



냉간 단조 베벨 기어의 표면 탈탄 방지를 위한 연구

2004. 06. 18

노태두¹, 정성환¹, 이영신², 이정환²

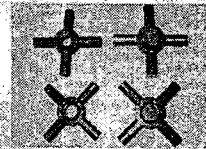
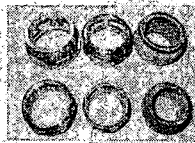
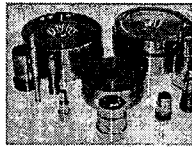
1. (주) 대연 정공
2. 한국기계연구원

 (주) 대연 정공

 한국기계연구원


 National Research Lab
 국립산정밀단조연구소 netforging.kimm.re.kr


주요 생산 품목 (회사현황)




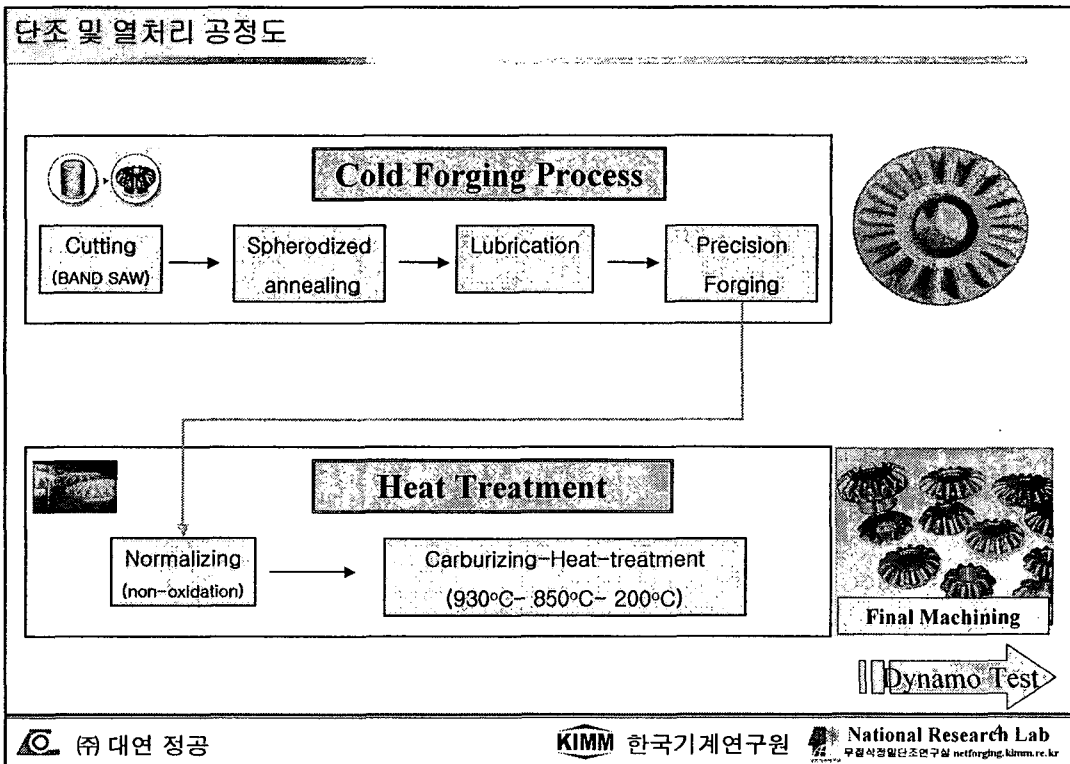
