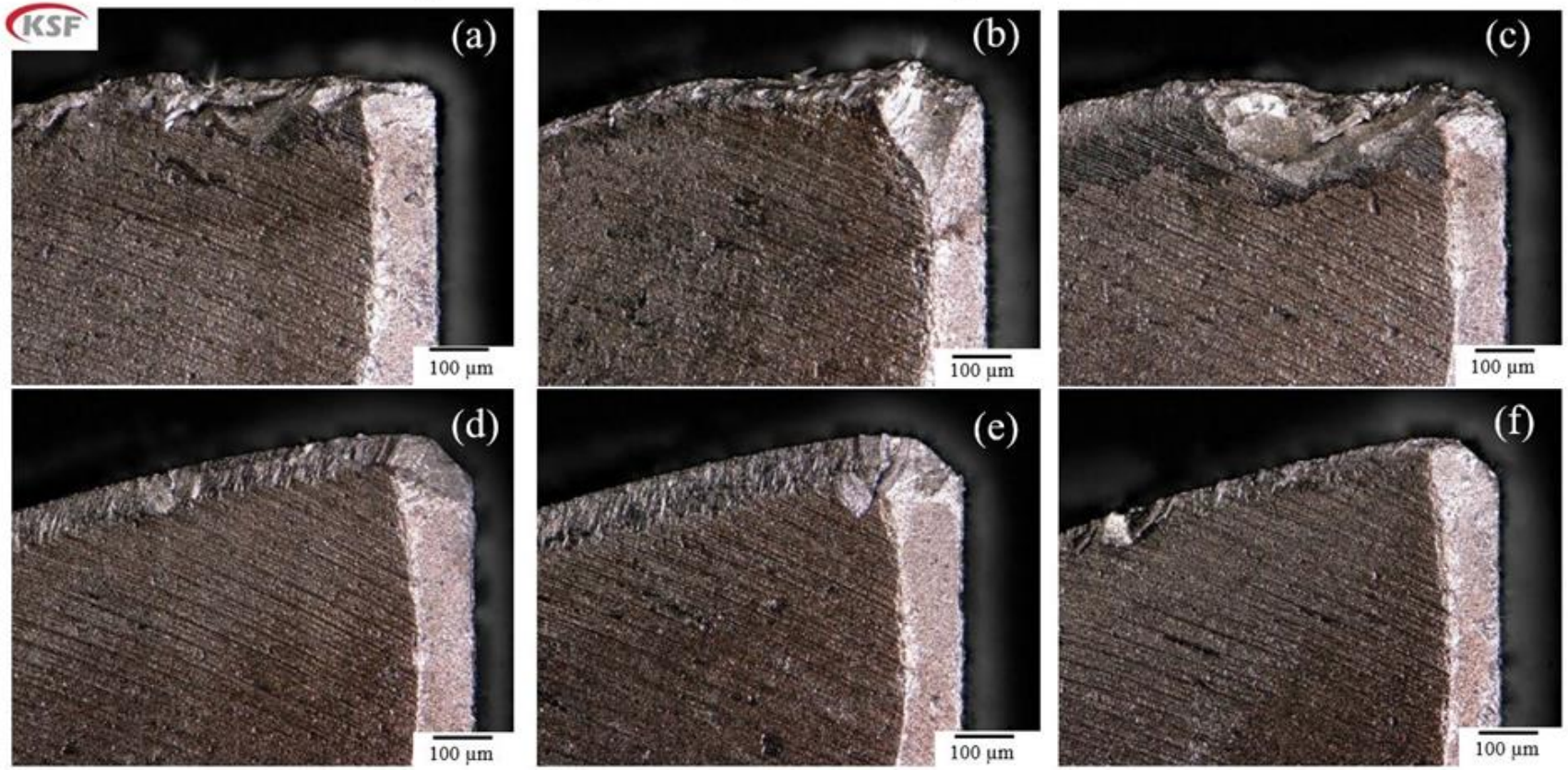
Milling under flood cooling

Tool wear

a_p = 5 mm; a_e = 2 mm; v_c = 200 m/min, v_f = 796 mm/min

Emulsion

sc-CO_2



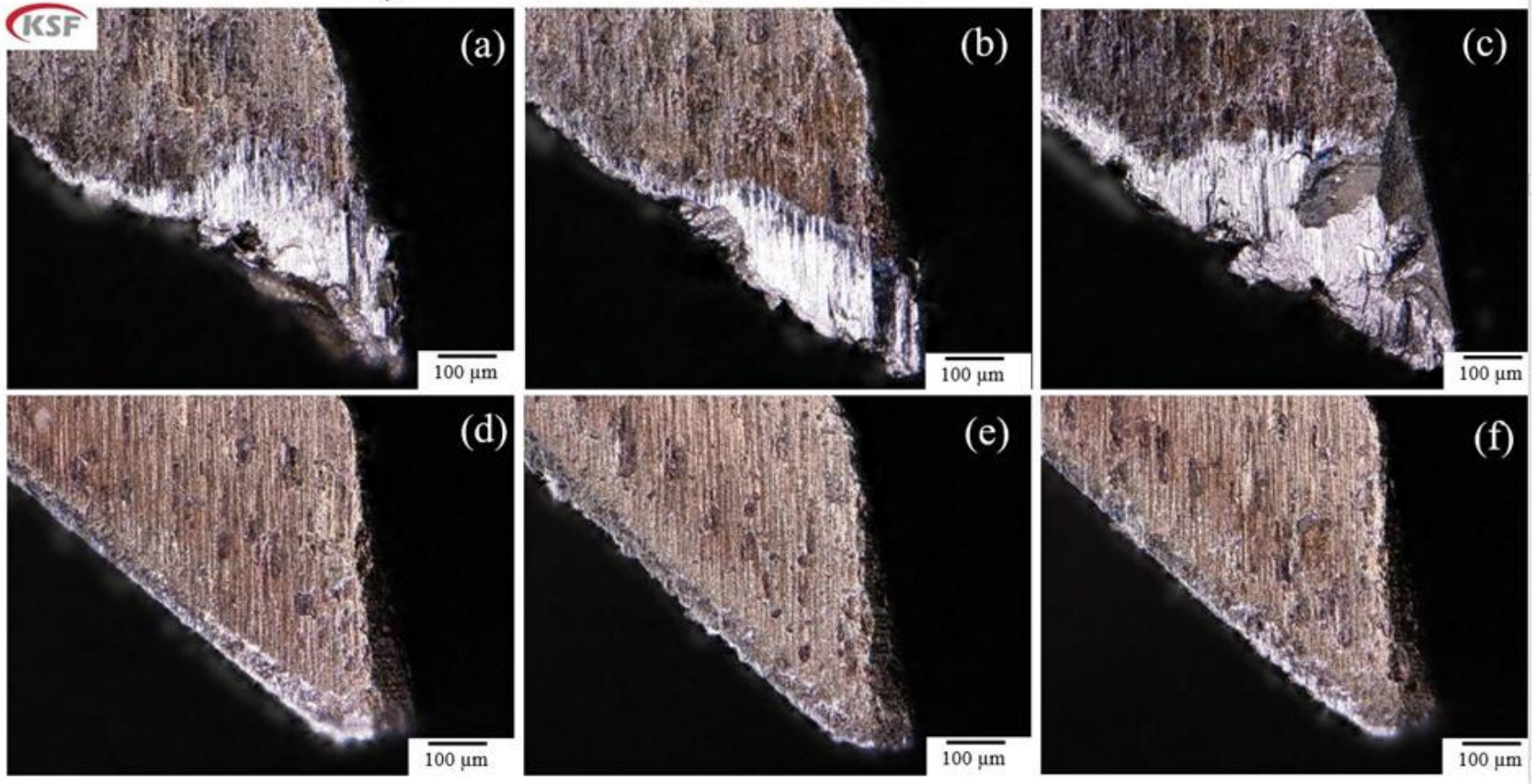
