

Advanced Kirigami: A Comparative Study

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Introduction

Cybermanufacturing

- Requires precision and speed on scalable and highly customized products which has been primarily based on 3D printing or additive manufacturing from wire or powder precursors.
- Such 3D printing is extremely slow and difficult to use in making shell like objects. A large majority of the products are based on creating hollow or shell like objects.
- Kirigami is the art of cutting and bending paper materials, and with additional alterations, this is applicable to polymers and sheet metals.

Objective

Understand the advantages of advanced kirigami against additive manufacturing in the modern cybermanufacturing process.

Methodology

Goal

- Identify the springback angles and fracture of workpieces undergoing physical and chemical deformation.

Physical Machining Process

- Using CNC milling to cut workpieces with different groove height and tool shape.

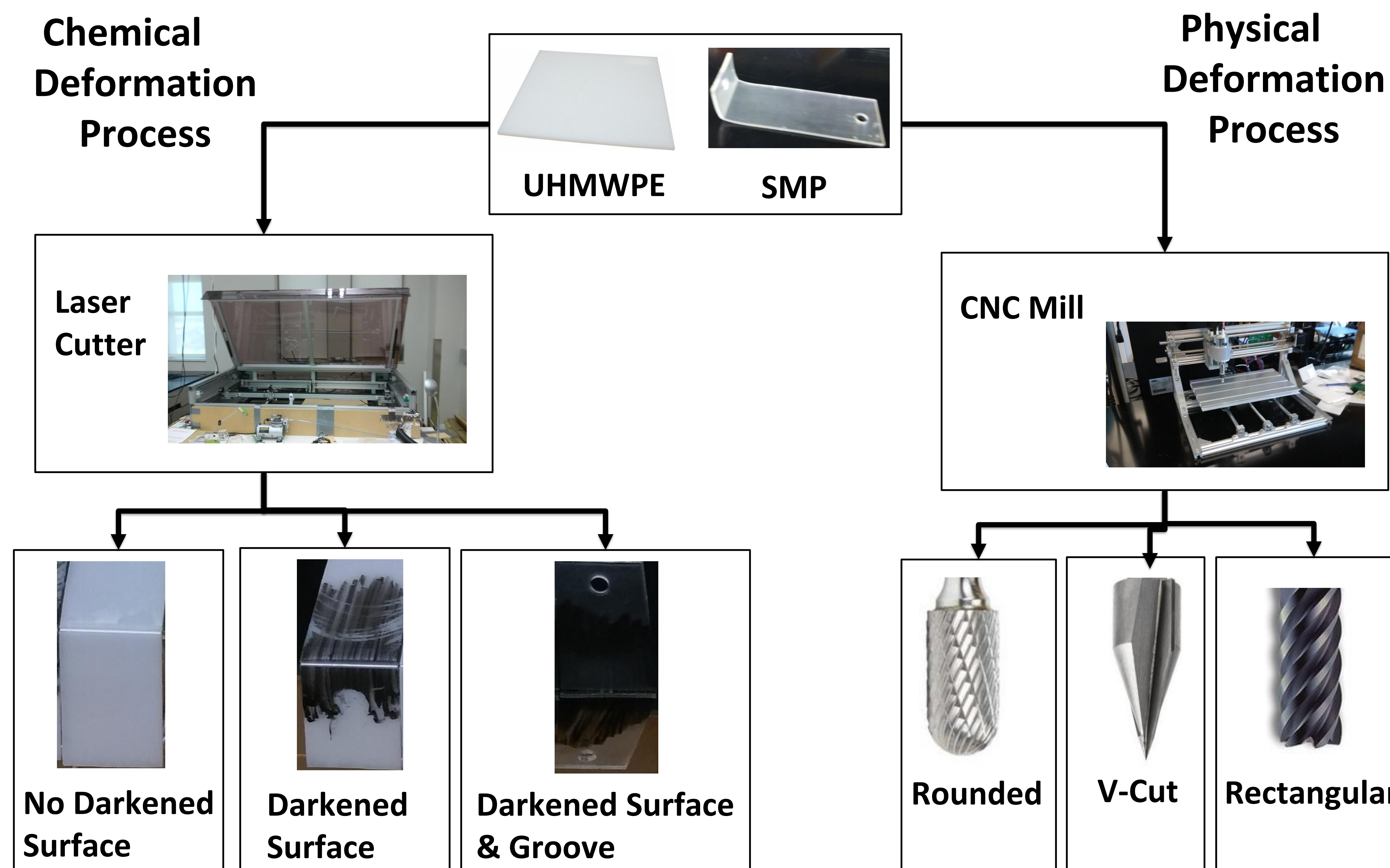
Chemical Machining Process

- Using Lasersaur to burn the material on the surface of workpieces.

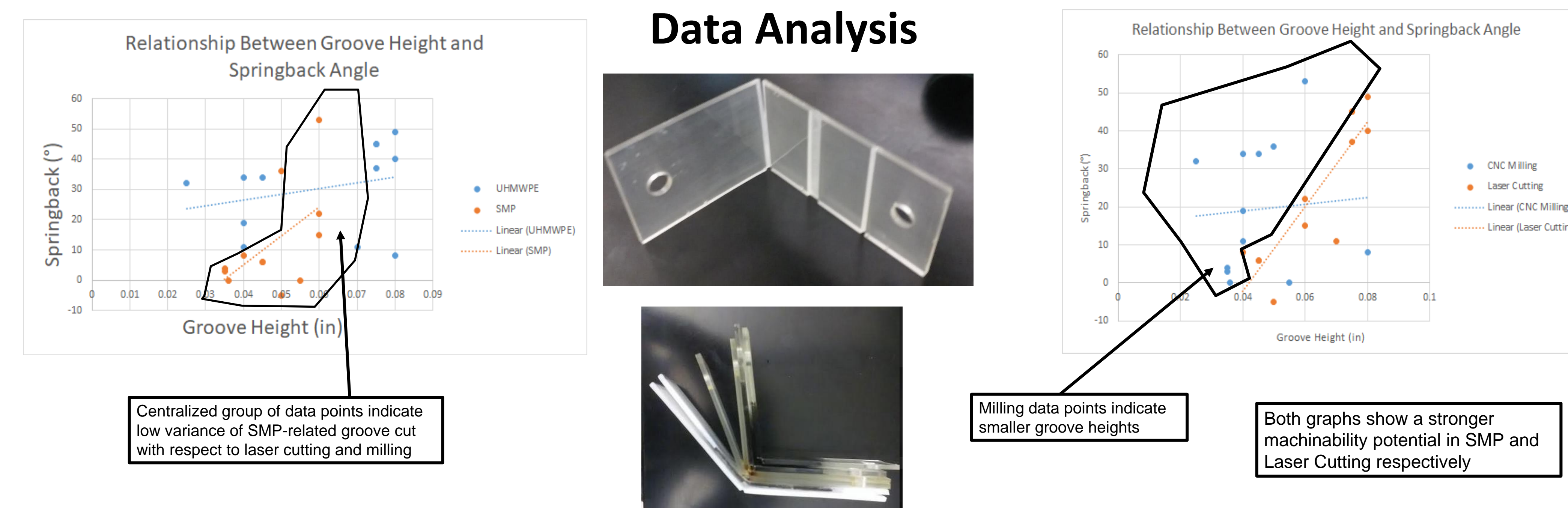
Bending Process

- The workpieces' slot created by physical and chemical method allows a sharper bend.

Test Process



Data Analysis



	Fracture Percentage
CNC Milling	25%
Rectangular	8%
Rounded	0%
V-Cut	17%
Laser Cutting	17%
Blackened	0%
Blackened w/ Groove	8%
NA	8%
SMP	42%
UHMWPE	0%

