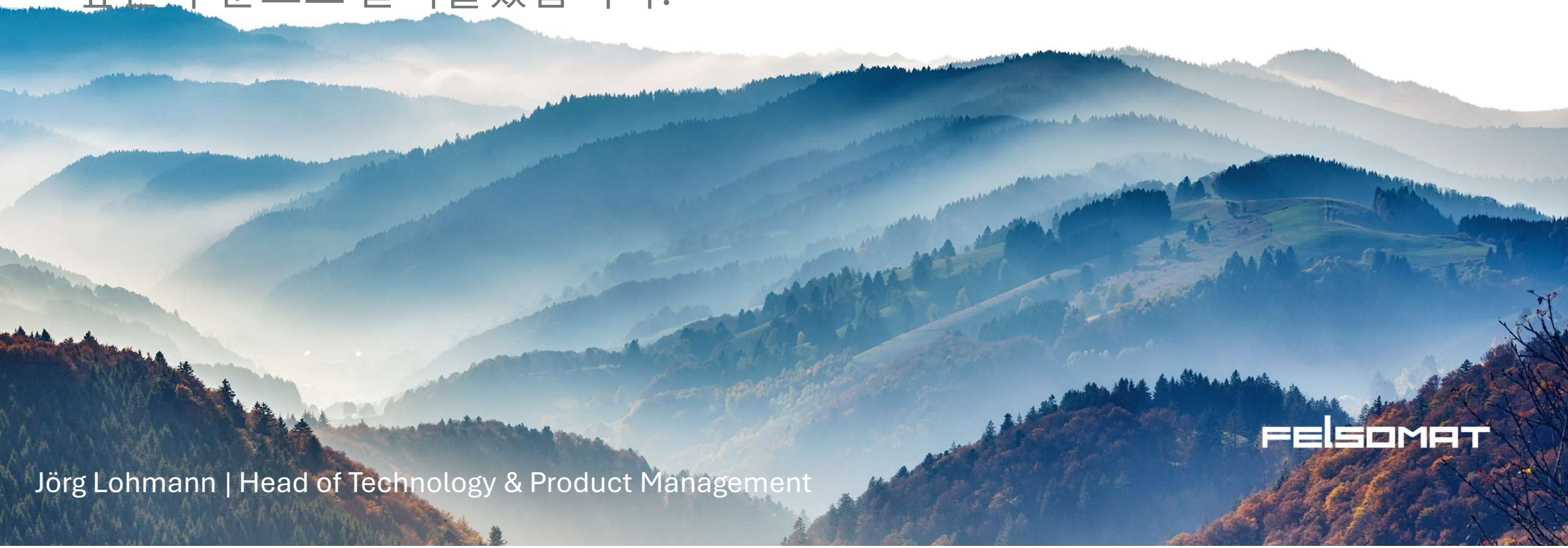
Flexspline hobbing

당사는 하모닉 드라이브용 플렉스 스플라인 호빙 가공 기술을 한 차원 더 높은 수준으로 끌어올렸습니다.



Jörg Lohmann | Head of Technology & Product Management

기어 가공에 중점을 둔
FELSOMAT-Products

기어 제조에 대한 해답

기어의 완전한 가공을 위한 제조 시스템

2 x FTC 240
FELSOMAT Turning Cell
OP10 / 20:

1 x FHC Series
FELSOMAT Hobbing Cell
OP30 / 40:

1 x FLW Series
FELSOMAT Laser Welder
OP50:

1 x FTC 240
FELSOMAT Turning Cell
OP70:

1 x RX YYY
Reishauer Gear Grinding/ Power Skiving
OP80:

OP10 / 20
Turning/ Turning

OP30 /40
Hobbing/ Chamfering

OP50
Joining

OP60
Hardening

OP70
Hard Turning

OP80
Gear Grinding //Hard Skiving

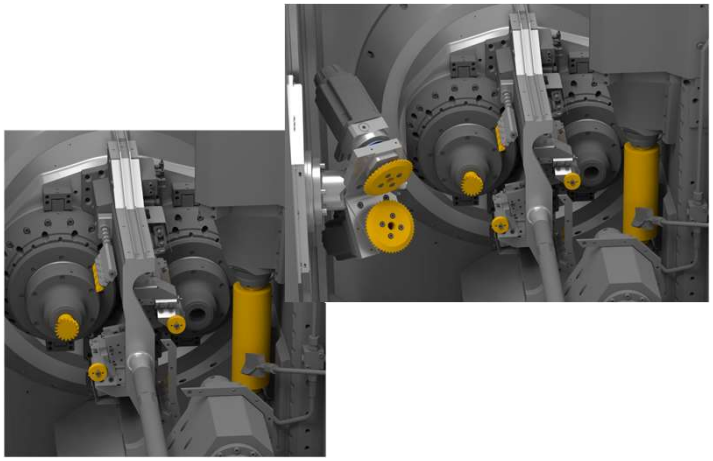
Automation Systems

FELSOMAT

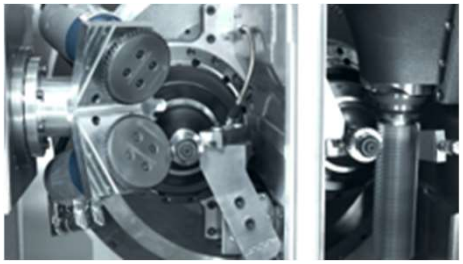
FELSOMAT FHC 80 | FHC 240

호빙 및 챔퍼링 기술의 효율적인 결합

	FHC 80	FHC 240
		
» Basic principle:	Double spindle in a drum	Double spindle in a drum
» Tailstock:	Yes (option)	Yes (option)
» Module:	Max. 3	Max. 5
» Part OD:	Max. 100 mm	Max. 240 mm
» Hob OD:	Max. 70 mm	Max. 100 mm
» Chamfering:	ChamferSkiving (option)	ChamferSkiving (option)



Video



FELSOMAT FHC 80 | FHC 240

FHC 80 – 이중 스핀들 호빙

Video

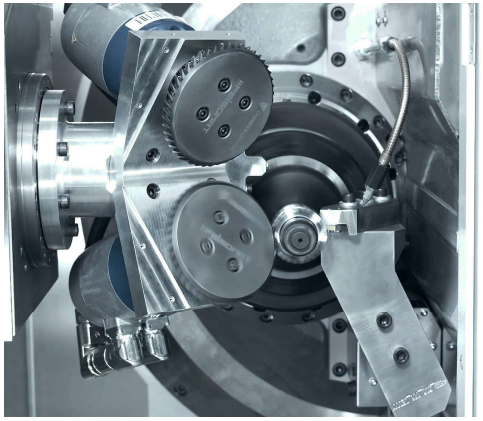
FELSOMAT FHC-Series

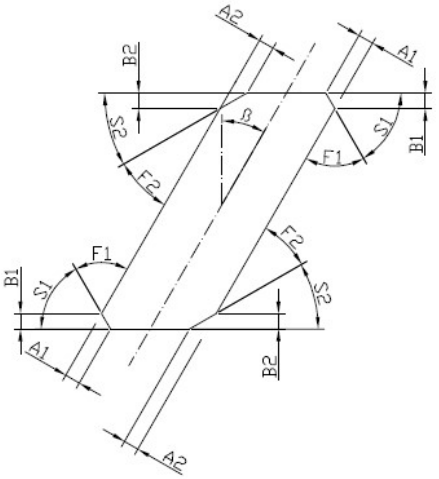
고객의 혜택| USPs

1. 칩 투 칩 타임 2초 미만으로 최고의 생산성을 달성합니다.
   - » 독특한 개념의 이중 스핀들 호빙 방식
   - » 두 스핀들을 이용한 동시 가공
   - » 오리엔테이션, 로딩 등의 작업은 무부하 시간에 수행됩니다.

2. 2차적인 버(Burr) 발생이 없는 가공이 보장됩니다.
   - » ChamferSkiving은 무변형 칩 제거 챔퍼링 기술입니다.
   - » 호빙-챔퍼링-호빙 가공 사이클은 기어 플랭크에 2차적인 버가 없도록 보장합니다.

