

# Cobalt based – medical focus

## Material properties

- + resistant to wear  
(hard material 45-50 HRC).
- + can be cast into complex shapes.
- + high corrosion resistance.
- + stronger than stainless steel.
- twice the weight of stainless steel.
- very brittle under impact loading.

The cobalt-based alloys in the medical area are mainly of two types: CoCrMo and CoNiCrMo.

CoCrMo alloys are used in applications such as fixation screws, bone plates, shoulder, knee and hip replacement (coated or uncoated, cemented or uncemented).

In this chapter of the application guide we focus on the machining of hip joints in the material group CoCrMo.



## Chemical compositions of a few Co-based alloys for implants

### CoCr28Mo6 ASTM F75

Vitallium (Howmedica, Inc)  
Haynes-Stellite 21 (Cabot Corp.)  
Protasul-2 (Sulzer AG)  
Micrograin-Zimaloy (Zimmer)

Co	Cr	Mo	Mn	Si	Ni	Fe	C
58.9–69.5	27.0–30.0	5.0–7.0	Max 1.0	Max 1.0	Max 1.0	Max 0.75	Max 0.35

### CoCrMo ASTM F799

Forged CoCrMo  
Thermomechanical CoCrMo  
FHS (Forged high strength)

Co	Cr	Mo	Mn	Si	Ni	Fe	C	N
58–59	26.0–30.0	5.0–7.0	Max 1.0	Max 1.0	Max 1.0	Max 1.5	Max 0.35	Max 0.25

# Process considerations

## Component condition

The forgings are manufactured from castings or bar stock. This has some impact on the process, whilst the cast blank has less material to remove, the tough skin, with a certain degree of ovality, can cause difficulties if the insert is not fully engaged on the first pass. Bar stock requires much more material to be removed and normally there is a drilling operation to remove the bulk – see engineered solution page 58.

## Machining limitations

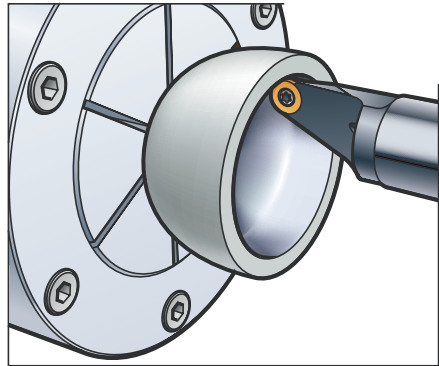
The process method and productivity are limited by the poor machinability of the material, difficult to access the internal sphere and also weak fixturing. Normally the casting has a spigot for fixturing whilst machining the internal feature, this spigot is later removed.

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## Machining stage – classification

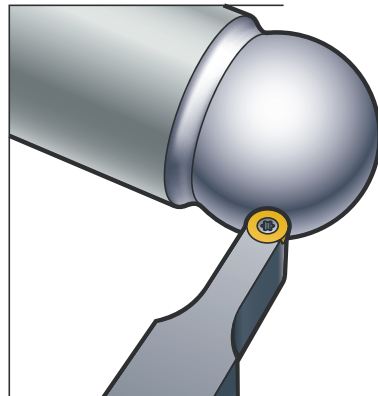
### Process/operation 1 – Internal cup

- Rough drilling – bar stock.
- Rough turning – up to 1 mm depth of cut.
- Semi-finish turning – 0.1–0.15 mm depth of cut.
- Finish turning – 0.05–0.15 mm depth of cut.
- Part off spigot.



### Process/operation 2 – External head

- Rough turning – up to 1 mm depth of cut.
- Semi-finish turning – 0.1–0.25 mm depth of cut.
- Finish turning – 0.05–0.15 mm depth of cut.
- Part off – bar stock.

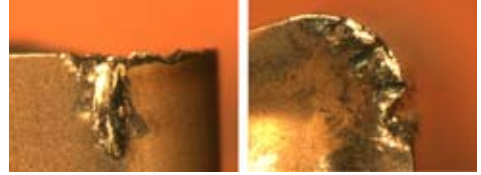


# Typical wear mechanisms

## Notch wear

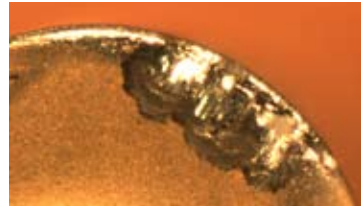
A mechanical wear which is concentrated at the depth of cut. This wear reduces the tool life drastically and produces a burr on the component.