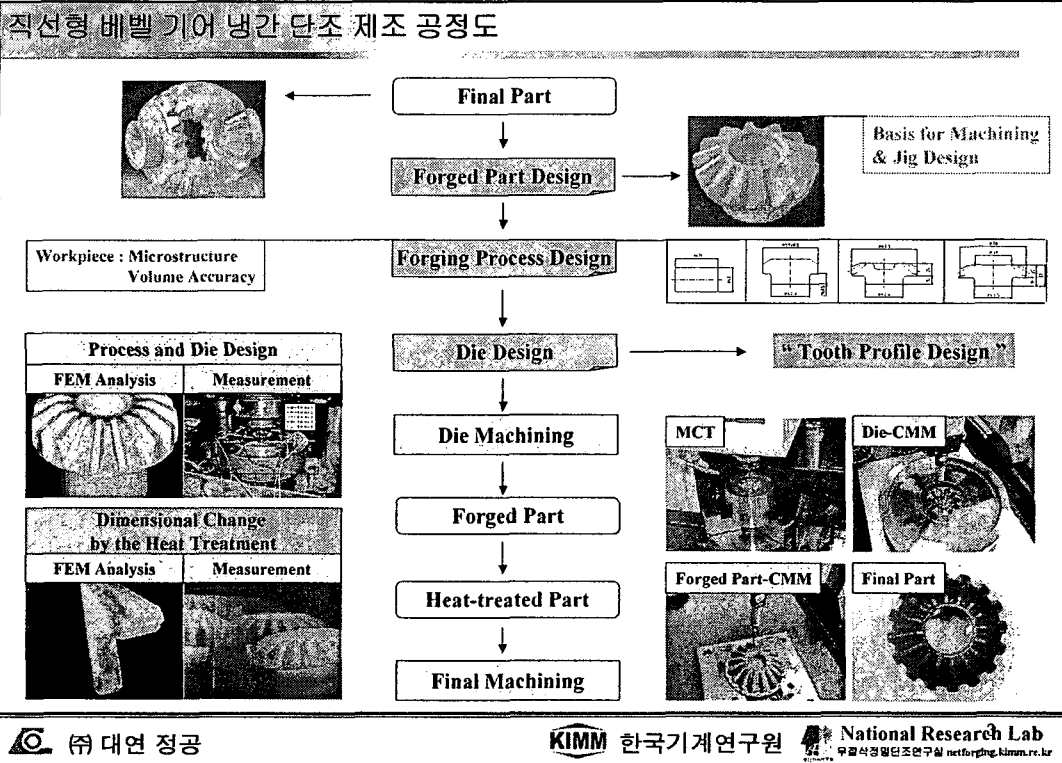
1965. 2. 1	대연산업사 설립
1981. 2. 1	대동공업(주) 전문화 인증업체
1985. 1. 31	유양중소기업 선정
1986. 10. 1	KIA가공(주) 협력업체 선정
1993. 12. 5	한국C.M.B(주) 협력업체 등록
1995. 7. 1	(주) 대연정공 설립/법인화
1995. 7. 28	(주)신트림 협력업체 등록
1996. 11. 30	동일중공업(주) 협력업체 등록
1997. 4. 10	WIA(주) 협력업체 등록
2000. 5. 30	DYMO(주) 협력업체 등록
2001. 3. 7	QS9000, ISO9002 인증 획득
2002. 12. 1	자동차 가공공장 증설