3. 챔퍼 스키빙: 정밀한 칩 제거 챔퍼링 방식
   - » 일체형 클램핑 - 고도의 정밀도 및 반복성을 제공합니다.
   - » 챔퍼의 형상과 각도를 능동적으로 설계할 수 있습니다.
   - » 효율적인 생산 원가 (부품당 1센트 미만)

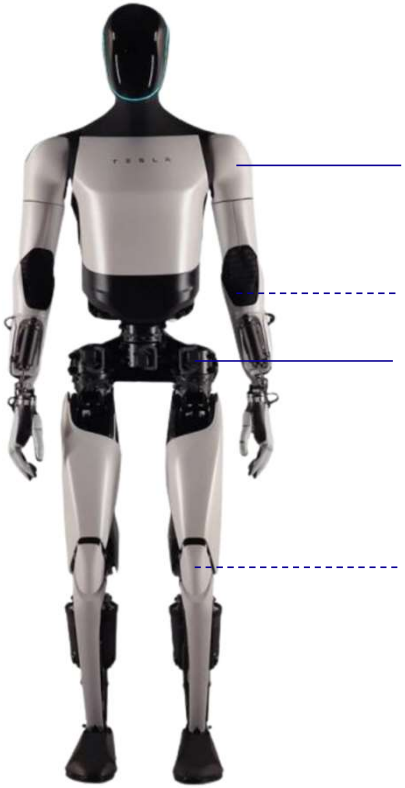




플렉스 스플라인 호빙 기술의 일단계 도약

Harmonic Drives

작동 원리



어깨

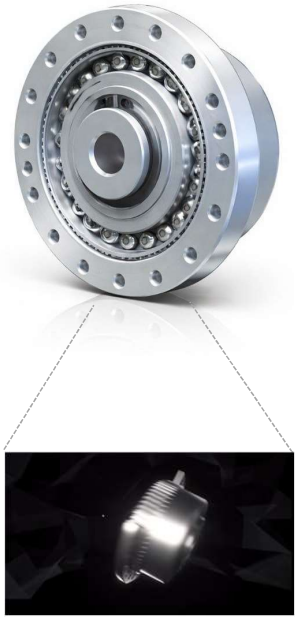
팔꿈치

골반

무릎

Source: Tesla Optimus / www.tesla.com

Harmonic Drive Gearbox



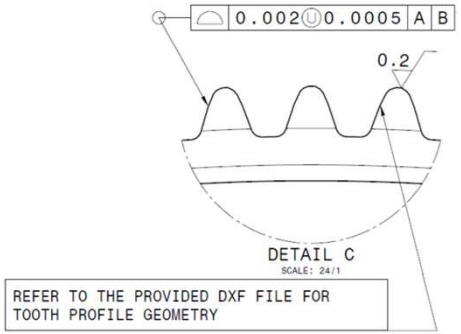
Source: www.harmonicdrive.de

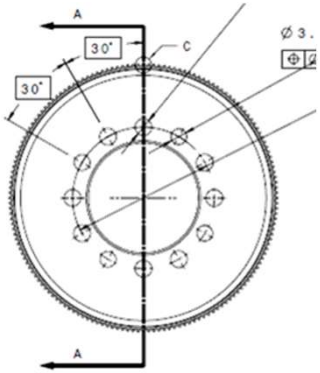
- Wave Generator
- **Flex Spline**
- Circular Spline

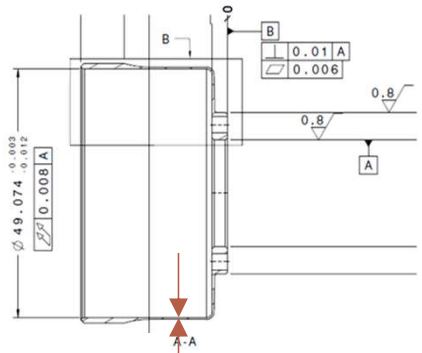
Harmonic Drives

Flex Splines | 특성 및 기어 데이타

Gear data (DIN ISO 21771:2022-05)			
Material:	Spring steel, tempered		
Module:	M_n	0,30	mm
No. of teeth:	z	180	-
Pressure angle:	α	~ 30,0	°
Tip-Ø:	d_a	51,3	mm
Root-Ø:	d_f	50,0	mm
Tooth height:	h_z	0,65	mm
Gear length:	b	9,0	mm