**Remedy:** It is an application related wear which is easiest solved by changing the entering angle (insert shape) rather than insert grade.



## Abrasive wear

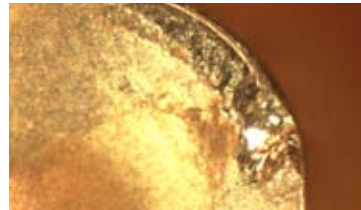
Mainly caused by the hard particles in the workpiece material rubbing or grinding the edge.



## Crater wear

Formed through the tool material being removed from the chip face by the hard particle grinding action.

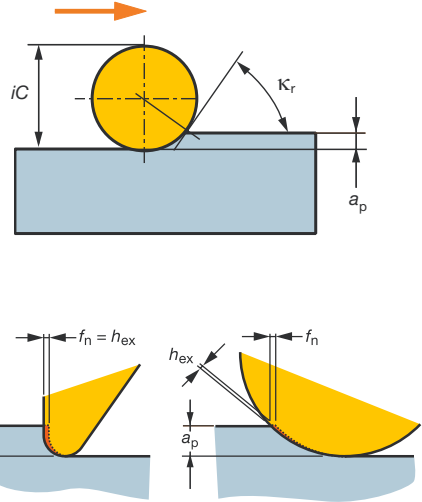
**Remedy:** Select a positive insert geometry. Reduce the speed to obtain a lower temperature.



# Insert shape selection

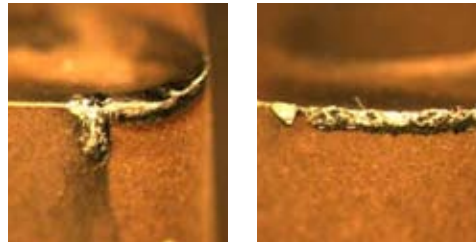
From the wear mechanisms it can be seen that a reduction in entering angle ( $\kappa_r$ ) has two clear advantages:

- Notch wear reduced giving longer more predictable wear with improved productivity.
- Reduced chip thickness – with a V or D style insert the chip thickness ( $h_{ex}$ ) is the same as the feed and the cutting length is the same as the depth of cut. Using a depth of cut below the radius reduces the chip thickness relative to feed and increases the cutting edge length. These give the end result of lower temperature and hence longer cutting length and high productivity capability.



A reduction in entering angle without reducing the depth of cut is best achieved by using a large radius – in practical terms a round insert.

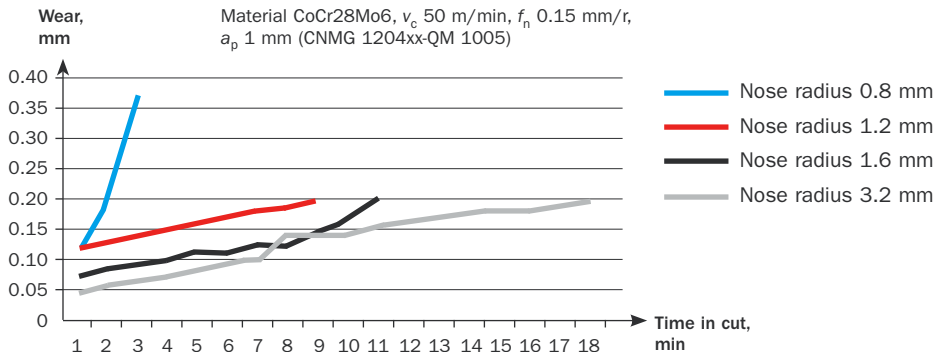
The diagram below shows the effect of the nose radius on tool life. An increase of 6 fold with the same grade.



Tool life: 3 min.  
Radius: 0.8 mm

Tool life: 18 min.  
Radius: 3.2 mm

## Effect of nose radius



# Optimised tools for internal machining

To capture the advantages offered by applying large radii, Sandvik Coromant has developed a range of tools which will pioneer traditional processes, giving both increased productivity and tool life.