1. 상 호 : (주) 대연 정공
2. 소재지 : 경남 진주시 삼평동 212-11번지
3. 설립일 : 1965년 2월 1일
4. 종업원수 : 53명
5. 공장용지 : 1) 단조 공장(대지 1,300평, 건평 1,250평)
 2) 가공 공장(대지 560평, 건평 480평)

 (주) 대연 정공

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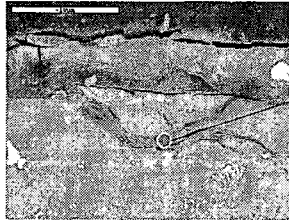
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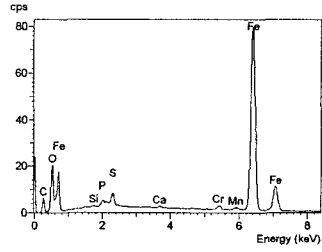
Dynamo Test

표면층 SEM-EDS 분석 : 단조품-Dynamo 시험 후

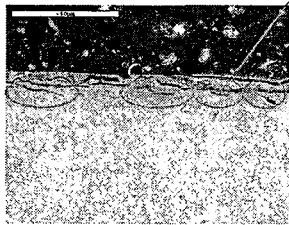
산화층
(5 μ m)



Crack



산화층



Elmt	Spect. Type	Element %	Atomic %
C	K ED	12.63	33.32
O	K ED	11.41	22.59
Si	K ED	0.21	0.24
P	K ED	0.54	0.55
S	K ED	1.36	1.34
Ca	K ED	0.20	0.16
Cr	K ED	0.79	0.48
Mn	K ED	0.58	0.33
Fe	K ED	72.29	41.00
Total		100.00	100.00

- Dynamo 시험 후 시편 표면에 Crack 존재
- 표면에 산화층 존재(5 μ m)
- 표면 산화층→ 크랙 발생→ 산화층 생성 원인 분석

단조 기어 표면 특성 분석

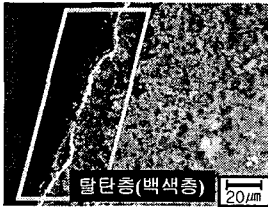
Normalizing
(non-oxidation)

Carburizing-Heat-treatment
(930°C- 850°C- 200°C)

Final Machining

Dynamo Test

Pinion

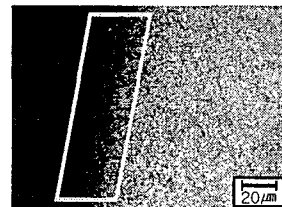


탈탄층(백색층)

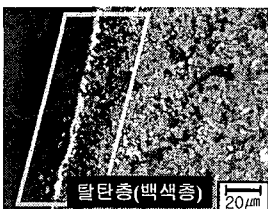
Pinion



Pinion

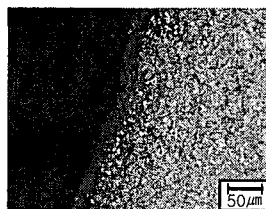


Side Gear

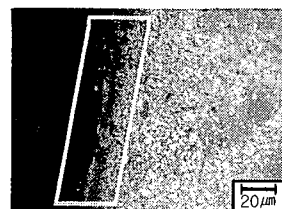


탈탄층(백색층)