Wall-thickness < 0,4 mm

Flex Spline hobbing

Benchmark | 최첨단 솔루션

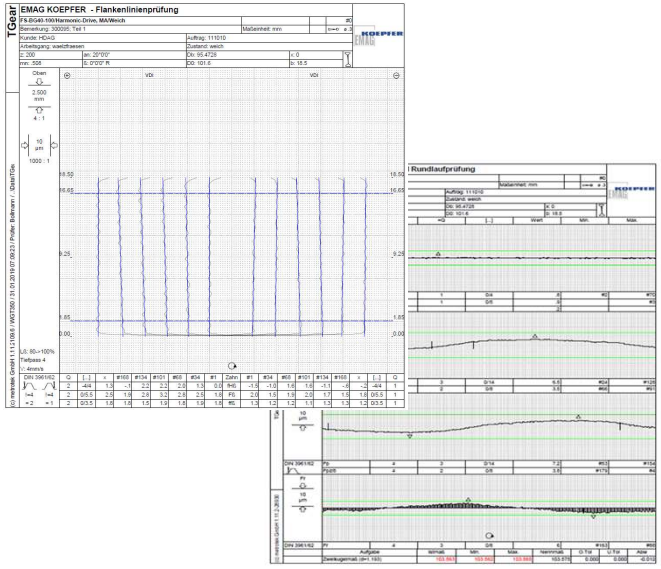
Hobbing Machine
E사 hobbing machine

공정 상세:

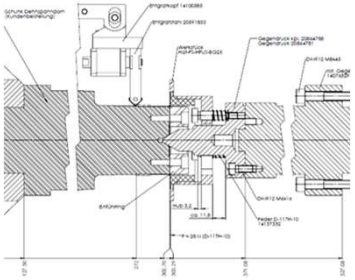
- Single spindle machine
- Wet hobbing
- Hob TC Ø 40 x 160/155 x Ø22
- No. of starts: 3 with 12 gashes
- Accuracy class: “AAAA” DIN 3972
- Hydraulically exp. mandrel (Schunk)
- Cycle time: 64 sec.
  → thereof 12 sec. idle time!

기어 정도:

- Accuracy class 4 (ISO 1328-1:2013)



Video



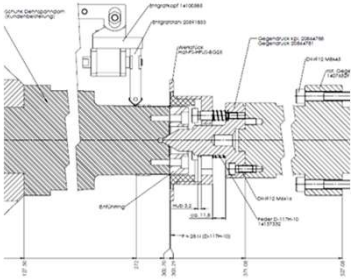
Flex Spline hobbing

Benchmark | 최첨단 솔루션

Hobbing Machine
E사 hobbing machine

공정 상세:

- ~~Single spindle machine~~
- ~~Wet hobbing~~
- Hob TC ~~Ø 40 x 160/155 x Ø22~~
- No. of starts: ~~3 with 12 gashes~~
- Accuracy class: “AAAA” DIN 3972
- Hydraulically exp. mandrel (Schunk)
- Cycle time: 64 sec.
  → thereof 12 sec. idle time!



FELSOMAT
새로운 공정 설계

- → **Double** spindle machine – idle time 1 sec.
- → **Dry** hobbing – increase cutting speed up to + 30 %
- → Hob TC Ø **Z0** x **180/175** x Ø22
- → Increase no. of starts to **X** with **Y** gashes

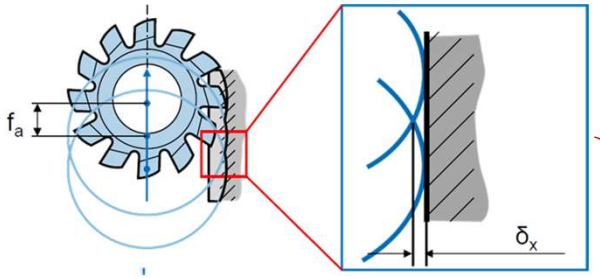
spinning/centriguation 및 blow-off 과정 생략.
cycle time 감소 – 생산성 증가!