Two available in styles:

Insert style	Insert size, mm	Boring bar diameter, mm
DCMT	11	20
Round	8 and 10	20

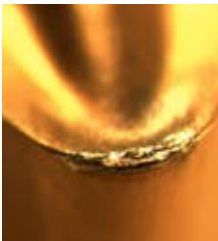
$v_c$  70 m/min,  $f_n$  0.1 mm/r,  $a_p$  0.5 mm, material cobalt chromium



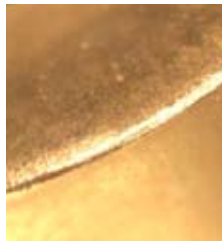
Holder: A20M-ADXCL 11-R  
Insert: DCGT 11T308-UM 1025



Holder: A20M-SRXDL 08-R  
Insert: R300-0828E-PL 1030



1 component.



10 components.

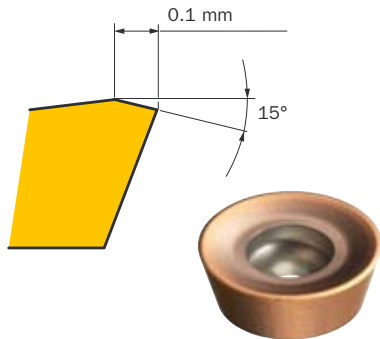
## Round insert geometries

- R300-0828E-PL 1030
- R300-1032E-PL 1030

+ periphery ground.

+ light cutting.

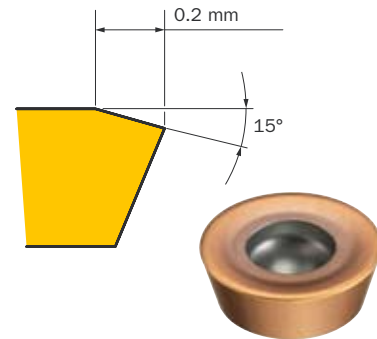
+ low vibration/cutting forces



- R300-0828E-PH 1030
- R300-1032E-PH 1030

+ direct pressed.

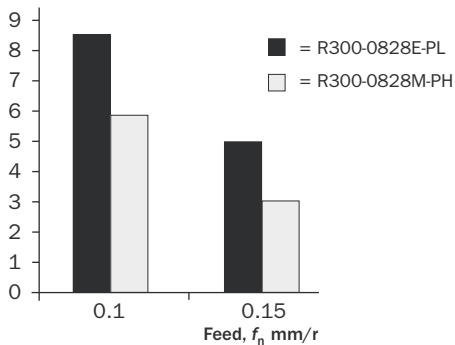
+ need of stable fixture.



## Effect of feed

Facing to centre – Cobalt chromium  
 $D_c$  46 mm,  $v_c$  70 m/min,  $a_p$  0.5 mm, GC1030

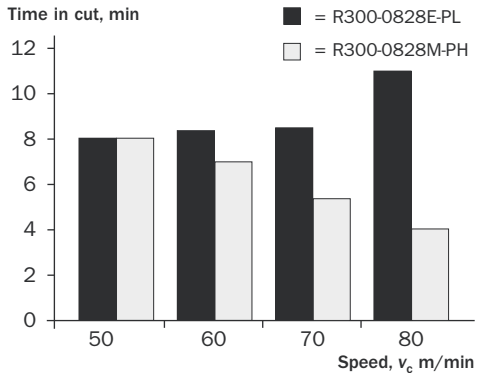
Time in cut, min



## Effect of speed

Facing to centre – Cobalt chromium  
 $D_c$  46 mm,  $f_n$  0.1 mm/r,  $a_p$  0.5 mm, GC1030

Time in cut, min



$D_m$  46 mm

**Example:**  
 At  $v_c$  70 m/min,  $f_n$  0.1 mm/r,  
 time per pass would be 29 sec.  
 At  $v_c$  70 m/min,  $f_n$  0.15 mm/r,  
 time per pass would be 20 sec.

