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General Presentation

PEKK Powder Coatings

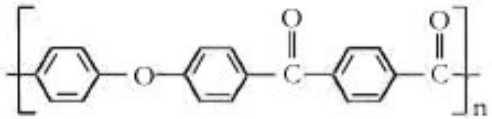
VELOX

General properties of Poly *(Aryl Ether Ketone)*

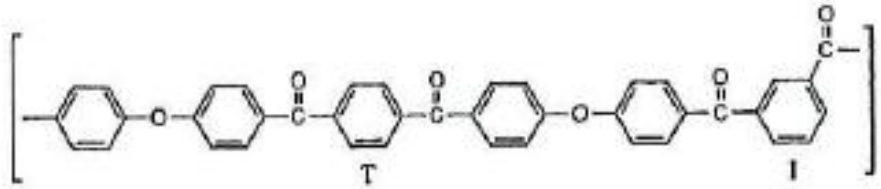
- Aryl groups, Ether and Keto linkages have very high thermal stability
- Resulting chemical backbone and crystalline structures offer an impressive combination of properties :
  - **Outstanding high temperature performance**
    - Heat Deflection Temperature 150 – 170°C for neat resins
    - Continuous Use Temperature 250 – 260°C, short term exposure up to 300°C
  - **Unique combination of strength, stiffness, impact resistance, wear resistance**
  - **Excellent combustion resistance properties**
    - Inherently flame retardant, low level of smoke
  - **Resistance to virtually all organic and non organic chemicals**
    - High resistance to hydrolysis
    - Only sensitive to very agressive reagents (fuming sulfuric and nitric acid, methylene chloride)
  - **High dielectric strength and good insulating properties**
- Some known limitations
  - **UV radiation sensitivity**
  - **Processing requires very high temperatures**

PEKK among PAEK polymers

- PEKK presents two distinctive features
  - **A first one : more keto and less ether linkages**
    - Leads to higher Tm, higher Tg, with benefits for different mechanical properties

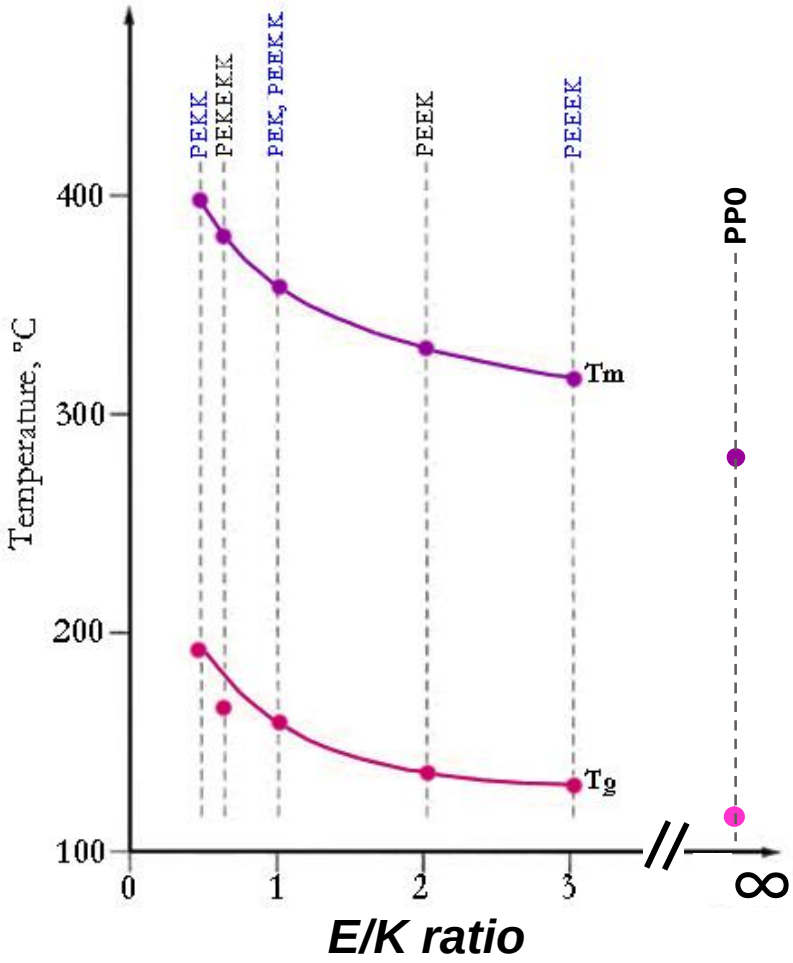


  - **A second one : some *tilted* keto linkages in the chain**
    - Thanks to Isophtaloyl moieties instead of only terephtaloyl ones
    - Allows to modulate crystallinity, Tm and crystallization rate
    - Gives an access to co-polymers, broadening possibilities in processing and applications



