

Simufact.forming - 塑性成形模拟仿真

Presented By: 黄晓铭

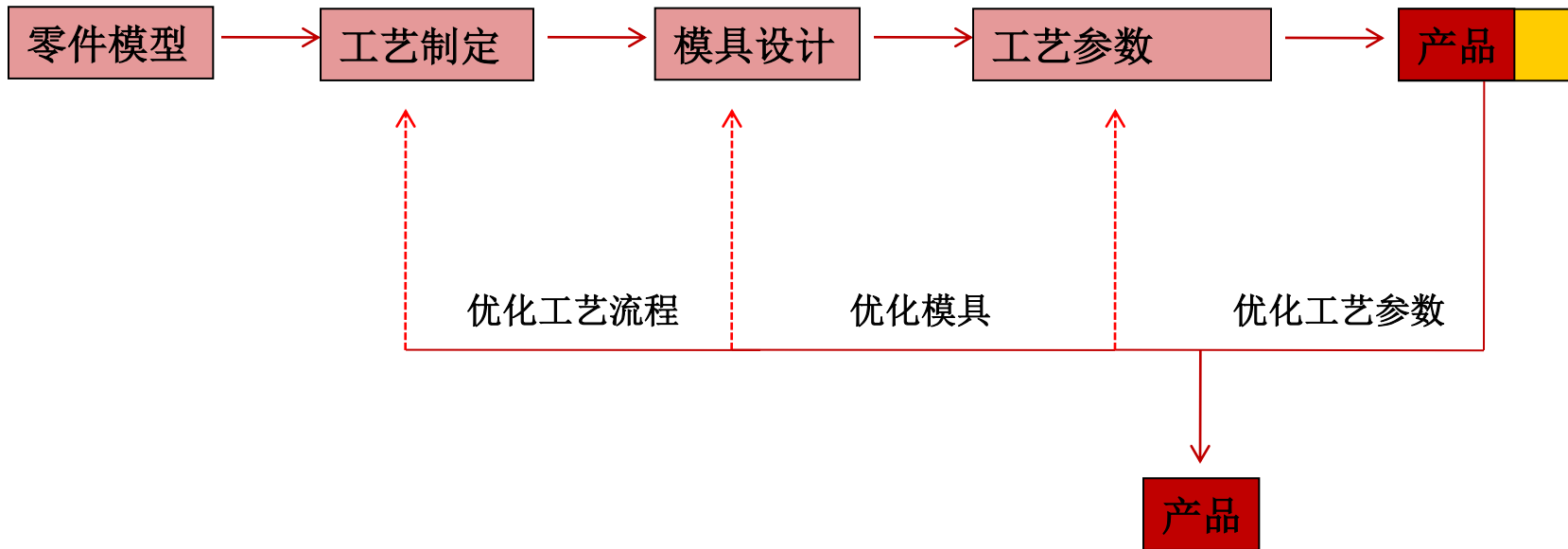
February 7, 2017

为什么需要仿真—加工制造业

各行业的科技进步均离不开先进的加工制造技术



为什么需要仿真—产品生产流程



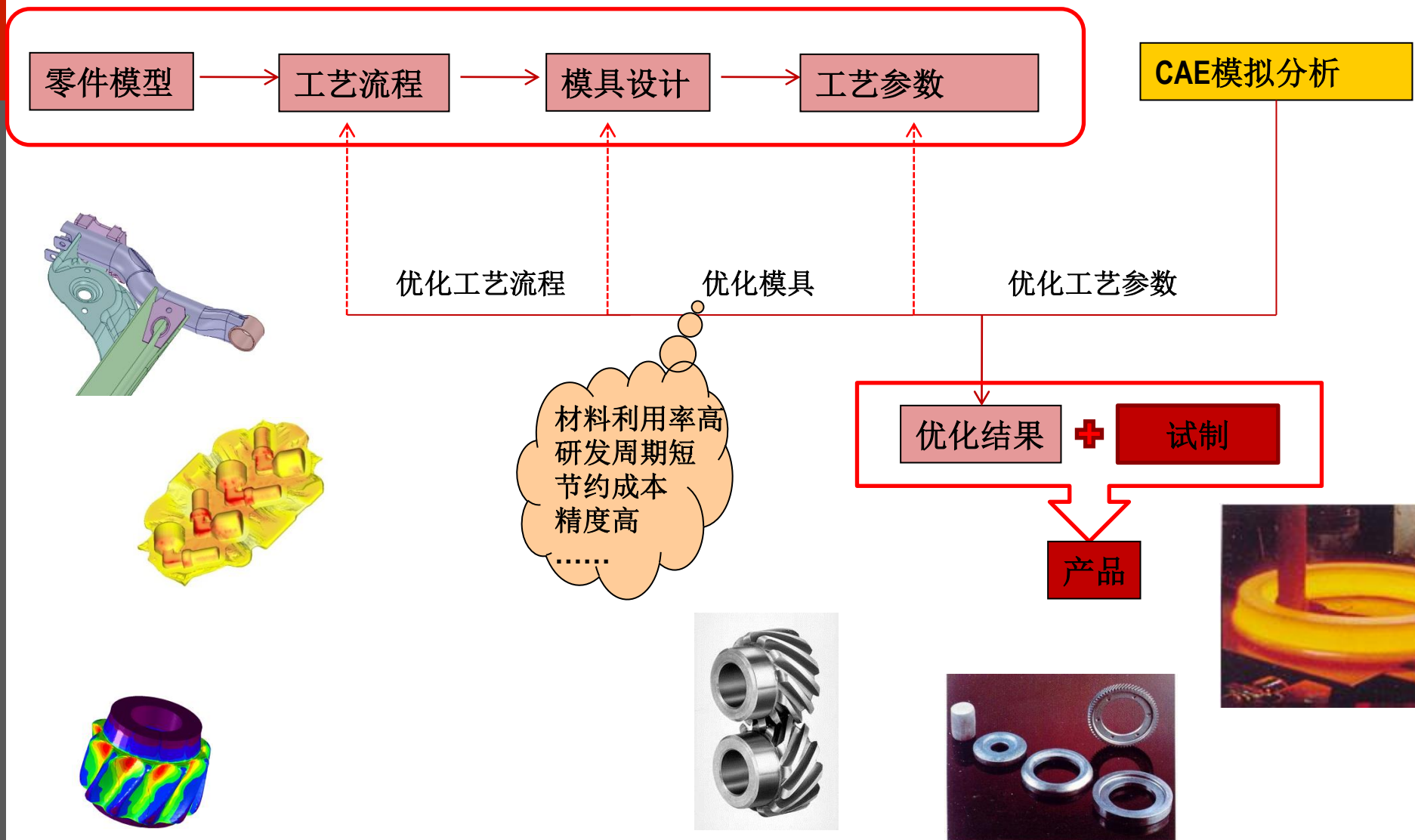
缺点:

- 1、人力物力浪费
- 2、研发周期长
- 3、成本高
- 4、精度低
- 5、产品竞争力低

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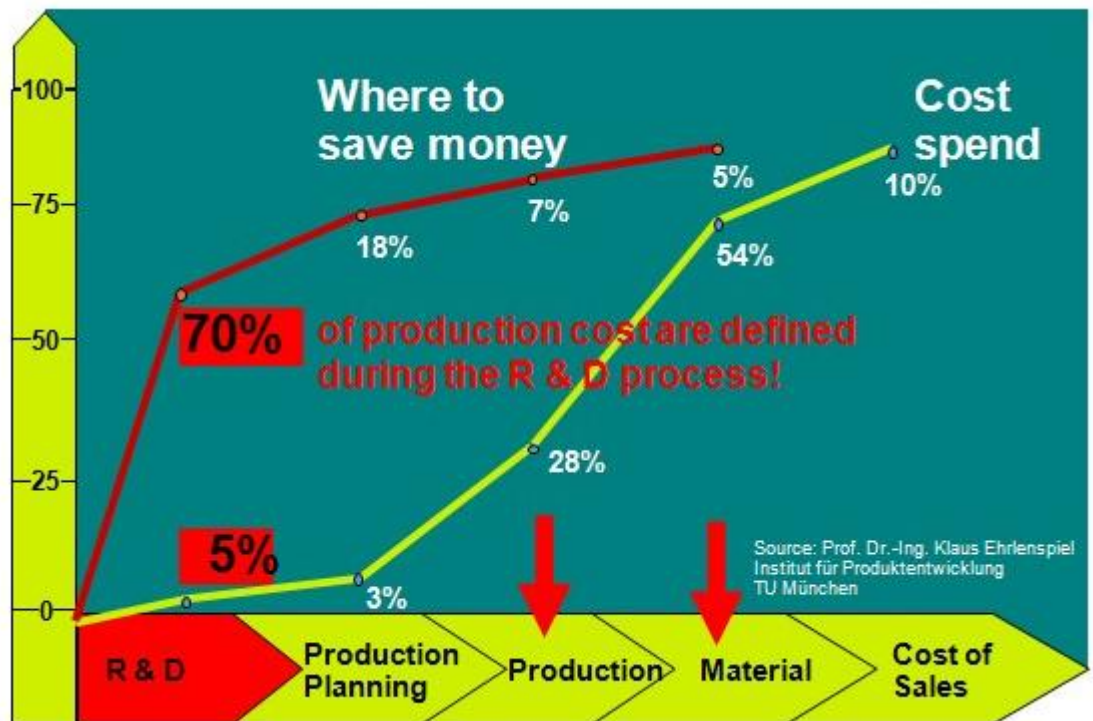


为什么需要仿真模拟？



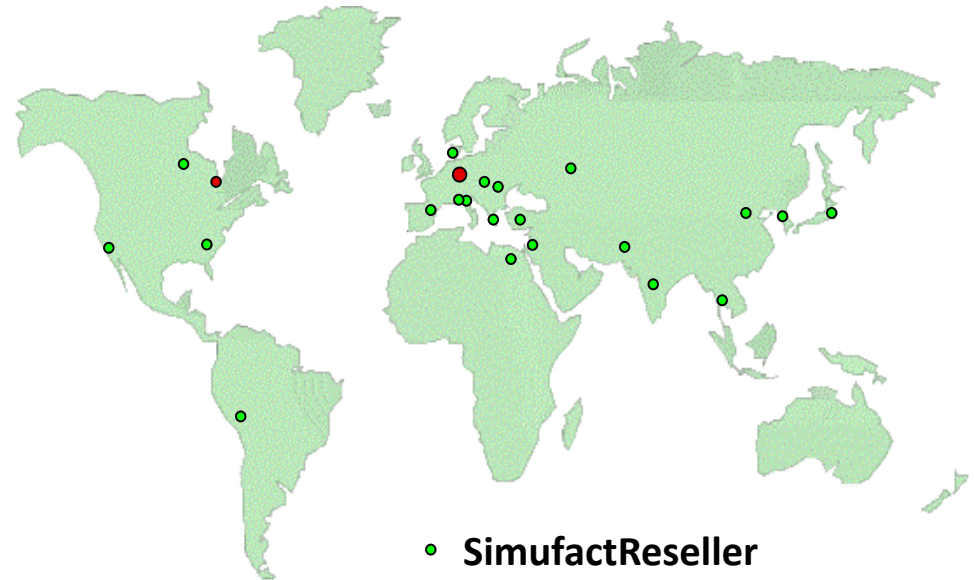
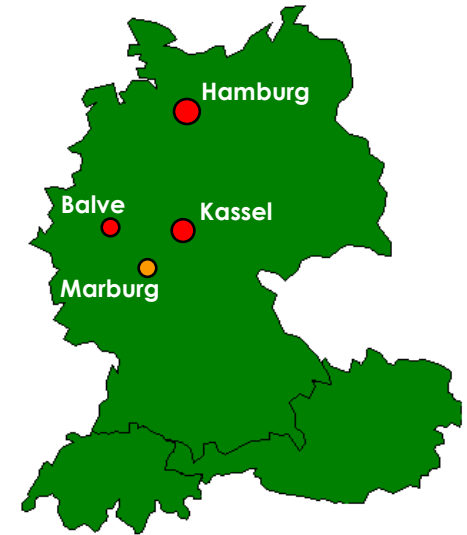
CAE软件帮助我们

