5강 단조 시뮬레이션의 사례와 단조의 상세 이해

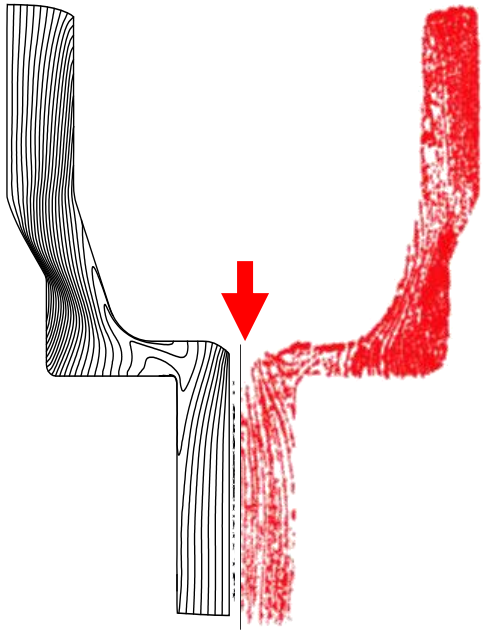
5강 목차

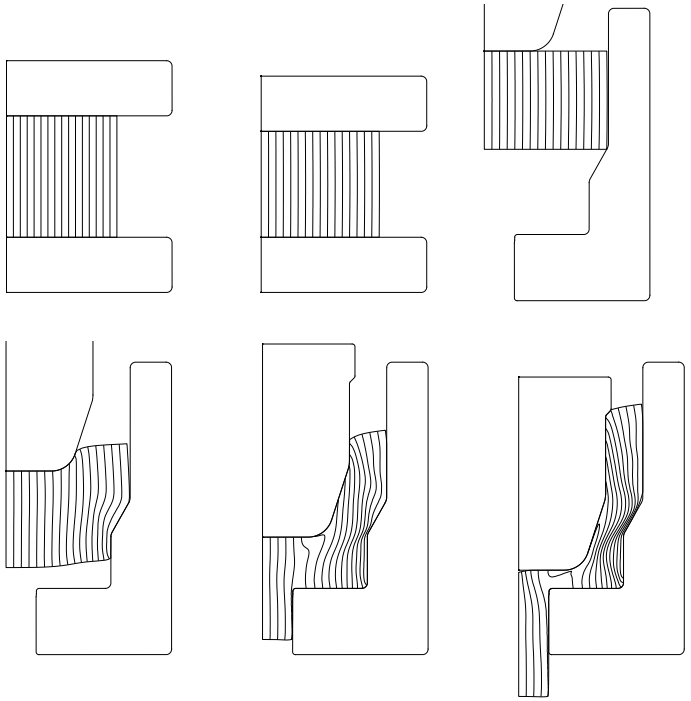
5.1 2차원
5.2 3차원

1. 2차원

일반냉간단조

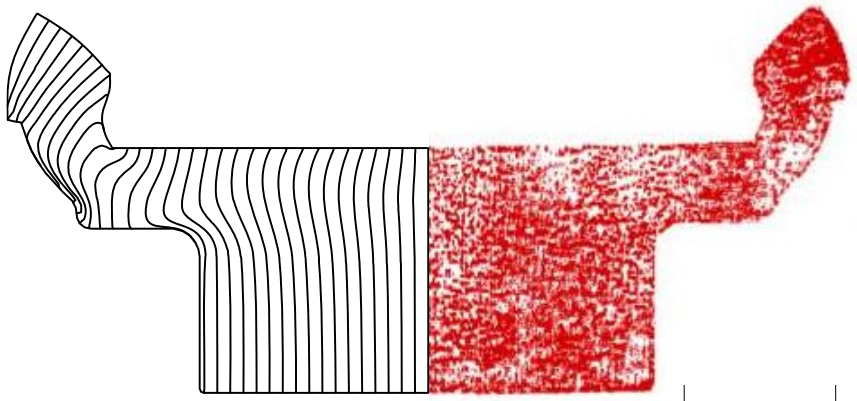
파이핑 결함

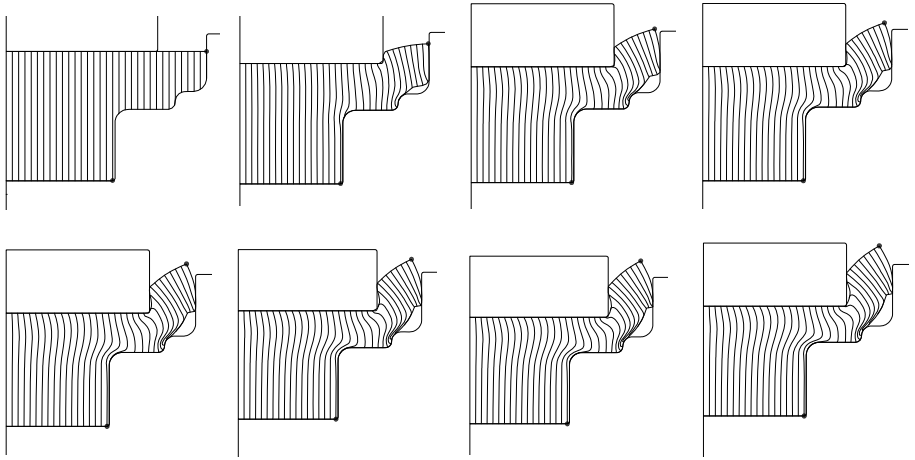




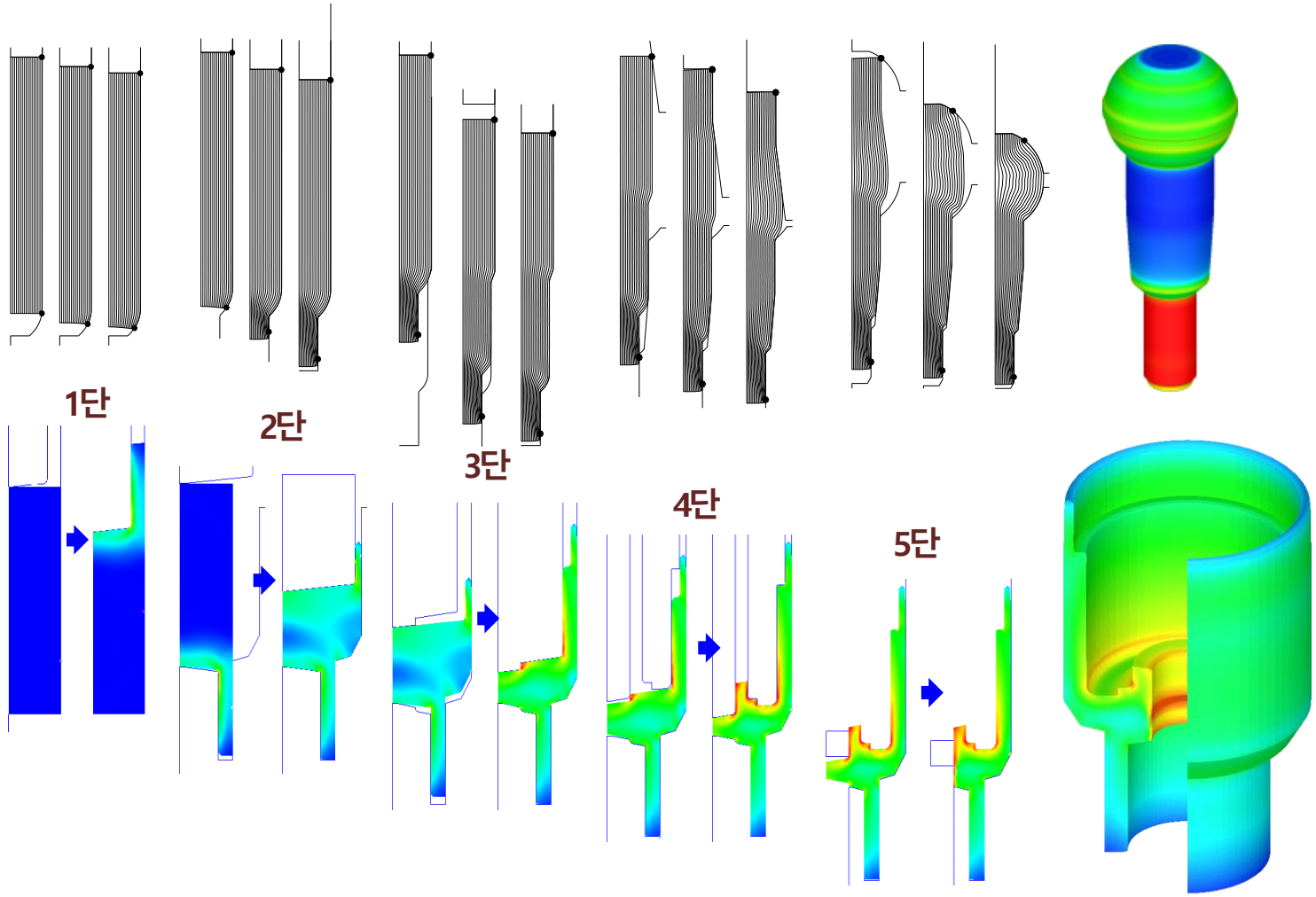
일반냉간단조

미충진 결함

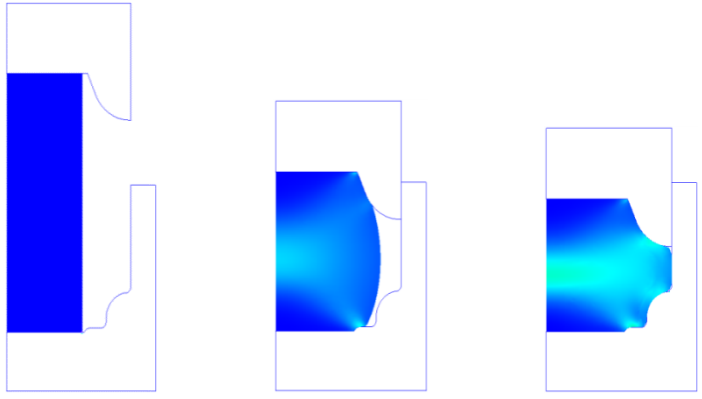




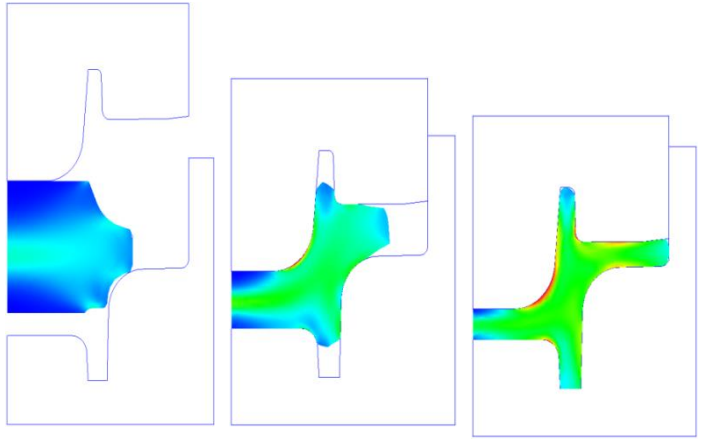
자동다단냉간단조



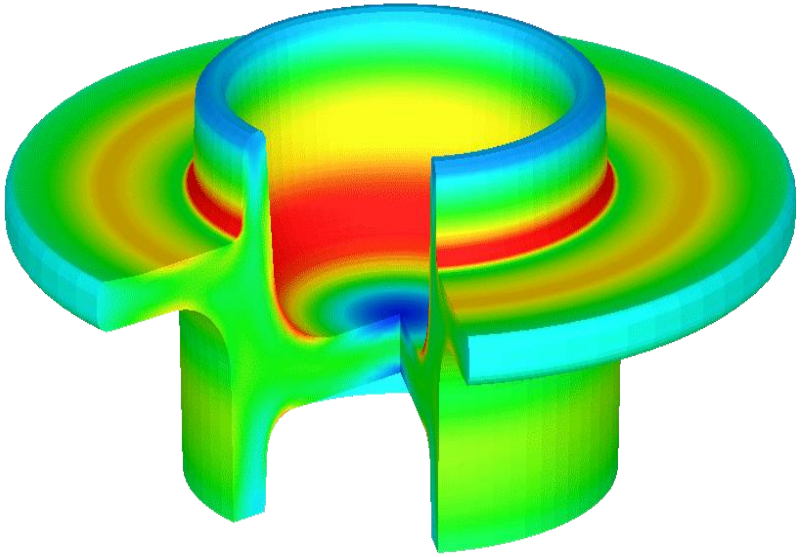
허브 열간밀폐단조



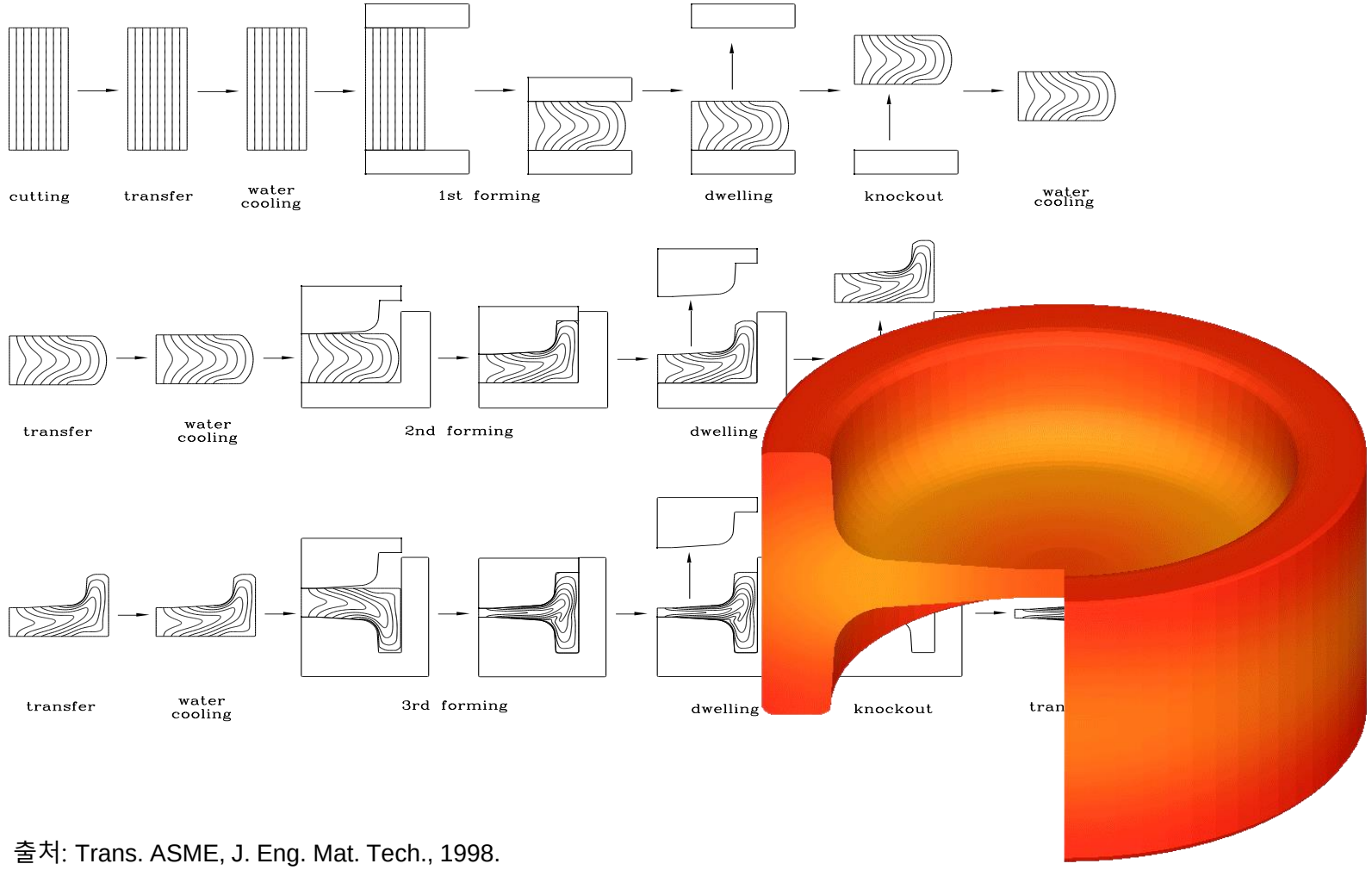
1단



2단

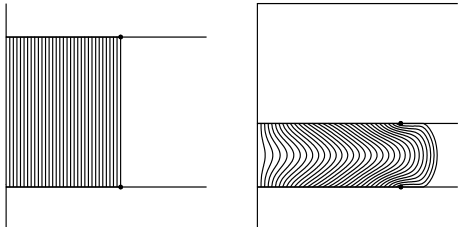


자동다단열간단조

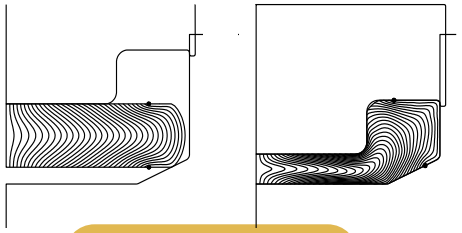


출처: Trans. ASME, J. Eng. Mat. Tech., 1998.

열냉간 복합단조



1단 -열간



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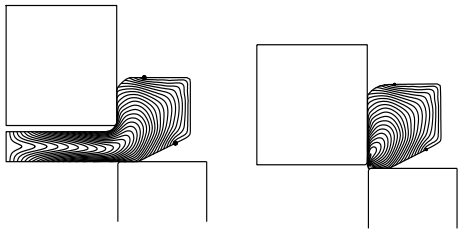

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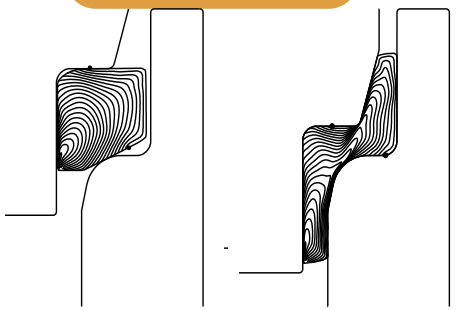

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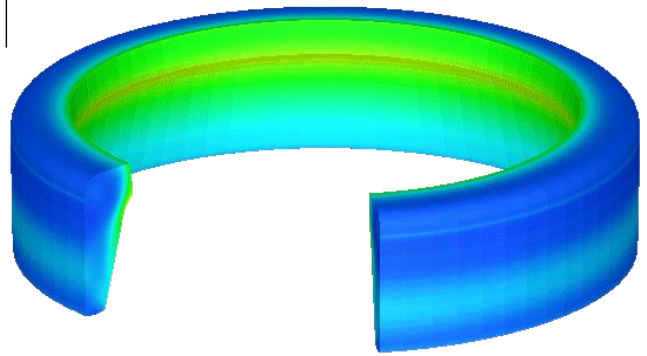

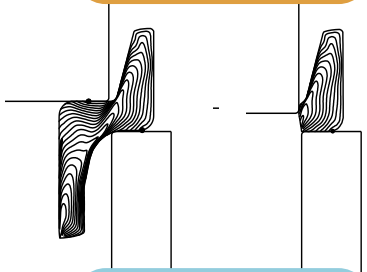

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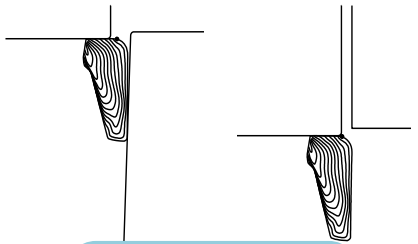
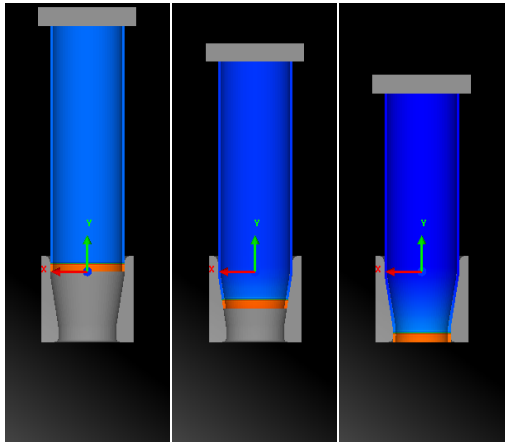


6단 -냉간

후방가압 튜브 인발



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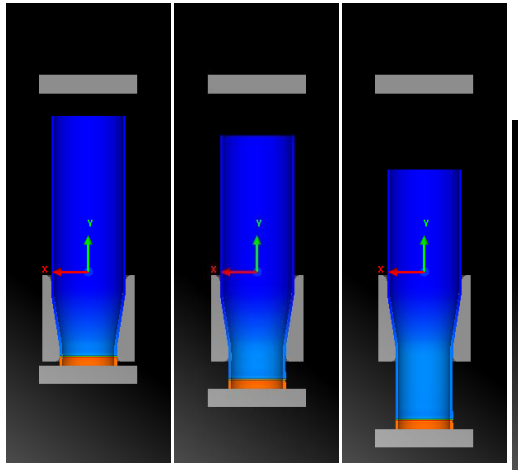

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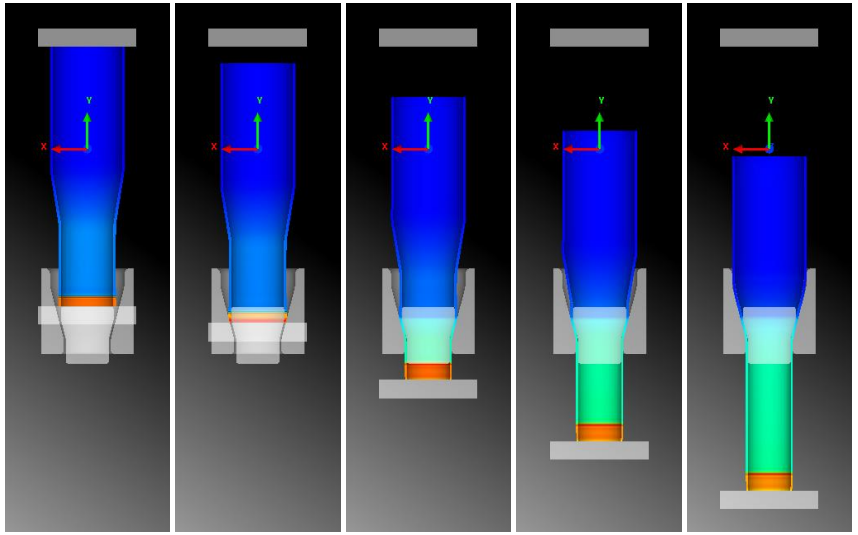

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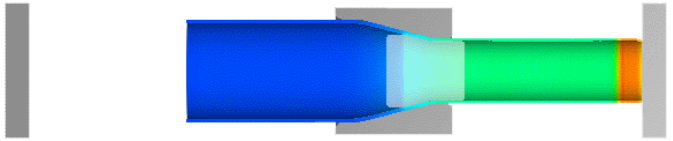
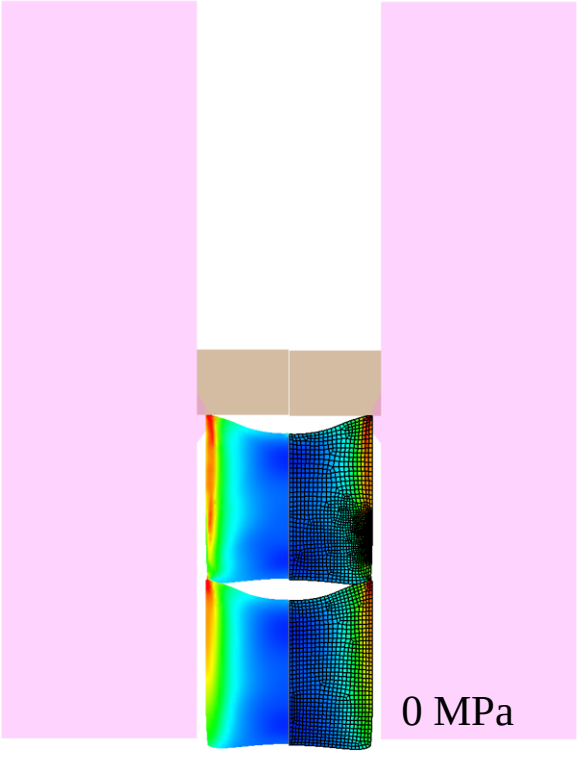
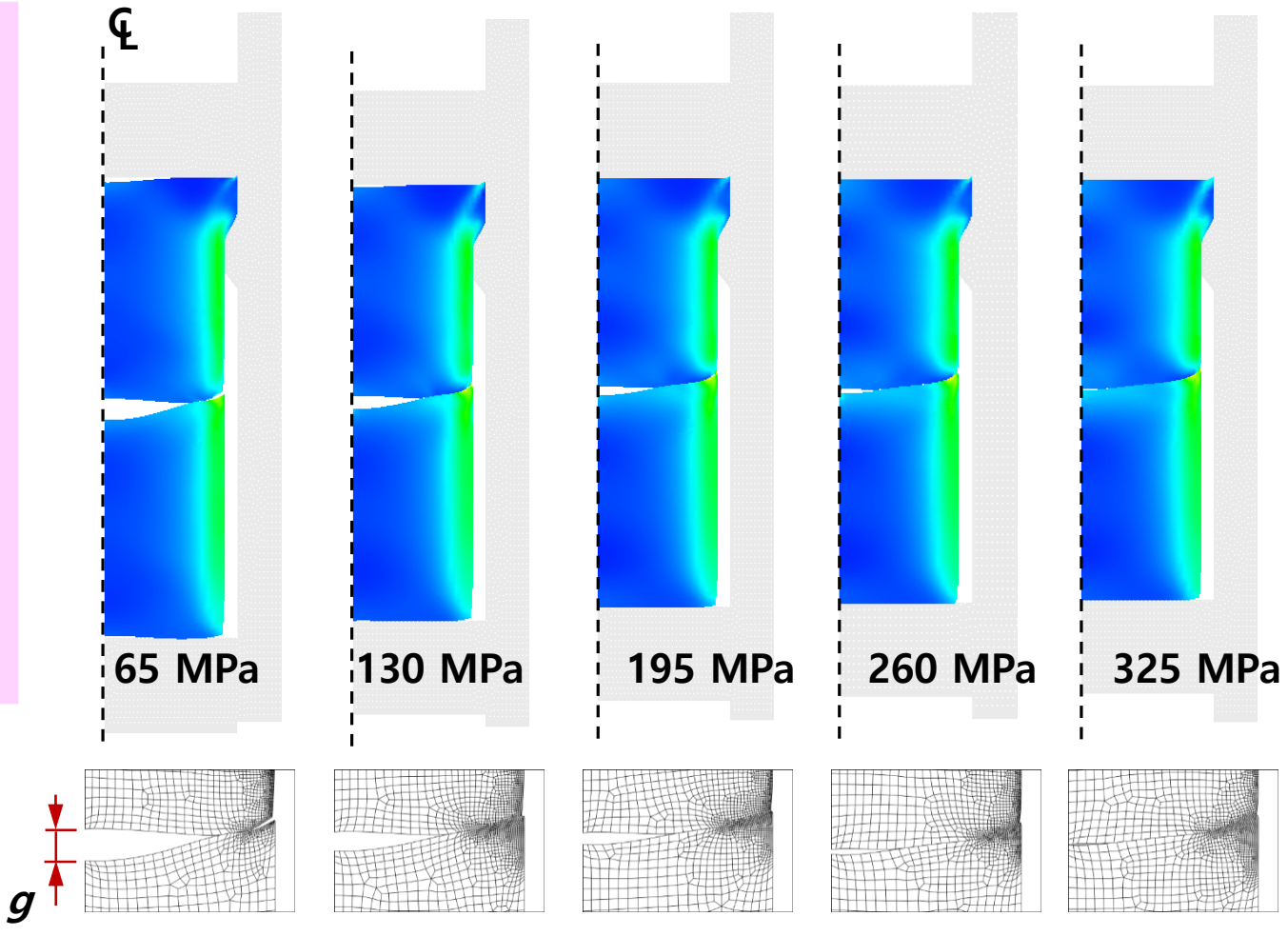


