Collaborative Engineering

Manufacturing Process - TKP

- Product Function
- Compatibility & Capability
- Mfg. Process TKP
- Mfg. Route Details

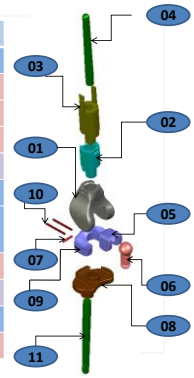
OrthoCAD Lab, I.I.T. Bombay

TKP Bio-Material – Characteristics

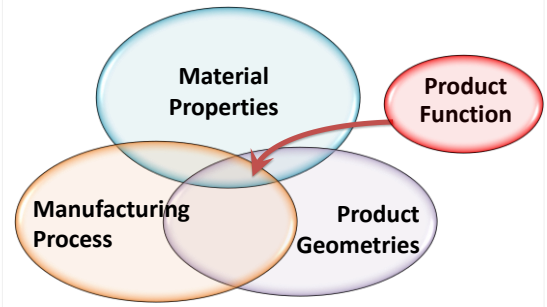
Characteristics	Stainless Steel - 316L	Ti-6Al-4V	Cobalt - Chromium	UHMW-PE
Stiffness	High	Low	Medium	Low
Strength	Medium	High	Medium	Medium
Corrosion Resistance	Low	Medium	High	High
Manufacturing Efficiency	High	Low	Medium	High
Bio-compatibility	Low	High	Medium	Medium
Fatigue Strength	Medium	High	High	Medium

Materials of Components

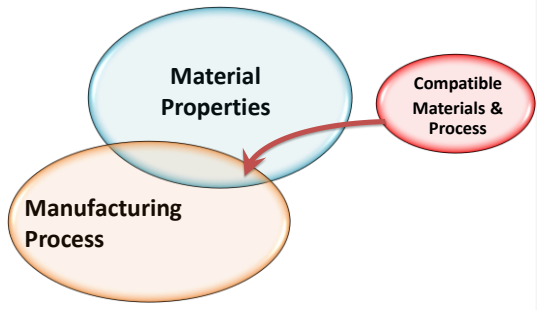
S.No	Part ID	Description	Qty	Material
01	FC	Femoral condyle	01	CoCrMo
02	FE	Femoral extension	01	Ti-6Al-4V
03	FR	Fork	01	Ti-6Al-4V
04	FS	Femoral stem	01	Ti-6Al-4V
05	BB	Bearing bush	01	UHMWPE
06	BP	Bearing pin	01	CoCrMo
07	BS	Bush locking screw	01	CoCrMo
08	TT	Tibial tray	01	Ti-6Al-4V
09	TP	Tibial poly	01	UHMWPE
10	PS	Pin locking screw	02	CoCrMo
11	TS	Tibial stem	01	Ti-6Al-4V



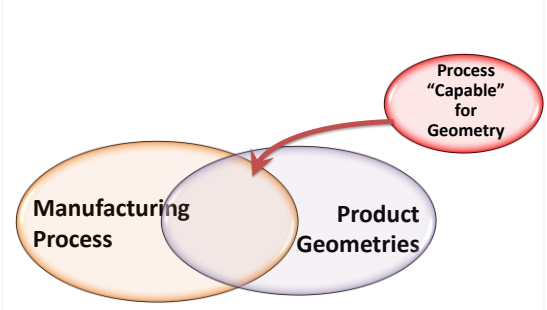
Product Function is Interdependent



Product Function is Interdependent



Product Function is Interdependent

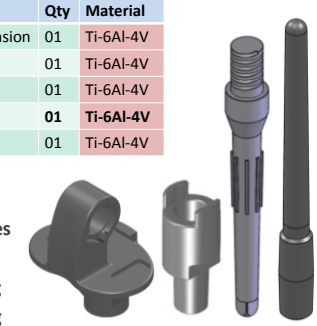


TKP: Manufacturing Process

- Machining – Removal
- Rapid Prototyping – Additive
- Casting & Molding – Remodeling (Heat)
- Forming, Shaping – Altering Geometry (Force, Temperature)
- Welding, Soldering – Assembly
- Finishing – Coating, Smoothening