- 缩短从设计到产品的周期
- 减少模具设计的费用
- 预估工艺过程中各种参数的影响
- 减少生产的费用
- 提高产品质量
- 了解材料性能
- 减少报废和材料浪费



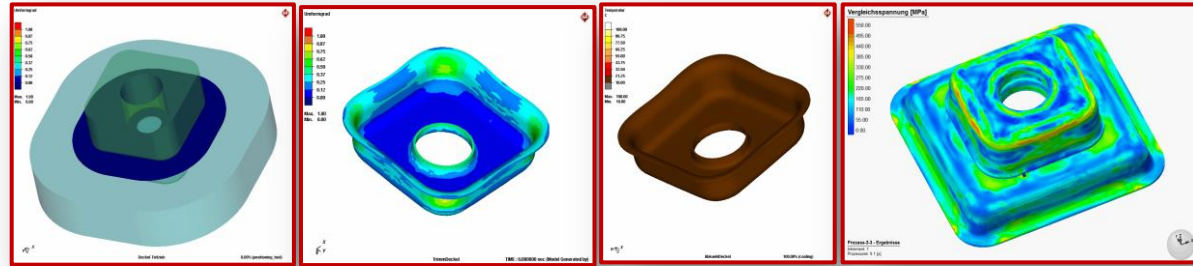
德国Simufact Engineering公司简介

- ✓ 总部位于德国汉堡，德国和美国研发中心
- ✓ **19年**的金属材料加工工艺仿真经验
- ✓ 开发锻压、热处理和焊接仿真软件，集成行业领先技术，合作伙伴：
 - ✓ **MSC.Software** – 求解器技术
 - ✓ **Altair Engineering** – 网格划分
 - ✓ **Sente Software** – 材料数据
 - ✓ **ITI TranscenData** – CAD接口
- ✓ 产品的使用培训
- ✓ 技术支持
- ✓ 工程咨询
- ✓ **2015年被MSC公司收购**
成为**MSC全资子公司**

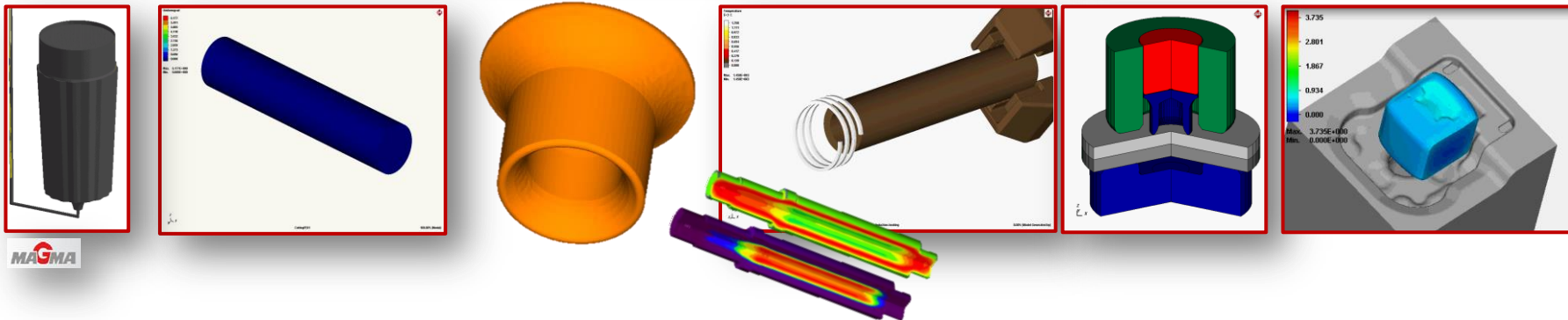


全工艺链仿真

Simufact全工艺链仿真技术



Optimization



MAGMA

Simufact软件介绍

所有工艺类型仿真应用

simufact.forming



Cold forming



Hot forging



General



Sheet forming



Rolling



Ring rolling



Open die



Heat treatment



Joining

simufact.welding

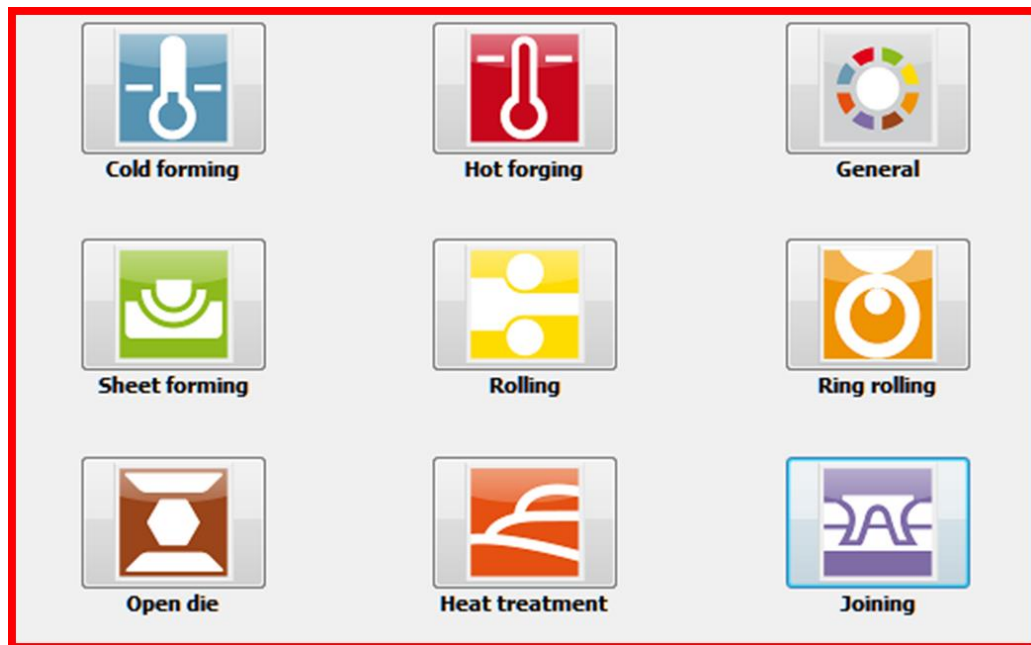


独立软件包

Simufact.forming新向导界面

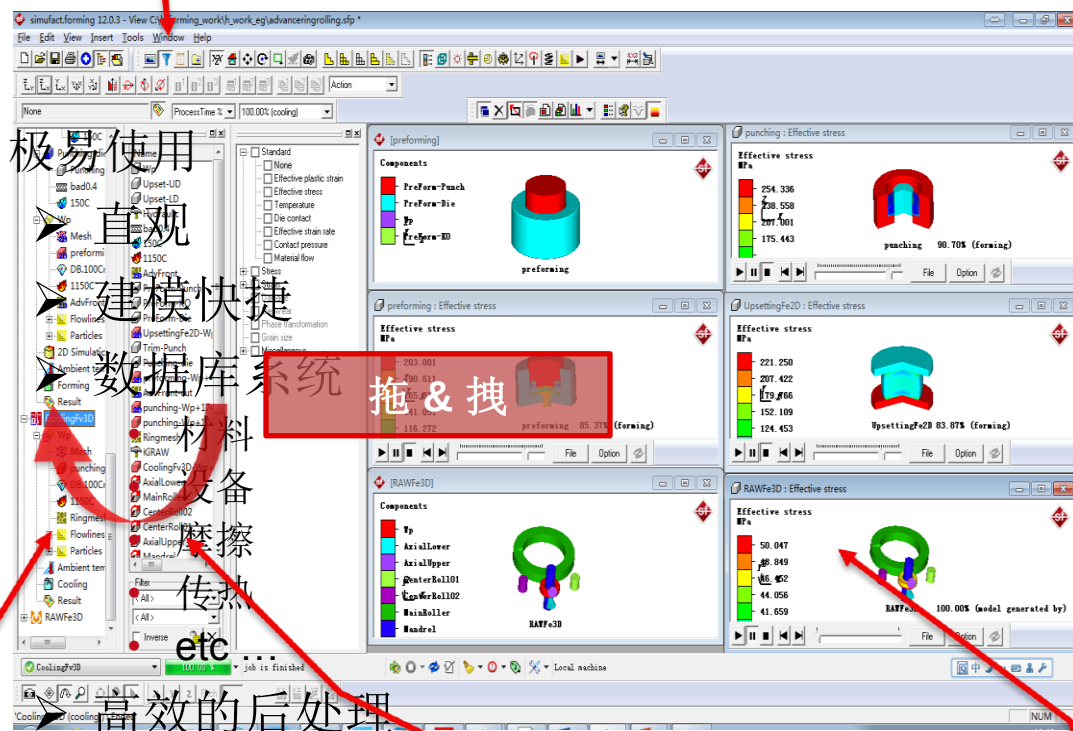
◆ 新向导界面

- 纵览Simufact.forming所有适用工艺仿真类型（包括工艺链仿真）
- 针对所选应用领域的特定工艺类型简化模型创建与参数设置
- 支持分析参数设置自定义(创建自己的标准设置)
- 自动调整默认设置参数 (简化用户设置)
 - 时间步长
 - 摩擦模型
 - 收敛准则
 - 求解器选择
 - 网格划分



Simufact.forming操作界面

Windows 风格界面



极易使用

➤ 直观

➤ 建模快捷

➤ 数据库系统

材料

设备

摩擦

传热

etc

➤ 高效的后期处理

工艺工程师和研发工程师

进程树

➤ 高级功能

备用区
(材料, 设备, CAD, 等.)

模型显示区

Simufact.forming求解器



simufact.forming

...