출처: KSTP 2009

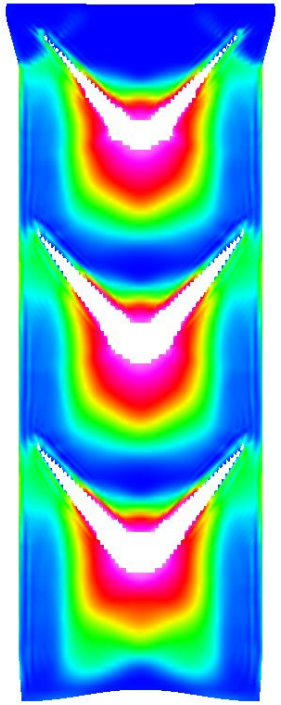
전방 가압 다물체 압출



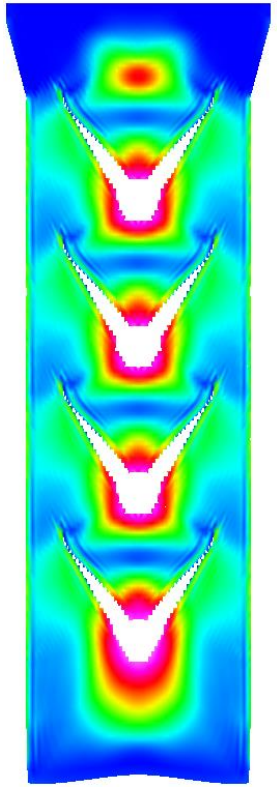


전방압력(MPa)	0	65	130	195	260	325
g(mm)	1.65	1.16	0.67	0.43	0.26	0.05

압출공정에서 셰브론 결함



α= 30°
R.A.=18
μ=0.03



α= 30°
R.A.=30
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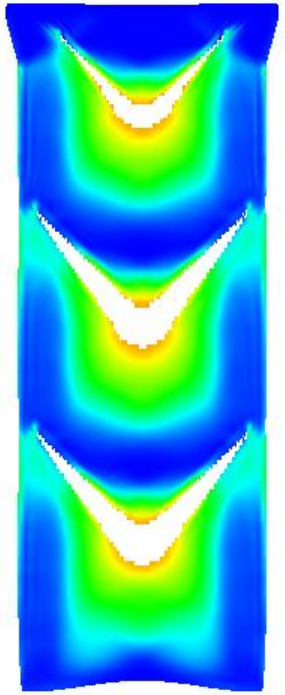
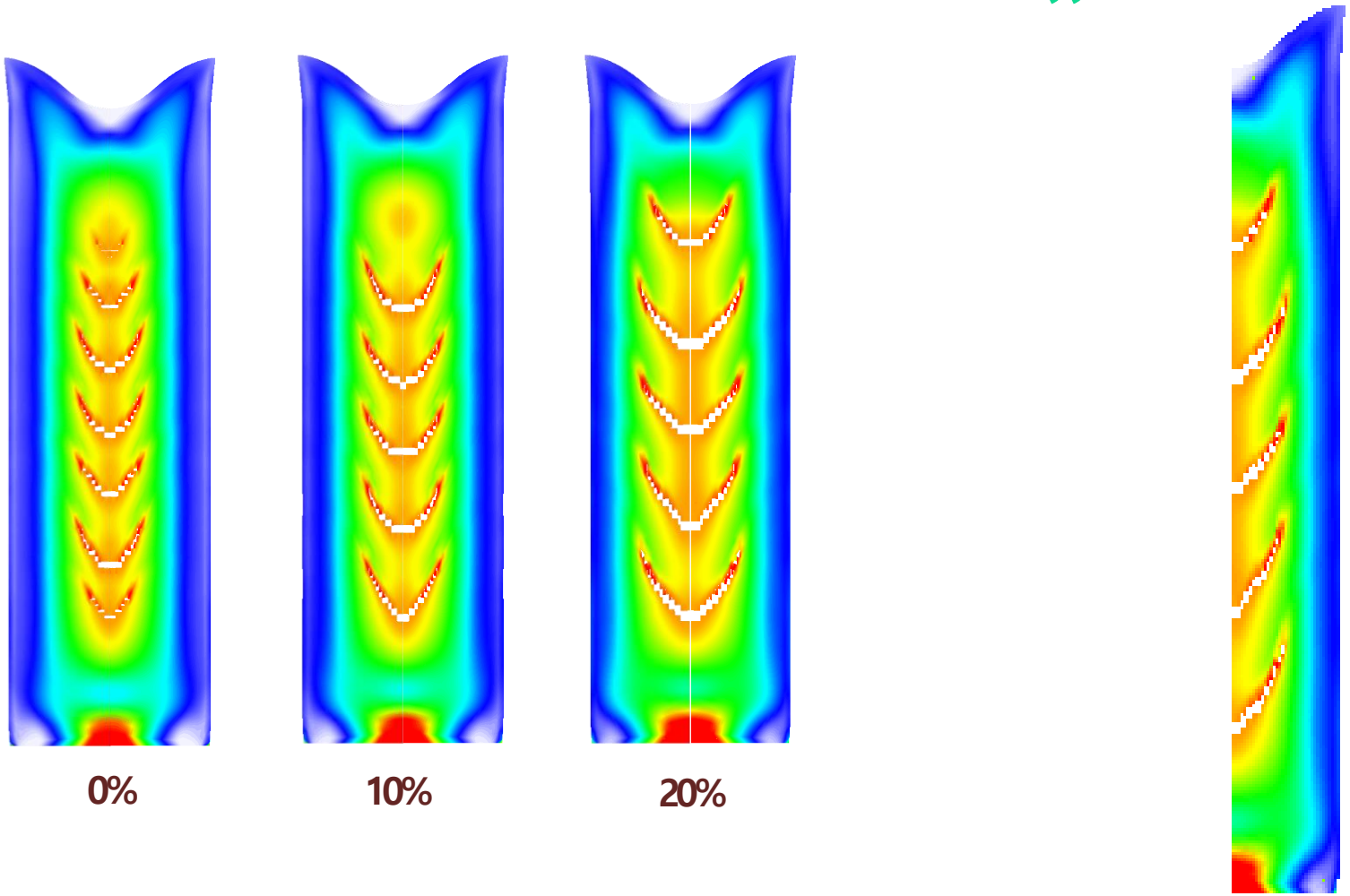


출처: KSPT 2010

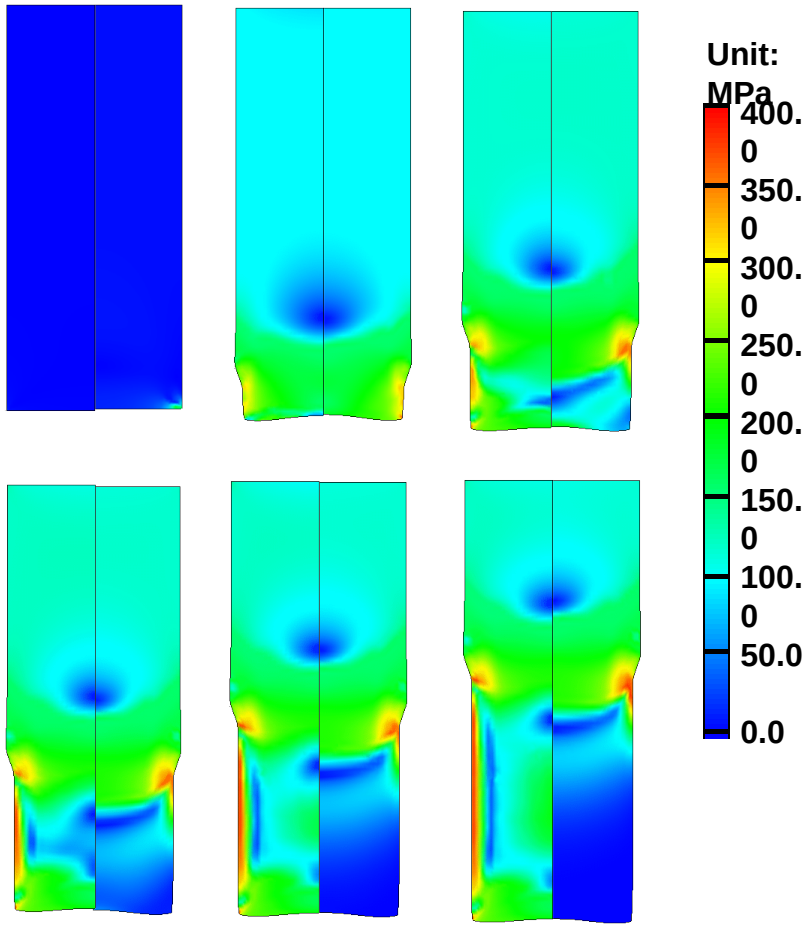
6단 인발 공정에서 중심파단 발생 예측

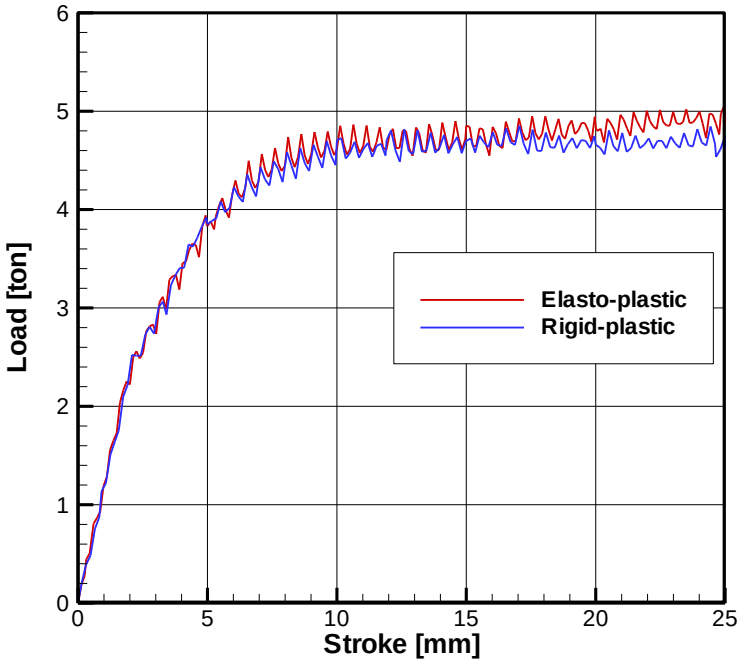
"후방 인장(초기항복응력 대비 백분율(%)) 부과"