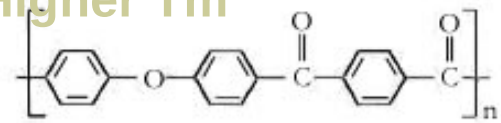
PEKK among PAEK polymers

- Tm and Tg increase with ketone linkages ratio

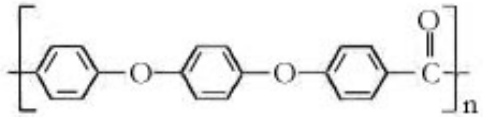


- **Keto linkages are less flexible than Ether linkages**
- => Stiffer polymer chains => **Higher Tg**
- **Keto linkages enhance packing efficiency of unit-cells**
- => Larger crystal binding energy
- => **Higher Tm**

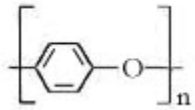
PEKK



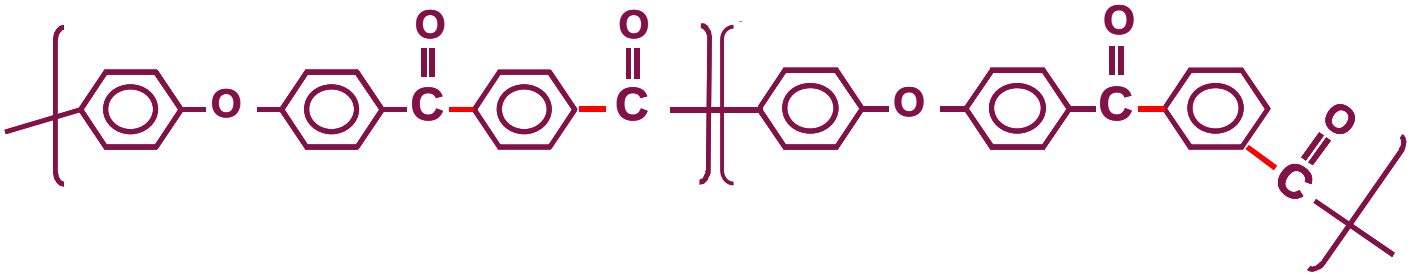
PEEK



PPO



T&I moieties give access to a Co-Polymer system



- Co-Polymer system
  - Variable isomer ratio Terephtalic Acid (T) & Isophtalic Acid (I)
  - Structural variation with T/I ratio

PEKK C	T/I = 80/20, Crystalline	Tg = 163°C	Tm = 360°C
PEKK SP	T/I = 60/40, Nearly amorphous	Tg = 155°C	Tm = 303°C
*PEKK D**	*T/I = 70/30, Crystalline*	*Tg = 161°C*	*Tm = 332°C*