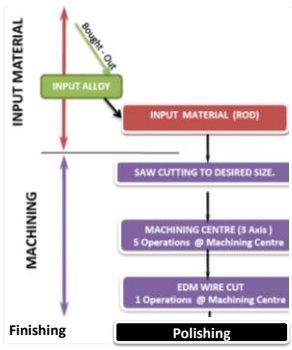
TKP: Manufacturing Process

S.No	Part ID	Description	Qty	Material
02	FE	Femoral extension	01	Ti-6Al-4V
03	FR	Fork	01	Ti-6Al-4V
04	FS	Femoral stem	01	Ti-6Al-4V
08	**TT**	**Tibial tray**	**01**	**Ti-6Al-4V**
11	TS	Tibial stem	01	Ti-6Al-4V



- Geometry
  - Cylindrical
  - Symmetrical Shapes
- Material – Ti 6Al 4V
  - Ease for machining
  - Difficult for casting

CNC Machining



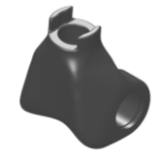
Tibial Tray

- M/c: Makino Max 65S,
- Electronica Wire Cut
- Material: Ti6Al4V
- Time: 28 hrs 45 min

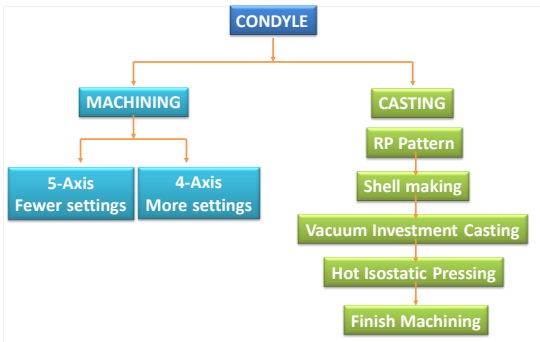
TKP: Manufacturing Process

S.No	Part ID	Description	Qty	Material
01	**FC**	**Femoral condyle**	**01**	**CoCrMo**
06	BP	Bearing pin	01	CoCrMo
07	BS	Bush locking screw	01	CoCrMo
10	PS	Pin locking screw	02	CoCrMo

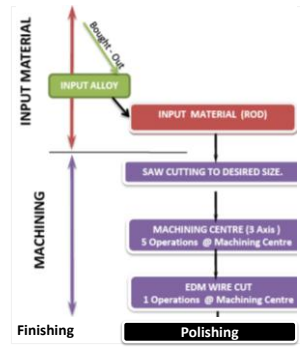
- Geometry
  - Complex Curvatures
  - High surface finish
- Material – Co-Cr-Mo
  - Difficulty in machining
  - Casting process needs standardization



TKP: Manufacturing Routes



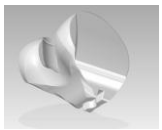
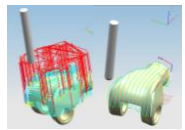
CNC Machining