V_w = 113850 mm^3

Tool wear

a_p = 5 mm; a_e = 2 mm; v_c = 200 m/min, v_f = 796 mm/min

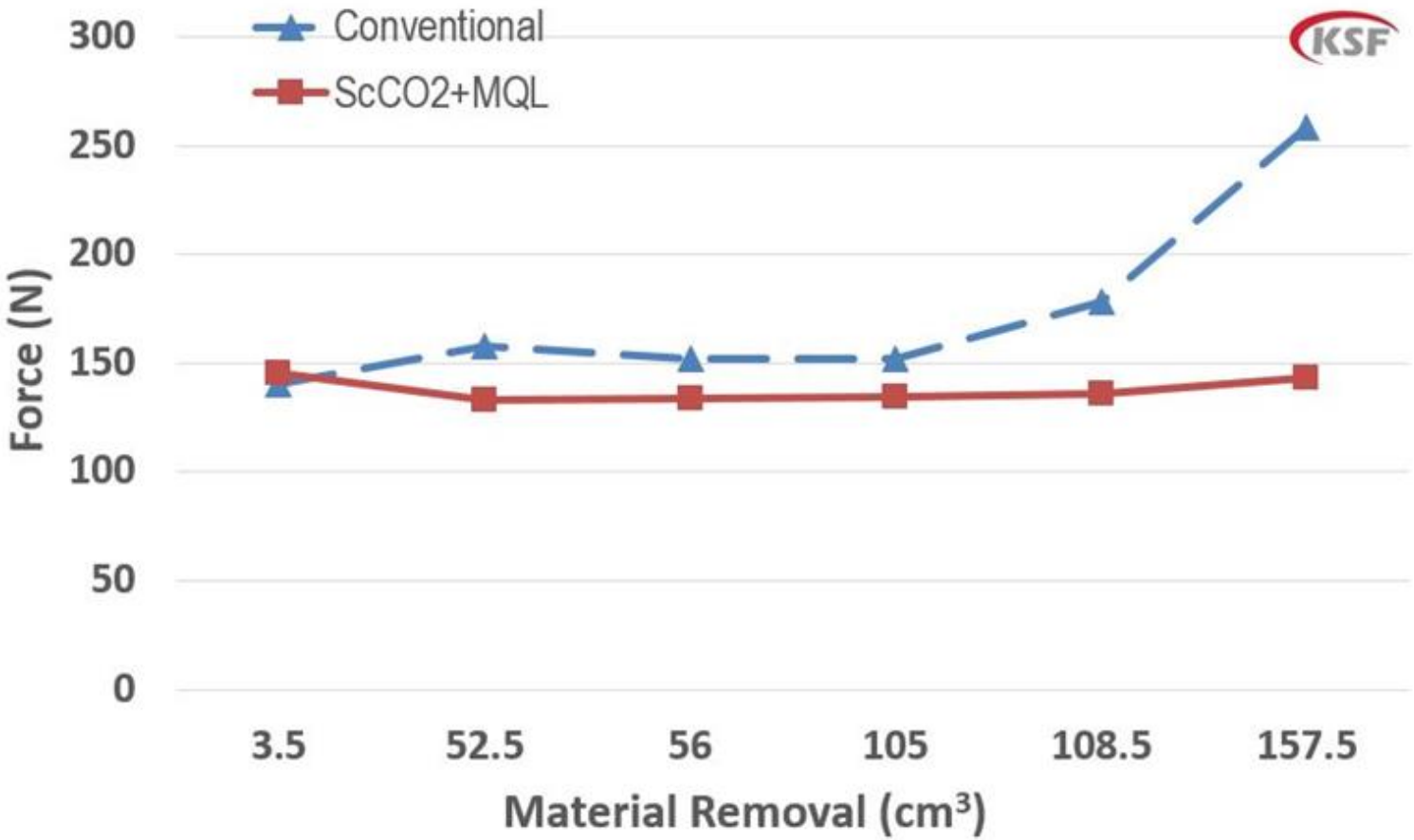
Emulsion

sc-CO_2

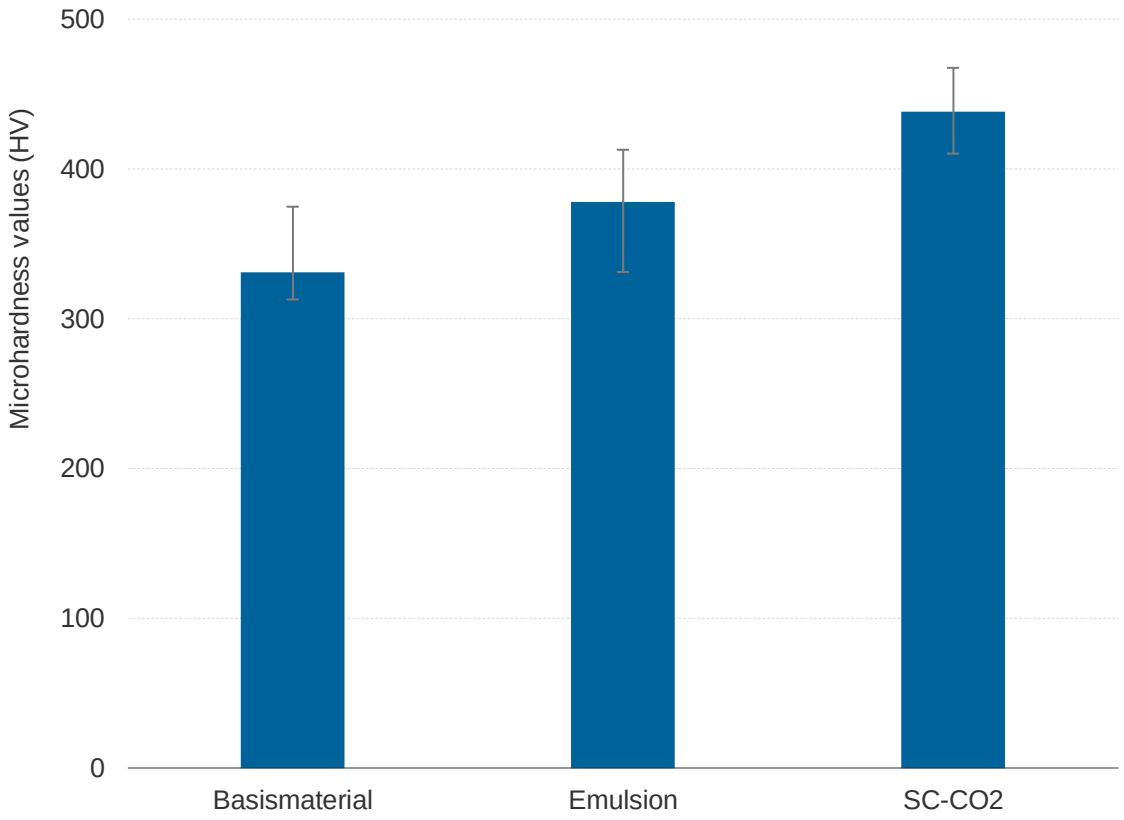