* *Development grade*

To be compared with

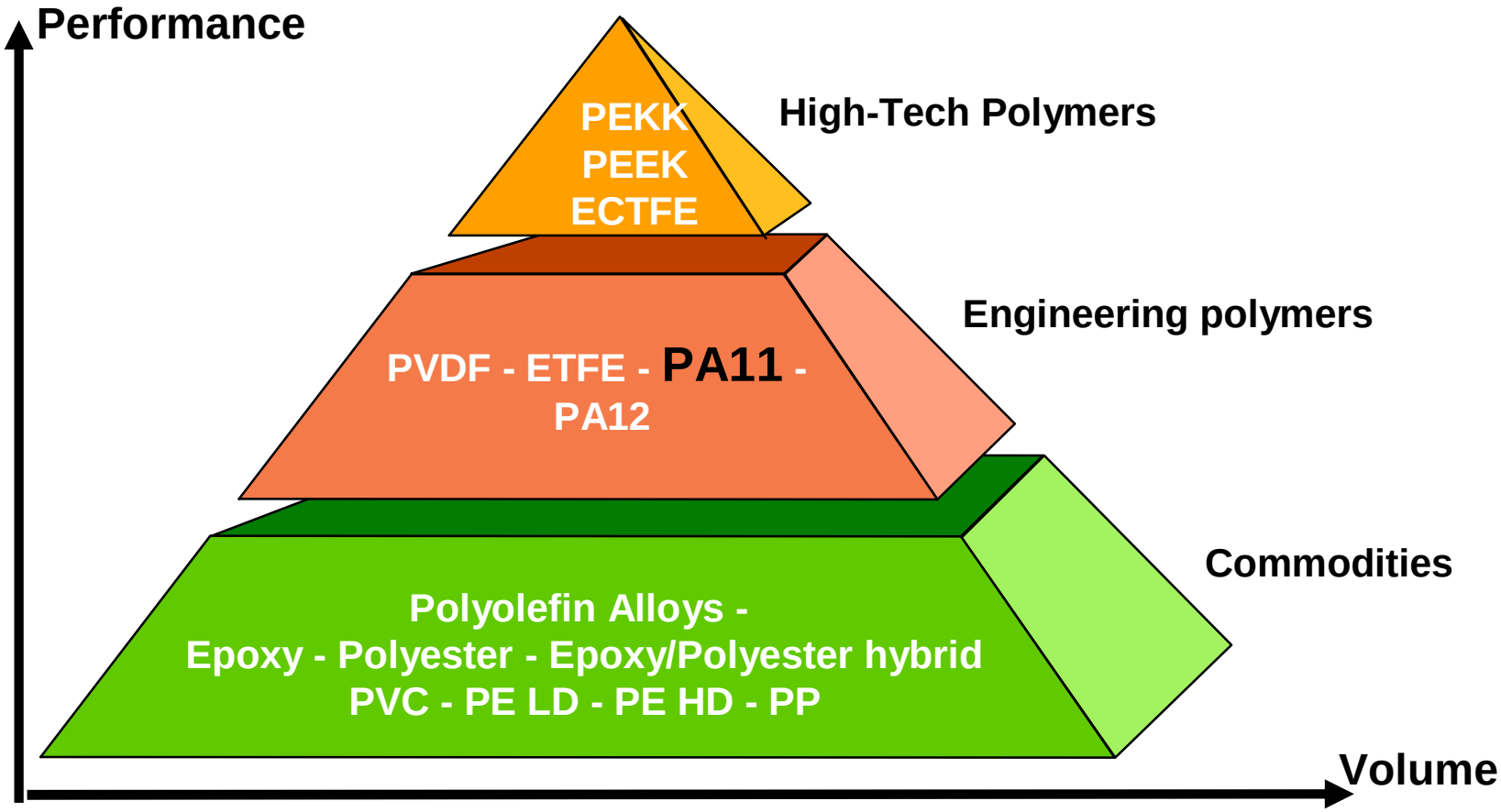
PEEK	Crystalline	Tg = 143°C	Tm = 343°C

PEKK C and PEKK SP

Property	PEKK-C	PEKK-SP	PEEK
Color	Beige	Translucent	Beige
Specific Gravity	1.31	1.28	1.30
Tensile Strength (psi)	16,000	13,000	16,000
Tensile Modulus (psi)	640,000	500,000	540,000
Elongation @ Brk	12%	80%	20%
Flexural Strength (psi)	28,000	20,000	25,000
Flexural Modulus (psi)	660,000	490,000	620,000
Compression Strength (psi)	30,000	15,000	17000
HDT @ 1.8 MPa	175	141	156
Tg (°C)	163	155	143
Tm (°C)	360	303	343

What is PEKK among High performance coatings?

Powders for coating



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Benefits of PEKK vs competitive materials