Side Gear

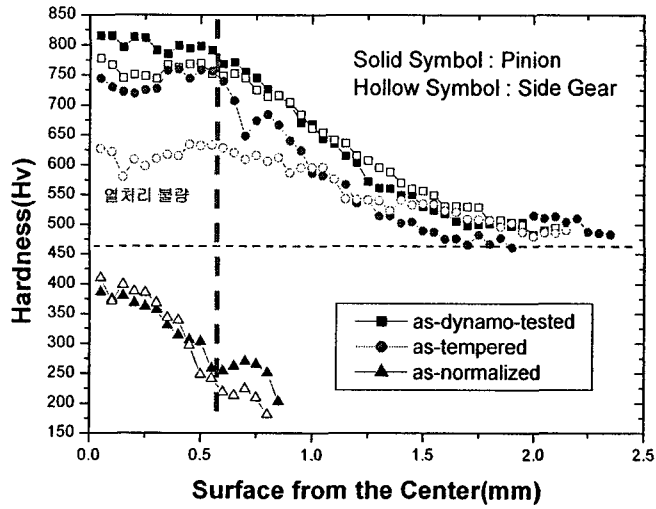


Side Gear



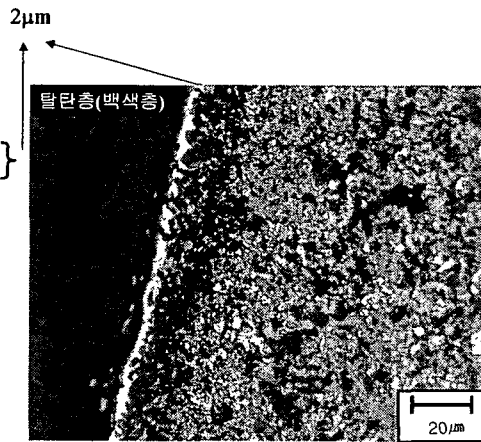
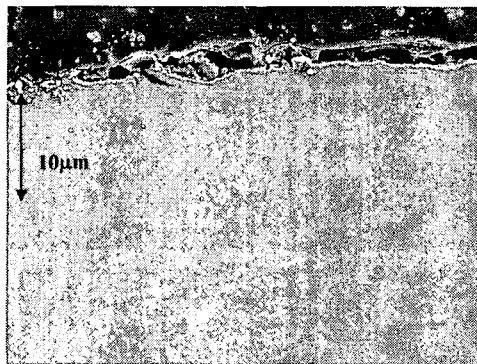
공정별 표면 경도 변화

[국산] 침탄층 : 경도 Hv750 ~ 800, 깊이 0.5mm



공정별 표면층 분석

SEM-EDS 분석 [단조 + Normalizing]

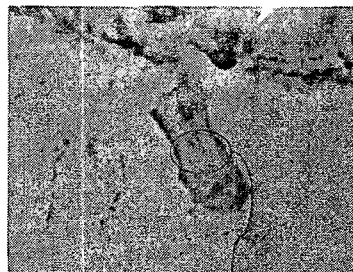
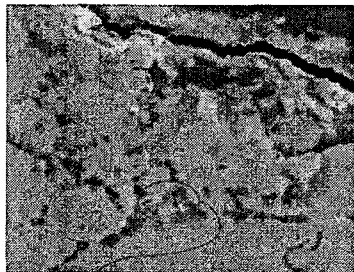


단조 후 Normalizing 처리를 무산화 분위기에서 수행했음에도 불구하고 표면에 산화층 생성되 있음.
→ 이전 공정(단조 전 소둔) 확인 필요

공정별 표면층 분석

SEM-EDS 분석 [원소재-표면 Scraping-Annealing]

Cr과 Mn 증가, 열처리시 O와 화합물을 생성한 것으로 사료됨.

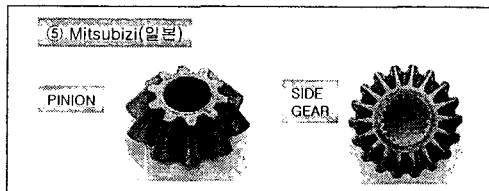
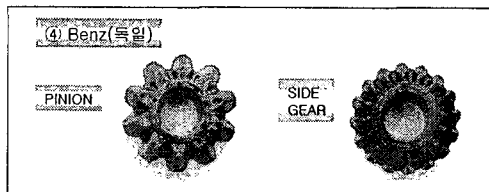
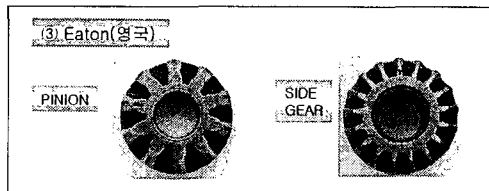
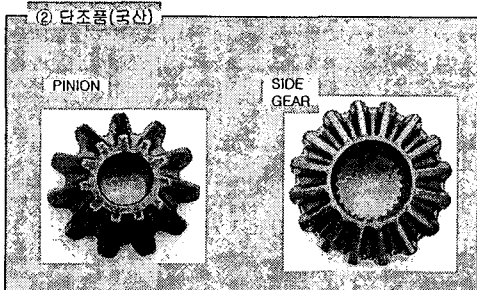
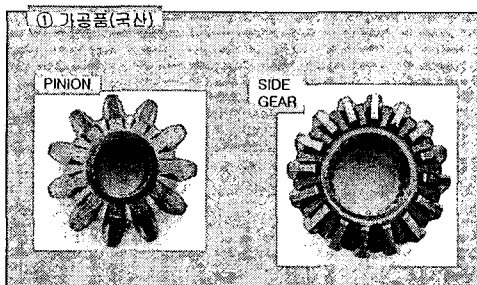