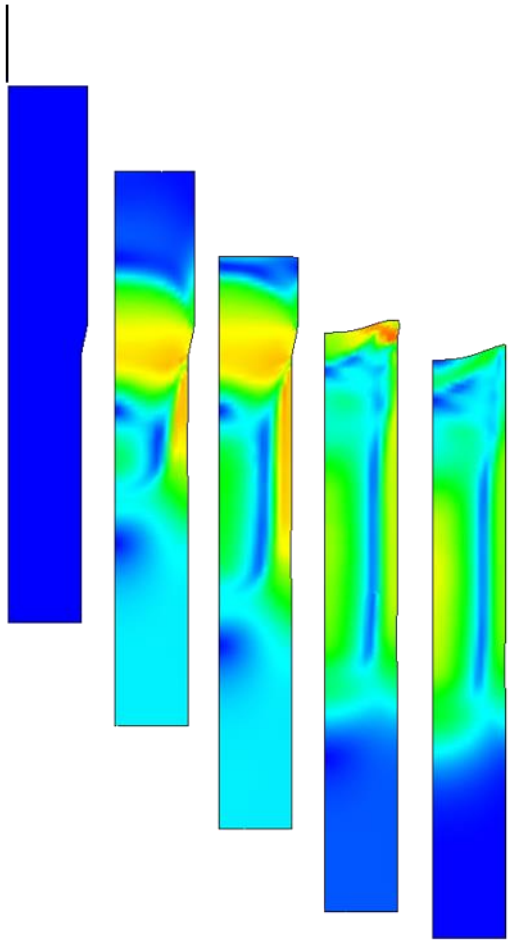
압출공정에서 잔류응력

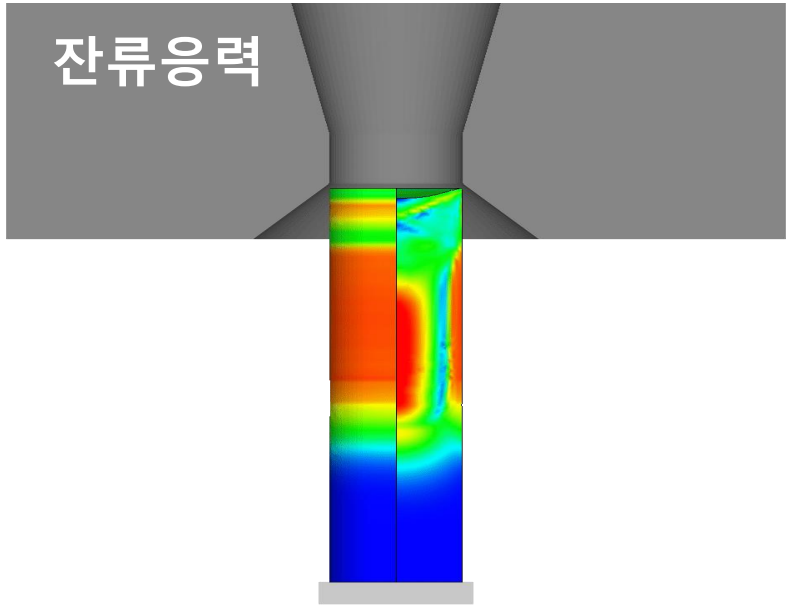
탄소성 강소성

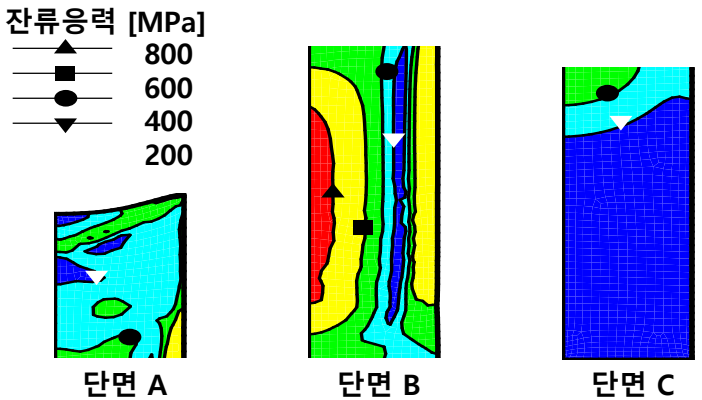




인발공정의 탄소성 유한요소 해석

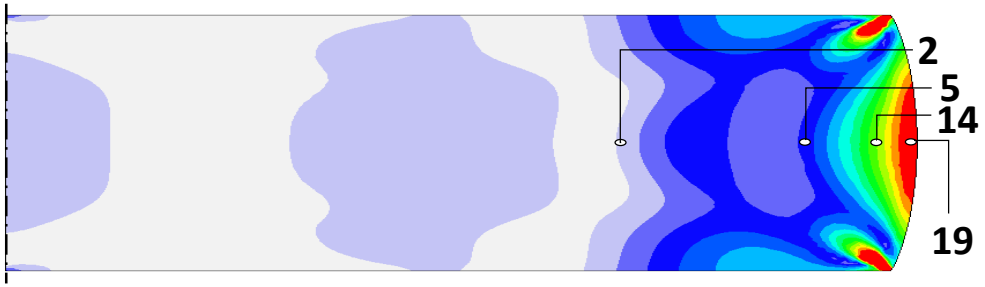




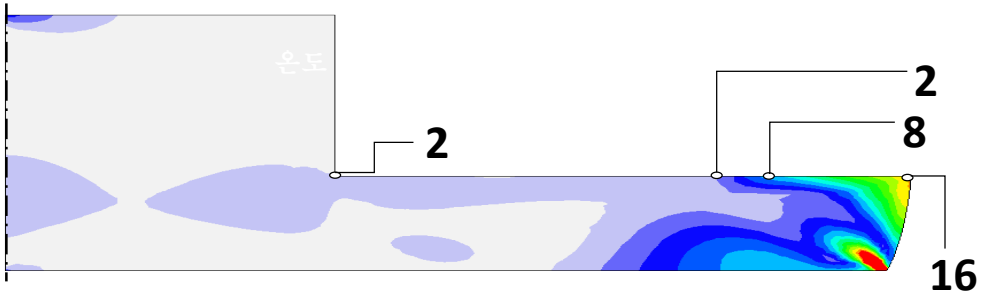


단조 후 절삭

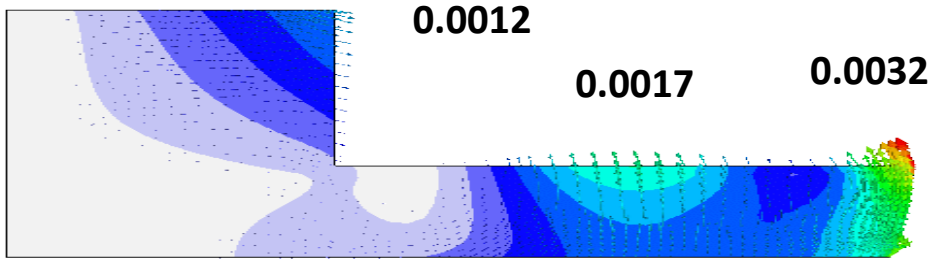
단조 후 잔류응력



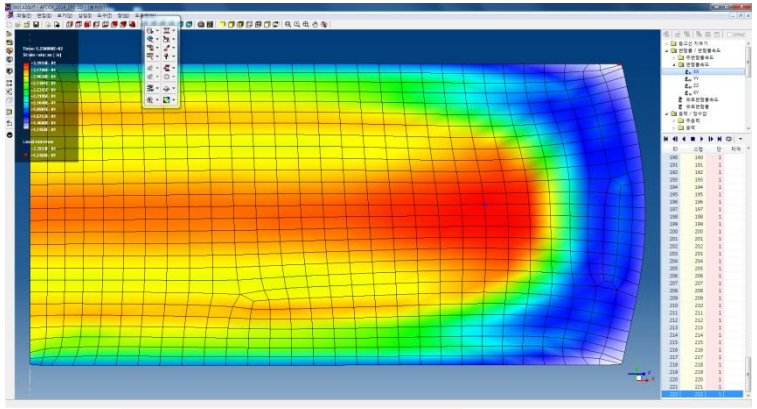
절삭 후 잔류응력



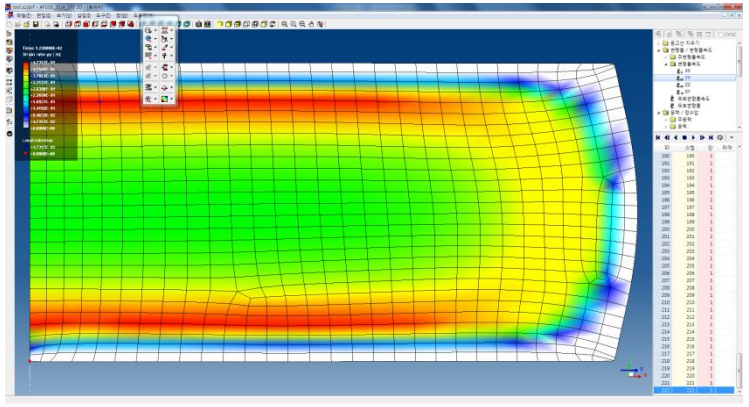
절삭 후 스프링백



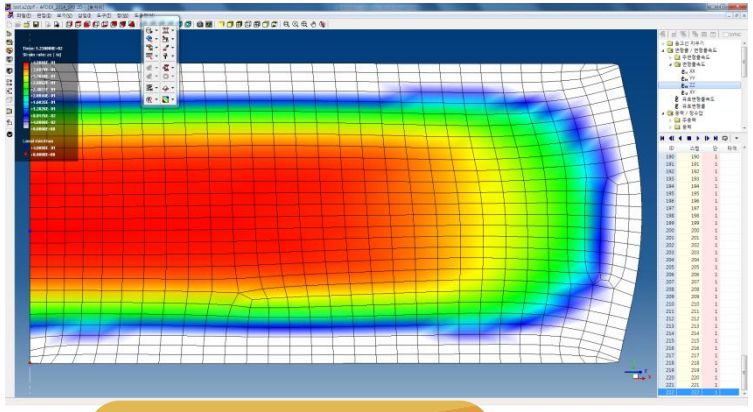
열처리 공정



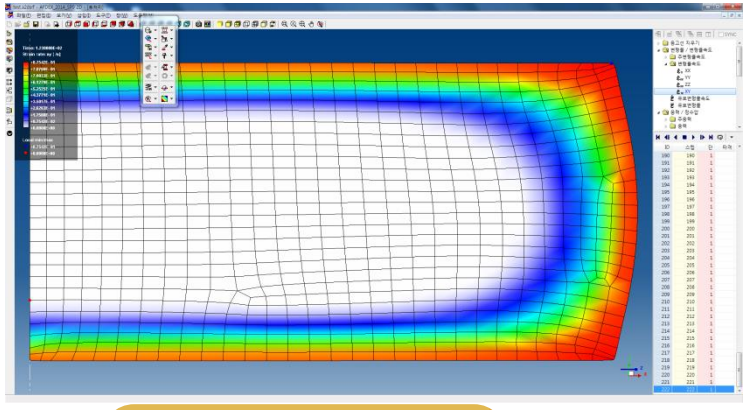
오오스테나이트 분율



퍼얼라이트 분율

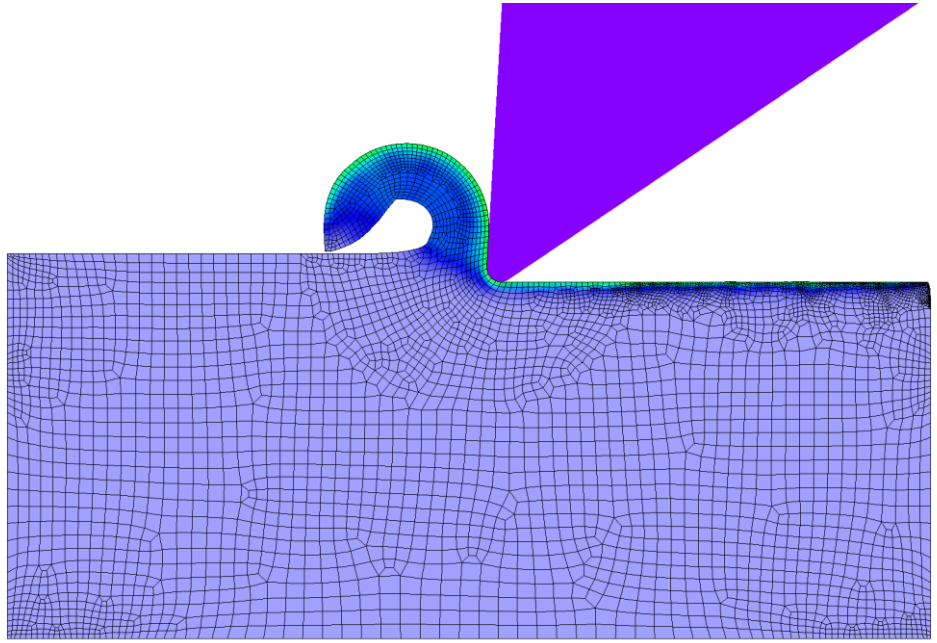


베이나이트 분율

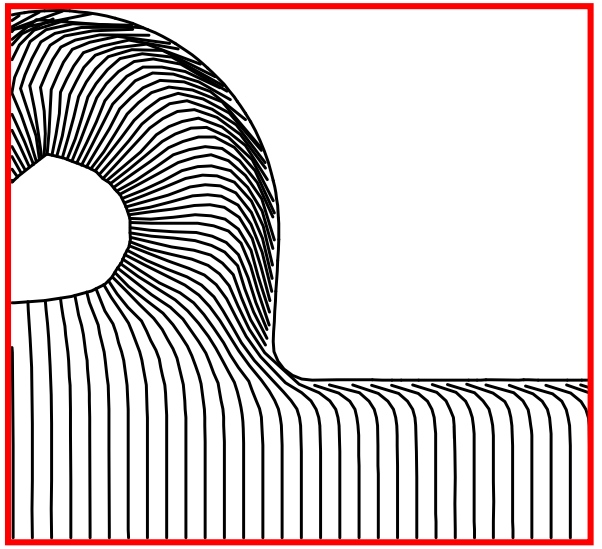


마르텐사이트 분율

기계가공 공정

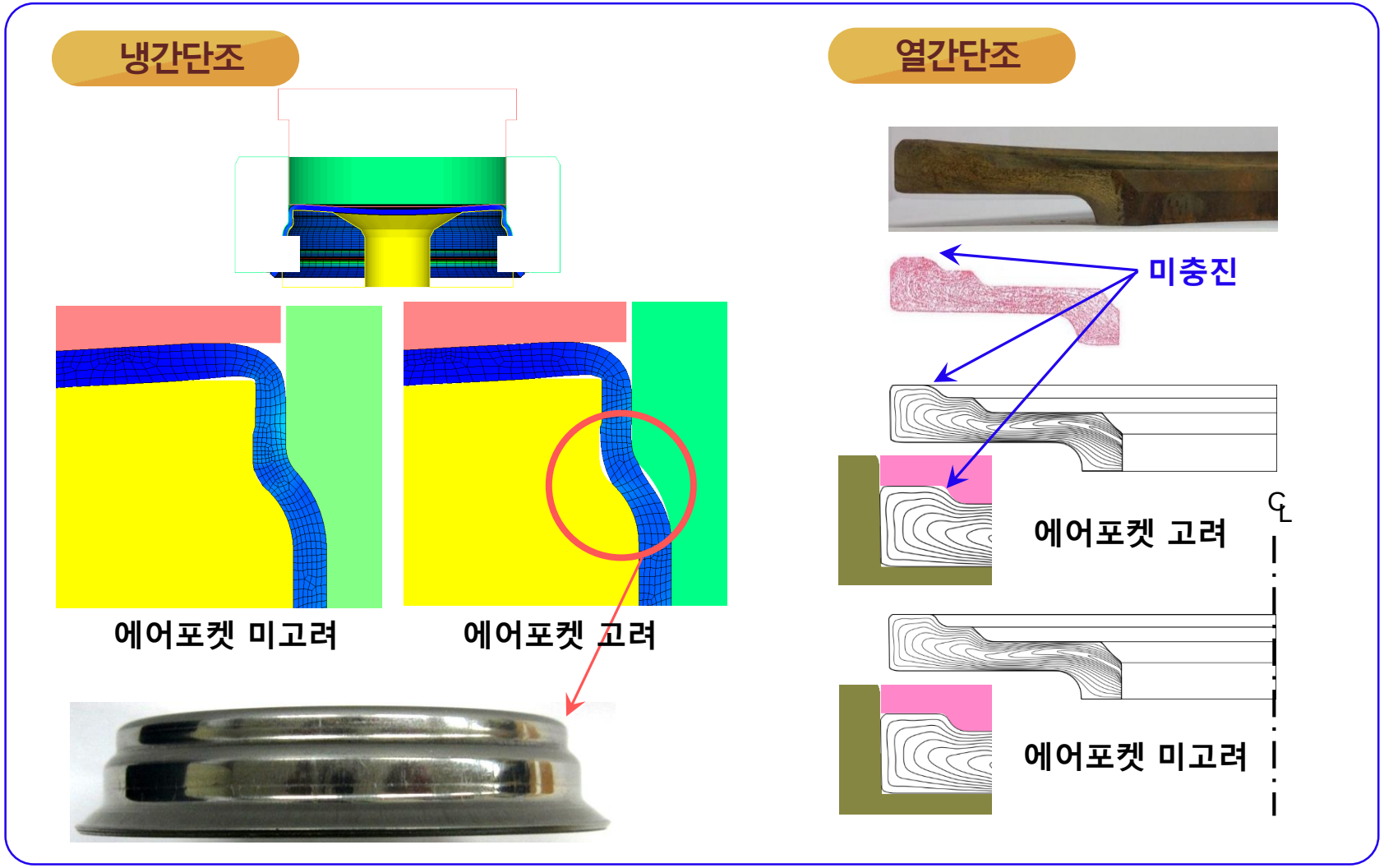


유효변형률

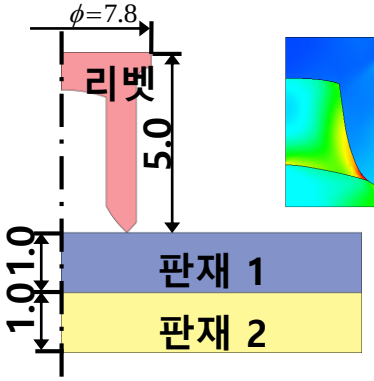


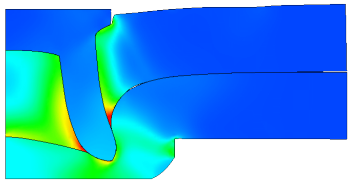
단류선

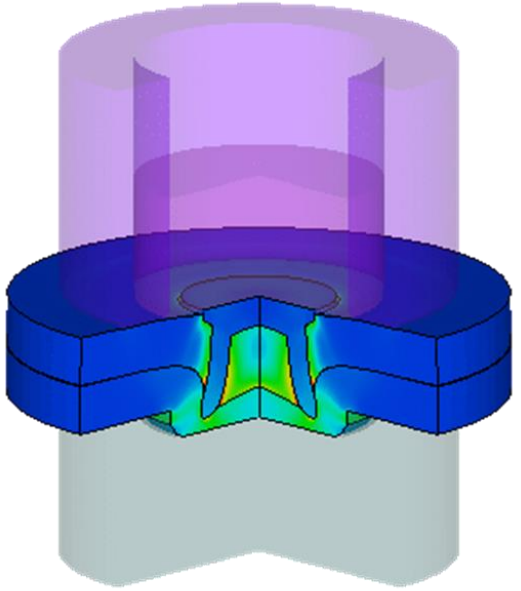
에어포케팅 현상

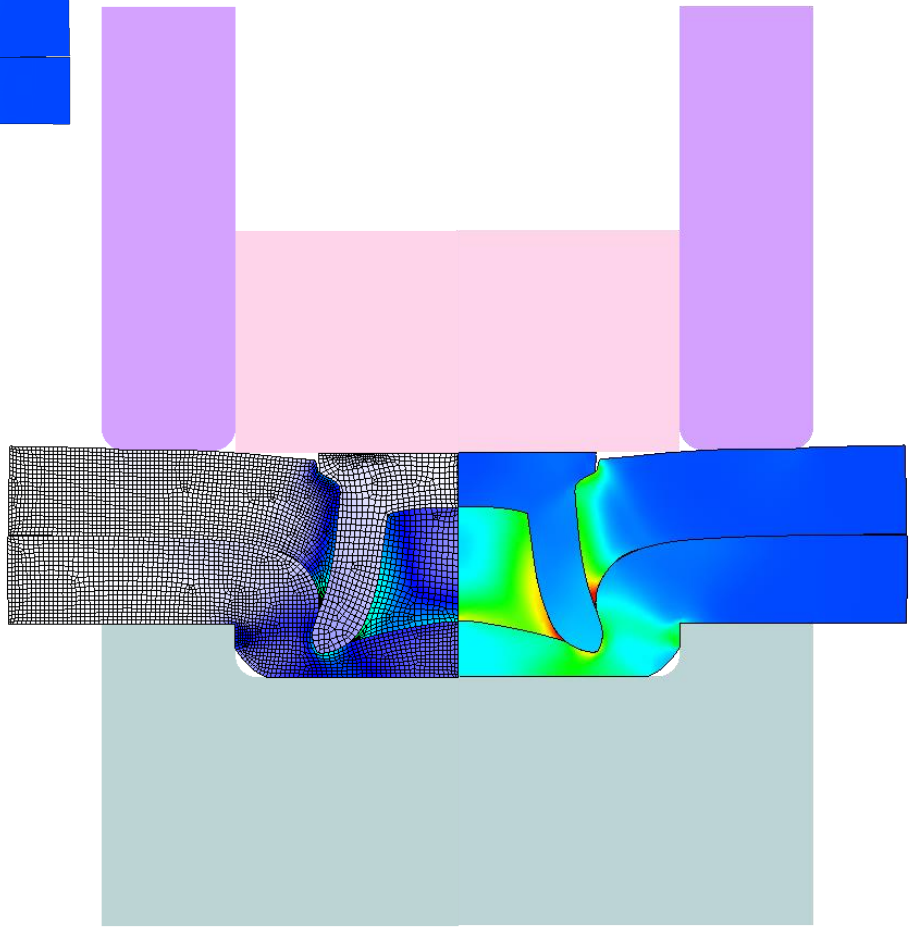


셀프 피어싱 리베팅

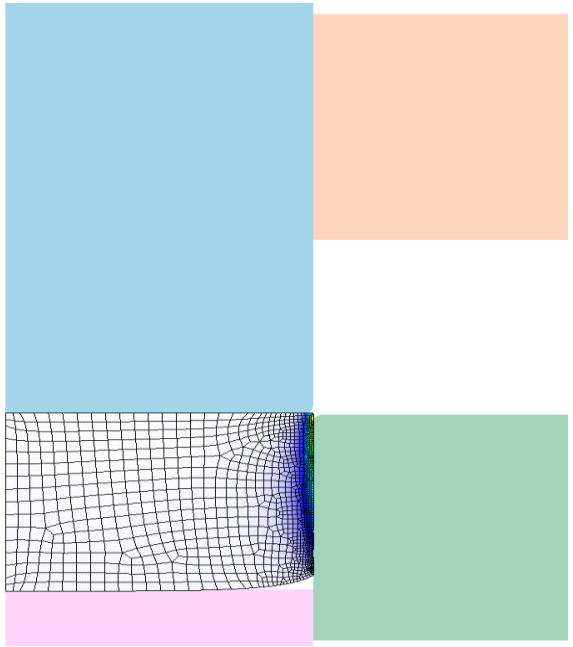


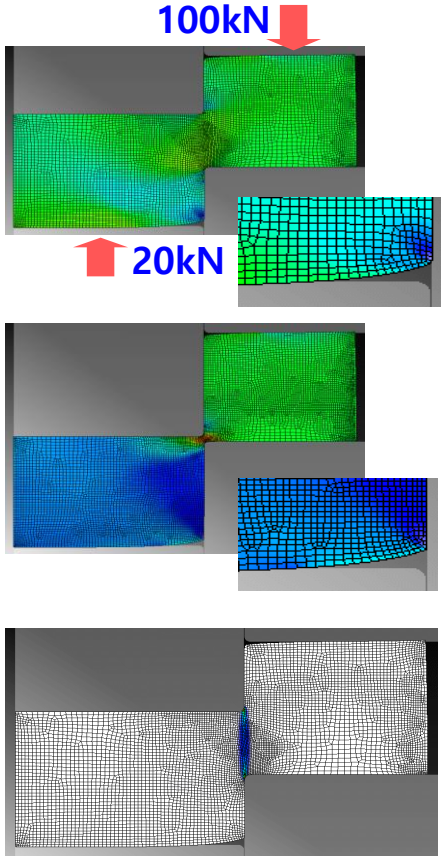


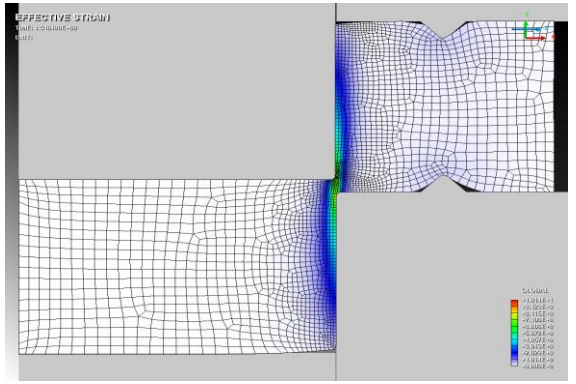


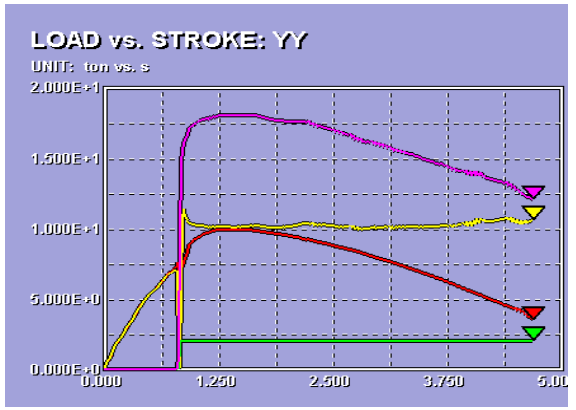


파인블랭킹(Fine blanking simulation)

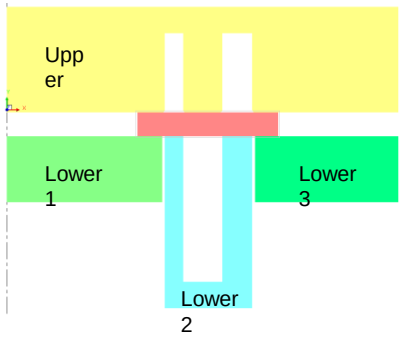


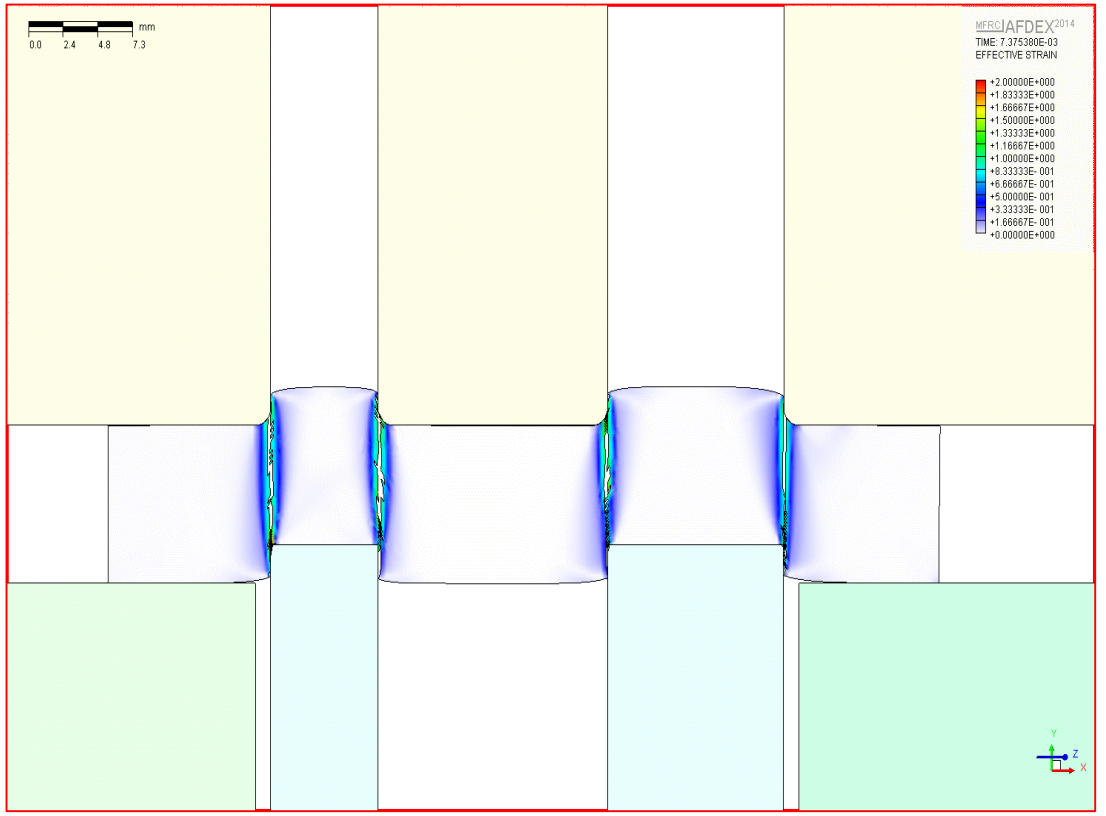






피어싱공정 해석


Upp
er
Lower
1
Lower
3
Lower
2


mm
0.0
2.4
4.8
7.3
MFRC AFDEX 2014
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EFFECTIVE STRAIN
+2.00000E+000
+1.83333E+000
+1.66667E+000
+1.50000E+000
+1.33333E+000
+1.16667E+000
+1.00000E+000
+8.33333E-001
+6.66667E-001
+5.00000E-001
+3.33333E-001
+1.66667E-001
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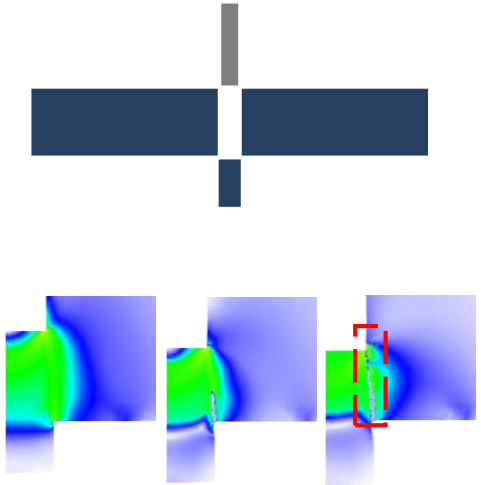
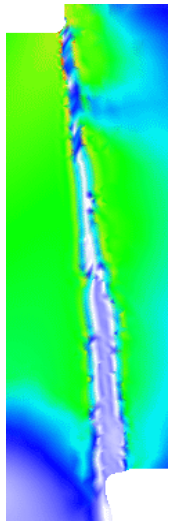
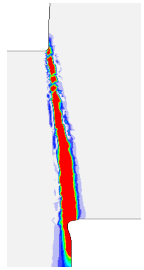
Y
Z
X

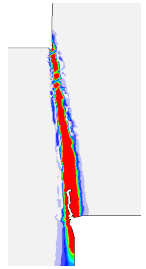
두꺼운 판재 피어싱 (딥피어싱)







(a) 4.896s



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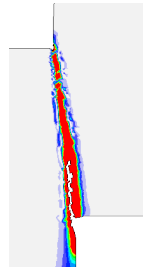

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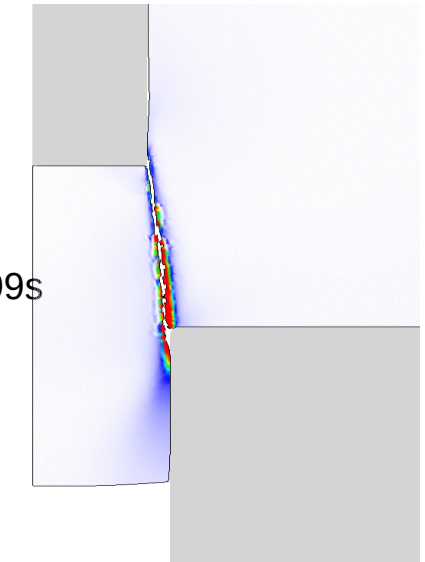

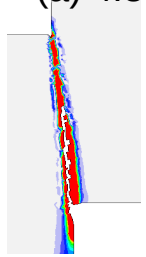

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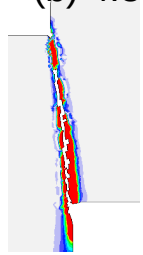

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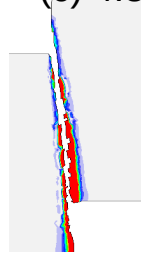

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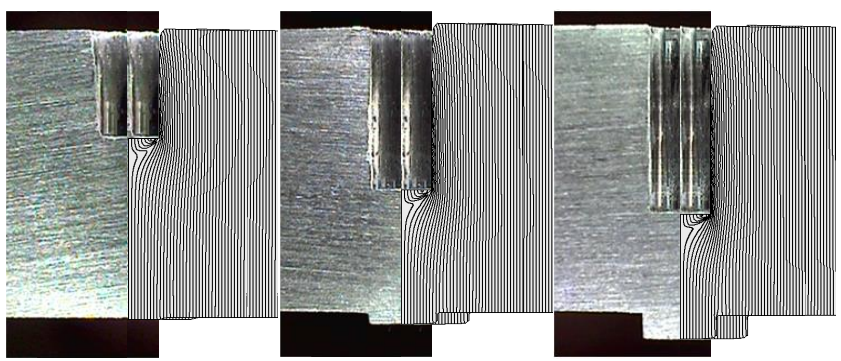

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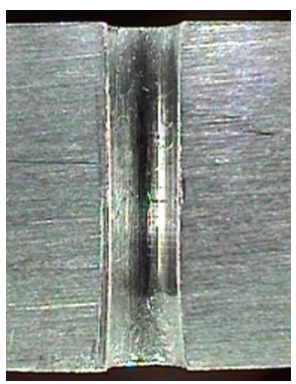
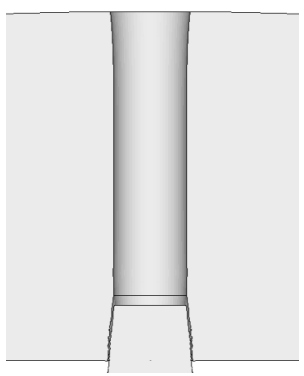