Advantages vs. PEEK

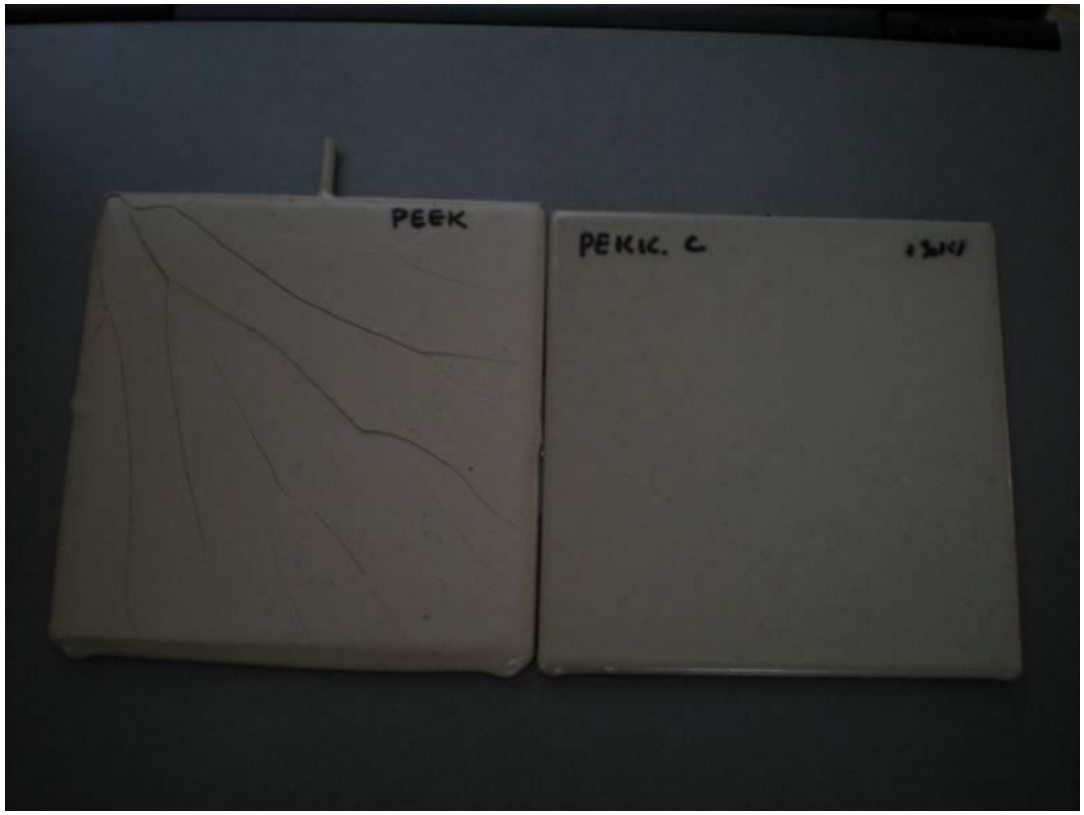
- On massive parts, **no cracking** observed when cooling is performed in air (for PEKK C)
- **Better wetting**
- **Better adhesion** (NFT 58-112)
- Better **impact resistance** (WIS 4-52-01; thickness 400µm)
  - PEKK C : 8J ; PEKK SP > 12J ; PEEK Vicote 702 : 4J

Process improvement:

- Lower processing temperature for SP
- Less sprayings required to reach a same thickness

No Crack after cooling

- Thickness from 3 to 6mm, Hot spray ð PEKK C > PEEK
  - PEEK coatings cooled in air cracks
  - No crack with PEKK C