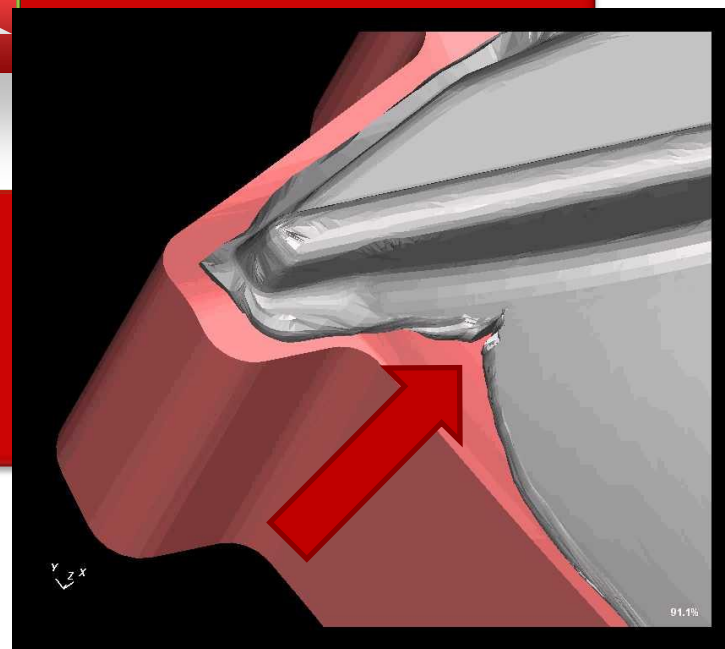
极易使用
精确
现实
求解快速
技术

有限单元法(FE)

有限体积法(FV)

CAD 导入
高级网格划分技术

Windows界面



- ◆ 每个求解器均有优点
- ◆ 取长补短

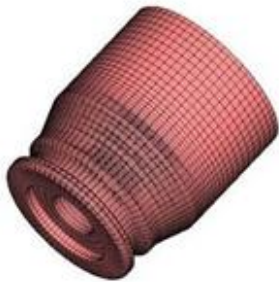
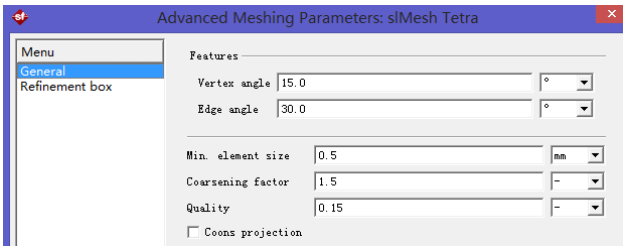
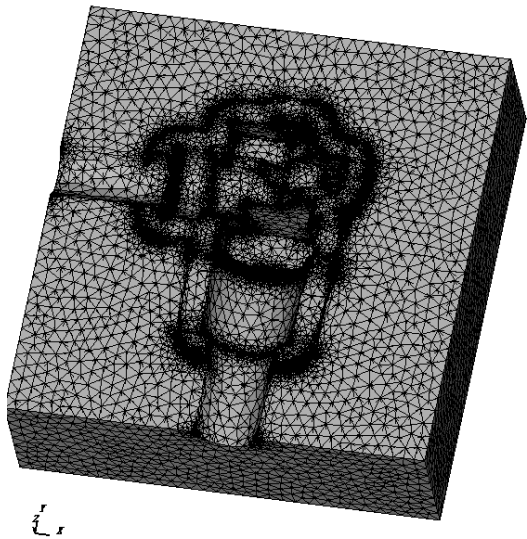
精确求解

基于Marc与Dytran计算准确



Simufact.forming单元类型及网格重划分

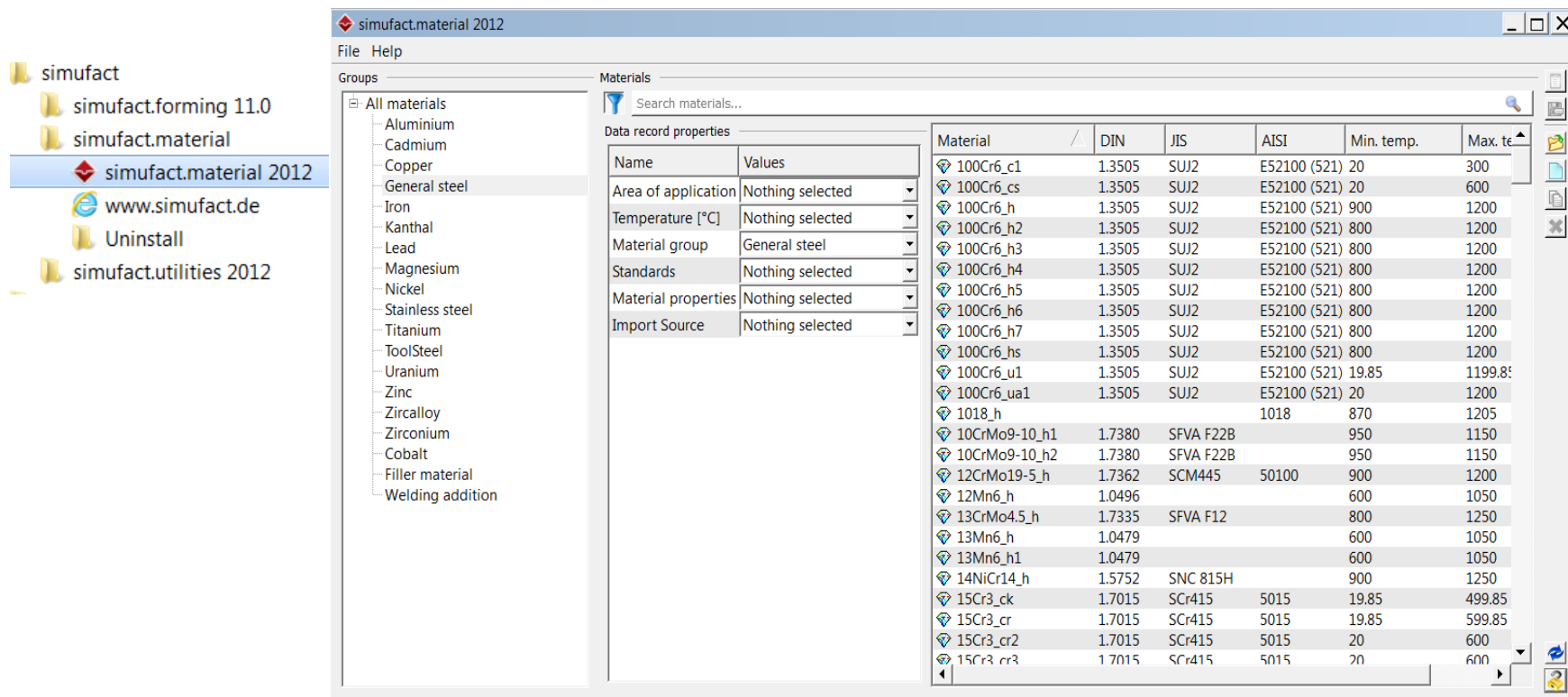
	Simufact
四面体单元	有四面体单元
六面体单元	有六面体单元，且可以自动进行六面体单元划分和重划分。
实体壳单元	有单边精度和双边精度的实体壳单元
网格划分	采用了自适应网格技术，可以快速、高质量全自动生成六面体、四面体、实体壳单元等网格，有效地减少技术员的工作量，还可以在计算的时候根据曲率自动细化边角部的网格。



材料

◆ 材料数据库界面（Material）：

- 独立软件，不依赖于模型
- 材料参数在模拟中写入UMT文件，供求解器使用
- 包含不同标准（AISI/JIS/DIN/EN），不同种类的材料（>600）
- 支持自定义或导入新材料



材料

Properties for 42CrMo4-HT_jmat

Menu

- General properties
- Chemical composi...
- Mechanical proper...
- Thermal properties
- Flow curves
- Anisotropy
- Damage
- Microstructure
- Phase transformation
- Data sheet

General properties

Name: 42CrMo4-HT_jmat

Variant: Define variant

Internal name: Define internal na...

DIN: 1.7225

JIS: Define JIS

AISI: Define AISI

Class: none

Group: General steel

Import source: JMatPro

Created by: Define creator

☐ Weldability

☐ Tool steel (purely elastic behavior)

☐ Default material

☐ Rigid plasticity

Comment

Alloy calculated with JMatPro
JMatPro VERSION 6.2
ALLOY_ID_WT% C.38Cr.99Cu.17Fe97.33Mn.64Mo.16Ni.08Si.23V.02
ALLOY_ID_AT% C1.739Cr1.046Cu0.147Fe95.789Mn0.64Mo0.09166Ni0.07492Si0.45V0.02158
GRAIN_SIZE_ASTM = 9.0
GRAIN_SIZE_MICRONS = 17.910796933601382
AUSTENITISATION_TEMP_C = 850.0
COOLING RATE (C/s) = 13.382038203417798

Flow Curves

Approach

Tables

Scope

	Min	Max	Unit
Temperature:	298.15	1123.15	K
Effective plastic strain:	0.0	4.0	-
Strain rate:	0.001	1000.0	1/s

Microstructure model

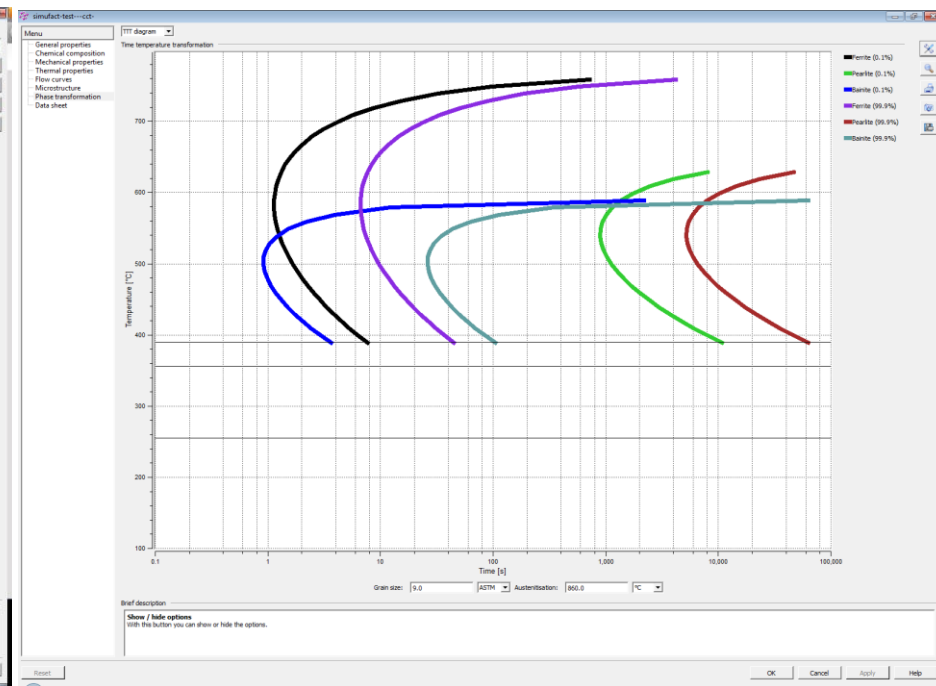
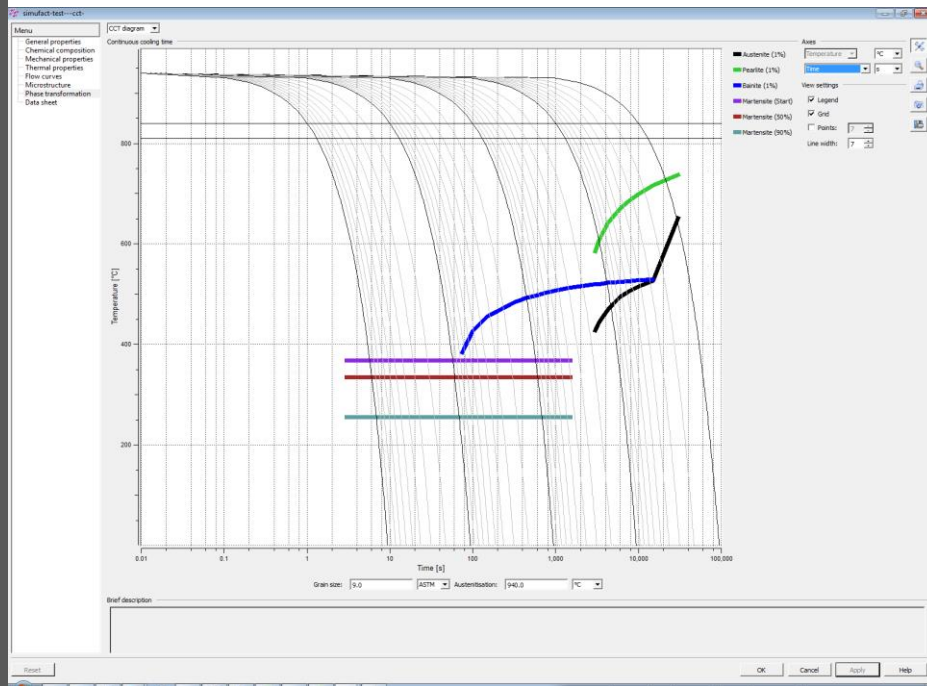
Brief description