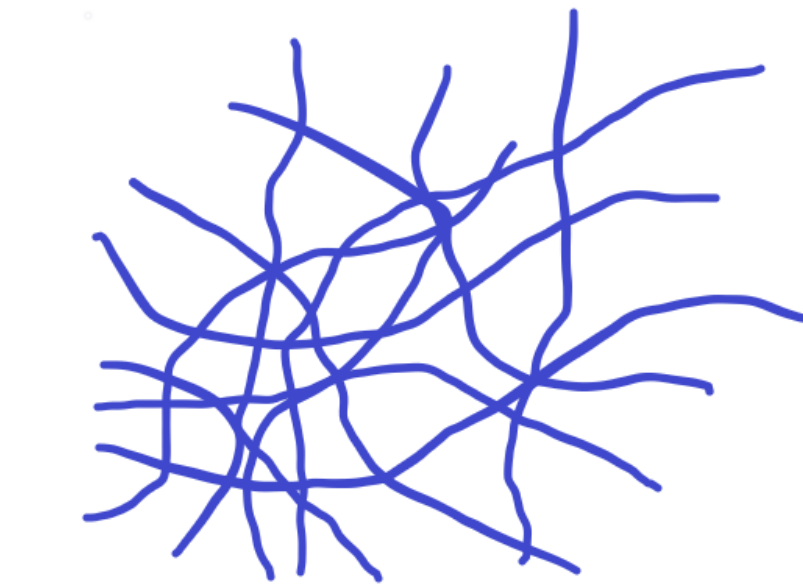


Fixed Angle	Laser Cutting	UHMWPE	SMP	Difference	CNC Milling	UHMWPE	SMP	Difference
	NA	45°	22°	23°		32°	36°	4°
	Blackened	45°	6°	39°		34°	NA	34°
	Blackened w/ Groove	37°	6°	31°		34°	53°	19°
			Avg	31°			Avg	19°
Timed	Laser Cutting	UHMWPE	SMP	Difference	CNC Milling	UHMWPE	SMP	Difference
	NA	11°	<1°	16°		6°	3°	5°
			Avg	16°				
						19°	4°	15°
						11°	NA	11°
							Avg	10°

Fracture

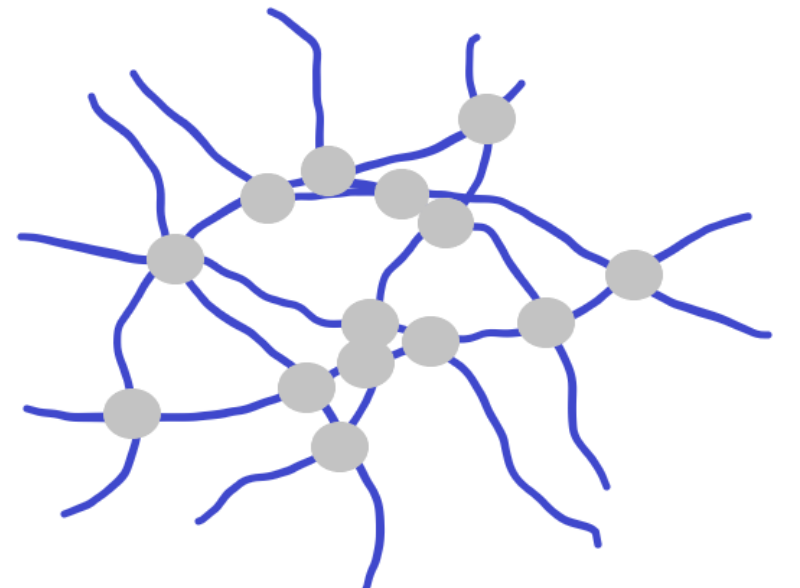
UHMWPE Vs. SMP

Thermoplastic - UHMWPE



- Tough, high stress-resistant material
- Can reshape many times over
- Held by Van Der Waals forces

Thermoset - SMP



- Resistant to temperature and chemical changes
- Can only reshape once
- Held by strong covalent bonds & cross-linked

Conclusion

- The UHMWPE has its best performance¹ on the physical deformation process by CNC Milling with the rounded groove-shape pattern due to its ability to reshape.
- The SMP has its best performance¹ on the chemical deformation process by laser cutting with the blackened surface
- The CNC milled SMP with the V-Cut has the most fractures.
- The laser cut SMP with a blackened surface had the best performance¹ overall.

1 – Best refers to lowest springback angle, greatest bend angle, and least amount of fracturing

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