Forming - Metals

	Steps of Process	Pros	Cons	Suitable For	
				Metal	Ceramic
Forging (鍛造)	1. Heating the metal 2. Shaping using press and force 3. Cooling	- Cheap -High production rate	- High tooling cost - Can't form complex shape	V	Due to the requirement of high heat and plastic deformation, making it less applicable to the brittle nature of ceramics.
Investment Casting (熔模鑄造)	Produce master pattern (母膜)→Mouldmaking→Wax injection→Wax pattern→Investment (coating, stuccoing 灰泥, hardening)→Sintering→Pouring→Remove →Finish Pattern mould→wax injection→wax pattern→investment→ de-wax→casting→remove shell and core→component	-Smooth surface -Complex forms	- Multi-stage and complex process - Costly	V	V
Machining (Milling) (研磨)	Rotate the cutters to remove material	-Customized -Complex designs	- Material waste - Slow - Costly	V	V
CNC	CNC machine→Automatic cutting to remove materials	- Stable quality - Efficient for high precision	- High initial cost (初始成本高因爲自動儀器貴)	V	V
Power metallurgy	Mix metal powders →Press into shape→ Sintering	- Minimal material waste - Mass production	- Limited size	V	V
Selective Laser Sintering (SLS)	Spread metal powder layer → Laser sinters selected areas →Repeat layers	Complex shape - No need for molds	- High energy consumption - Surface may be rough	V	V

Forming – Ceramics

		Steps of Process		Pros	Cons
Press forming		Place powder in a mold→High pressure → compress powder → Shaped		- Mass production - Produces dense, uniform parts	- Cannot make complex shape formation - High tooling costs（模具成本高）
Extrusion forming		Prepare ceramic paste 陶瓷漿→Extrude to form shape→ Dry and fire		- Suitable for symmetry and long shape - High production rate	- Limited to shapes - Shrinkage during drying
Slip casting		Prepare ceramic paste→ Pour into a porous mold→Water is absorbed, forming a solid layer→ Remove and fire the cast		- Complex shapes - Low tooling cost	- Slow process - Limited control the final density
Sintering		Prepare powder→ Press into shape→Sintering→Cooling		- Improves mechanical properties - Reduces porosity	- Precise temperature control - Time-consuming
Plasma-sprayed coating	HAp	To improve bioactivity	Inject ceramic powder into a plasma jet→ sprayed onto a surface→ solidifies	- Create dense, high-quality coatings - Applicable to various substrates	- High equipment cost - Can produce thermal stresses
	Sol-gel	improve mechanical strength, biocompatibility			

Summary（總結）:

- Press forming（壓制成型）是適合大量生產的工藝，但僅適用於簡單形狀。
- Extrusion forming（擠出成型）快速且適合製造長條形部件，但限制於橫截面均勻的形狀。
- Slip casting（注漿成型）是製造複雜形狀的好選擇，但過程較慢。
- Sintering（燒結）改善了陶瓷部件的機械性能，但需要精確的溫度控制。
- Plasma-sprayed coating（等離子噴塗塗層）則適用於創造高質量塗層，特別適用於熱障和生物醫療應用，但設備成本高。