Flex Spline hobbing

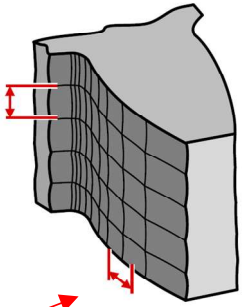
새로운 FELSOMAT Process 설계 | 차세대

호브의 매크로 형상을 변경하여 정밀도의 손실이 없이 생산 시간 절감 실현

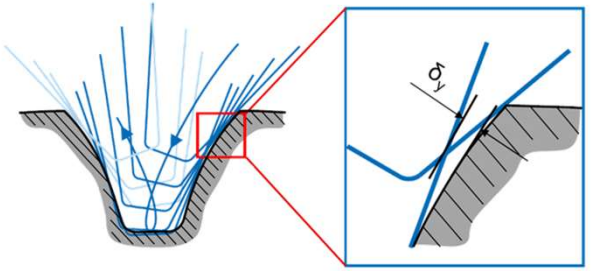
δ_x = Feed rate scallop mark



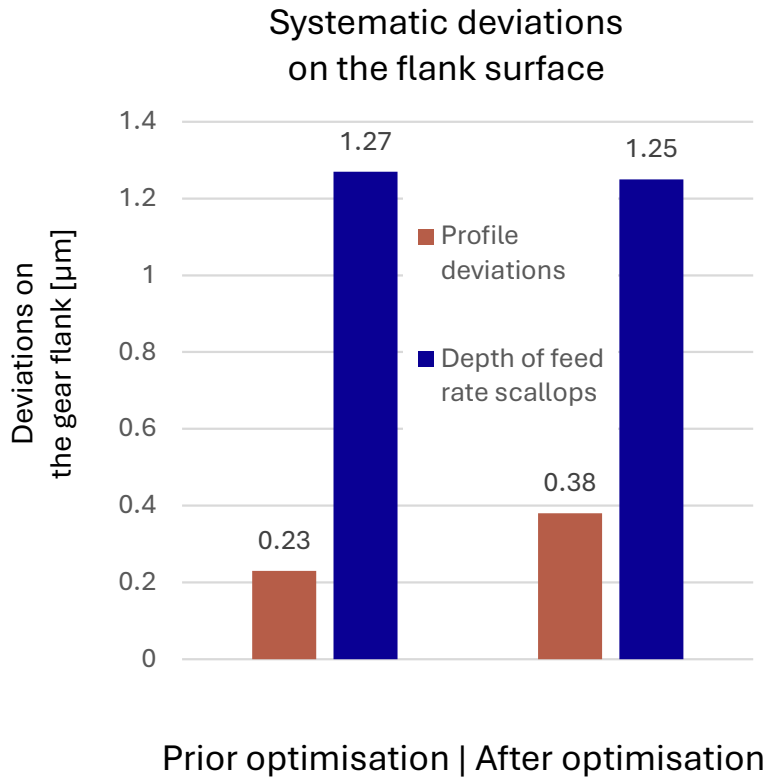
δ_x = Feed rate scallop mark



δ_y = Profile deviations



δ_y = Profile deviations



Flex Spline hobbing

새로운 FELSOMAT Process 설계 | 차세대

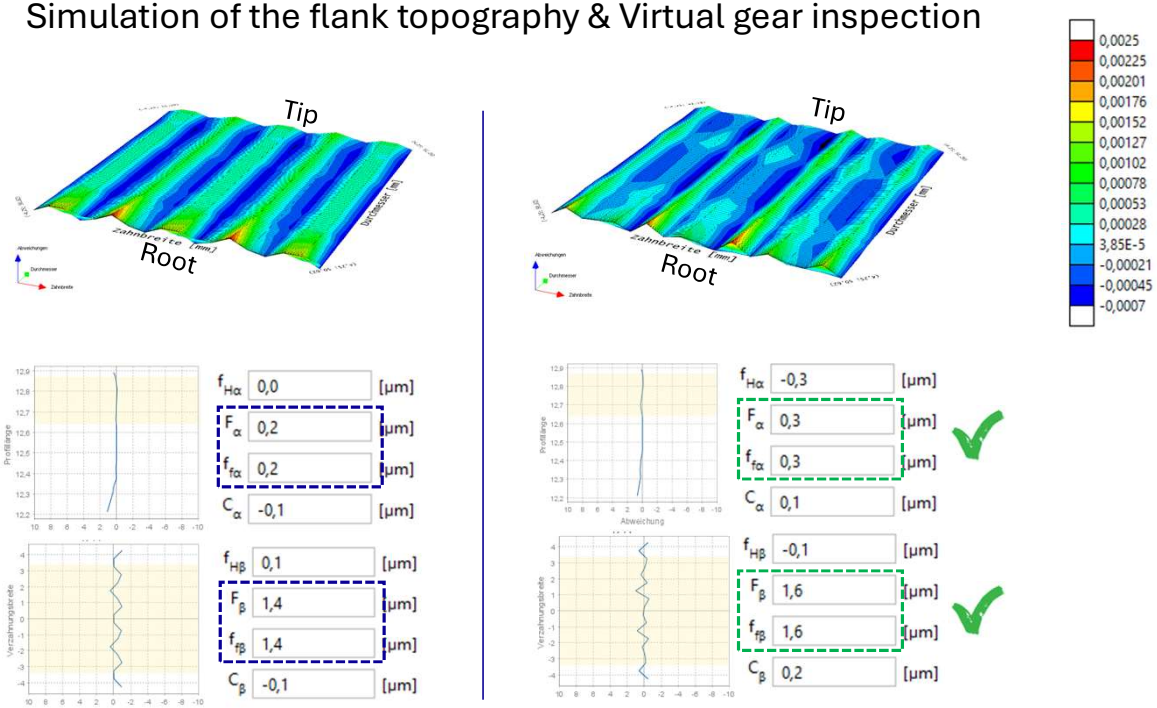
호브의 매크로 형상을 변경하여 정밀도의 손실이 없이 생산 시간 절감 실현

공정 상세:

- 동일한 재질 및 코팅 - 변경 사항 없음
- Hob dimensions Ø 40 x 160/155 x Ø22

  → Ø Z0 x 180/170 x Ø22
- No. of starts: 3 → X
- Qty. of gashes: 12 → XY
- Cutting speed V_c: 250 → 300 m/min
- Axial feed rate S_{ax}: 0,4 → 0,XY mm/wkpc. rev.

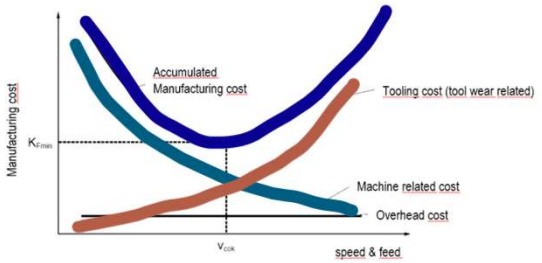
Simulation of the flank topography & Virtual gear inspection



Result of the current process design (left) and after improvement (right)