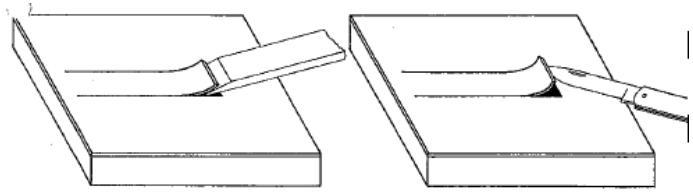


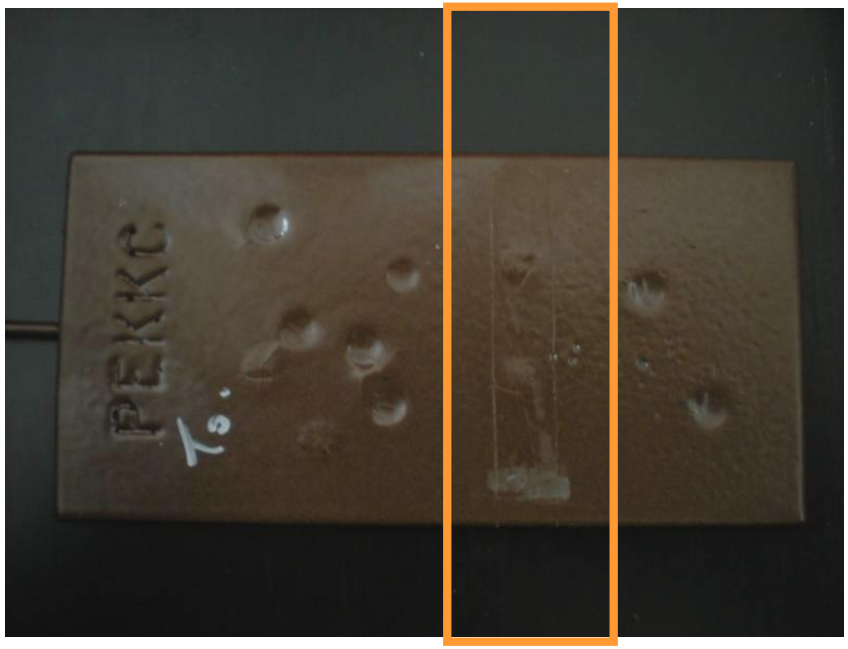
L With PEEK J With PEKK

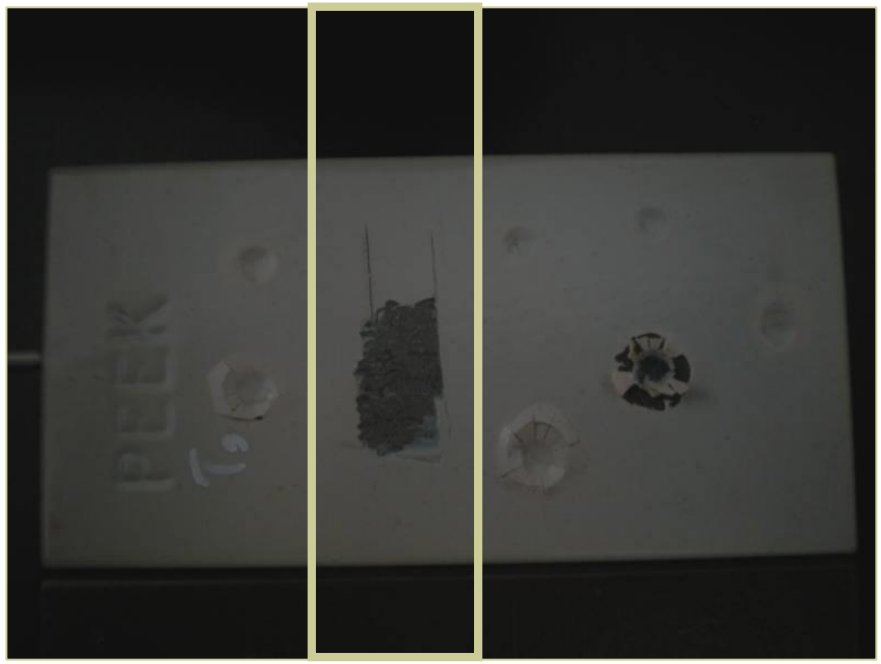
Better Adhesion

Standard NF T58-112 for adhesion measurements

Sample conditioning :
Temperature 20°C +/-2°C ; relative humidity 65% +/-5%







J With PEKK

L With PEEK

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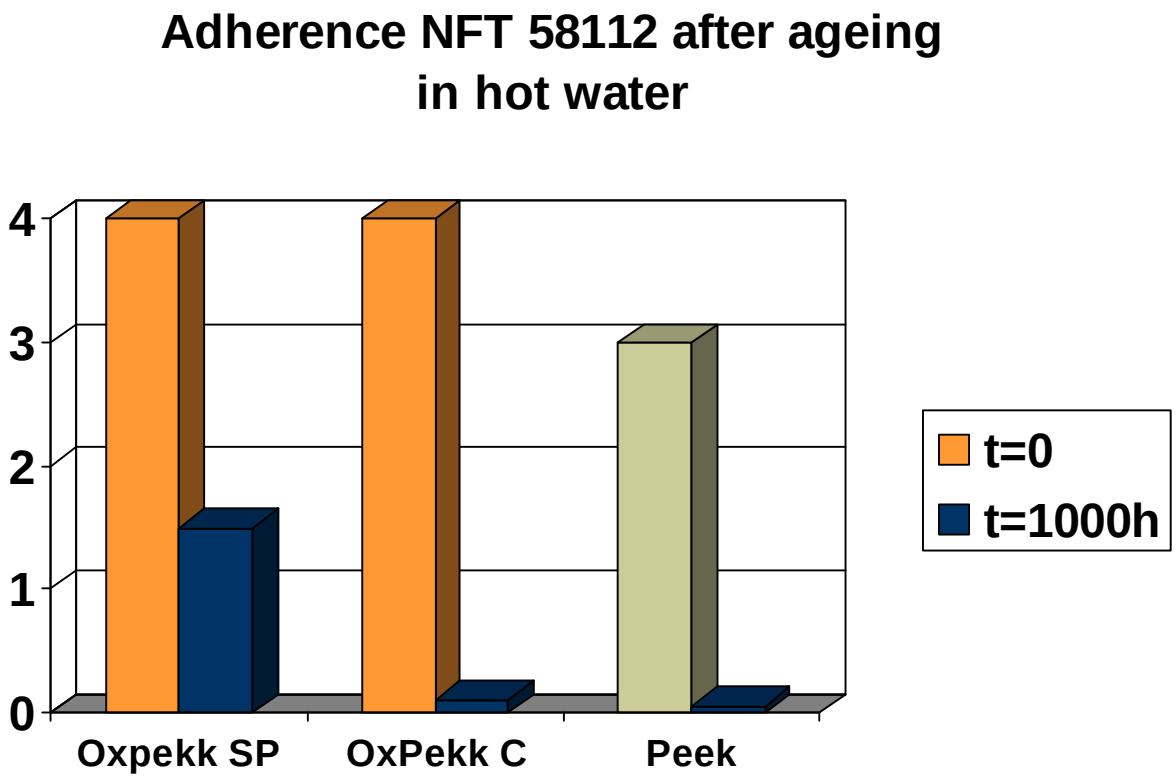
Better adhesion