Elmt	Spect.	Element	Atomic
Type	%	%	
C K	ED	12.20	35.19
O K	ED	6.53	14.13
Cr K	ED	6.07	4.04
Mn K	ED	3.62	2.28
Fe K	ED	71.24	44.17
Ni K	ED	0.14*	0.08*
Cu K	ED	0.19*	0.10*
Total		100.00	100.00

소둔 처리 공정
정밀 분석 필요

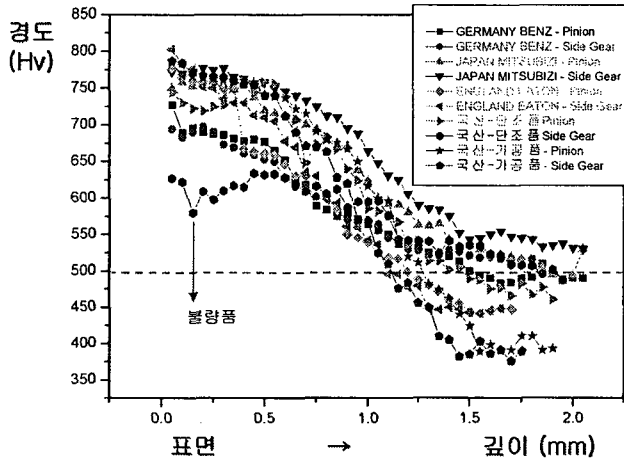
Elmt	Spect.	Element	Atomic
Type	%	%	
C K	ED	11.21	27.36
O K	ED	19.75	36.19
Cr K	ED	4.03	2.27
Mn K	ED	4.54	2.42
Fe K	ED	60.31	31.67
Ni K	ED	0.12*	0.06*
Cu K	ED	0.04*	0.02*
Total		100.00	100.00

제조사 별 특성 분석



제조사 별 특성 ; 경도

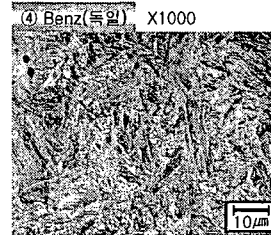
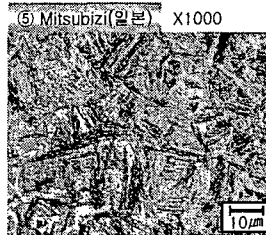
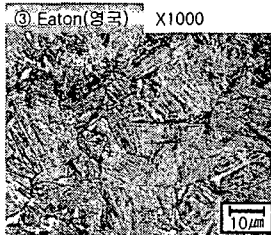
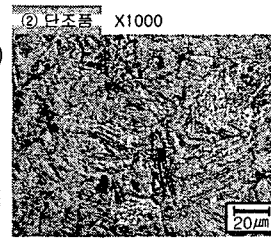
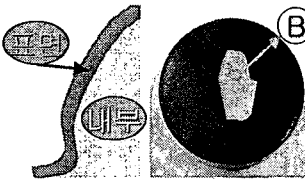
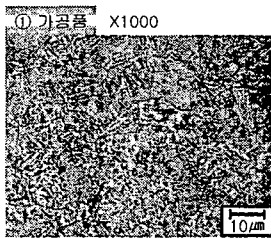
제품별 SIDE / PINION 경도 비교



	침탄층 경도 (Hv)	기지 경도 (Hv)	침탄층 깊이 (mm)
Ⅱ	700	500	0.5
Ⅲ	750	525	0.5
Ⅳ	750	450	0.5
Ⅴ	750~ 800	500	0.5