$D_m$  46 mm

**Example:**  
 At  $v_c$  50 m/min,  $f_n$  0.1 mm/r,  
 time per pass would be 41 sec.  
 At  $v_c$  80 m/min,  $f_n$  0.1 mm/r,  
 time per pass would be 25 sec.

# Recommended starting choices for cobalt based HRSA

Machining stage	Feature	1st choice	2nd choice	Cutting speed, m/min	Feed, mm/r	Depth of cut, mm	Metal removal rate cm <sup>3</sup> /min	Insert style
Rough turning	Internal	PL GC1030	PH GC1030	50–80	0.1–0.15	Up to 1.0	12	R300-08
		UM GC1025	UM GC1105	40–60	0.08–0.1	Up to 1.0	6	DCGT 11
	External	SM GC1105	SM S05F*	40–60	0.1–0.15	Up to 1.0	9	RCMT 10
		RO GC1105	RO S05F*	40–60	0.1–0.15	Up to 1.0	9	N123J2-0600
Semi-finish turning	Internal	PL GC1030		50–80	0.1–0.15	0.1–0.25	3	R300-08
		UM GC1105	UM GC1025	40–60	0.08–0.1	0.1–0.25	1.5	DCGT 11
	External	SM GC1105	SM S05F*	40–60	0.1–0.15	0.1–0.25	2.25	RCMT 10
		RO GC1105	RO S05F*	40–60	0.1–0.15	0.1–0.25	2.25	N123J2-0600
		GC1105	S05F*	40–60	0.08–0.12	0.1–0.25	1.8	DNGP
Finish turning	Internal	PM CT530	PL GC1030	40–60	0.08–0.12	0.05–0.15	1.1	R300-08
		UM GC1105	UM GC1025	40–60	0.08–0.1	0.05–0.15	0.9	DCGT 11
	External	GC1105	S05F*	40–60	0.08–0.15	0.05–0.15	1.35	DNGP
Parting		CM GC4125		40–60	0.05–0.1	–		N123G2-0300-0002
Grooving		GF GC1105		40–60	0.05–0.1	–		N123G2-0300-0002

\*S05F not recommended for facing to centre.

## Carbide insert grades

- GC1025 – PVD (TiAlN) coated micro-grained carbide.
  - Recommended for low speeds – good resistance to thermal shock and notch wear.
- GC1030 – Unique multi-layer PVD (TiAlN) coating.
  - Improved wear resistance over GC1025 with same toughness. High edge line security.
- GC1105 – Unique thin PVD (TiAlN) coating on hard fine grained substrate.
  - Excellent adhesion to the substrate even on sharp edges, good hot hardness.
- S05F – Thin CVD coating on hard fine grained substrate.
  - For applications where notch is not a significant problem ie round insert and finishing with small entering angle.
- CT530 – Uncoated cermet grade.
  - For finishing operations.
- GC1525 – A PVD (TiAlN) coated cermet.
  - Very high wear resistance and good edge toughness.
- GC4125 – PVD coated (TiAlN) fine grained substrate.
  - First choice for parting-off operations.

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## Engineered solution

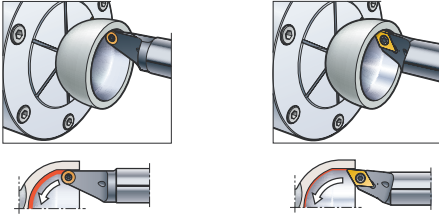
Developed to optimise the roughing from bar stock.

- Engineered Coromant U drill – dia 34 mm (000 441252R28)
  - WCMX 050308R-53, GC1020, H13A
- Start cutting data recommendation for titanium and cobalt chromium.
  - Speed  $v_c = 50-80$  m/min.
  - Feed  $f_n = 0.08-0.12$  mm/r.