Better wetting with PEKK

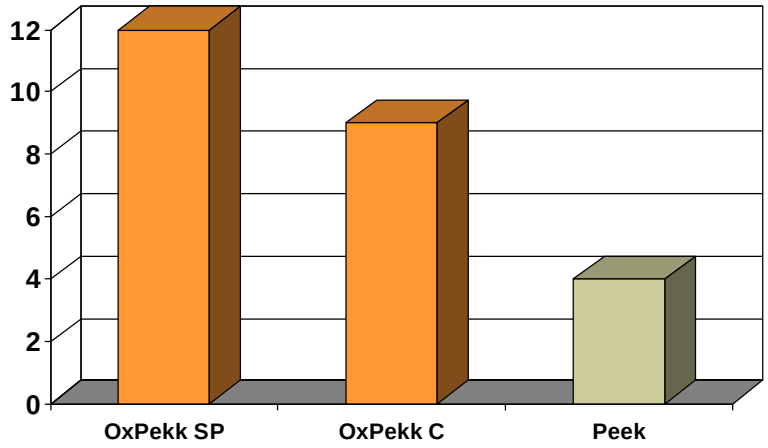
Fair wetting in the groove (same as PEEK)

Good wetting in the hole

(better than PEEK)

Non-welded angle
(better than PEEK)

Better impact resistance



Visual Coating aspect :

-PEKK SP : Rigid

-PEKK C : Brittle

-Peek : Very brittle

Processing guide

Surface preparation :

- The parts should be clean, free of grease or oil and also grit blasted.

Operating conditions :

- 1- Coating :
  - Hot spraying using an electrostatic gun with no voltage is recommended
  - The preheated metallic parts are sprayed and then, post-fused until the powder is completely molten.
  - Surface temperature of :
    - 390°C for PEKK-C to melt and form a film
    - 330°C for PEKK-SP
    - the post-fusing time needed to melt the powder depends on the thickness and design of the part
  - If necessary, this process can be repeated several times to build up and reach the expected thickness. Eventually the first spraying could be done on cold parts.

- 2- Cooling :
  - PEKK-C : cooling in air allow to recover the initial crystallinity of the product ; cooling in water requires an annealing at 200°C to recover the initial crystallinity, annealing time depends on the thickness and configuration of the part (30 min for PEKK-C if the parts are already at the right temperature).

Potential Application of interest

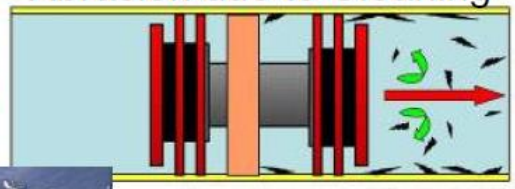
Chemical, Mining, Oil & Gas Industries: Pipe, Cylinders & Vessels

- Requirements:
  - Corrosion Resistance
  - Heat Resistance
  - Abrasion Resistance
  - Adhesion
  - Permeation Resistance

- Potential Applications:
  - Wear Pads
  - Pump and Valve Surface
  - Pipe IDs
  - Sensors

Corrosion & Abrasion due to crude and gases

Abrasion due to Cleaning



Potential Application of interest

Industrial

- Requirements:
  - Corrosion Resistance
  - Heat Resistance
  - Electrical Properties
  - Abrasion Resistance
  - Adhesion

- Potential Applications:
  - Electric motor Bearing surfaces
    - ✓ Thrust Pads
    - ✓ Thrust Washers
  - Pipes
  - Valves
  - Pumps
  - Bearing/Bushing surfaces