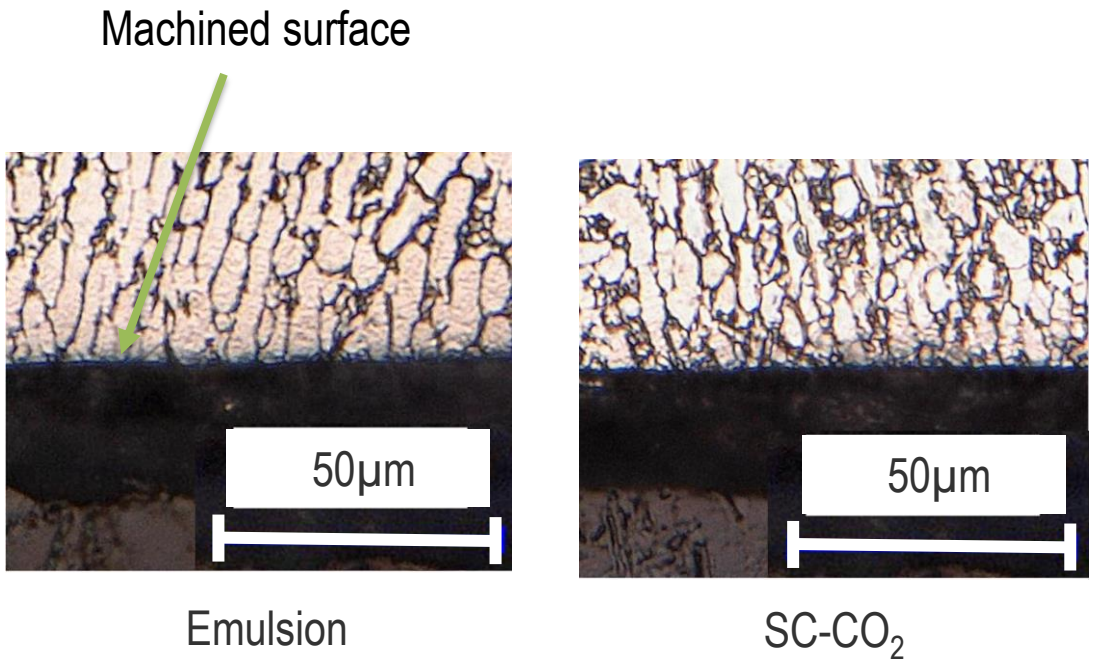
V_w = 113850 mm^3

Forces


Conventional
ScCO2+MQL
KSF
300
250
200
150
100
50
0
Force (N)
3.5
52.5
56
105
108.5
157.5
Material Removal (cm³)

Subsurface





Emulsion

SC-CO_2

Summary

SC-CO2 Milling of titanium:

- Reliable machining at higher Material Removal Rates
- Significantly increased tool life
- Significantly lower cutting forces
- Increased surface micro-hardness