# Sandvik Coromant component/feature solutions

Cups with small radius requirement and/or unstable fixturing (min. dia = 34 mm)



## Roughing



Holder: A20M-SRXDR 08-R  
 Insert: R300-0828E-PL 1030  
 Cutting data:  $v_c = 50\text{--}80$  m/min,  
 $f_n = 0.1\text{--}0.15$  mm/r,  $a_p \leq 1$  mm

## Semi-finishing



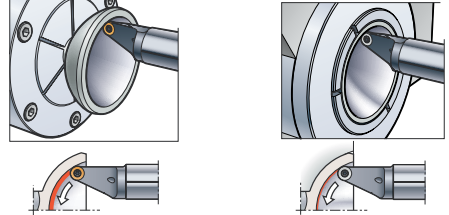
Holder: A20M-SDXCR 11-R  
 Insert: DCGT11T308-UM 1105  
 Cutting data:  $v_c = 40\text{--}60$  m/min,  
 $f_n = 0.08\text{--}0.1$  mm/r,  $a_p = 0.1\text{--}0.25$  mm

## Finishing



Holder: A20M-SDXCR 11-R  
 Insert: DCGT11T308-UM 1105  
 Cutting data:  $v_c = 40\text{--}60$  m/min,  
 $f_n = 0.08\text{--}0.1$  mm/r,  $a_p = 0.05\text{--}0.15$  mm

Cups with no radii restrictions and/or stable fixture (min. dia = 34 mm)



## Roughing



Holder: A20M-SRXDR 08-R  
 Insert: R300-0828E-PL 1030  
 Cutting data:  $v_c = 50\text{--}80$  m/min,  
 $f_n = 0.1\text{--}0.15$  mm/r,  $a_p \leq 1$  mm

## Semi-finishing



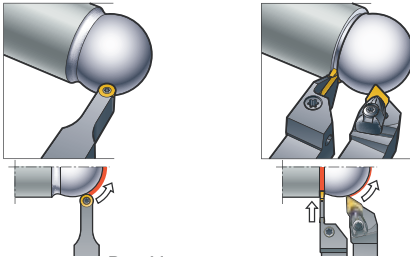
Holder: A20M-SRXDR 08-R  
 Insert: R300-0828E-PL 1030  
 Cutting data:  $v_c = 50\text{--}80$  m/min,  
 $f_n = 0.1\text{--}0.15$  mm/r,  $a_p = 0.1\text{--}0.25$  mm

## Finishing



Holder: A20M-SRXDR 08-R  
 Insert: R300-0828E-PL 530  
 Cutting data:  $v_c = 40\text{--}60$  m/min,  
 $f_n = 0.08\text{--}0.12$  mm/r,  $a_p = 0.05\text{--}0.15$  mm

Producing heads from bar material



## Roughing



Holder: SRDCN 2020K 10-A  
 Insert: RCMT 10 T3 MO-SM 1105  
 Cutting data:  $v_c = 40\text{--}60$  m/min,  
 $f_n = 0.1\text{--}0.15$  mm/rev,  $a_p \leq 1$  mm

## Finishing



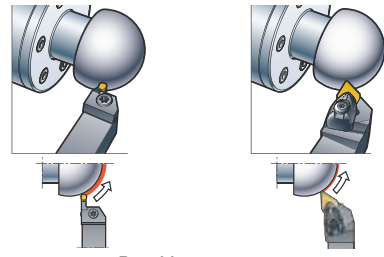
Holder: DDJNR/L 2020K15  
 Insert: DNGP 15 06 08 1105  
 Cutting data:  $v_c = 40\text{--}60$  m/min,  
 $f_n = 0.08\text{--}0.12$  mm/r,  $a_p = 0.05\text{--}0.25$  mm

## Parting off



Holder: RF123F20-1616B  
 Insert: N123F2-0250-0002-CM 4125  
 Cutting data:  $v_c = 40\text{--}60$  m/min,  
 $f_n = 0.05\text{--}0.1$  mm/rev

Producing heads from forged material



## Roughing



Holder: RF123J13-2525MB  
 Insert: N123J2-0600-R0 4125  
 Cutting data:  $v_c = 40\text{--}60$  m/min,  
 $f_n = 0.1\text{--}0.15$  mm/rev,  $a_p \leq 1$  mm

## Finishing



Holder: DDJNR/L 2020K15  
 Insert: DNGP 15 06 08 1105  
 Cutting data:  $v_c = 40\text{--}60$  m/min,  
 $f_n = 0.08\text{--}0.12$  mm/r,  $a_p = 0.05\text{--}0.25$  mm