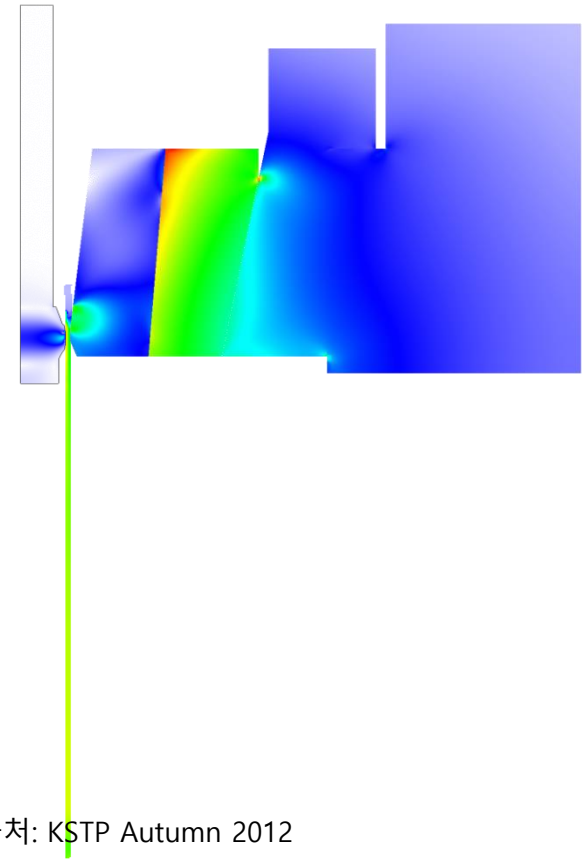
실험

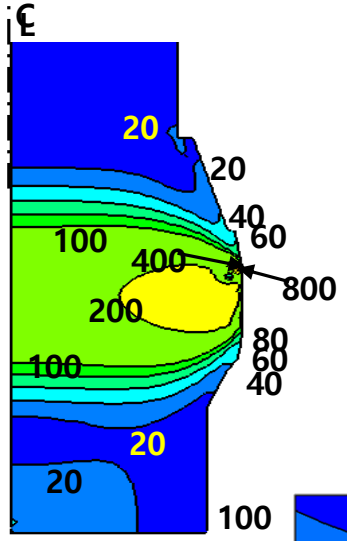


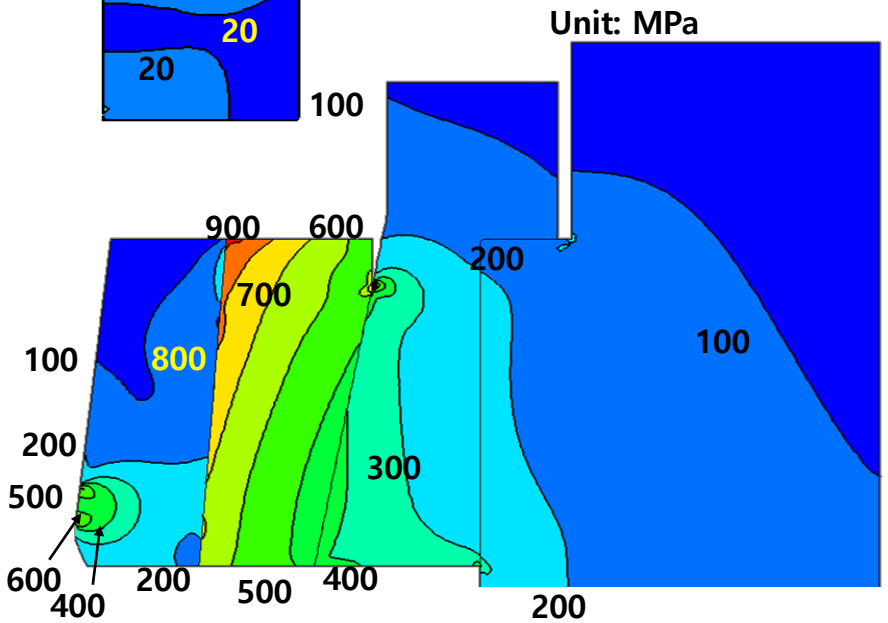
해석

연속 금형 구조해석

튜브인발공정의 해석

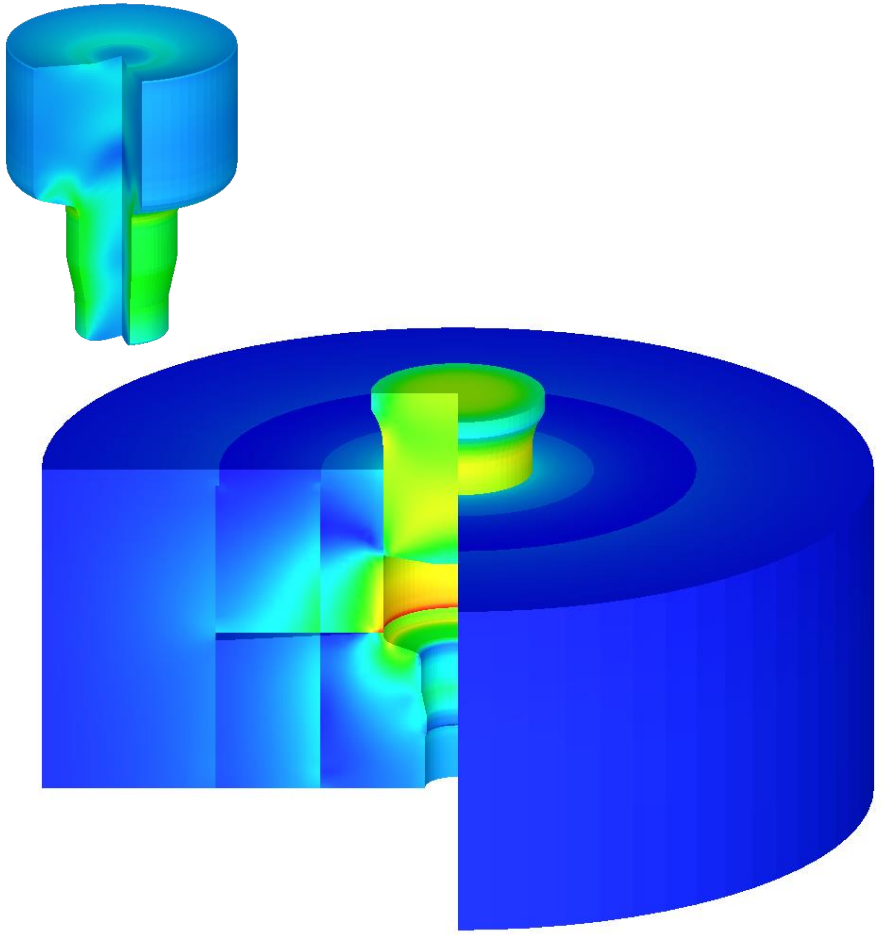


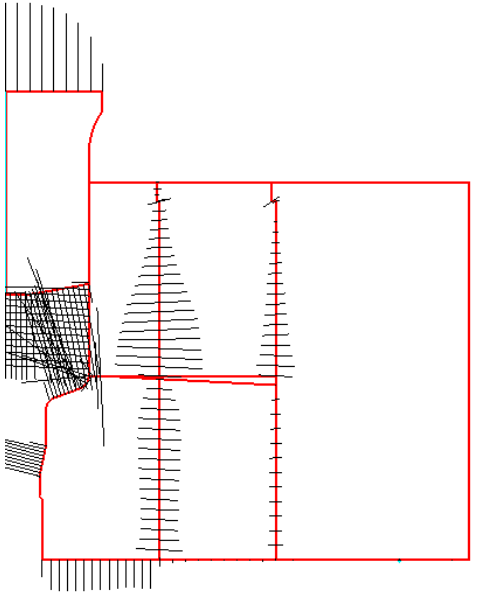




출처: KSTP Autumn 2012

금형구조해석, 열박음 기능

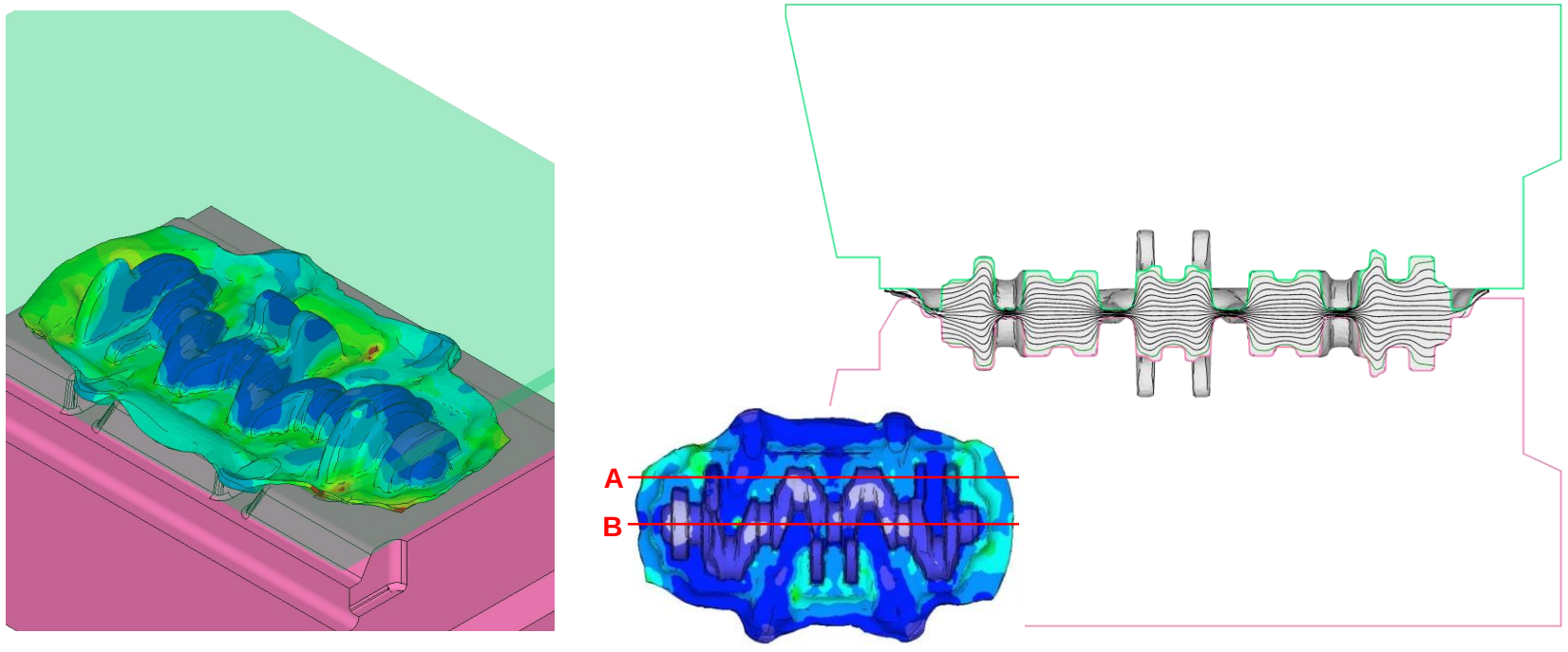


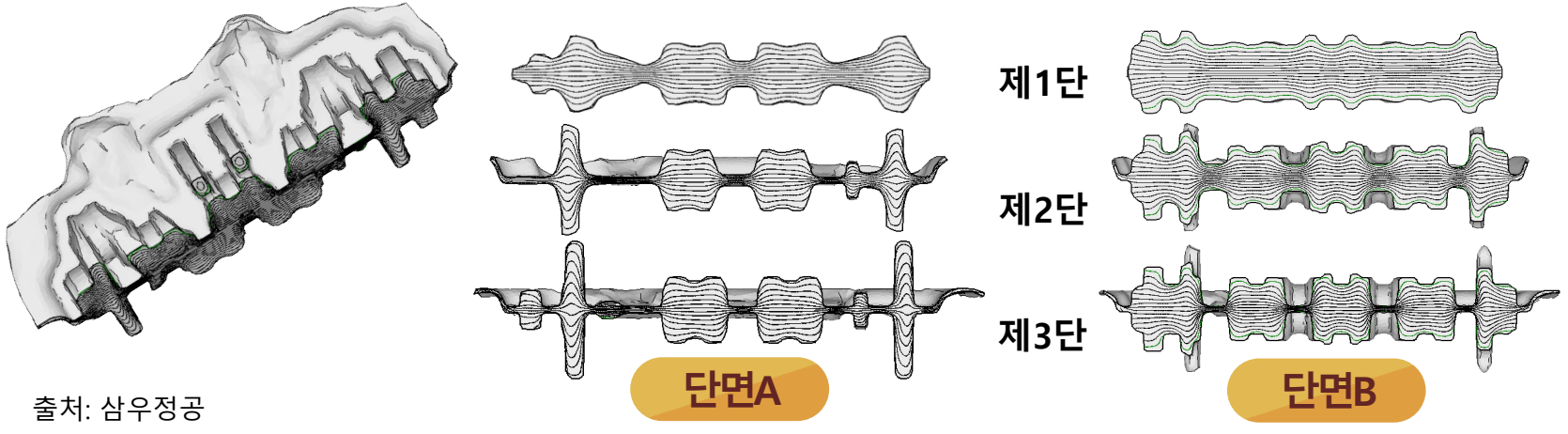


출처: 일진금속

2.
3차원

크랭크샤프트 열간형단조

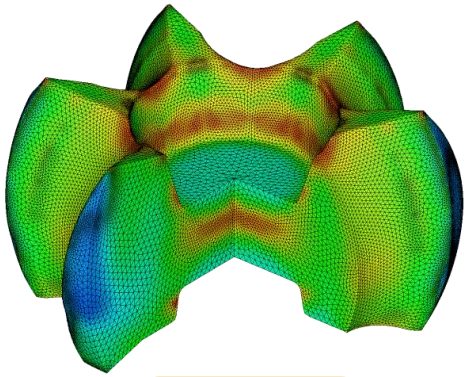




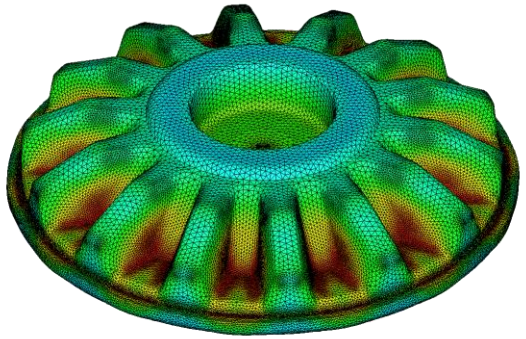
출처: 삼우정공

냉간폐쇄단조

장축 베벨기어



인너레이스



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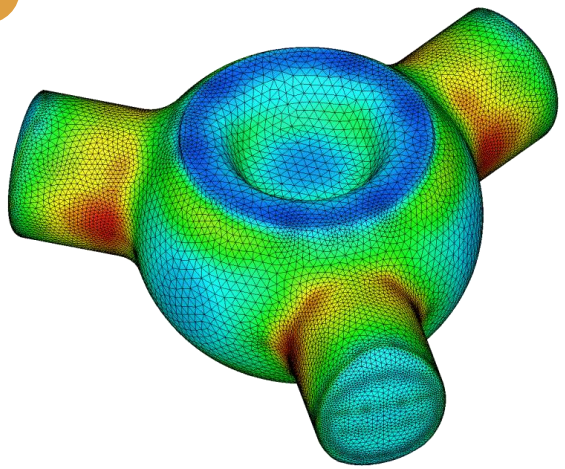
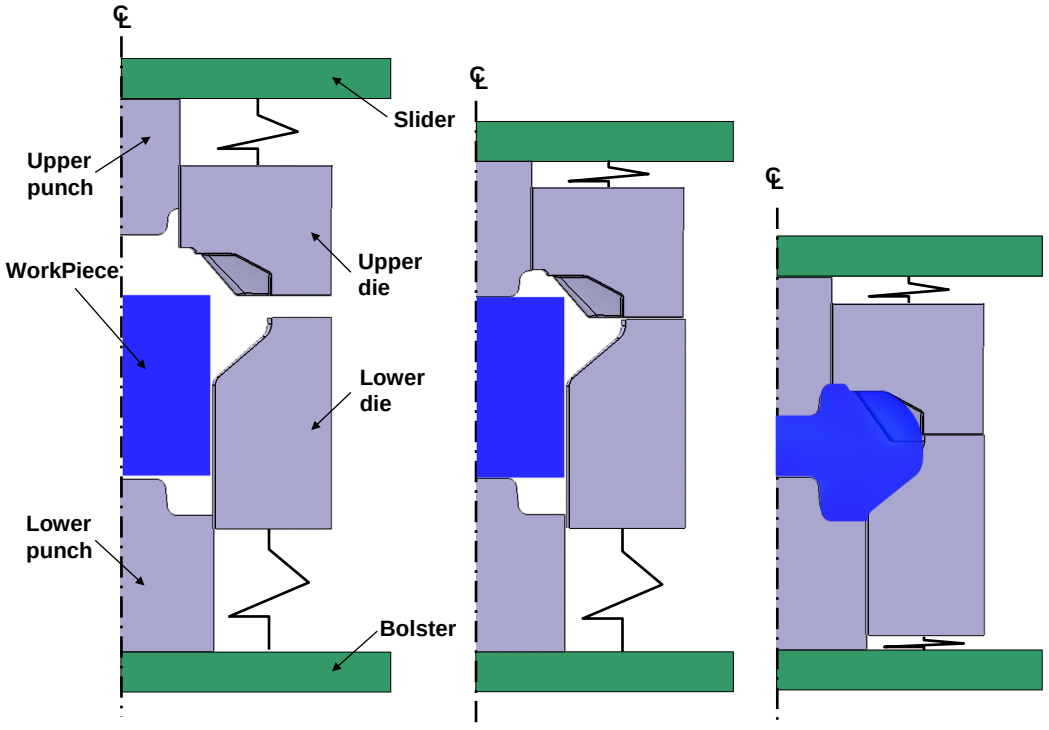
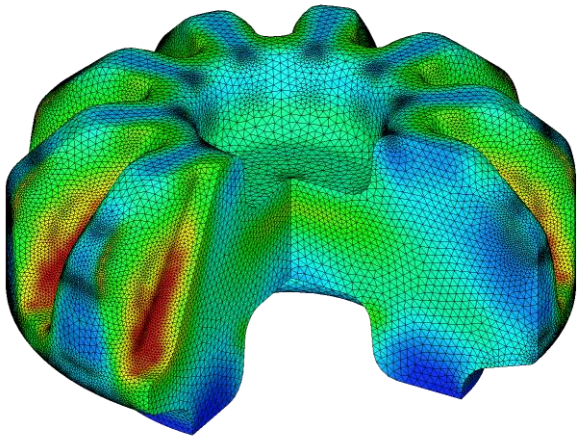


트라이포드

냉간폐쇄단조

베벨기어 폐쇄단조 개념





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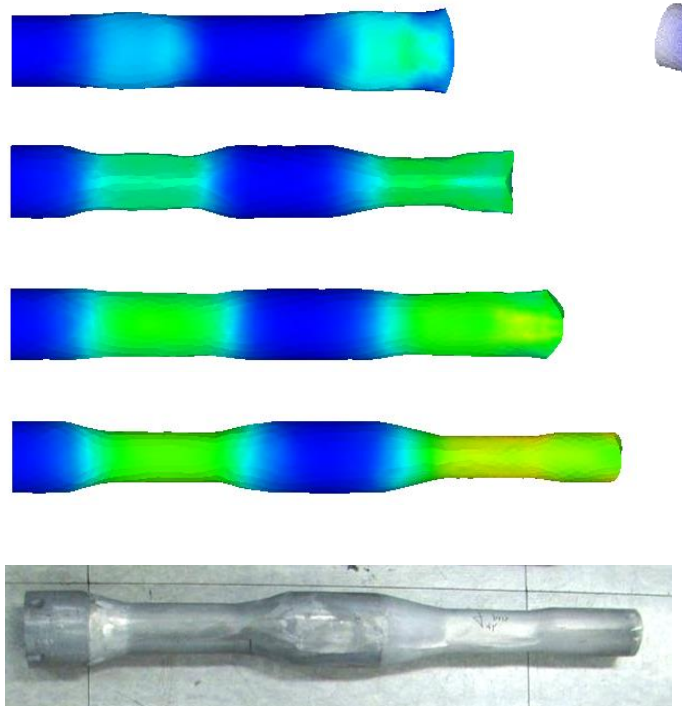
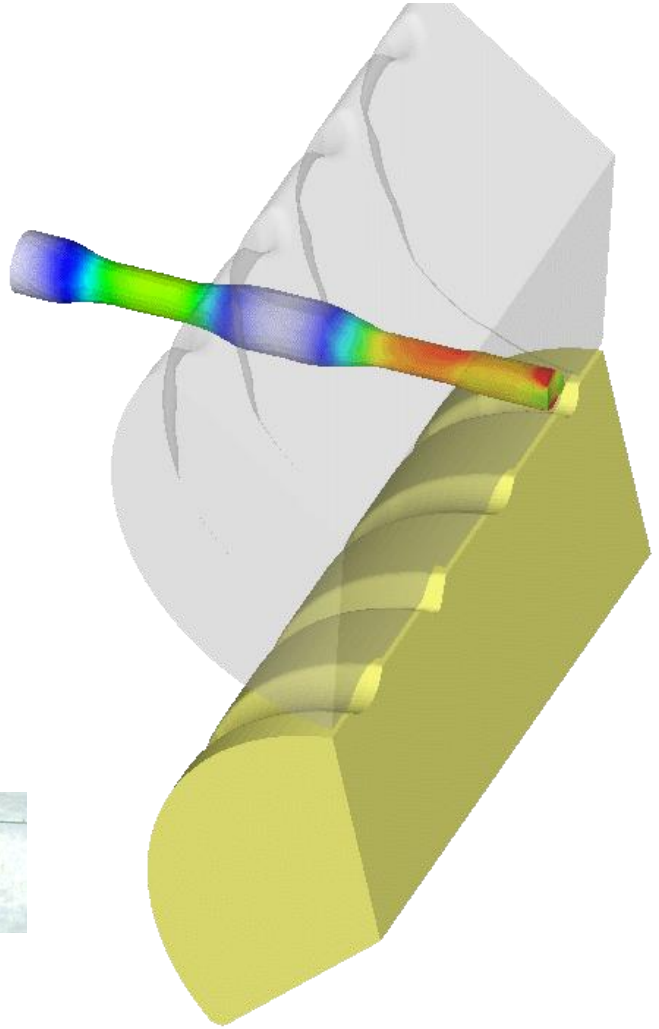
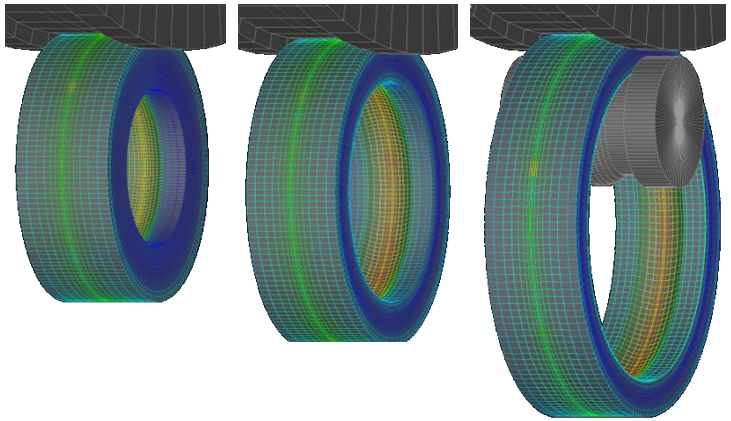


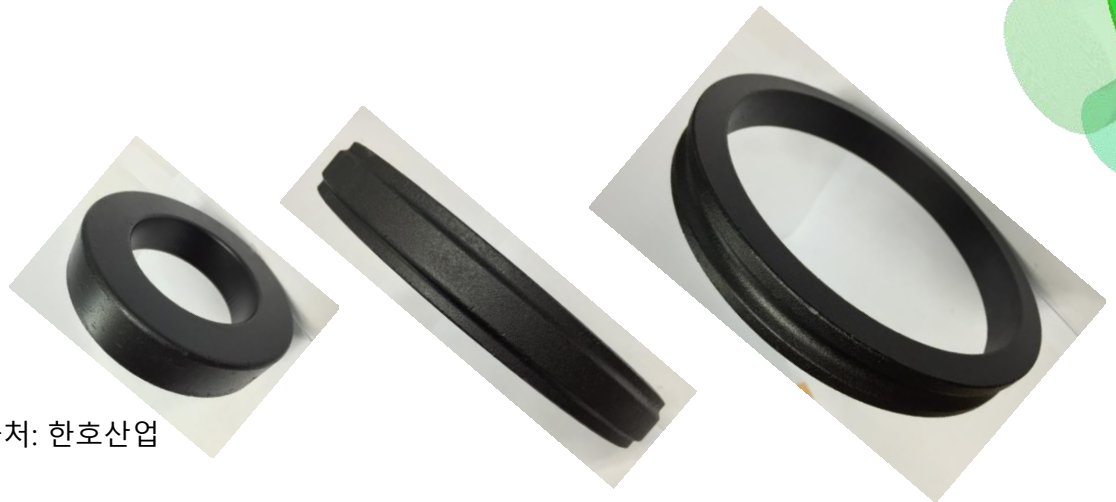


출처: 센트랄모텍

링롤링

냉간 형상 링롤링

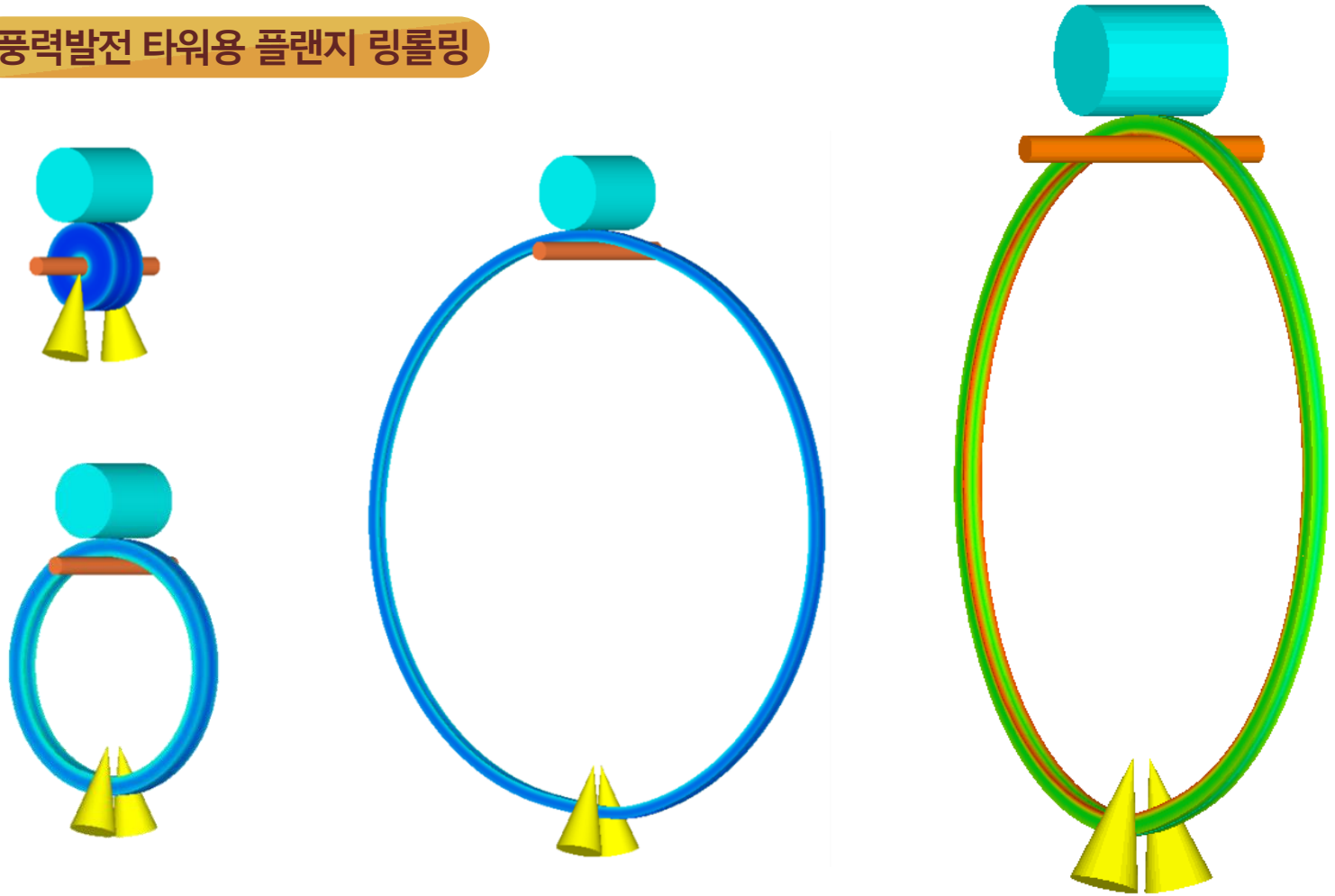




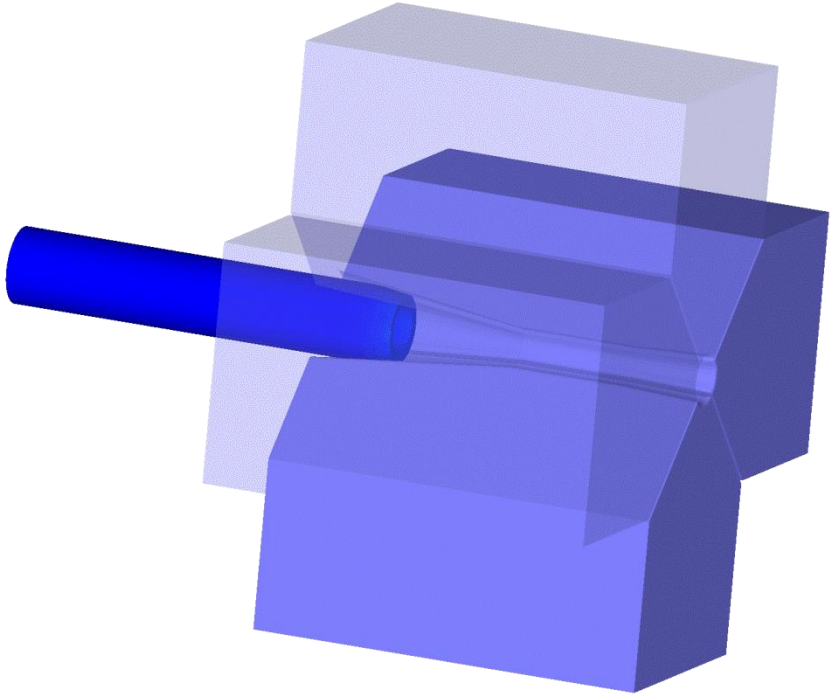
출처: 한호산업

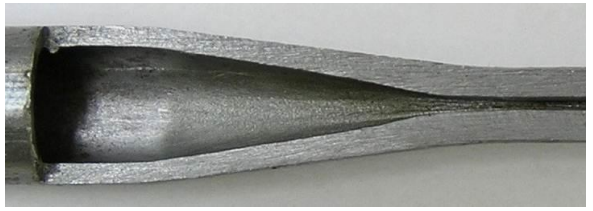
링롤링

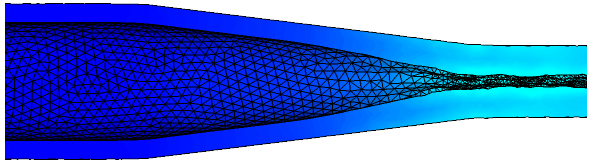
풍력발전 타워용 플랜지 링롤링



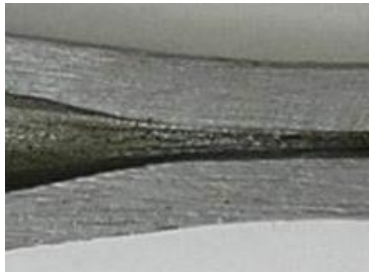
스웨이징 (Swaging)







실험



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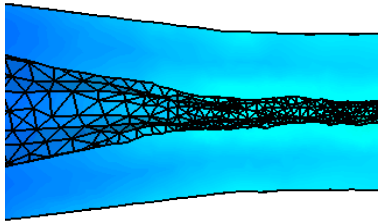
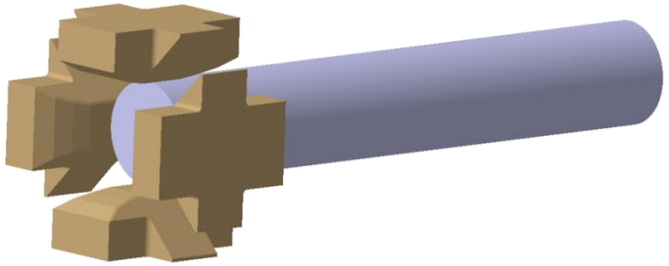
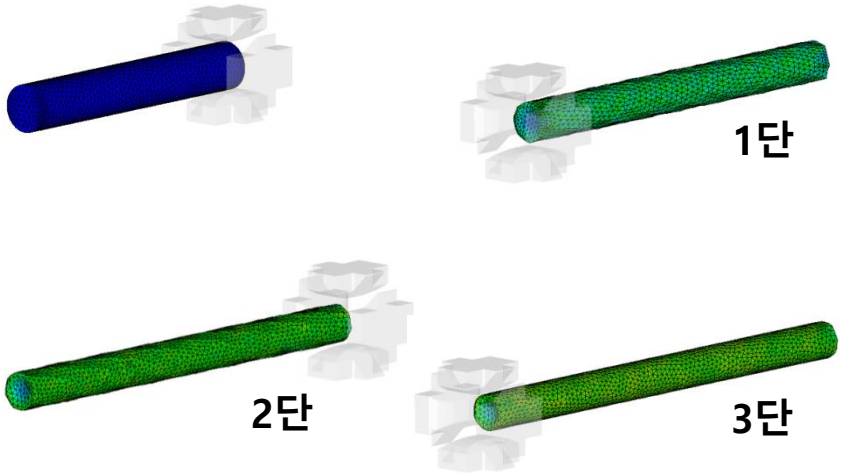