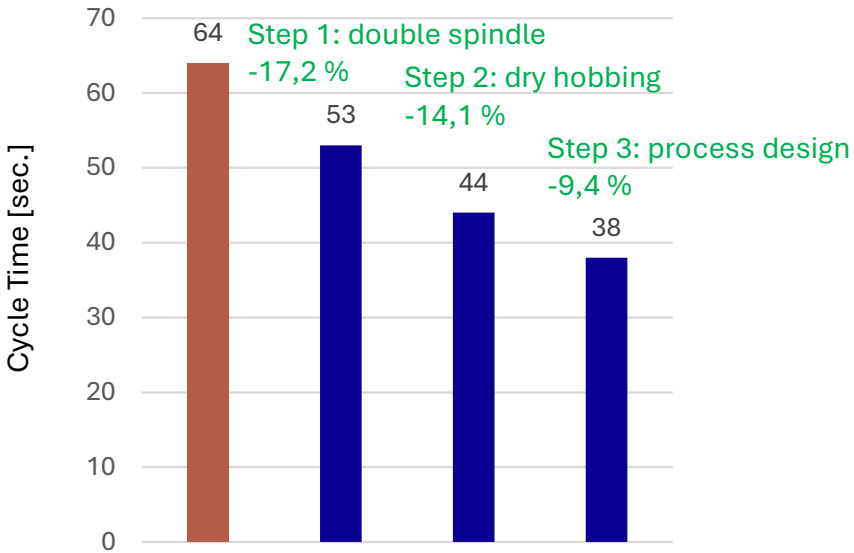
Flex Spline hobbing

사이클 타임 | 생산 단가 고찰

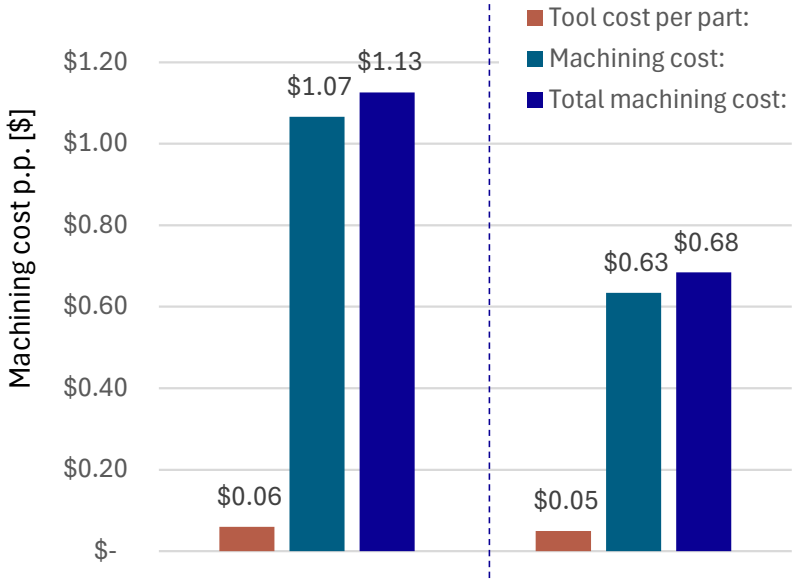


Cost per part

Cycle time reduction



Potential of cycle time reduction: Total - 40.6 %

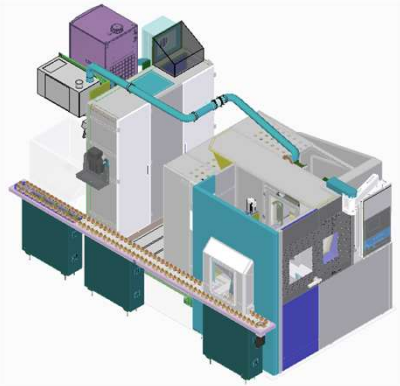


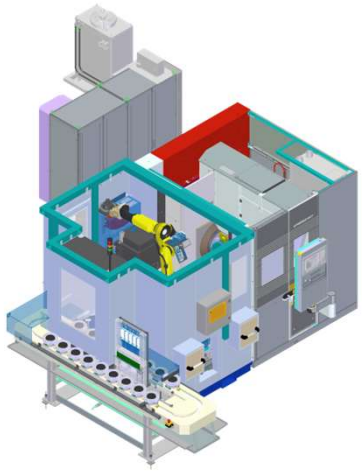
Potential cost saving: Total - 39.3 % !

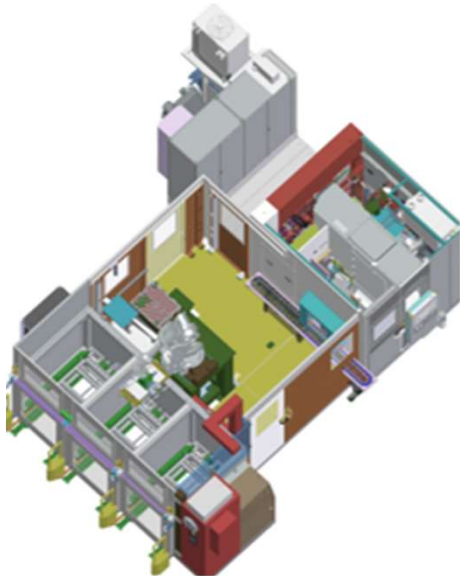
* Based on an estimated machine hour rate of $ 60 | Tool life of 6 m / hob tooth.