- ◆ 一套完整的材料数据包括：
 - 基本信息/化学成分/机械性能/热参数/屈服曲线/各向异性/疲劳/晶粒模型/相变图/数据总结
- ◆ 支持材料文件格式：
 - umt/gmt (Matilda)/jmt (JMatPro)/mfd/mat/sf (simufact.forming)

材料

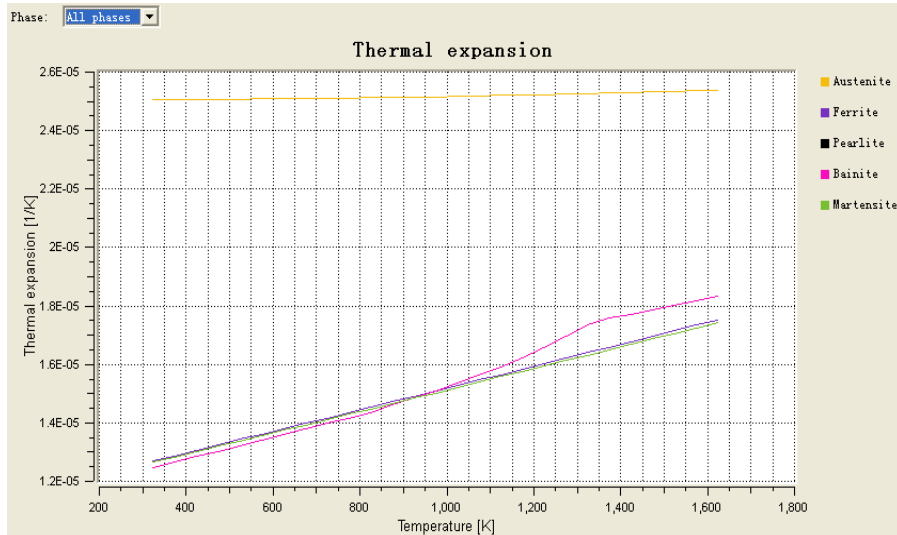
◆ 相变（Phase transformation）：

- 连续相变（CCT）和等温相变（TTT）曲线（JMatPro）
- 奥氏体向各相转变的数据：体积变化/潜热/TRIP效应
- 准确计算变形和残余应力



材料

●考虑不同相的混合材料属性

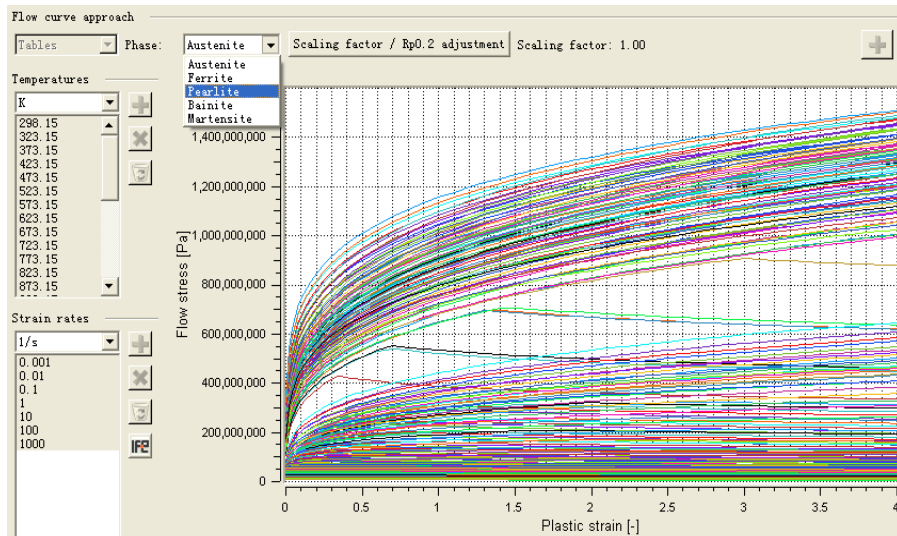


●设置材料初始相成份含量百分比

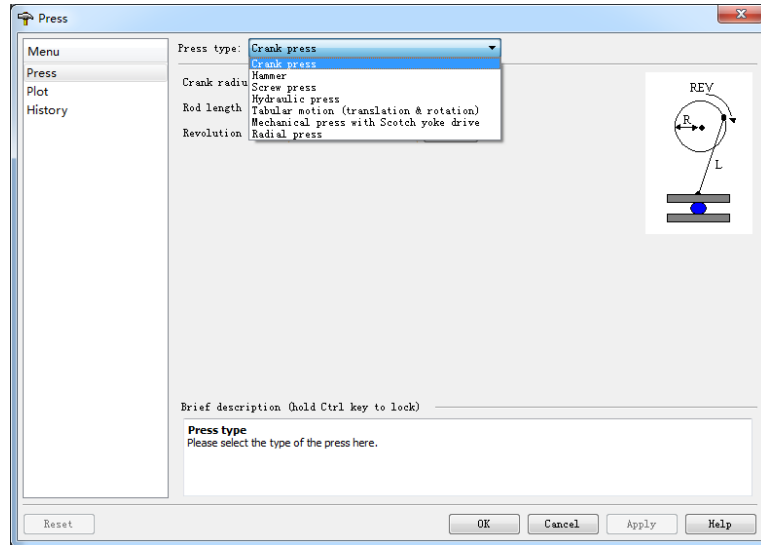
☒ Material Phases

Fraction of...

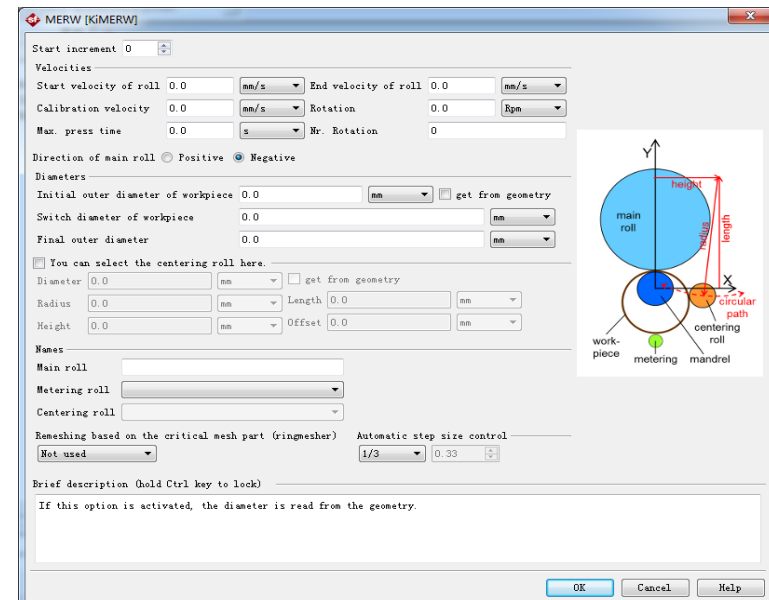
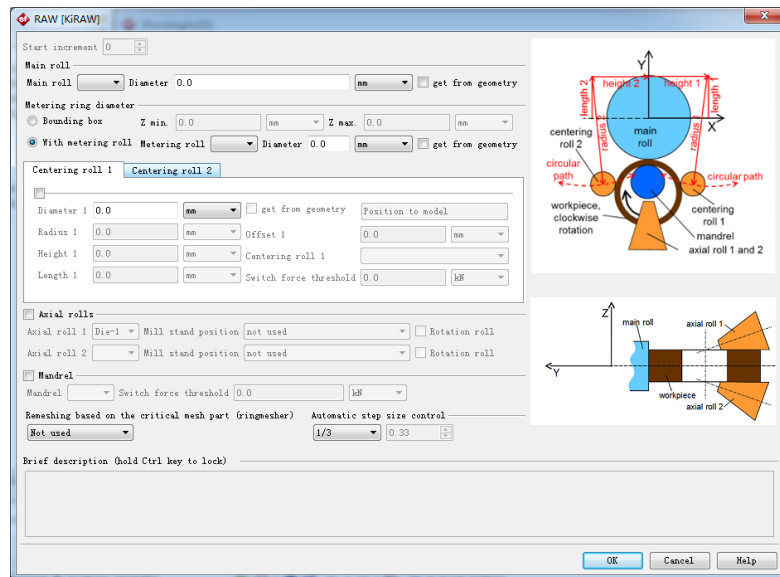
Austenite	92.0	%	▼
Ferrite	6.0	%	▼
Pearlite	2.0	%	▼
Bainite	0.0	%	▼
Martensite	0.0	%	▼
Sum	100.0	%	▼