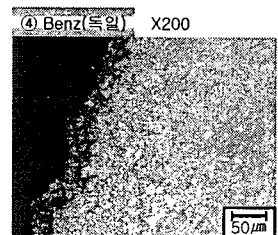
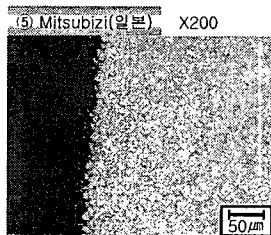
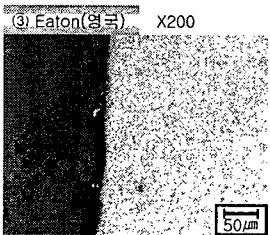
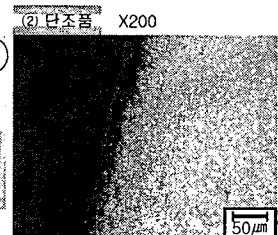
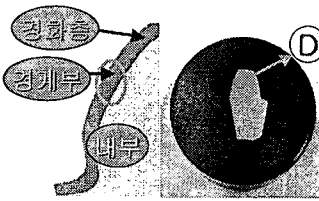
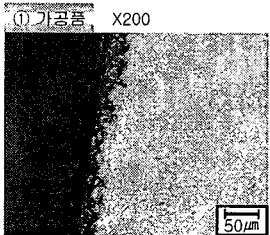
제조사 별 특성 분석

PINION



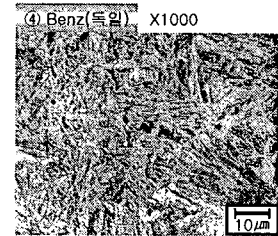
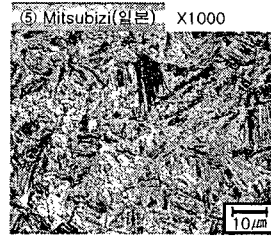
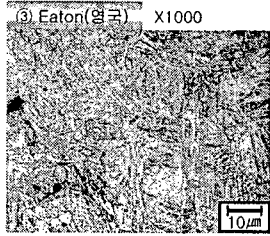
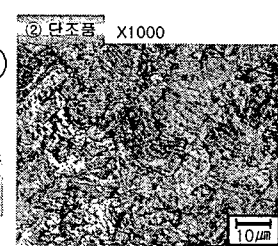
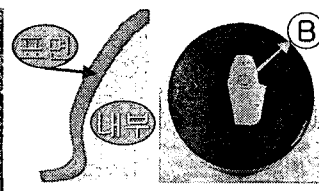
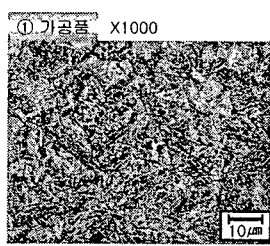
제조사 별 특성 분석

PINION



제조사 별 특성 분석

SIDE GEAR

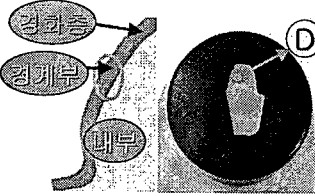


제조사 별 특성 분석

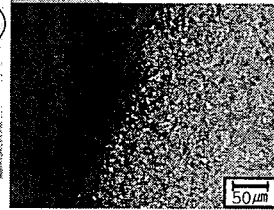
SIDE GEAR



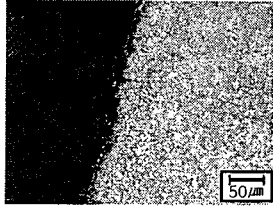
① 가공품 X200



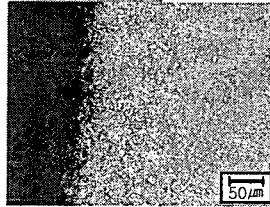
② 단조품 X200



③ Eaton(영국) X200



⑤ Mitsubizi(일본) X200



④ Benz(독일) X200



㈜ 대연 정공

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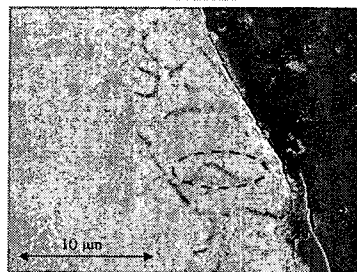
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제조사 별 특성 분석 : Side Gear