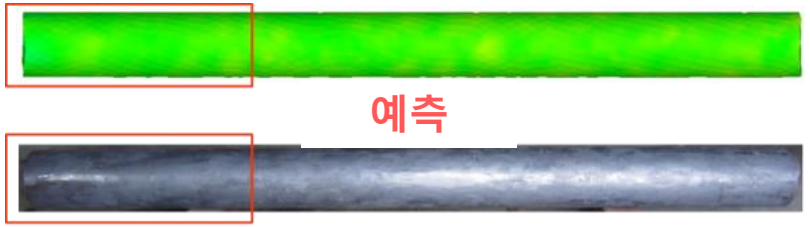
출처: KITECH

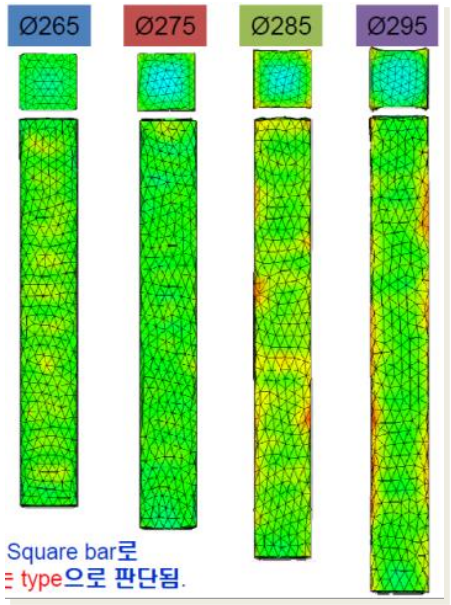
반경단조

원형/사각 축의 반경단조





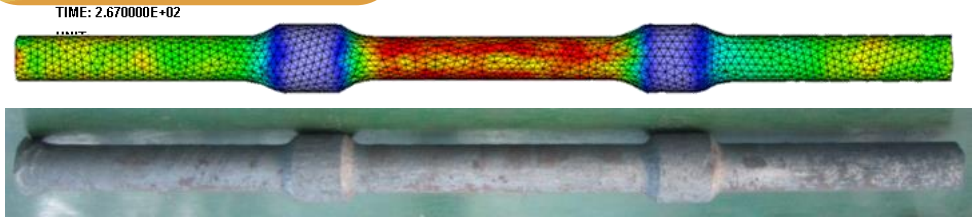


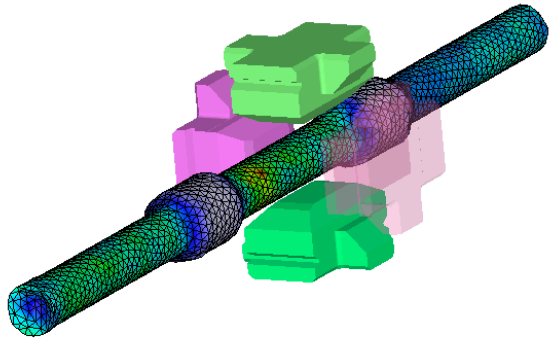


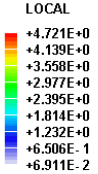
출처: 용현BM

반경단조

계단 봉의 반경단조

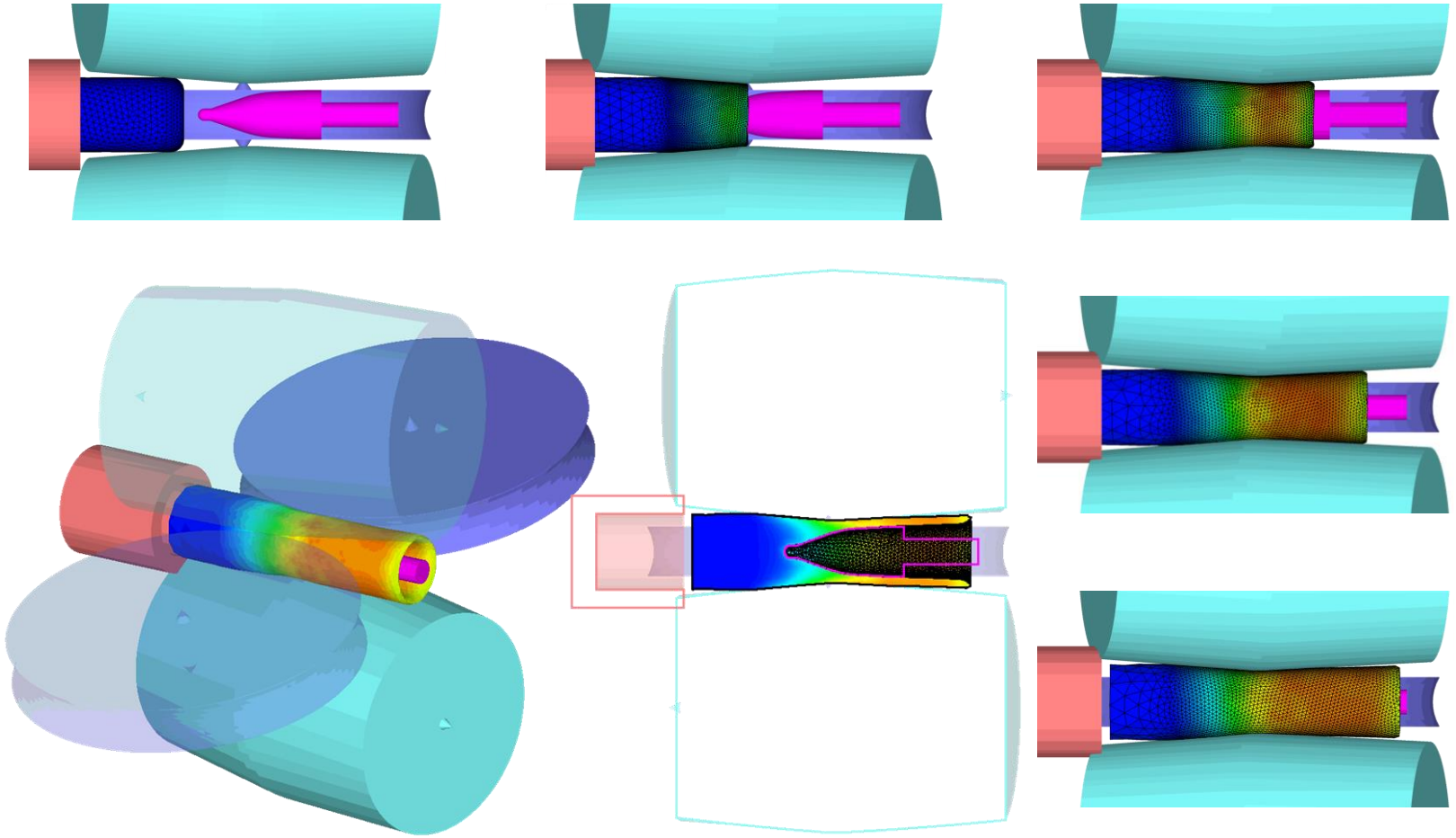






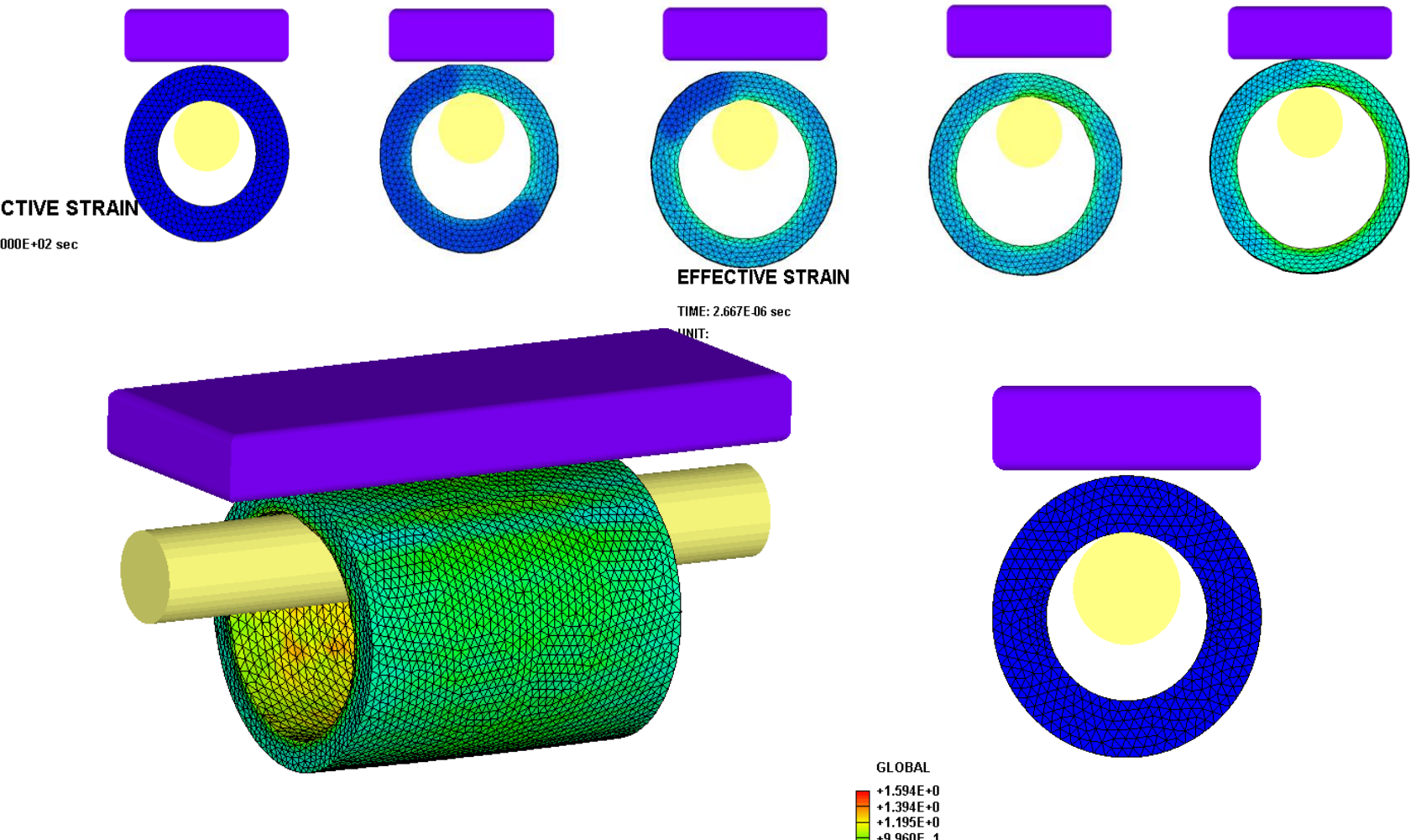
출처: 용현BM

롤피어싱(Roll piercing)

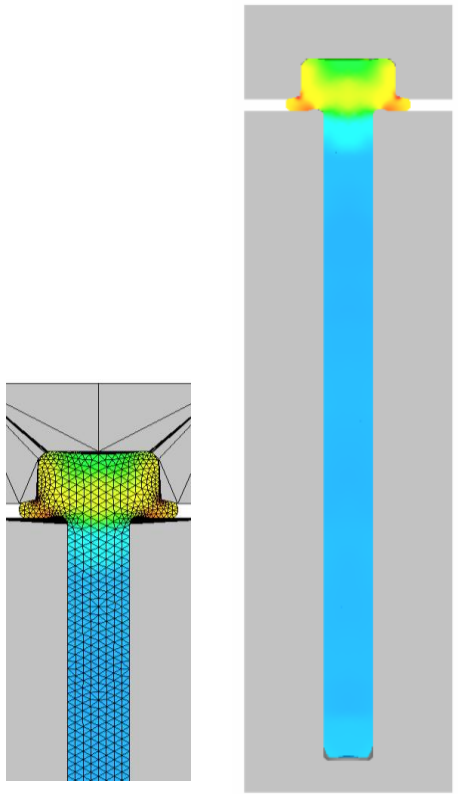


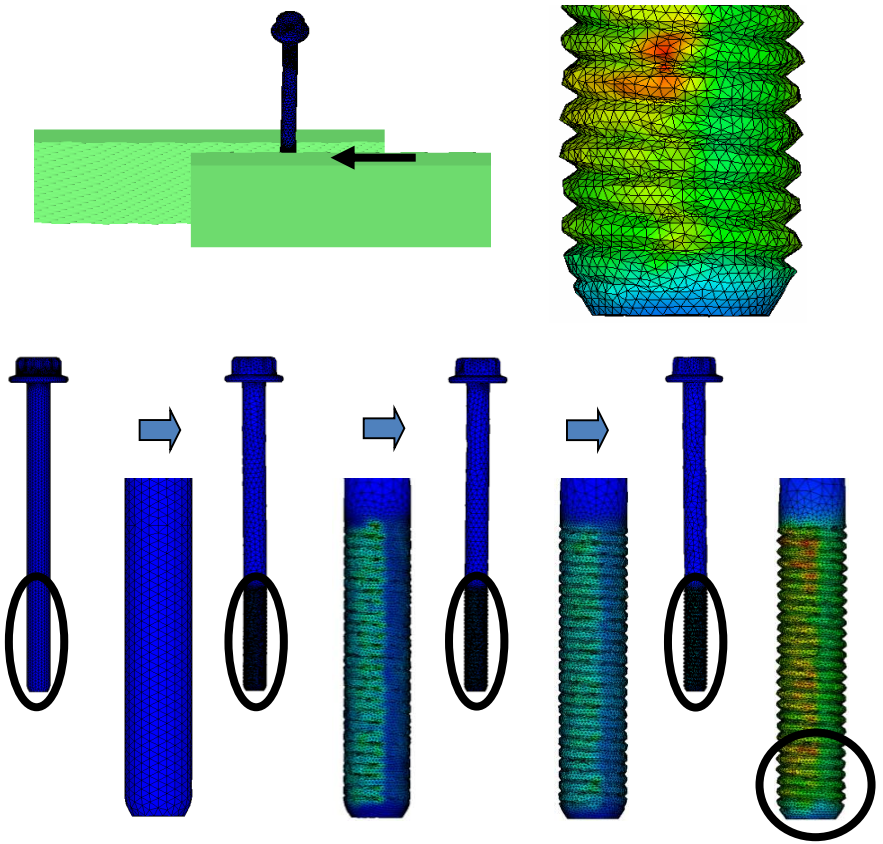
출처: 용현BM

반경링단조(Radial ring forging)



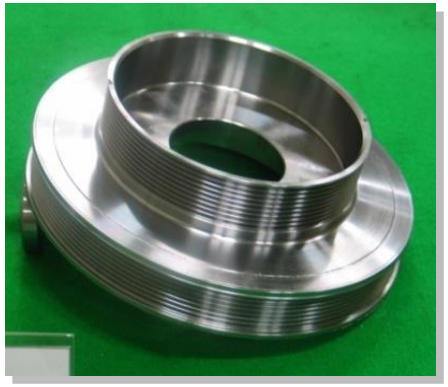
나사소재 단조 및 전조(Thread rolling)

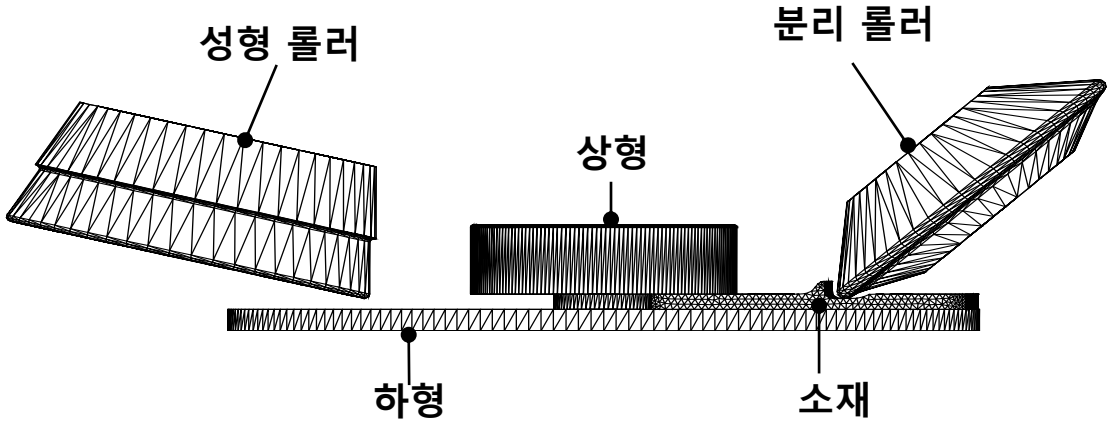


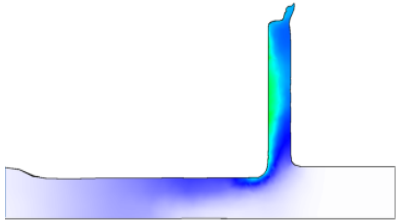


출처: Metal Forming 2010, 영신금속

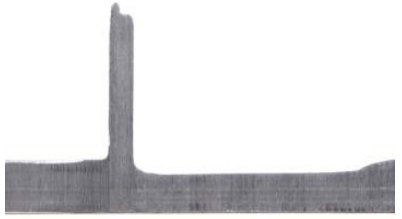
칩리스 포밍 (플로우 포밍)



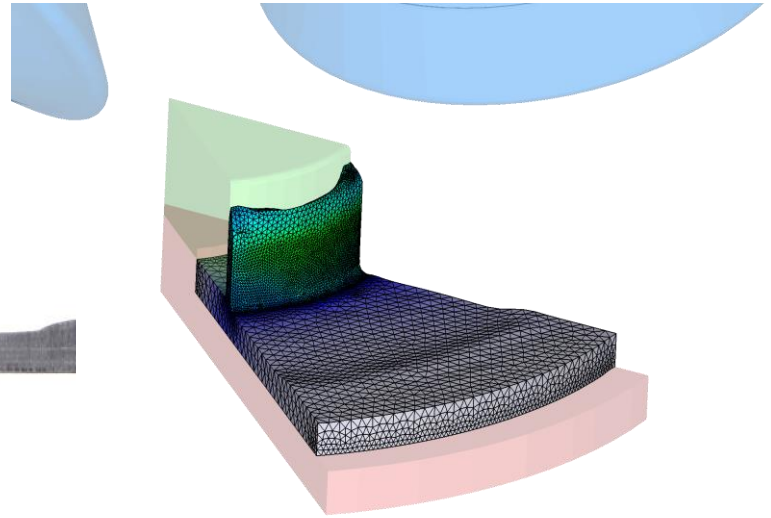




예측



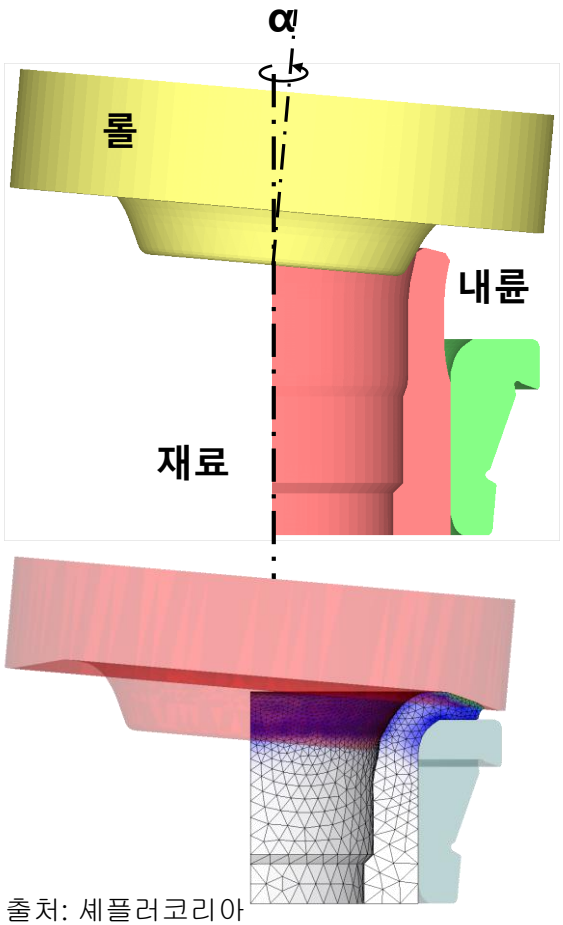
실험

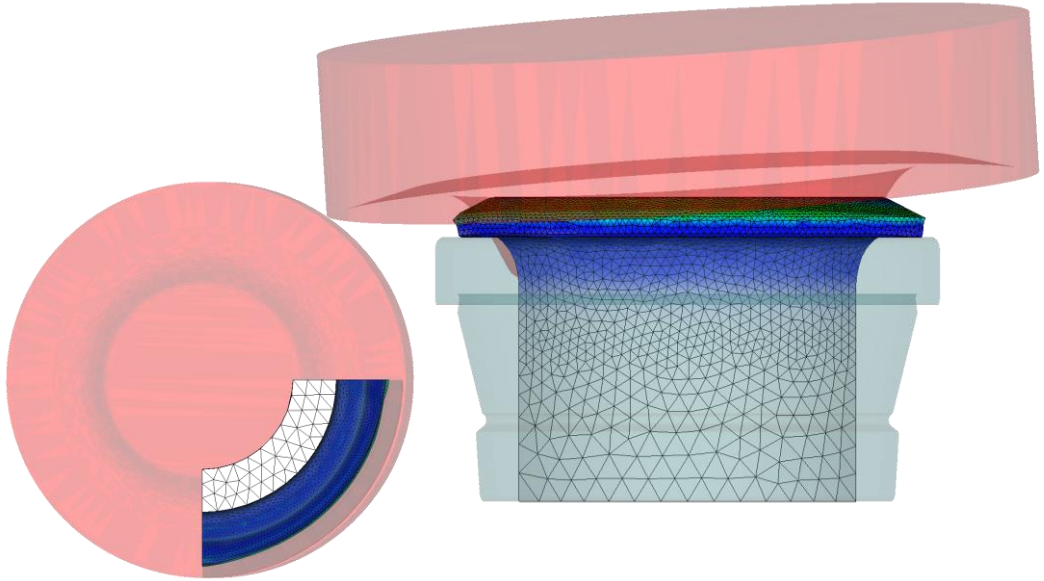


출처: ROFT

회전단조 (Rotary forging)

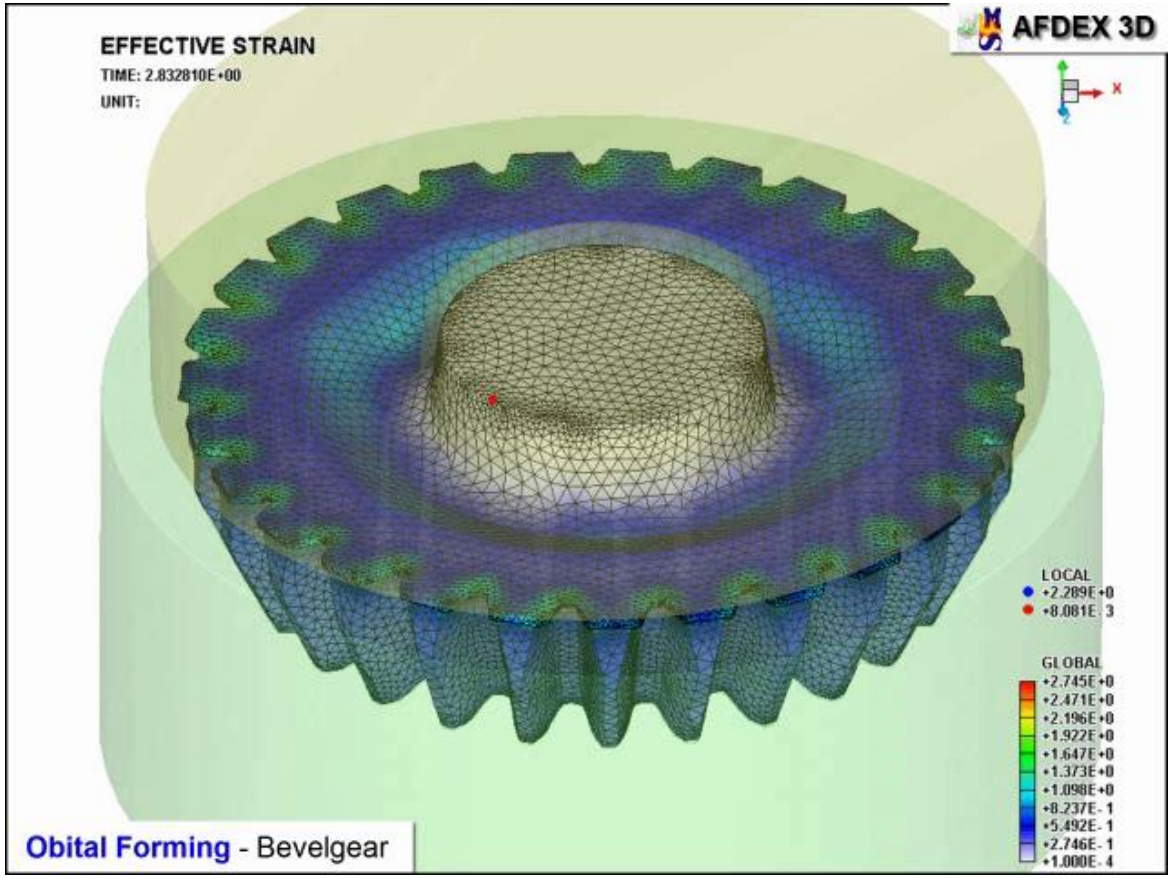
허브베이링 조립공정





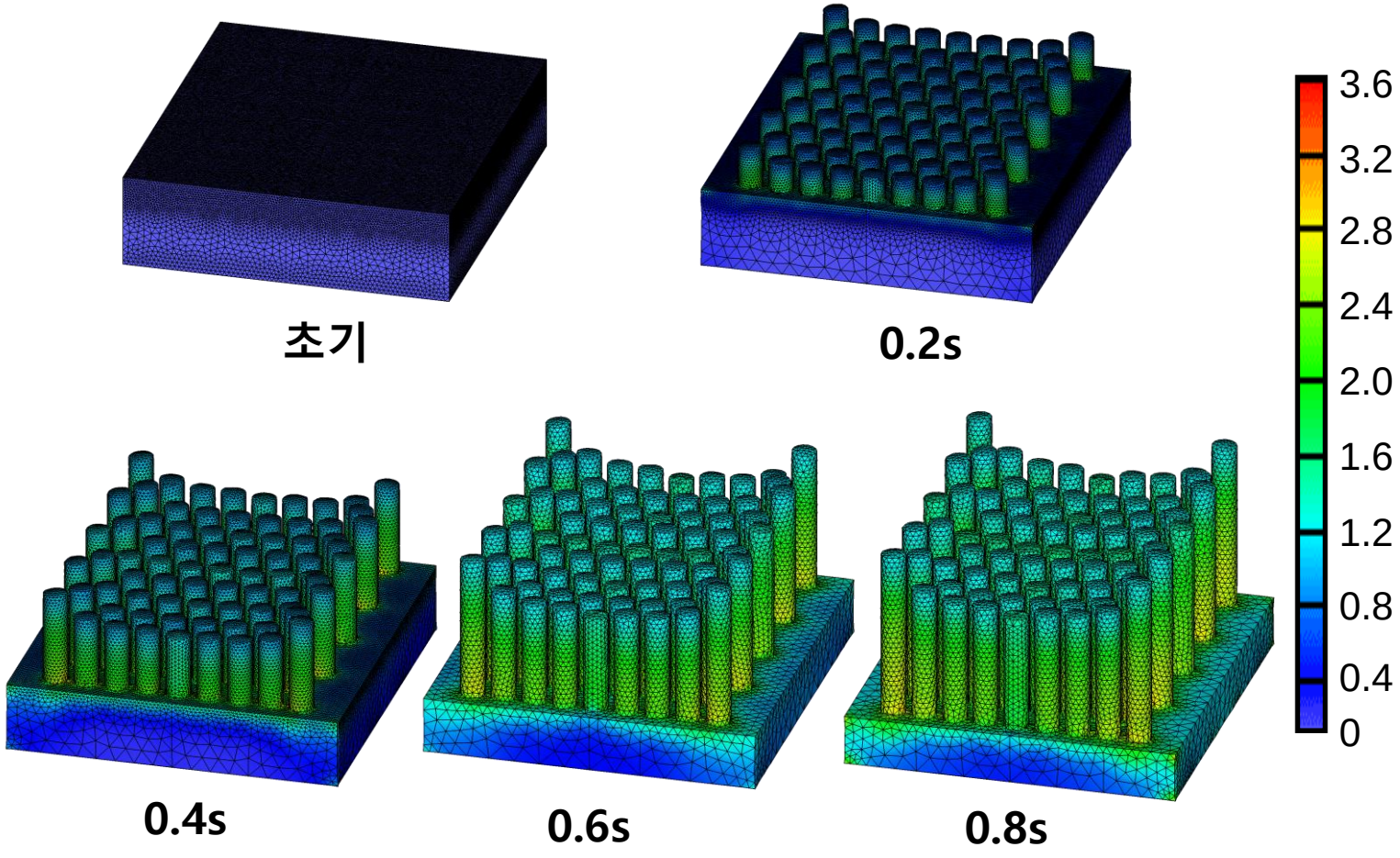
출처: 셰플러코리아

회전단조 (Rotary forging)