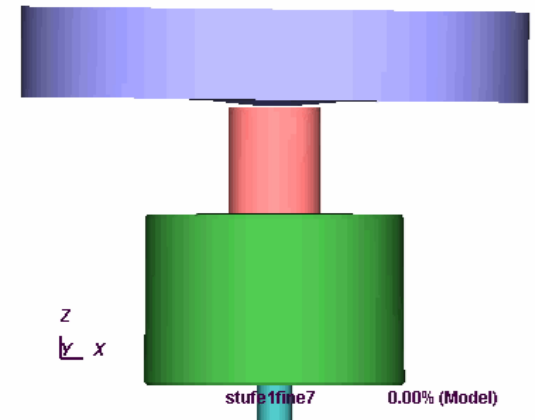
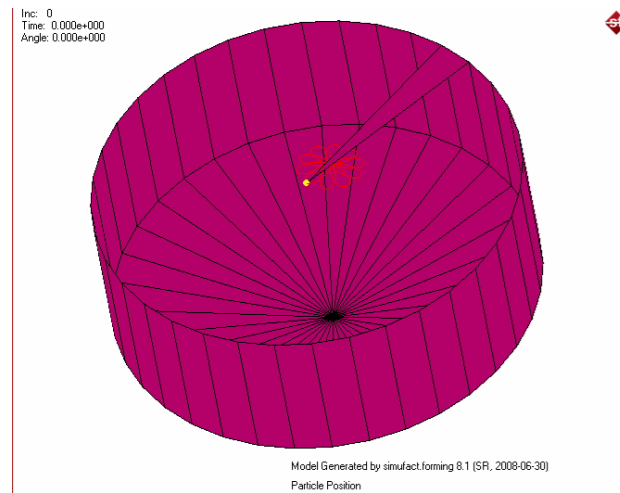
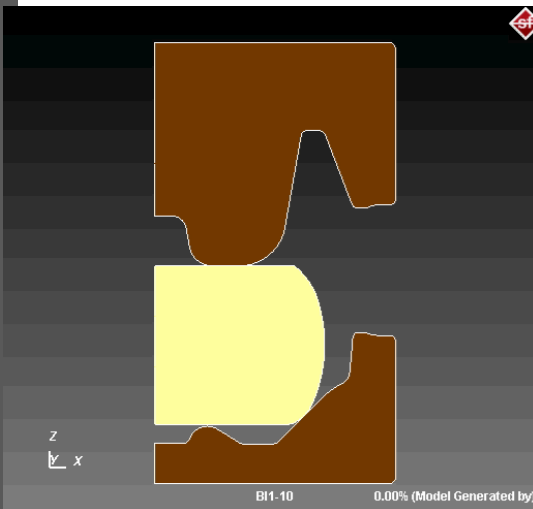
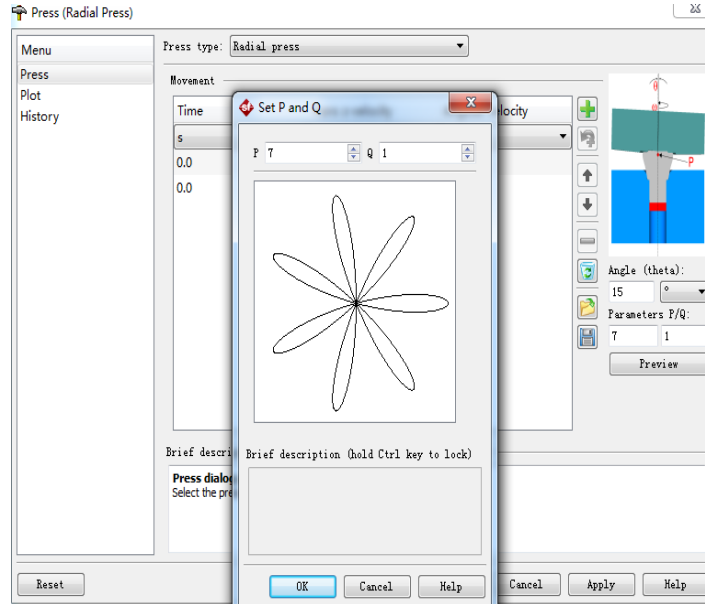
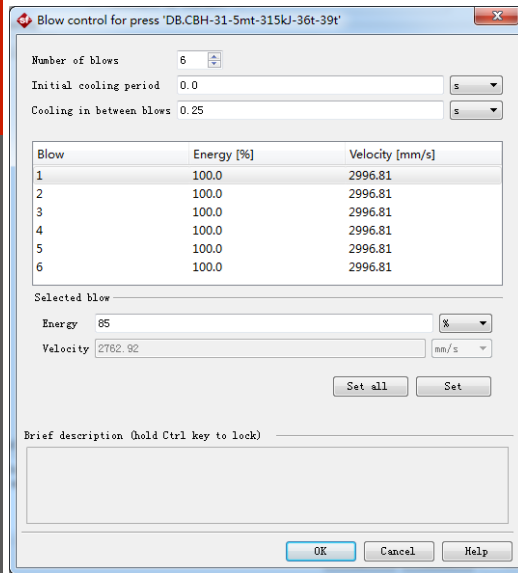
Simufact.forming设备库



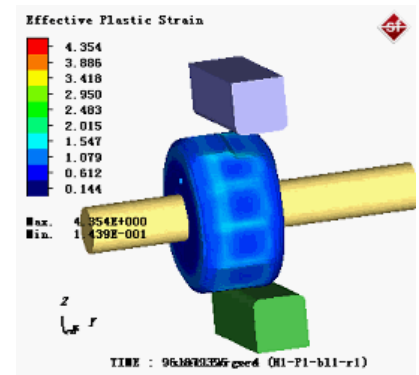
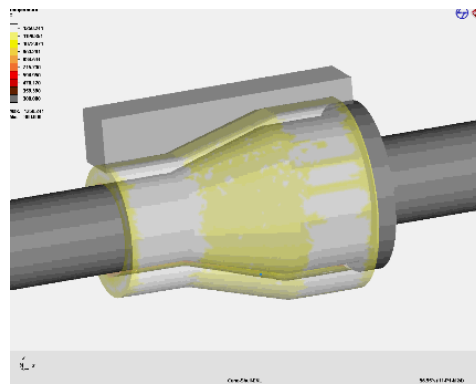
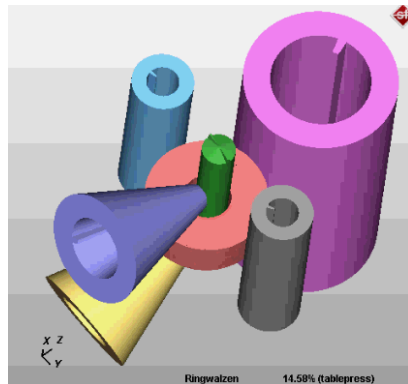
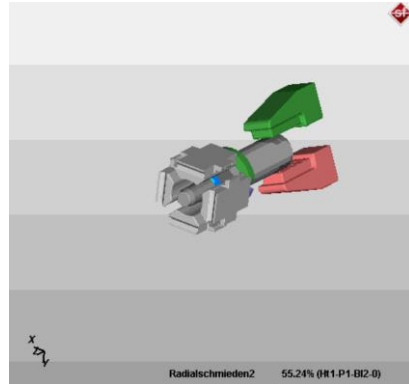
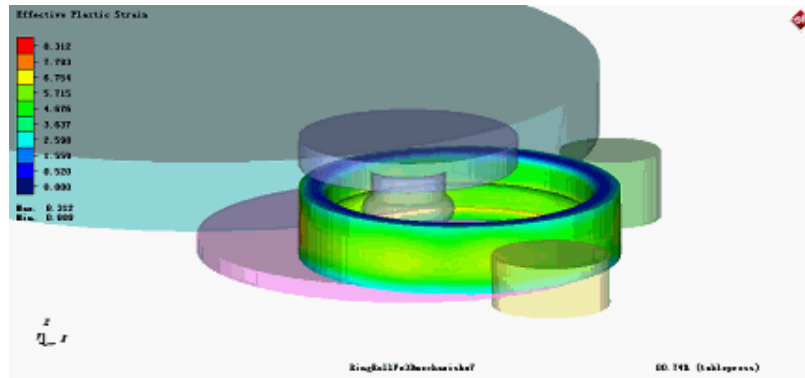
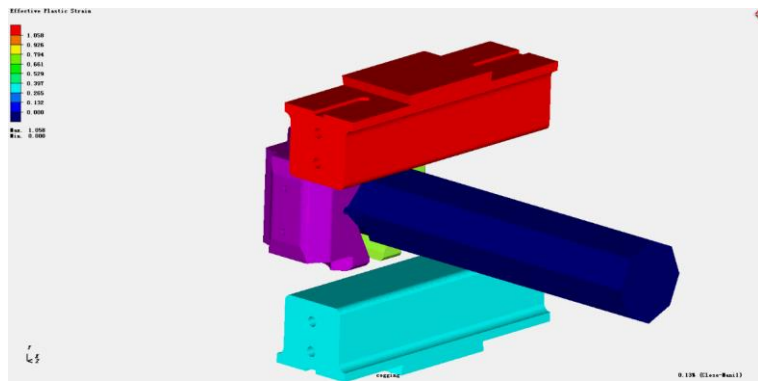
曲柄压力机、螺旋压力机、对击锤、液压机、机械压力机等设备都有模型，还可以修改设备具体运动参数，并且具有环轧、开坯锻、扩孔、芯棒扩孔、摆碾等设备



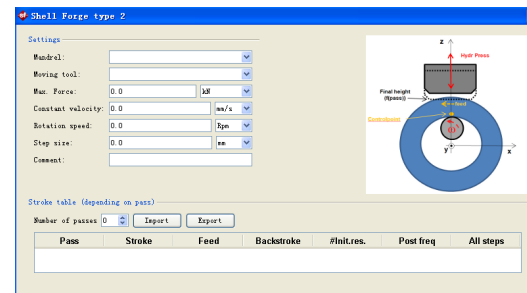
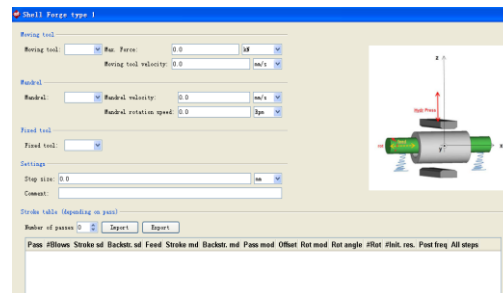
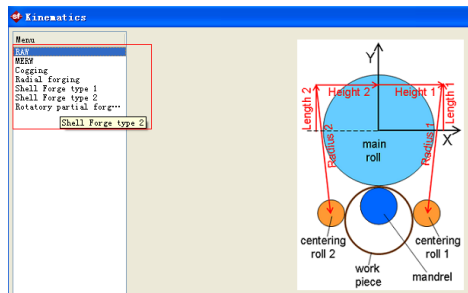
Simufact.forming特殊设备库