② 크산 단조품 : Side Gear

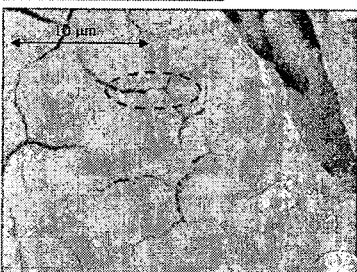


③ Eaton(영국) : Side Gear

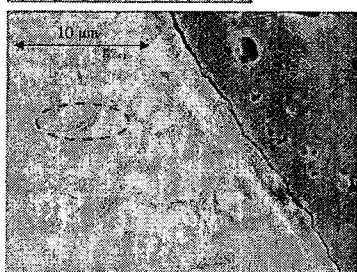


Crack

④ Benz(독일) : Side Gear



⑤ Mitsubizi(일본) : Side Gear



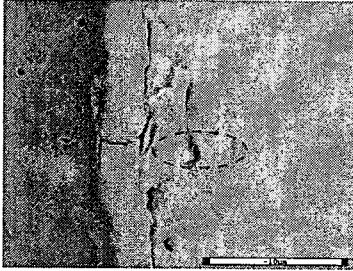
㈜ 대연 정공

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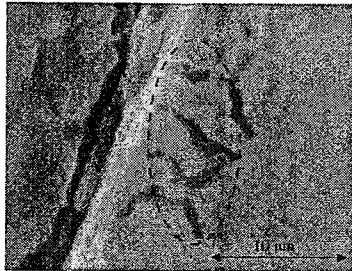
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제조사 별 특성 분석 : Pinion

② 국산 단조품 : Pinion



③ Eaton(영국) : Pinion

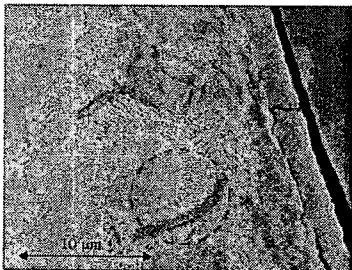


④ Benz(독일) : Pinion



Crack

⑤ Mitsubizi(일본) : Pinion



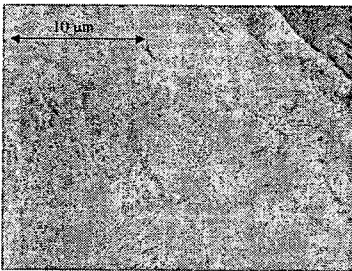
㈜ 대연 정공

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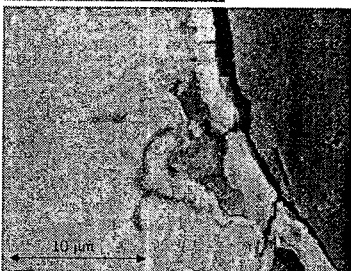
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공정별 특성 비교 : 기계가공 vs 단조품

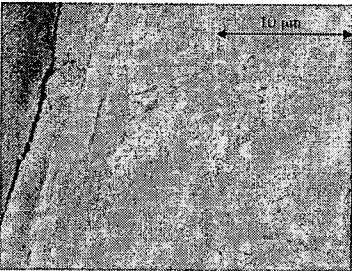
① 국산가공품 : Side Gear



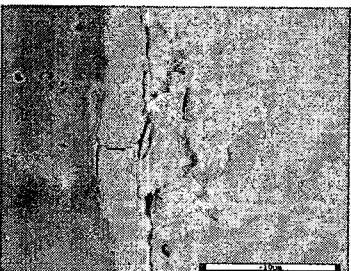
② 국산 단조품 : Side Gear



① 국산가공품 : Pinion



② 국산 단조품 : Pinion

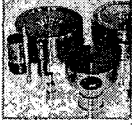


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Summary and Discussion



무산화 분위기 열처리 필요

-Annealing

-Normalizing