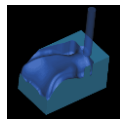


Condyle

- M/c: Makino Max 65S,
- Material: CoCr
- Time: 32 hrs 30 min

TKP: Condyle Machining Planning

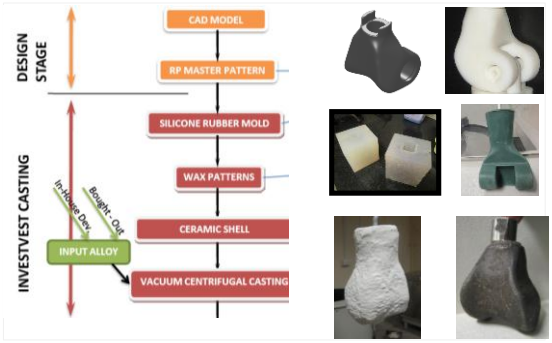

CAD Model | CAM: Tool path | Machining

Investment Casting

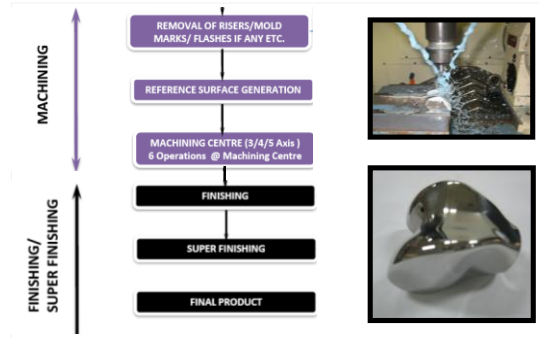
- TKP – Functional Material
  - Co-Cr Condyle
  - Near net rapid casting route

- Co-28Cr-6Mo – ASTM F75 (UNS R30075)
- Alloy Developed in-house
- Achieved by > 1750°C & nominal Vacuum levels
- Uniform Dissolution & Distribution - Mo & Cr in Co
- Porosity Free Casting
- Less Machining Required on Condyle surface

Investment Casting



Investment Casting

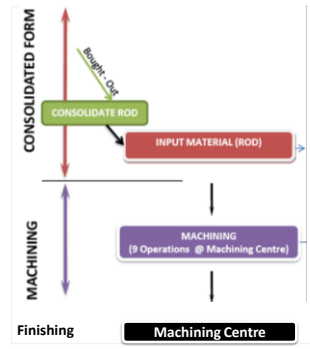


TKP: Manufacturing Process

S.No	Part ID	Description	Qty	Material
05	BB	Bearing bush	01	UHMWPE
09	**TP**	**Tibial poly**	**01**	**UHMWPE**

- Geometry
  - Complex Curvatures
  - High surface finish
- Material – UHMWPE
  - Difficulty in forming
  - Difficulty in machining

CNC Machining



Tibial Poly

- M/c: Makino Max 65S
- Milling Center
- Material: UHMWPE
- Time: 6 hrs

Hot Forming – UHMWPE

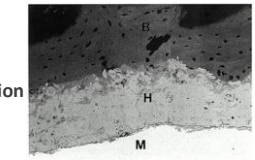
- TKP – Functional Material
  - UHMWPE Finishing
  - Hot forming / Machining

- Imported as Extruded Rods/ Compression Molded Sheets
- Roughness optimized 0.35 – 0.4 microns
- Process Parameters Optimized (10 Trials)
- Forming Thickness (~ 2mm)
- Job-Material Time Temperature Relationship
- Die @ 600°C & UHMWPE @ RT

Osteo – Integration

- "Hydroxyapatite" – porous calcium phosphate ceramic
- Pore size
- Pore type
- Surface roughness
- Growth factors/ inhibitors
- Drug deliver

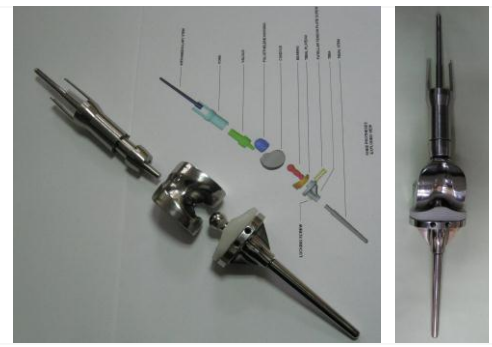
- BONE GROWTH – Bio-integration
- Mfg - Plasma Spray



M-Metal Substrate, H- Hydroxyapatite, B-Bone

TKP Parts – Functional Materials

TKP Assembled – Functional Materials



SUMMARY

- Materials compatible Selection
- Shape capable process identification
- Optimization/ Standardization of parameters
- Process sequencing and planning