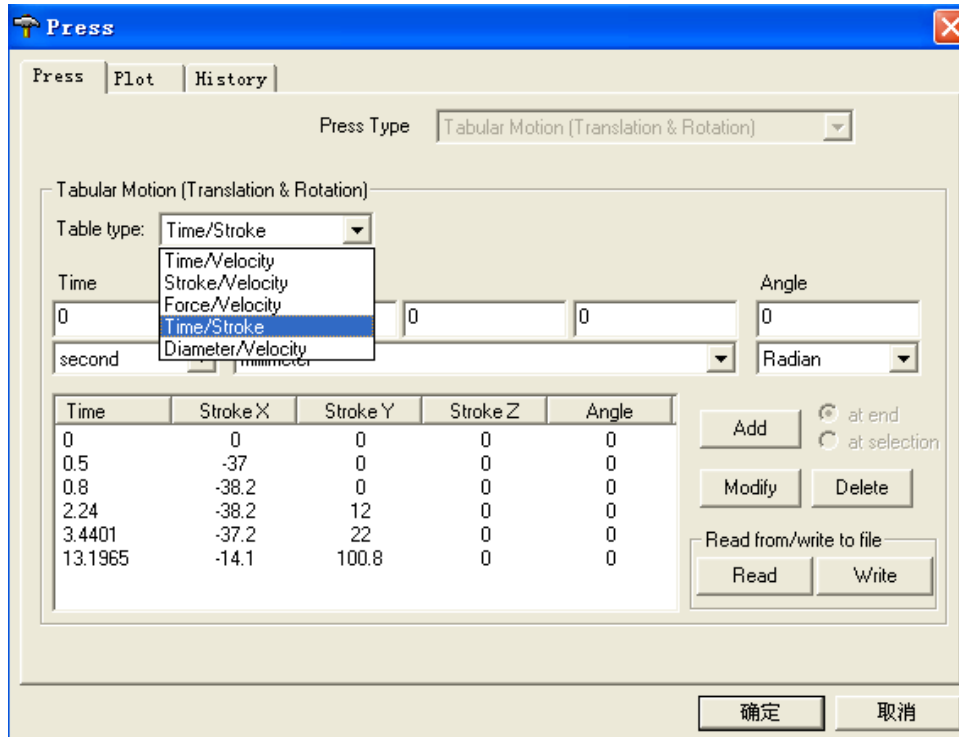
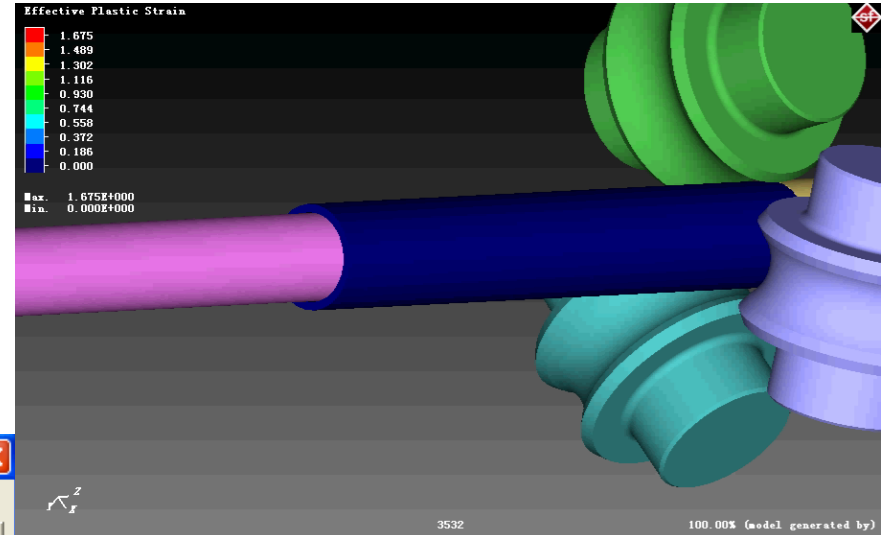
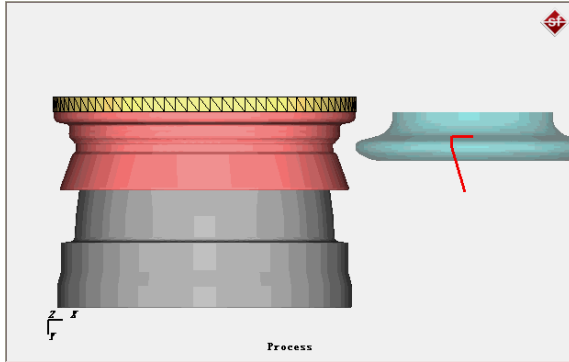
自由锻工艺模拟



集成常用立式/卧式环轧、开坯锻、马杠扩孔、芯棒拔长、摆碾等复杂设备



Simufact.forming 复杂运动路径定义

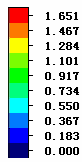


Simufact中很容易定义两个方向或三个方向复合的运动。

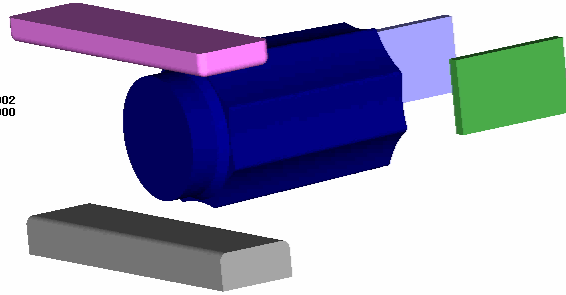
Excel文件导入

拔长案例

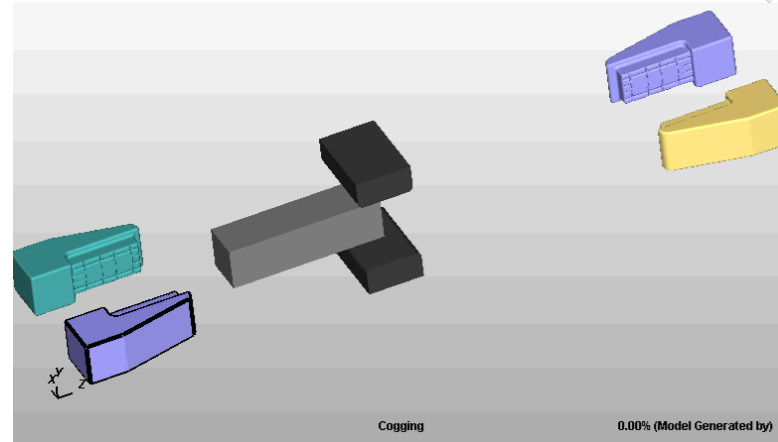
Effective Stress
E+2 MPa



Max. 1.651E+002
Min. 0.000E+000



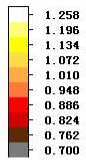
jaw TIME : 0.000000 sec (Model Generated by)



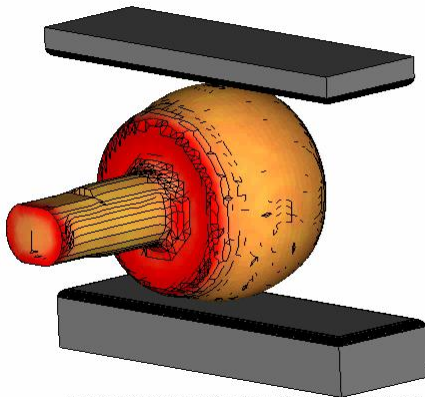
Cogging

0.00% (Model Generated by)

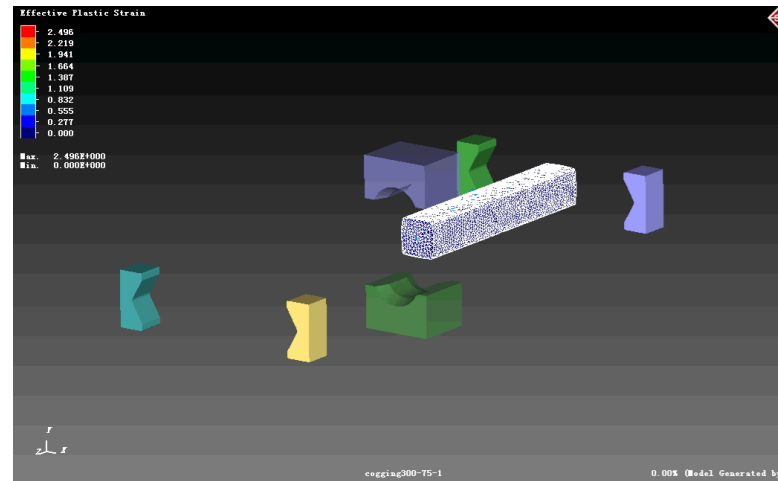
Temperature
E+3 C



Max. 1.258E+003
Min. 0.000E+000



UpsettingFe300N : 0.000000 sec (Model Generated by)

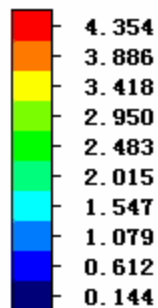


cogging300-T5-1

0.00% (Model Generated by)

芯棒拔长模拟

Effective Plastic Strain



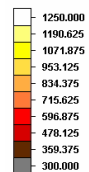
Max. 4.354E+000
Min. 1.439E-001



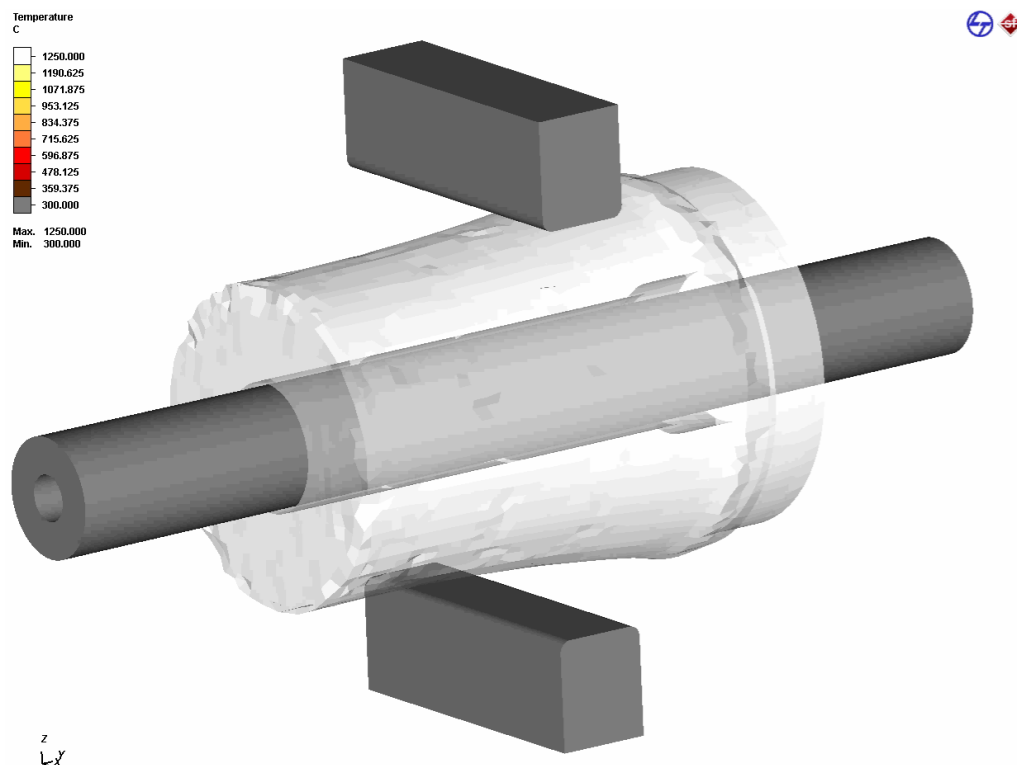
TIME : 1.91631837e-04 (H1-P1-b11-r0)