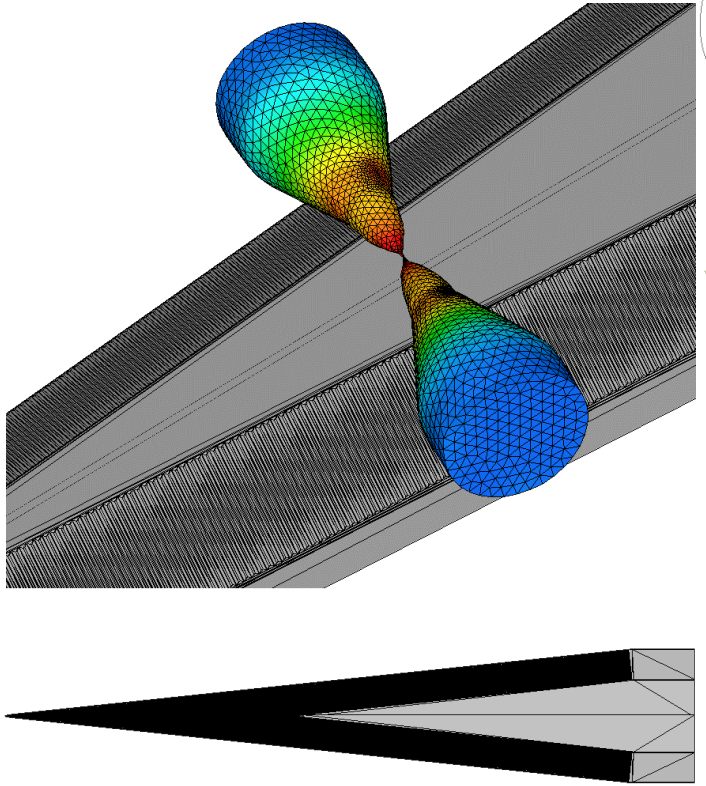


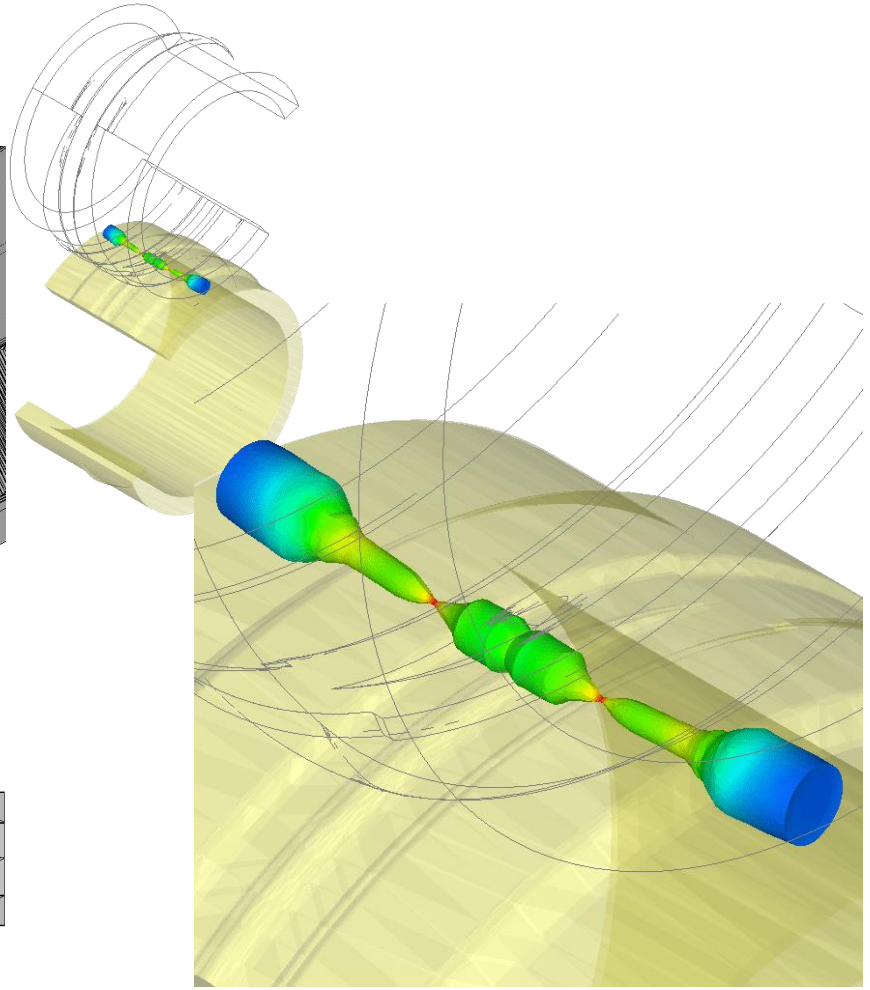
출처: BRIMET

히트싱크 단조(Heat sink forging)



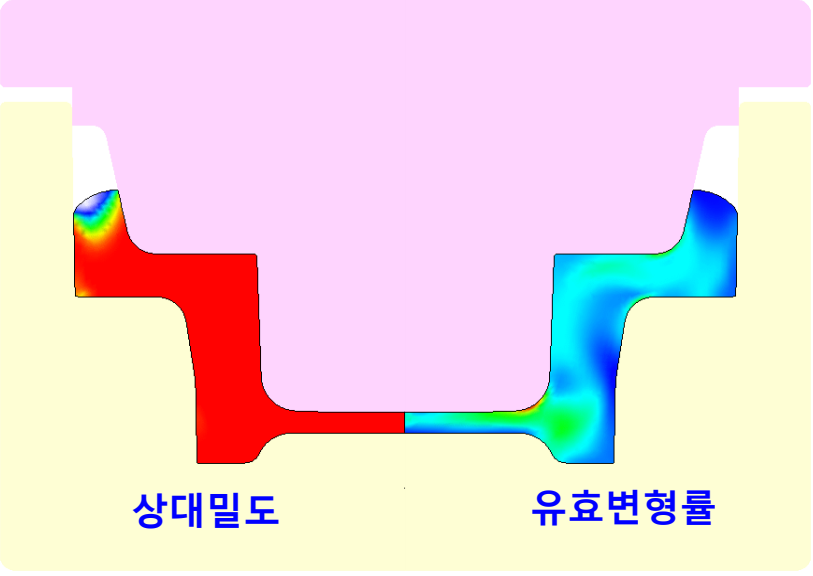
크로스웨지롤링 (Cross-wedge rolling)

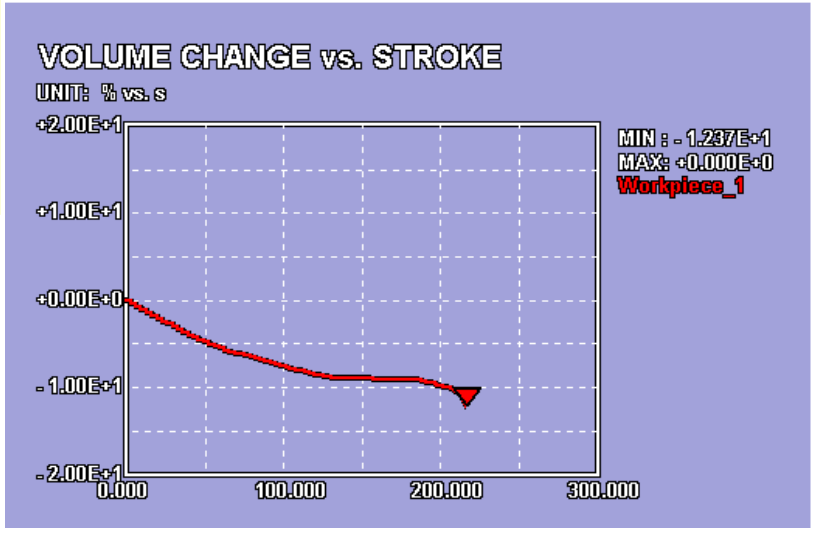




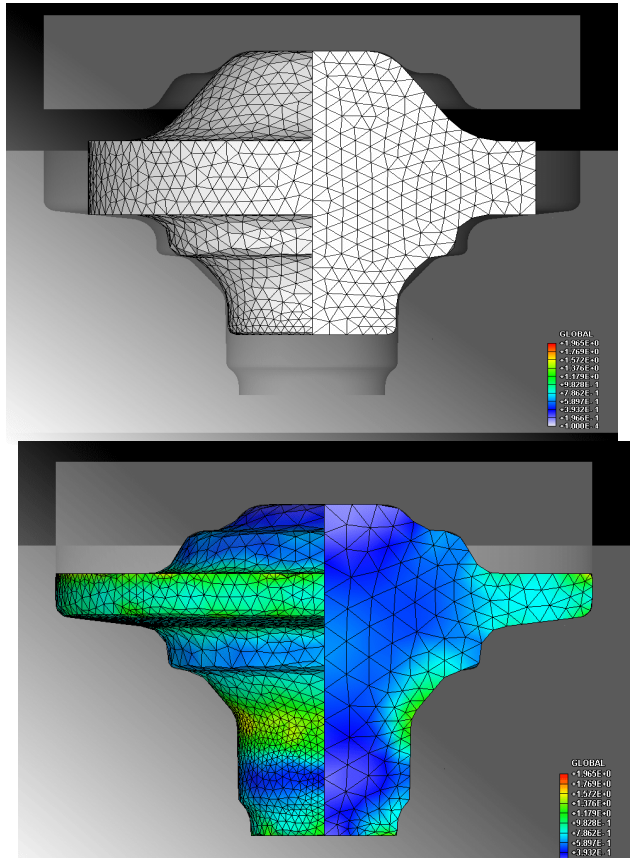
출처: BRIMET

분말단조(Powder forging)

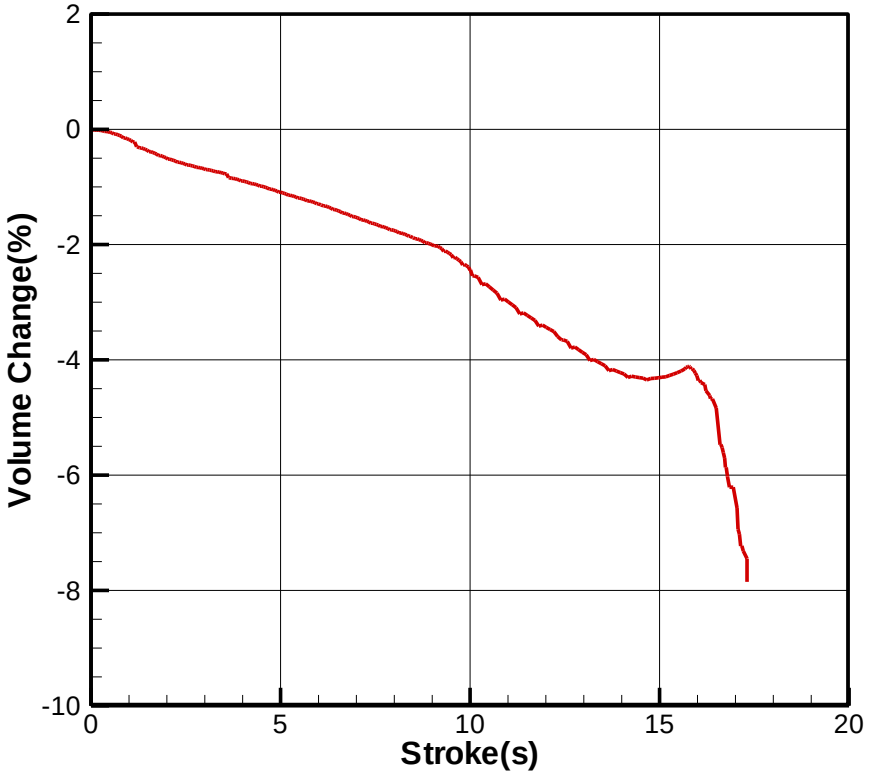




분말단조(Powder forging)



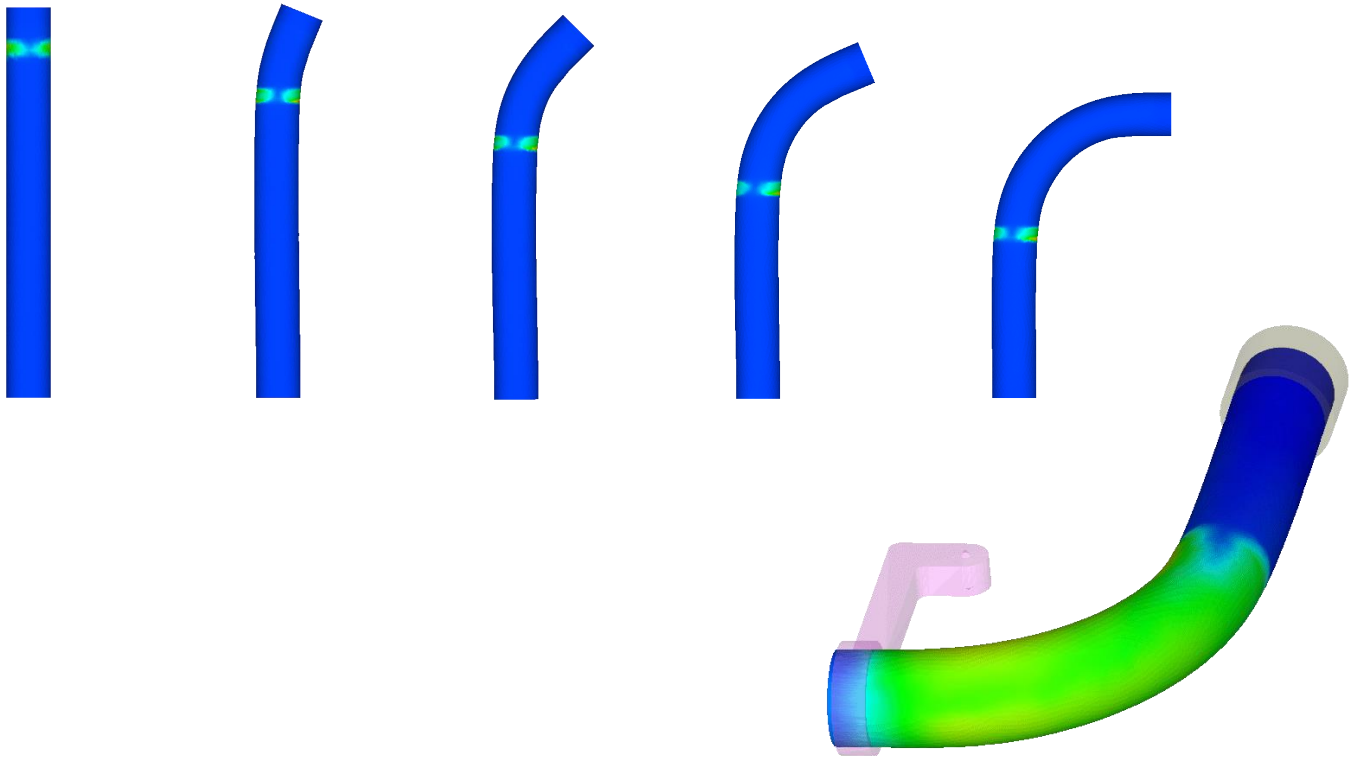
상대밀도



부피변화

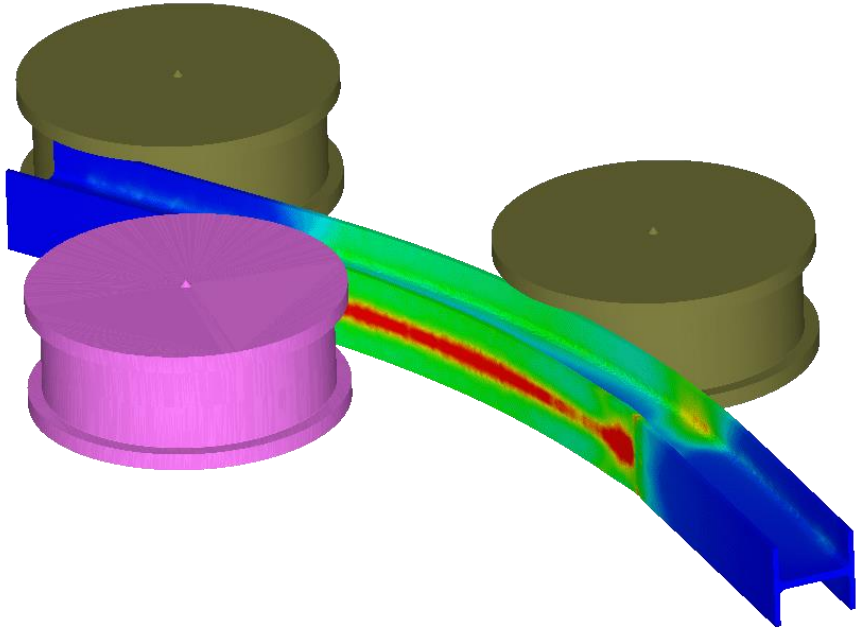
보 벤딩(Beam bending)

유도가열벤딩



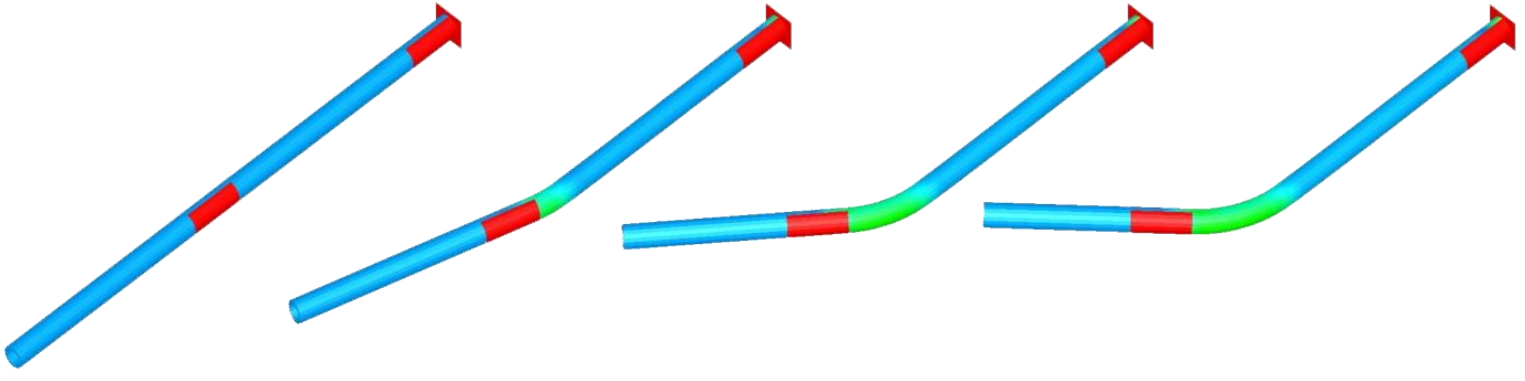
보 벤딩(Beam bending)

롤벤딩



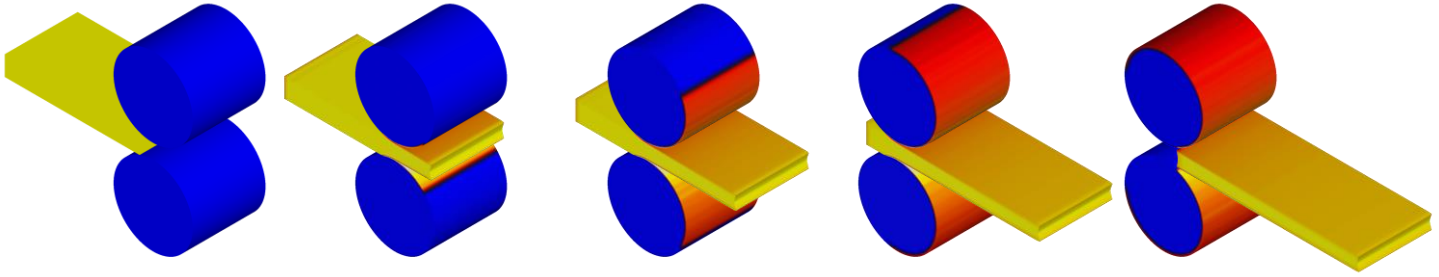
보 벤딩(Beam bending)