Flex Spline hobbing

FELSOMAT Automation Concepts





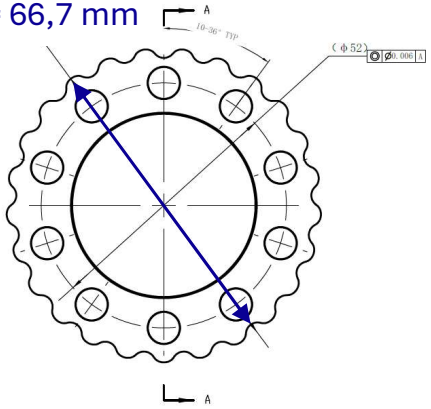


Feature \ Solution	1. Conveyor belt	2. Conveyor belt + Robot Cell	3. Robot Cell + Stacker Cell
Capacity:	36 | 120 workpieces	36 workpieces	480 workpieces
Duration of unmanned operation:	42 | 80 mins	42 mins	320 min (5,3 h)
Special application:	-	Integration of add. operations possible (brushing, measuring, etc.)	Integration of add. operations possible (brushing, measuring, etc.)

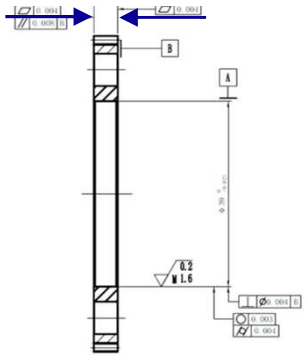
Further potential for FELSOMAT

Discs of Cycloidal Reducer Gearboxes

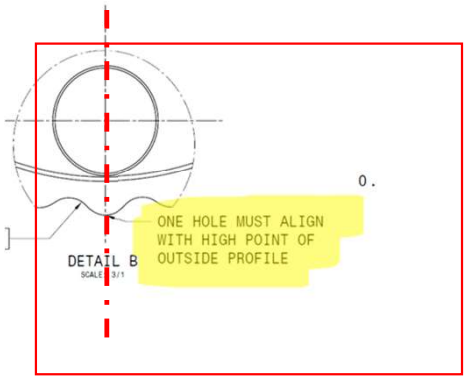
OD = 66,7 mm



Width = 5,0 mm

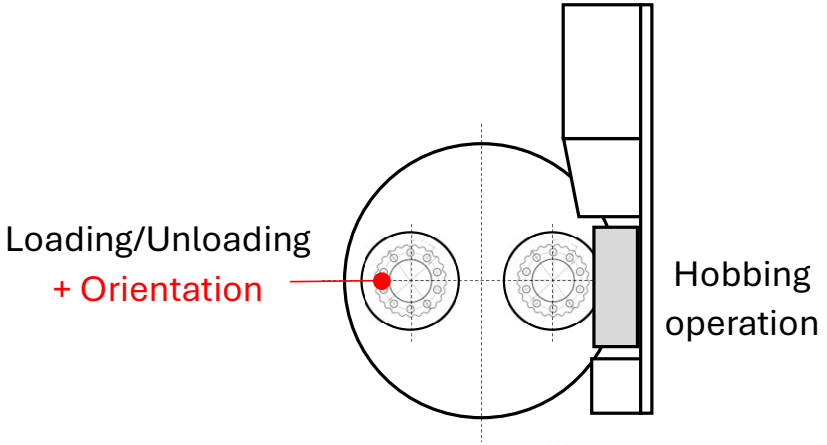


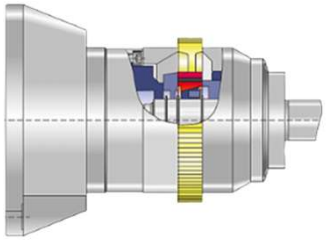
Number ofteeth	Z	25
Theoretical roller diameter	dr	4.8
Theoretical roller P.C.D diameter	Dp	70
Eccentricity Distance	e	0.9
Theoretical addendum diameter	da	66.8
Theoretical dedendum diameter	df	63.2
Theoretical tooth height	h	1.8
Accuracy Standard	JIS 1702:1998	

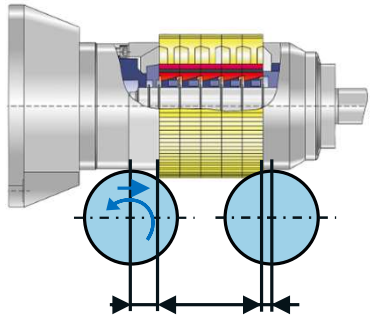


FHC 80

Loading/Unloading + orientation in the idle time







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