Temperature
C



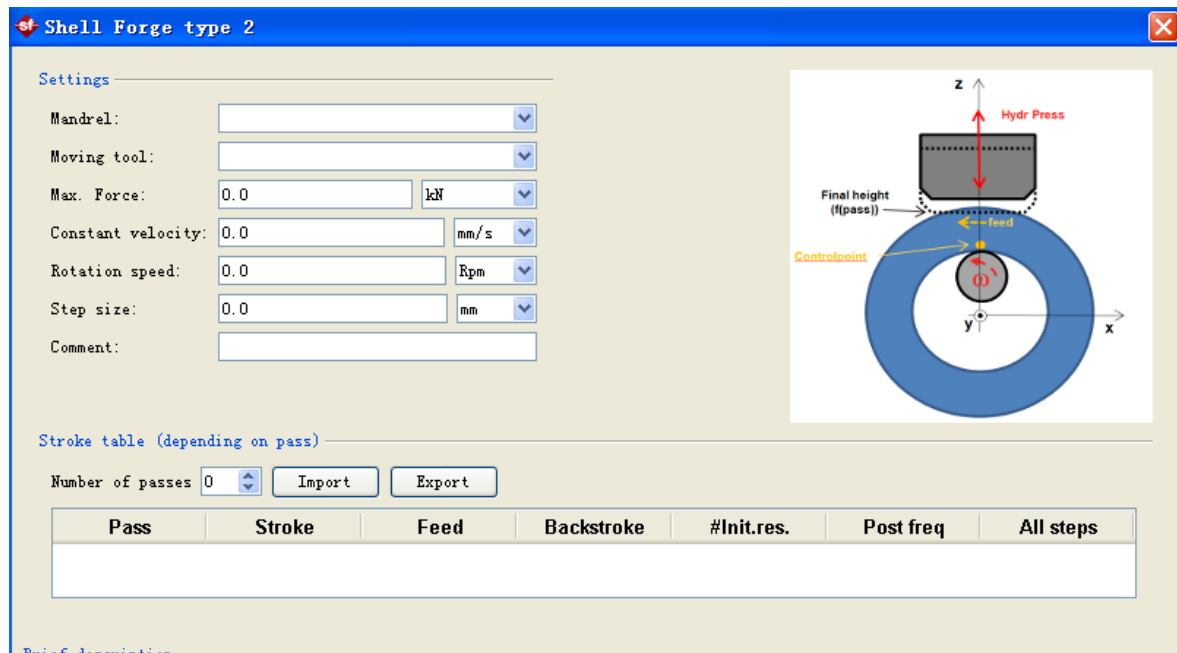
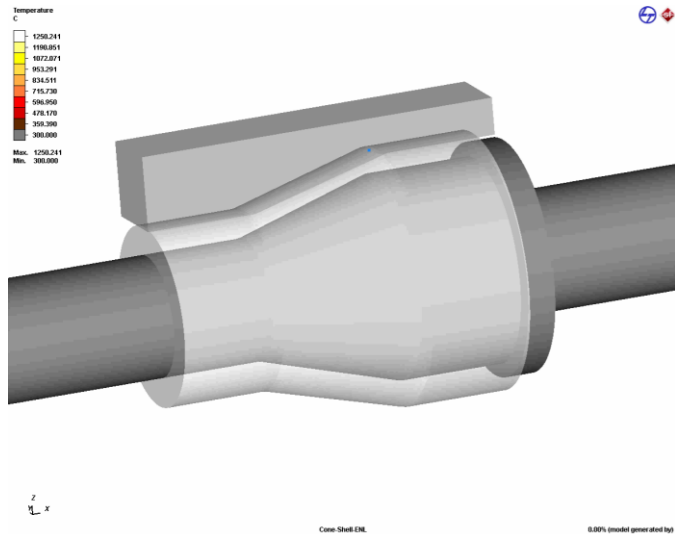
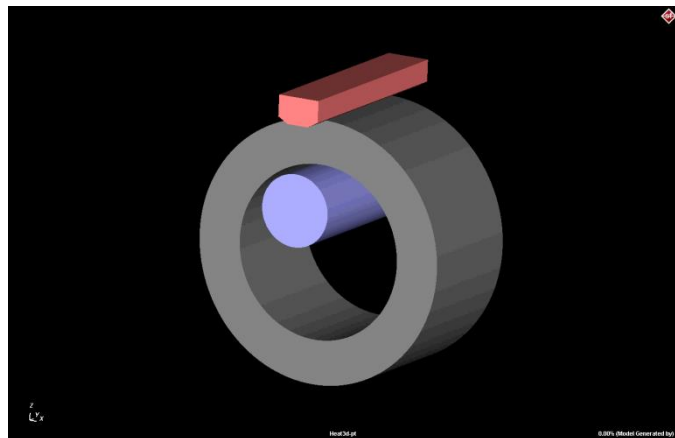
Max. 1250.000
Min. 300.000



drawing-2

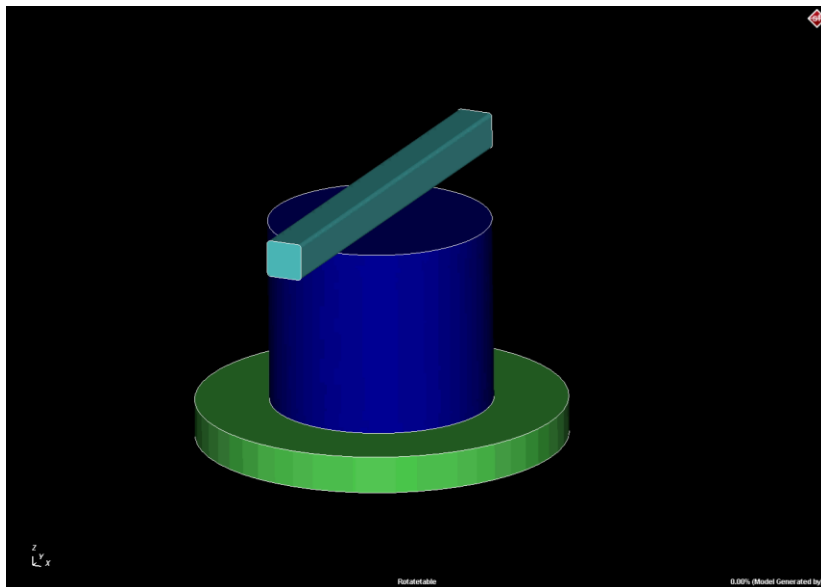
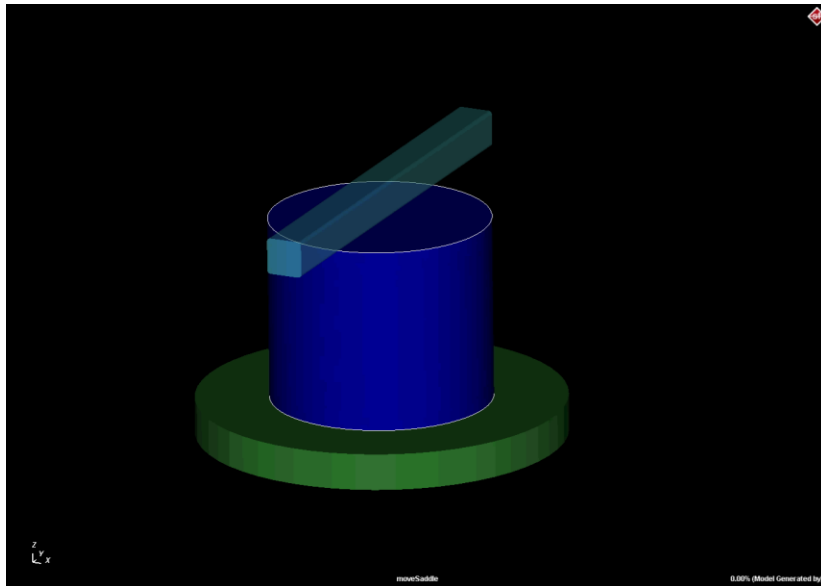
0.00% (model generated by)

马杠扩孔模拟



Simufact具有马杠扩孔模块。采用shellforge2设备可以很容易对马杠扩孔整个工艺进行仿真模拟。

碾压模拟



Rotatory partial forging [KiRotatoryPartial-1]

Settings

Saddle:

Table:

Max. Force: kN

Step size: mm

Velocities

Saddle downwards: mm/s

Saddle upwards: mm/s

Saddle feed sideways: mm/s

Saddle return to initial X-position: mm/s

Table feed: mm/s

Table rotation between strokes: Rpm

Table rotation between passes: Rpm

Comment:

Stroke table (depending on pass)

Number of passes: Import Export

Length in: Angle in:

Pass	Init. table feed [mm]	Init. table rot [°]	Init. saddle h. feed [mm]	# Strokes	First stroke [mm]	Backstroke [mm]	Feed btw. strokes [mm]	Return to center	Opt.
1	0	0	0	12	50	40	0	yes	0
2	0	15	0	12	90	30	0	yes	0

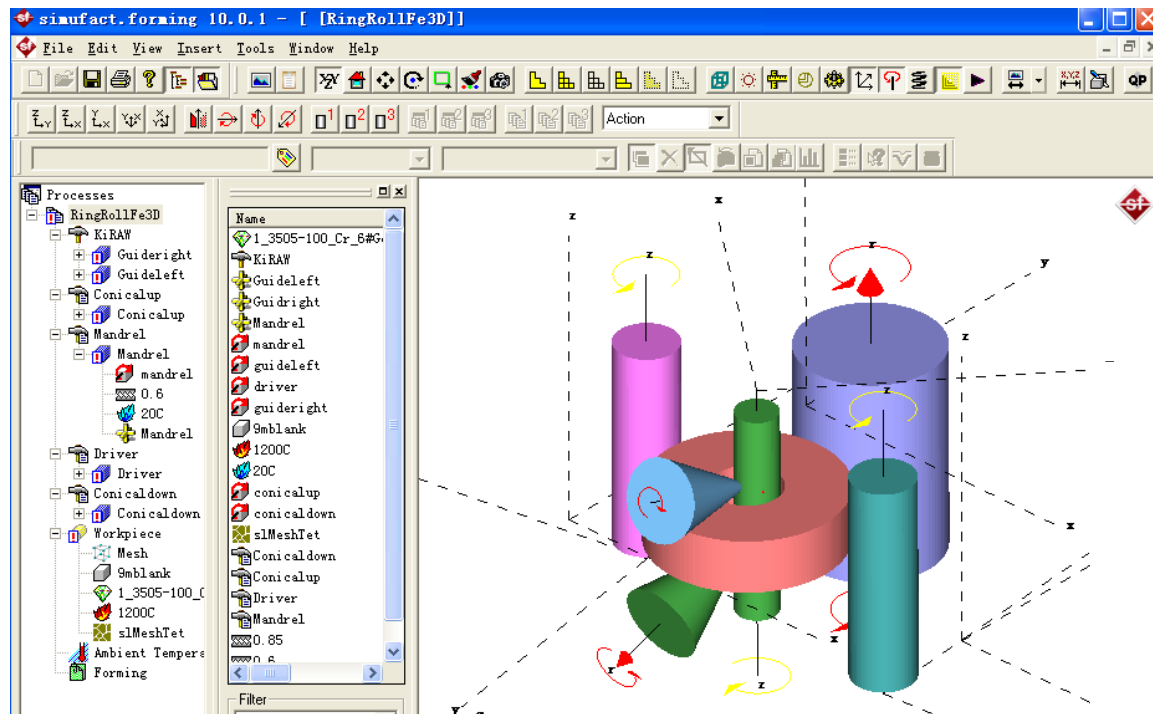
Brief description

The step size. [More...](#) (F1)