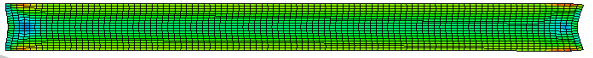
파이프벤딩



압연

평면변형 압연

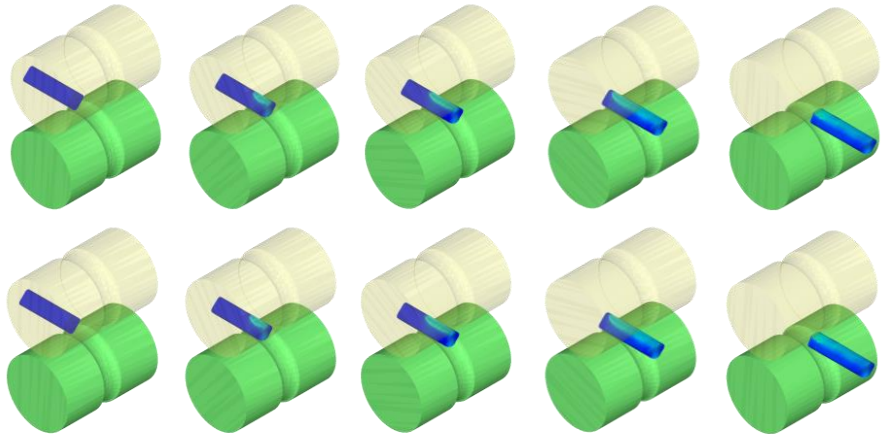


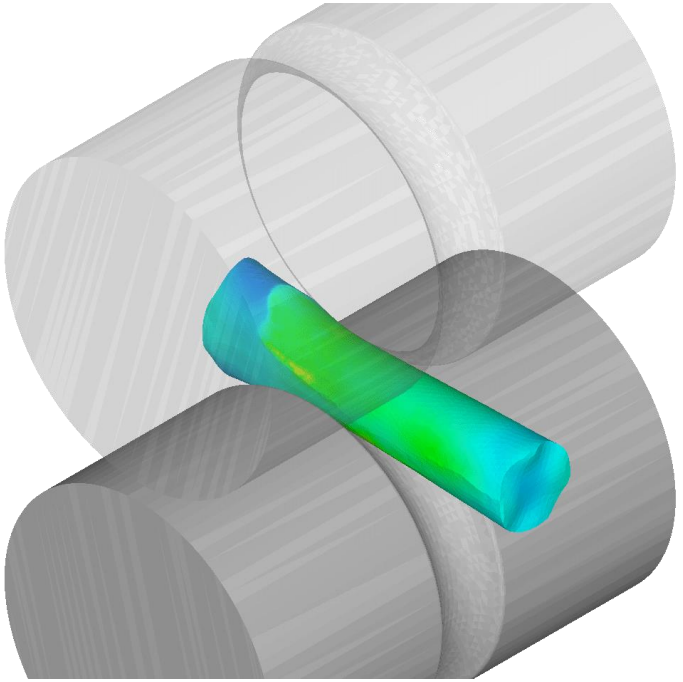


압연

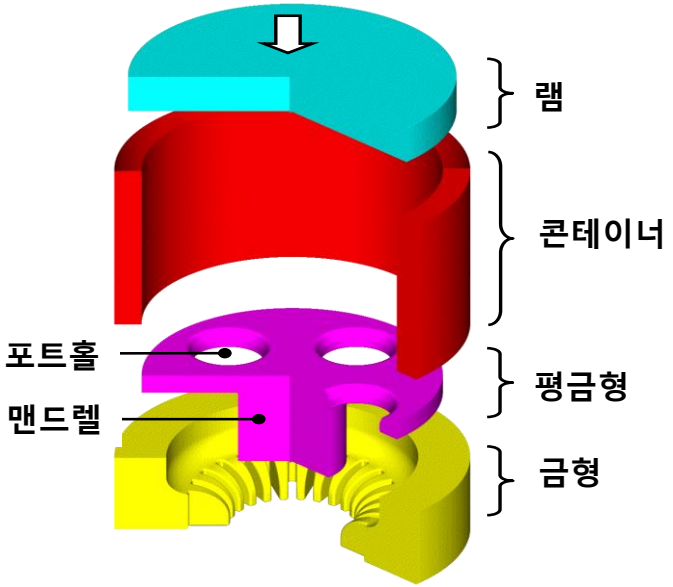
형상압연

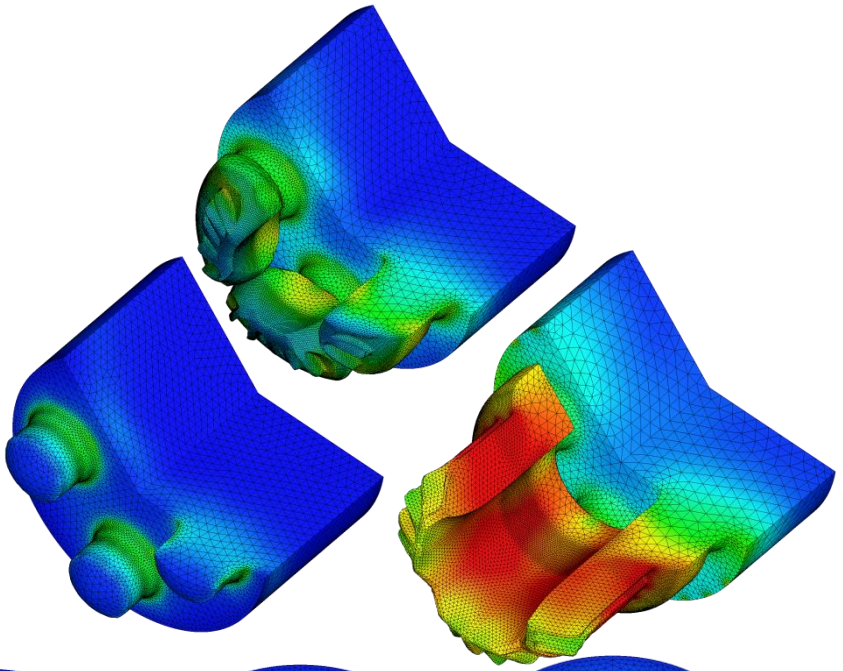
사각형 → 타원 → 원형

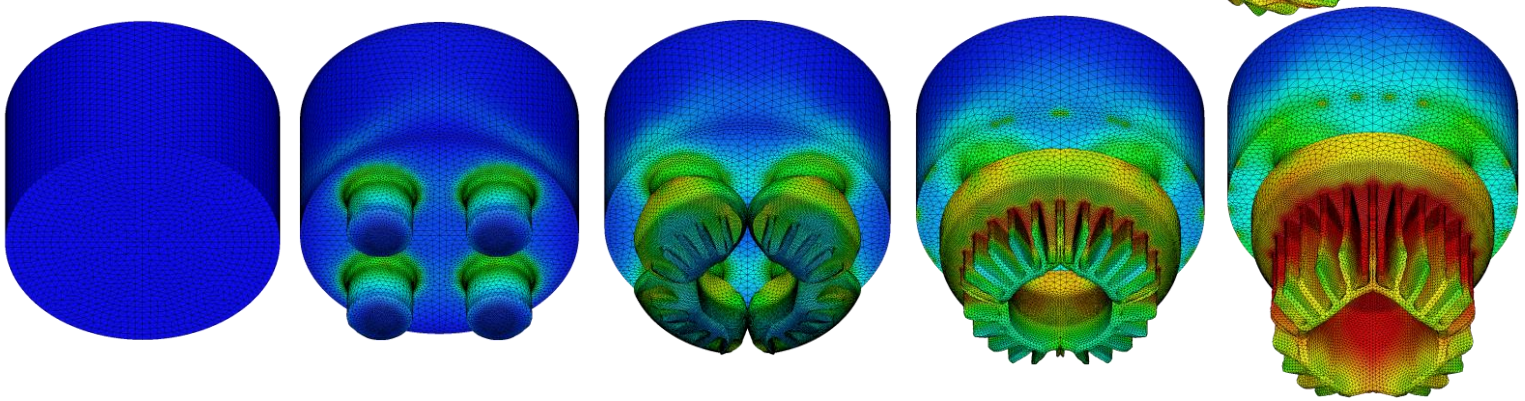




알루미늄 중공 제품의 압출

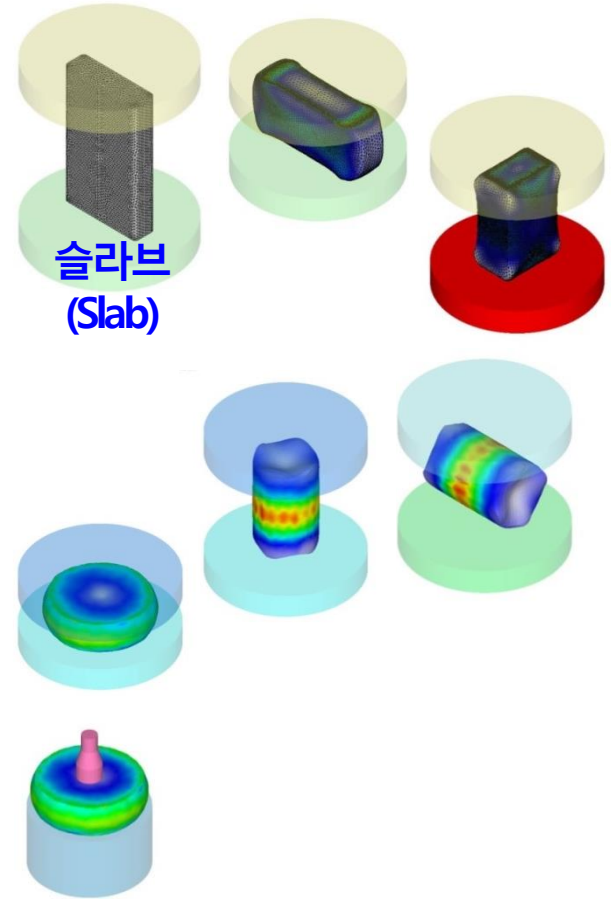


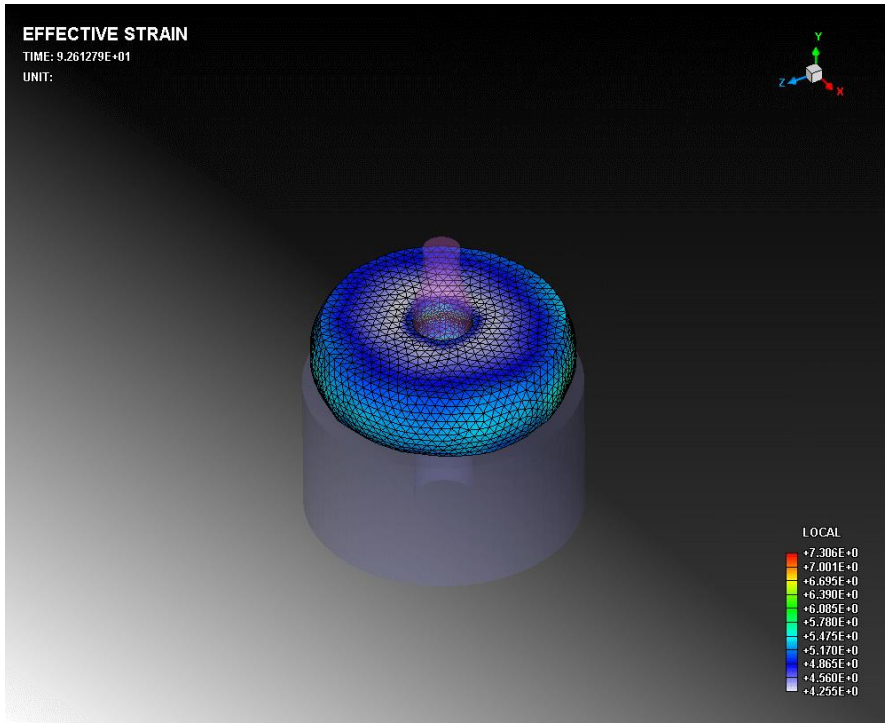




대형 베어링 내외륜 제조공정 - 1

자유단조

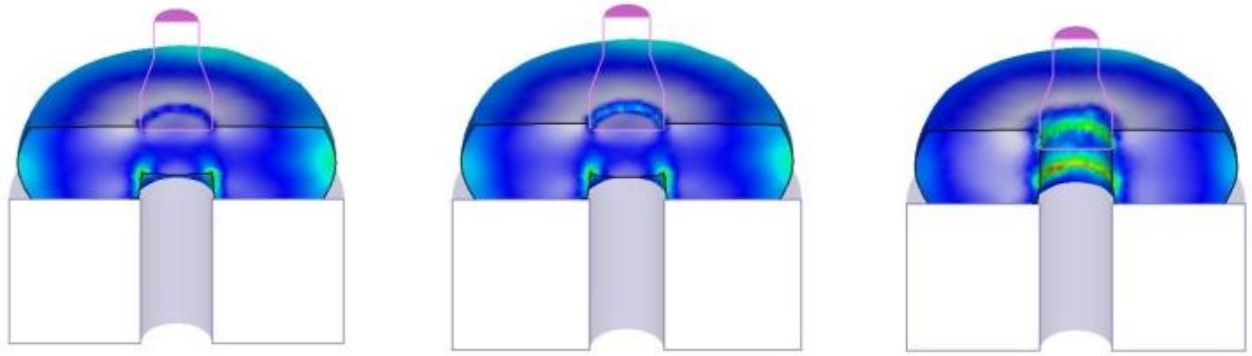




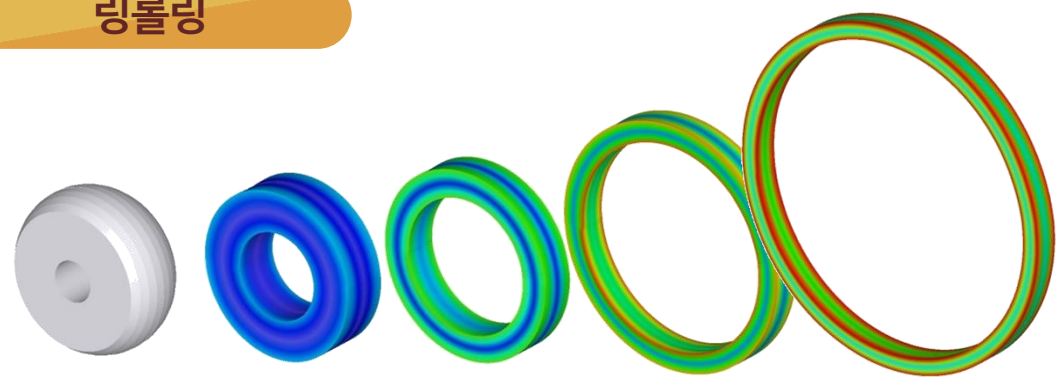
MFCAE2013(용현BM)

대형 베어링 내외륜 제조공정 - 2

피어싱

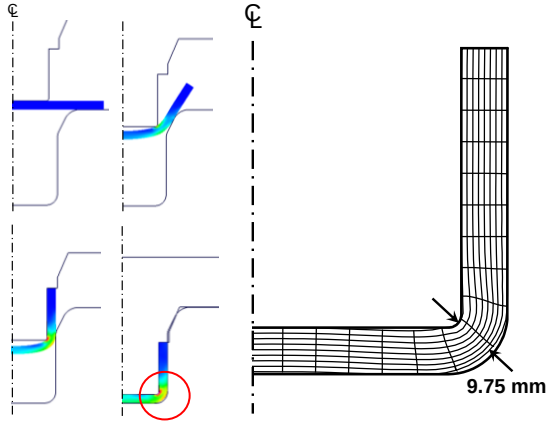


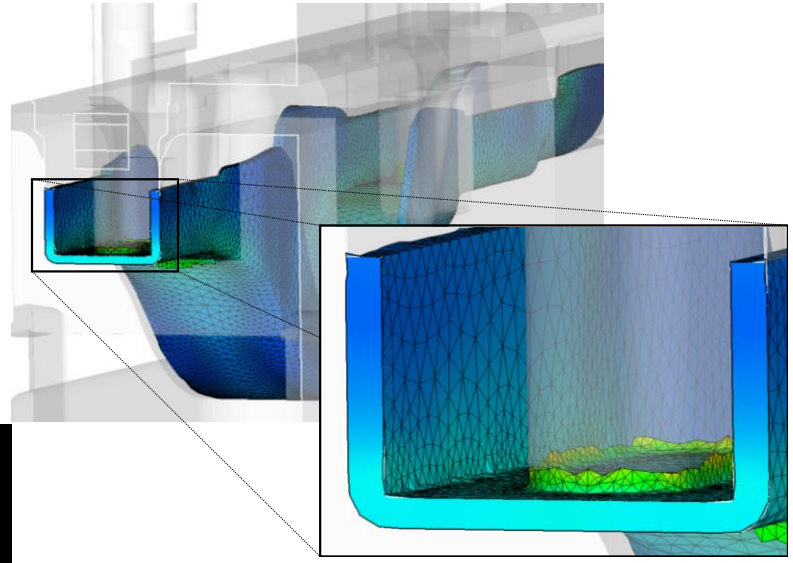
링롤링

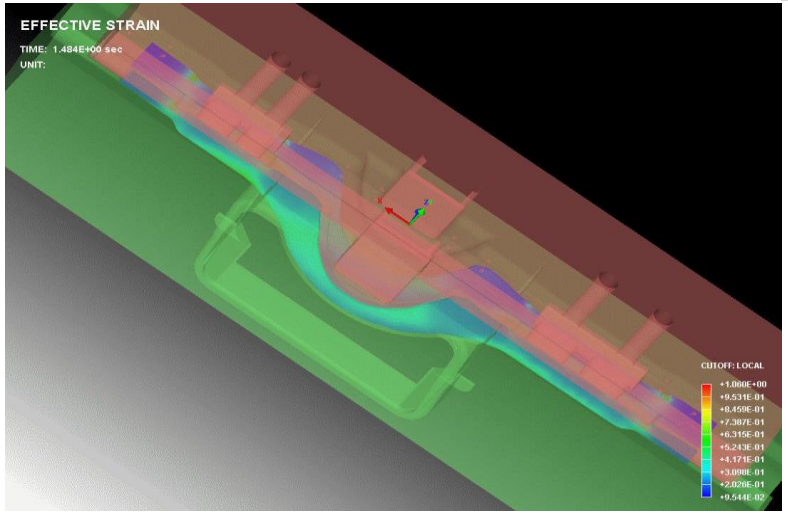


출처: MFCAE2013(용현BM)

고온 판단조 (Hot plate forging)



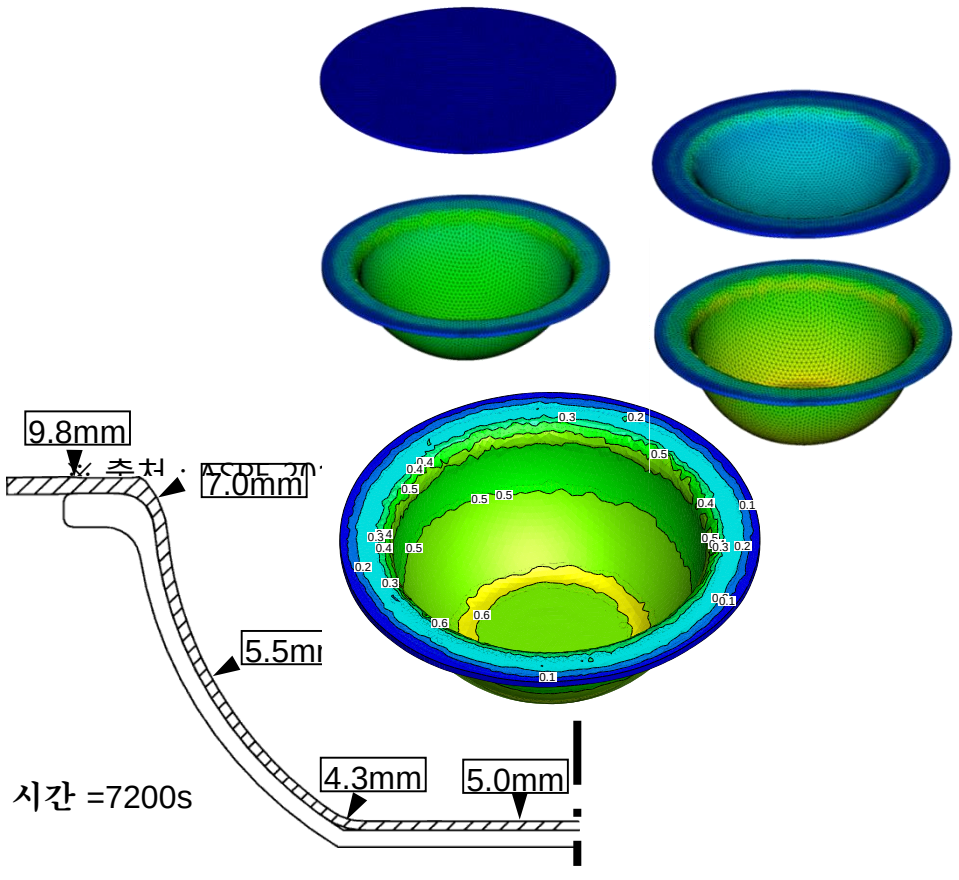


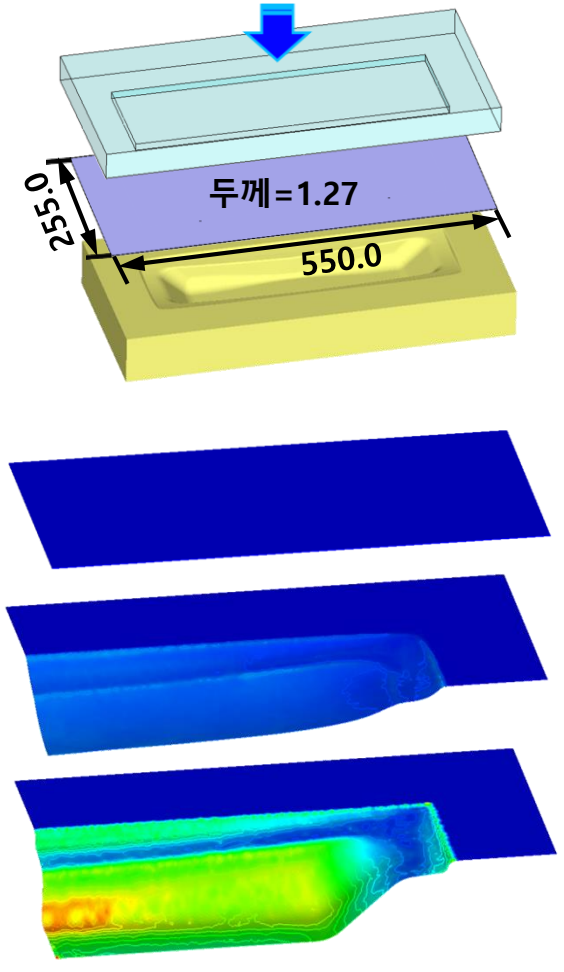


출처: 한국소성가공학회 2010, 지성정밀

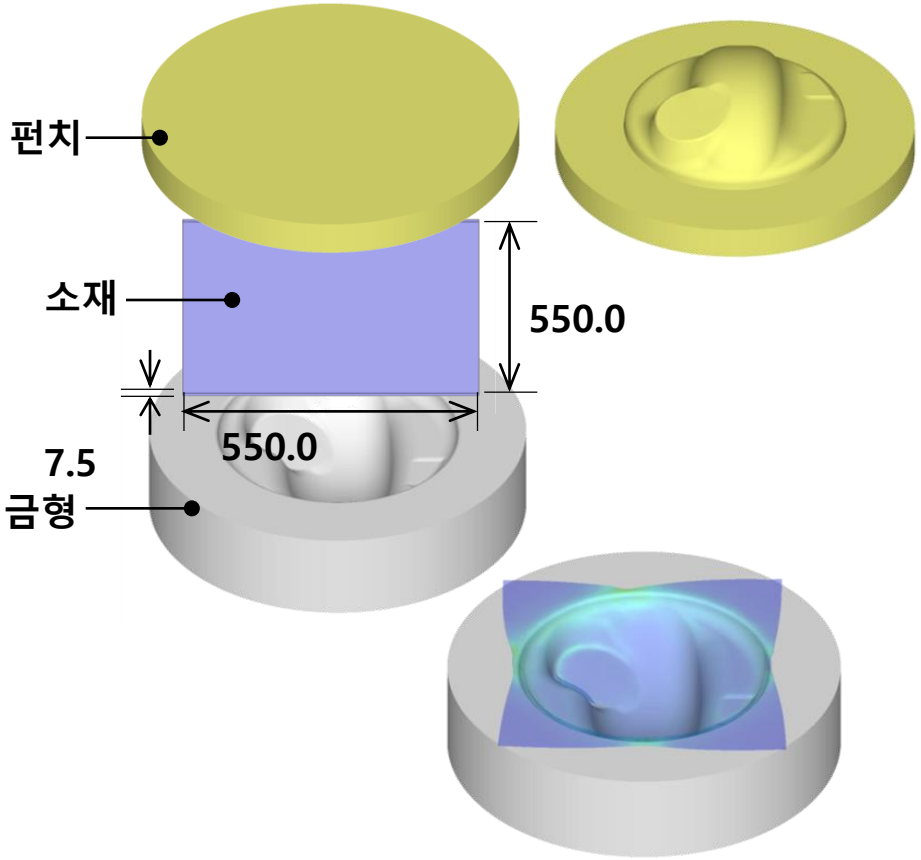
초소성 성형 공정

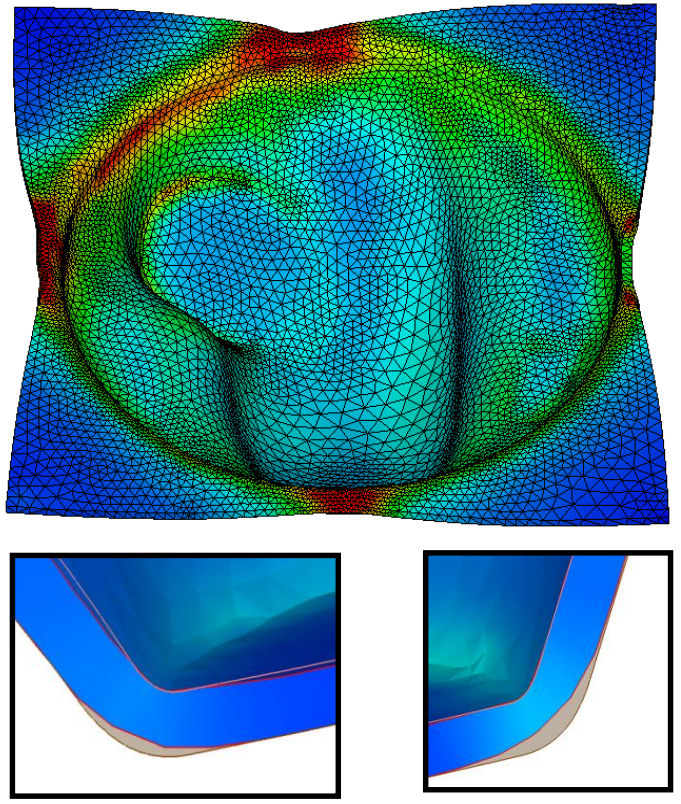
변형률속도





판단조 (Plate forging)





출처: 한국소성가공학회 2010 춘계학술대회, 지성정밀

사각컵 딥드로잉

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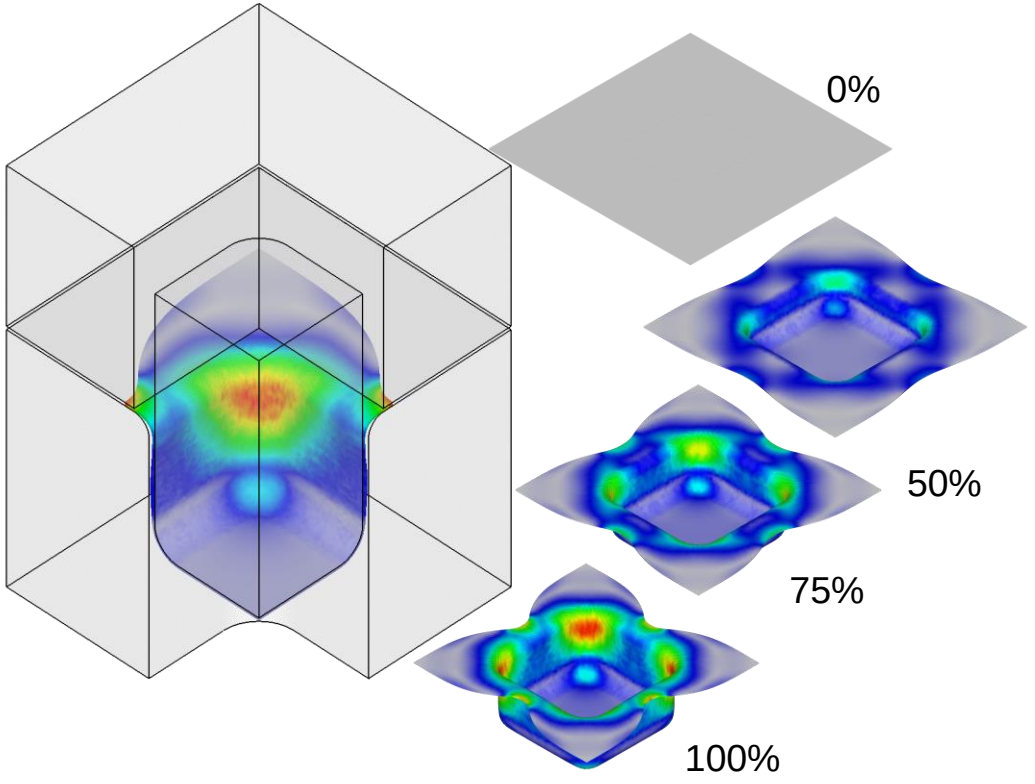

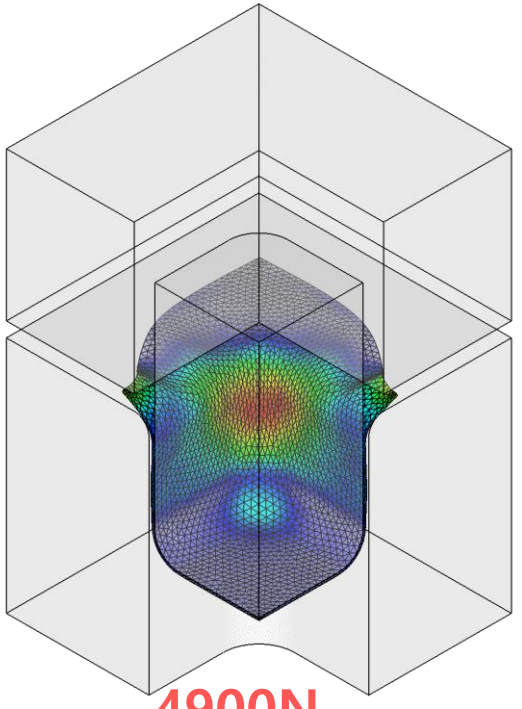

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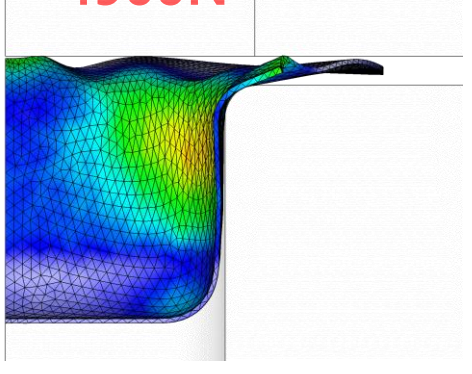

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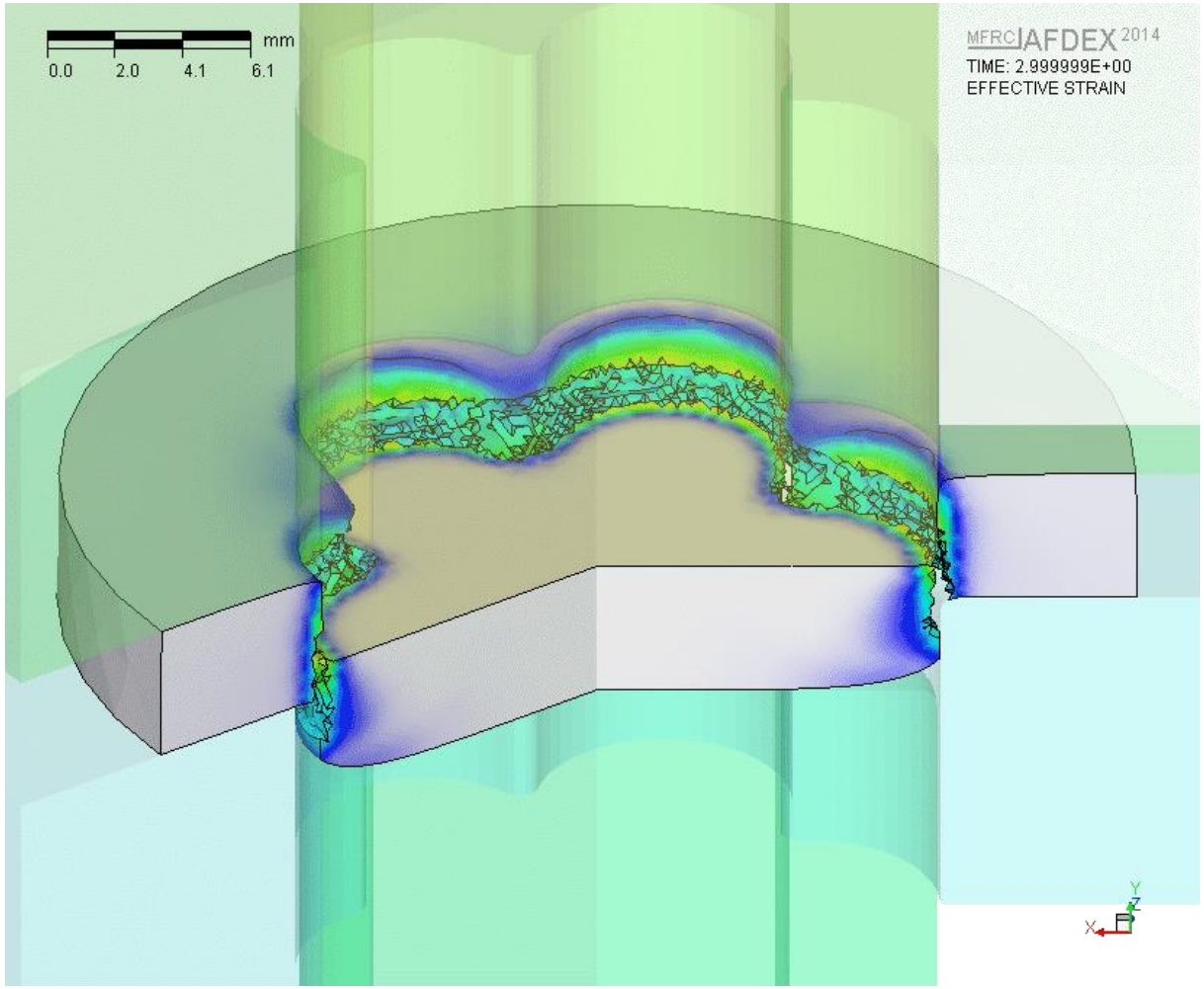
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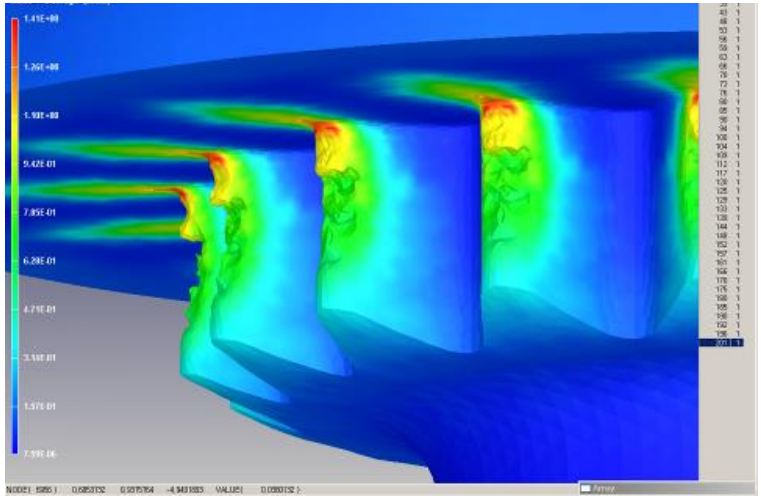
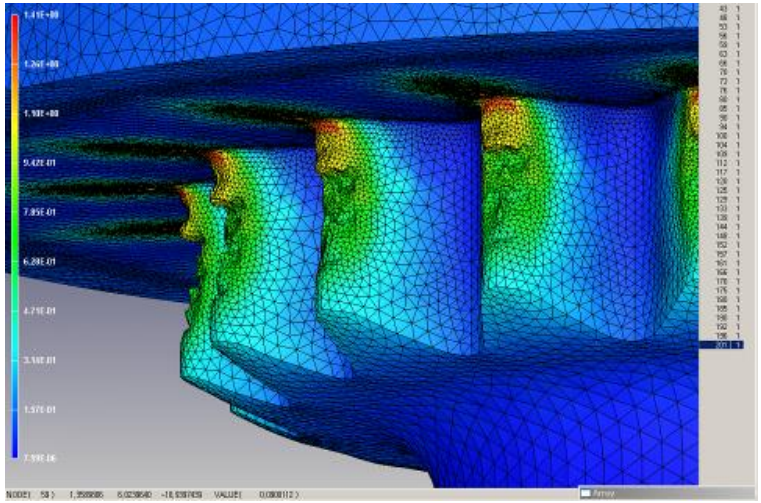
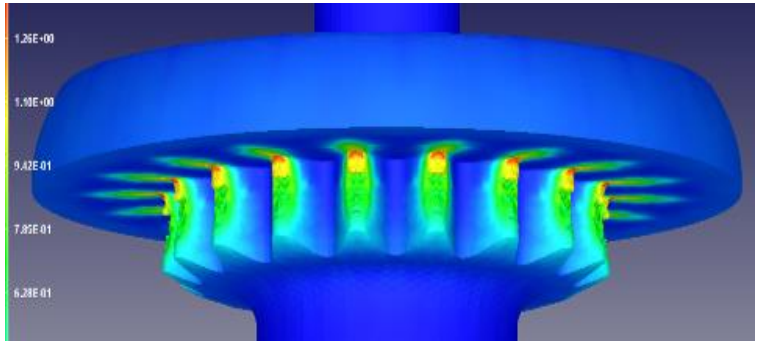
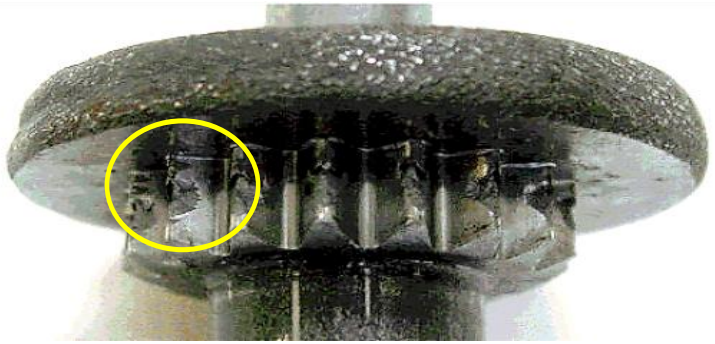


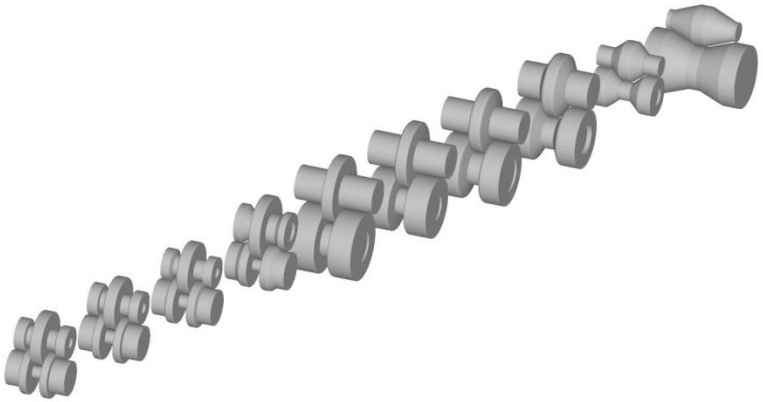


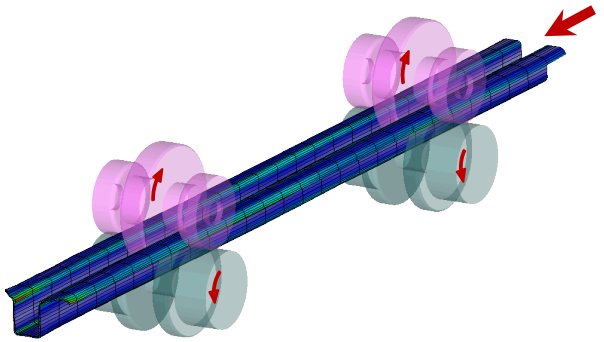




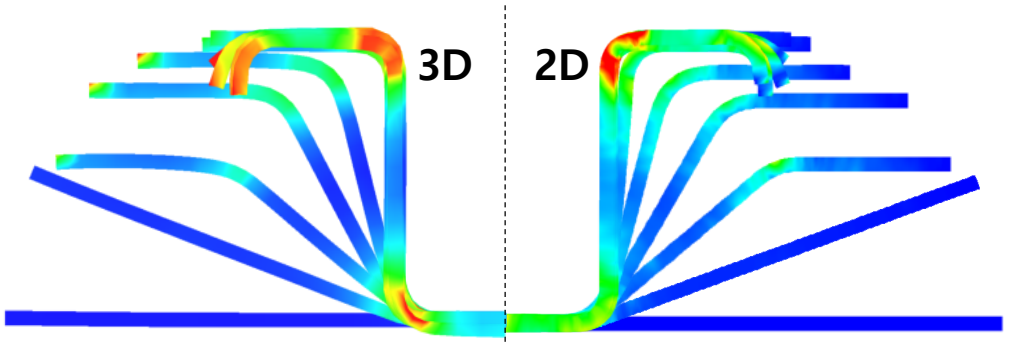
출처: ASHAI-SUNAC

롤포밍 (Roll forming)





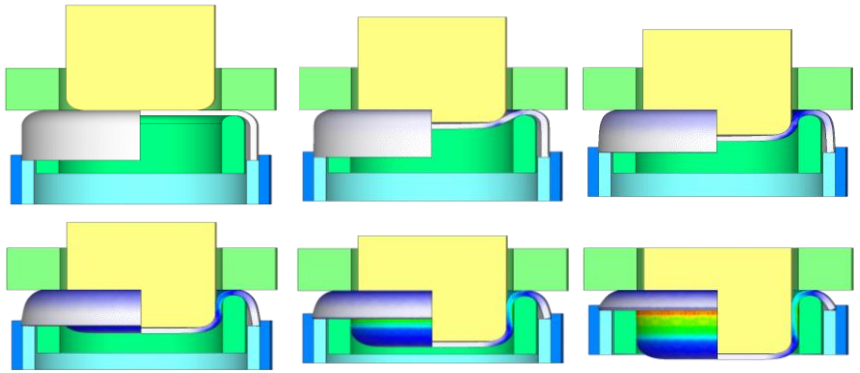
롤스텐드 #5

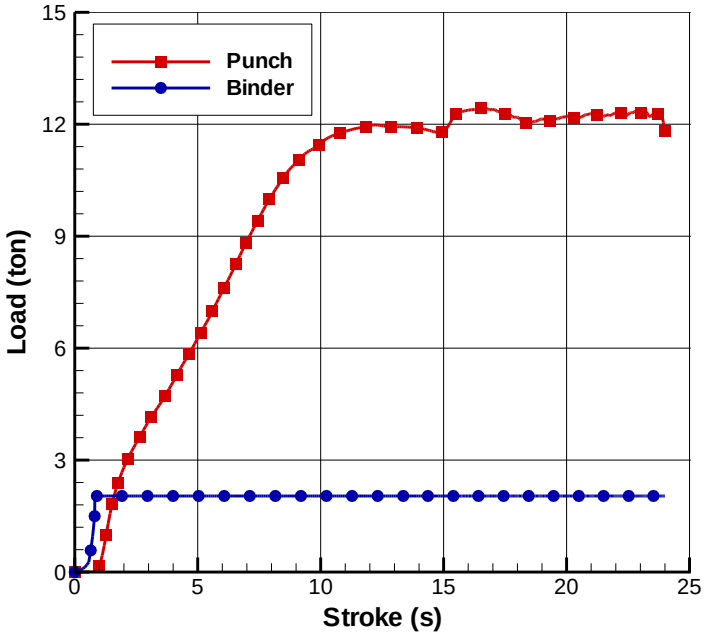


플라워 패턴

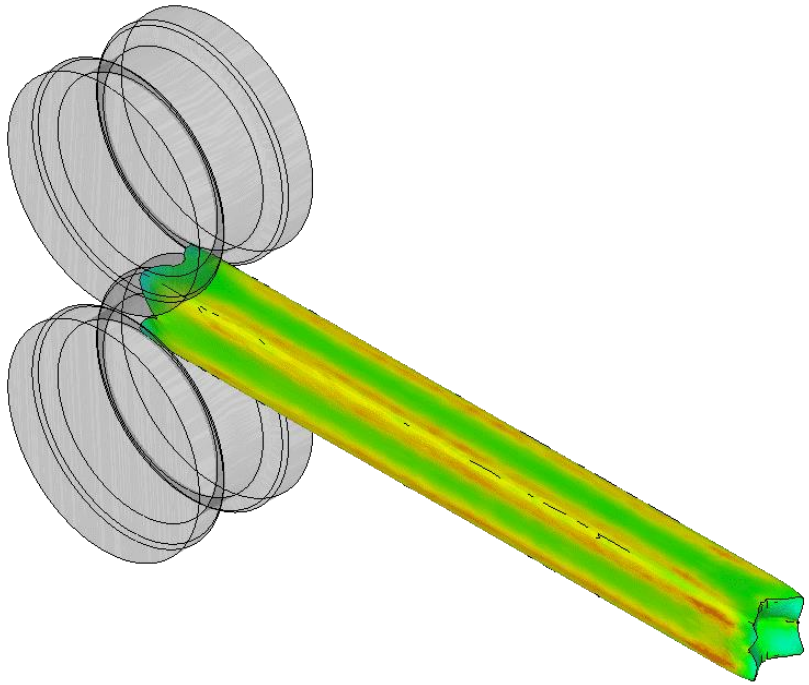
출처: ASTK

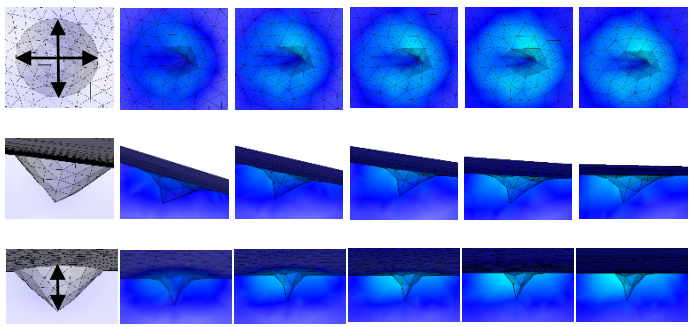
그림자 금형 사용 판단조





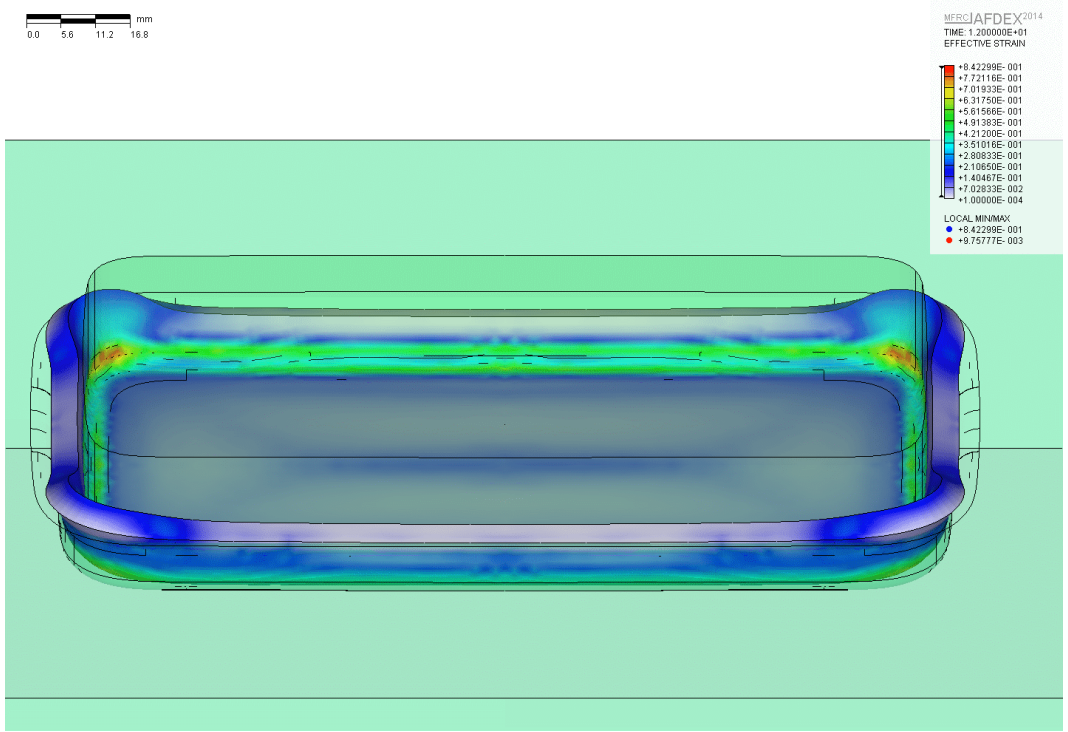
강편압연

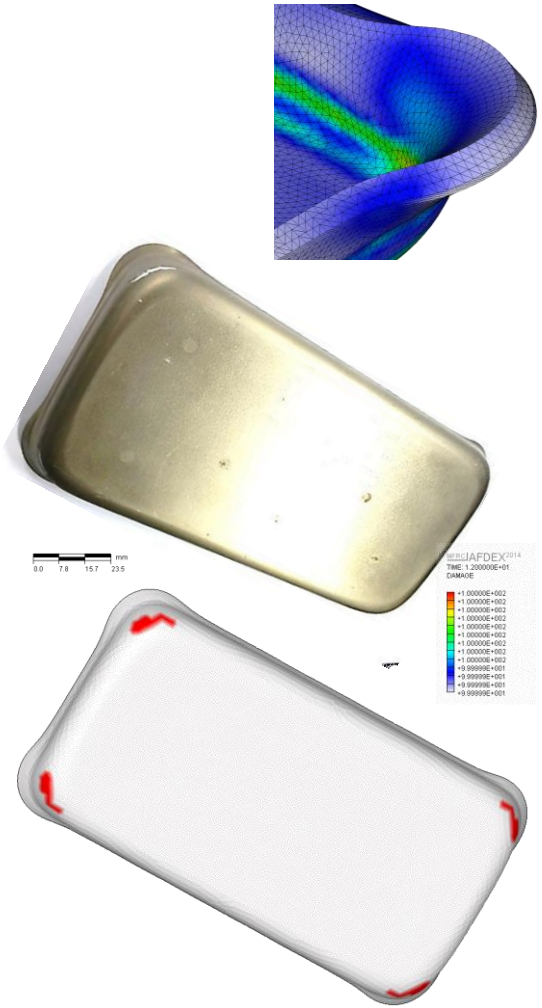




출처: 한국소성가공학회 2015 춘계학술대회, POSCO

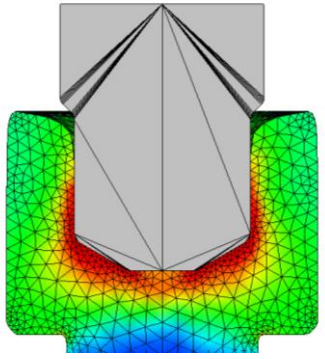
복합판재성형 및 클래드 소재 성형

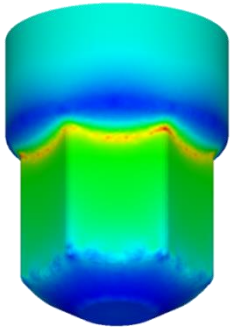


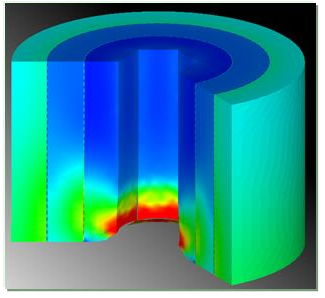


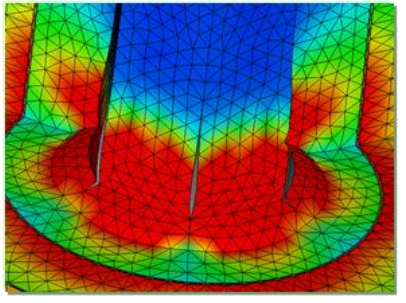
출처: 한국소성가공학회 2015 춘계학술대회, 삼성전자

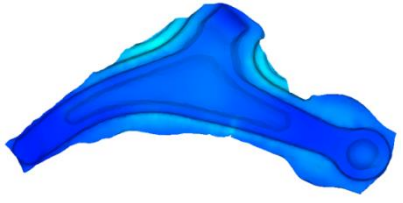
금형구조해석, 열박음 기능

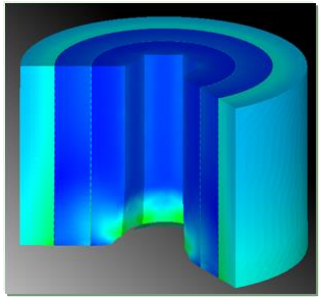


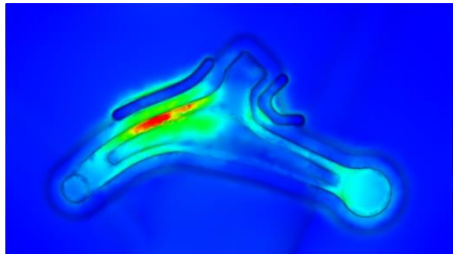


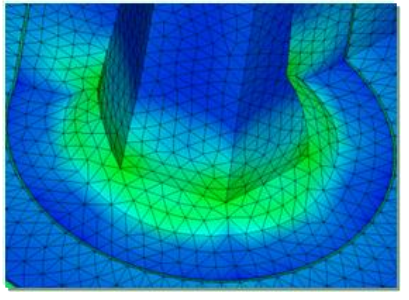
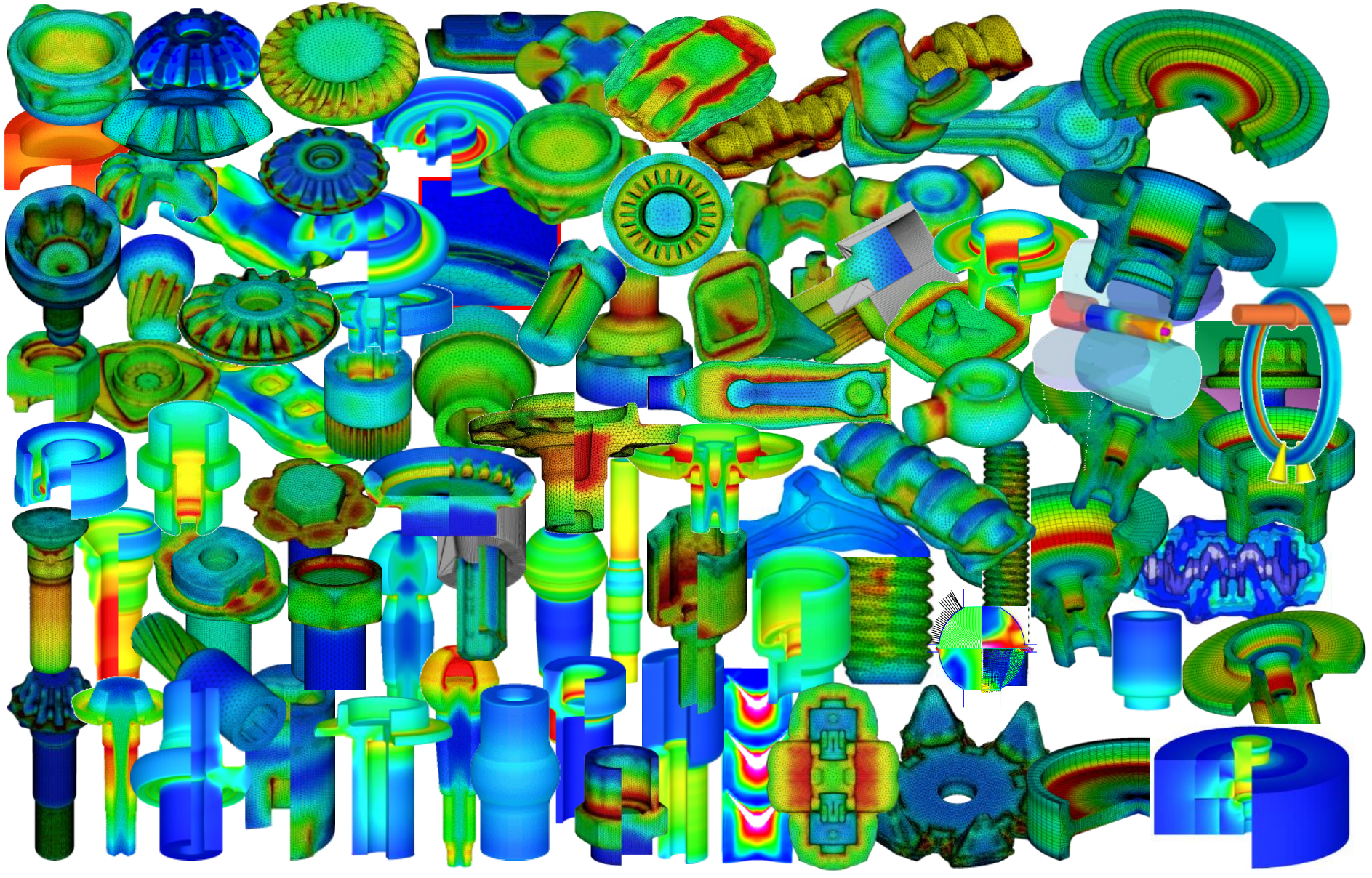












적용 사례들