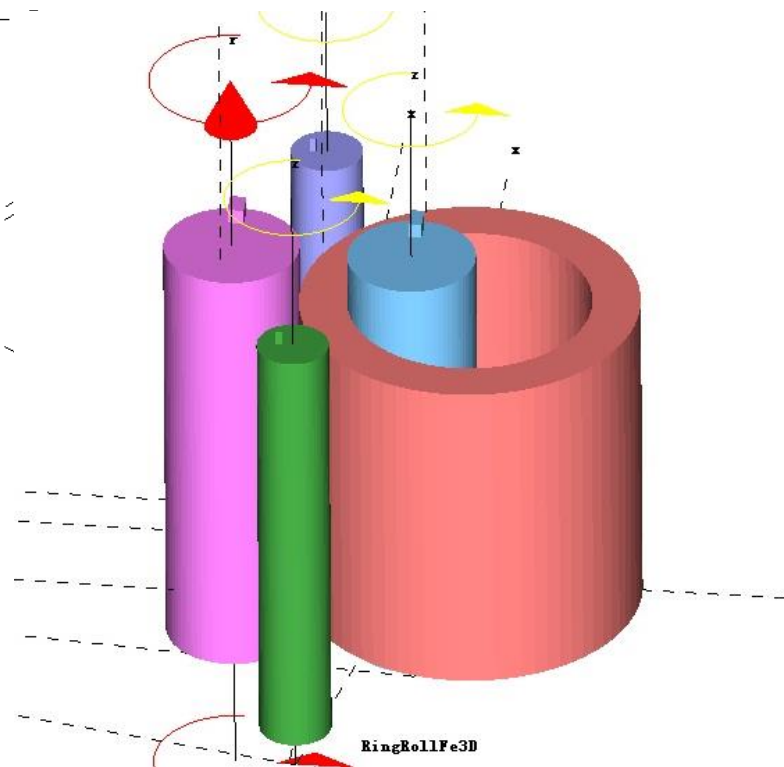
OK Cancel Help

Simufact集成碾压设备，极易对碾压过程进行建模仿真

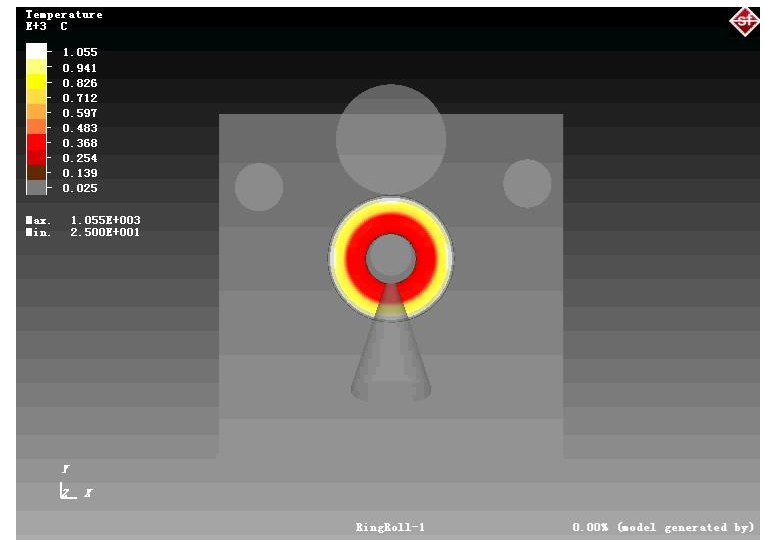
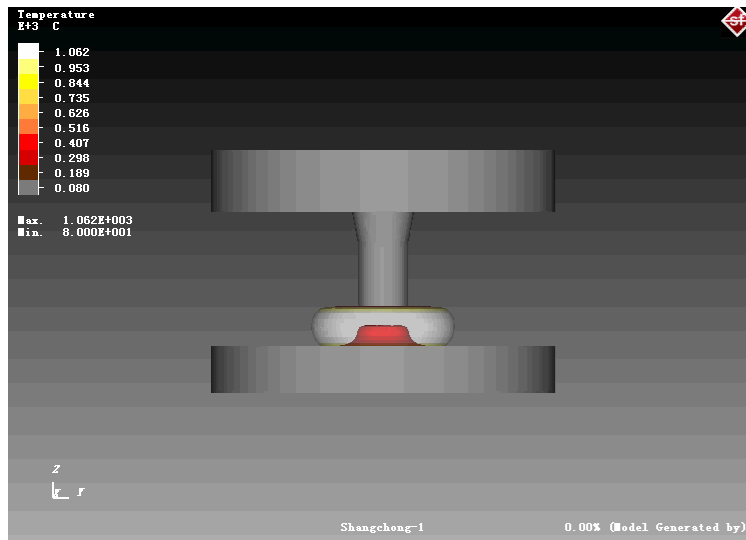
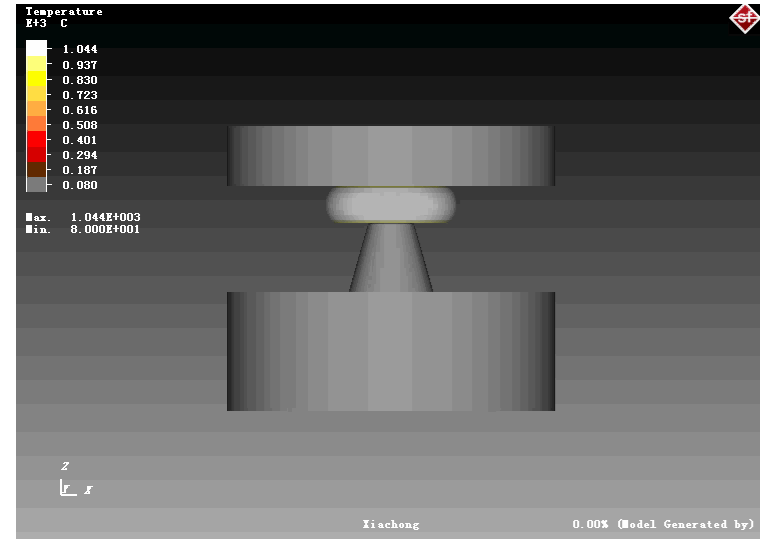
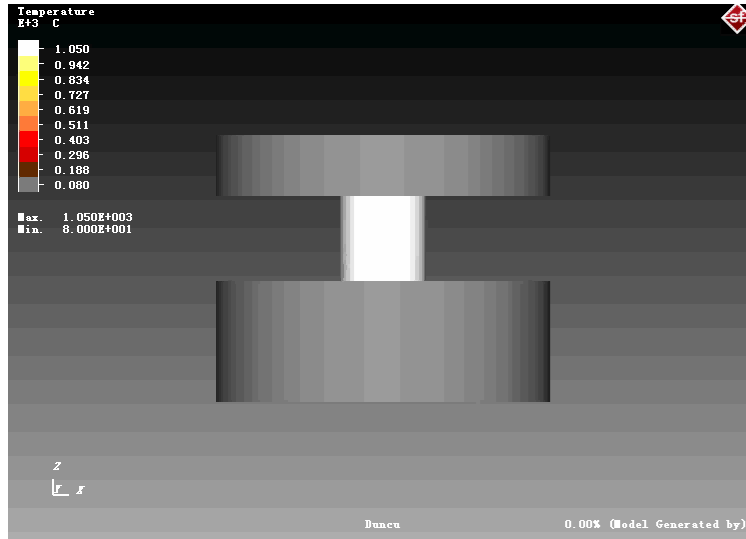
开放性环轧仿真建模



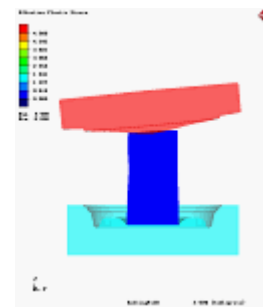
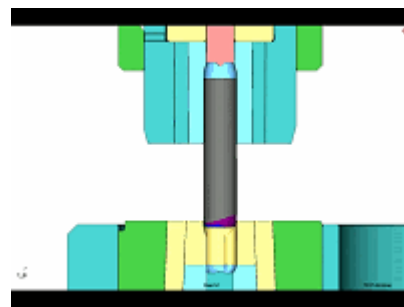
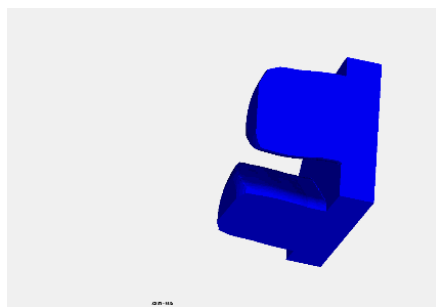
Simufact基本上可以实现目前所有环轧工艺的仿真，且从制坯、扩孔、冲孔、环轧整个工艺流程可以进行一体化模拟。考虑条件充分。



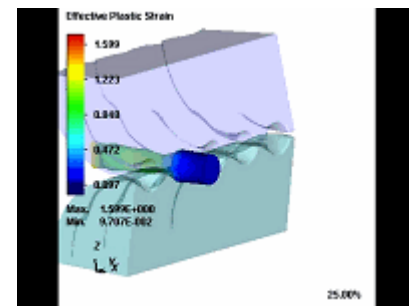
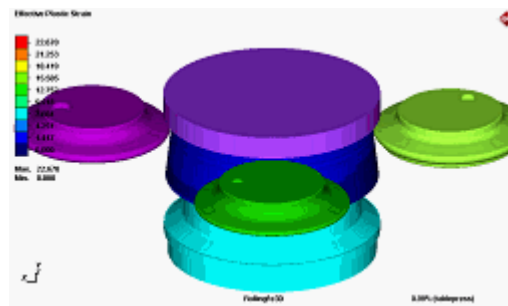
环轧全工艺模拟



锻造挤压成形工艺模拟

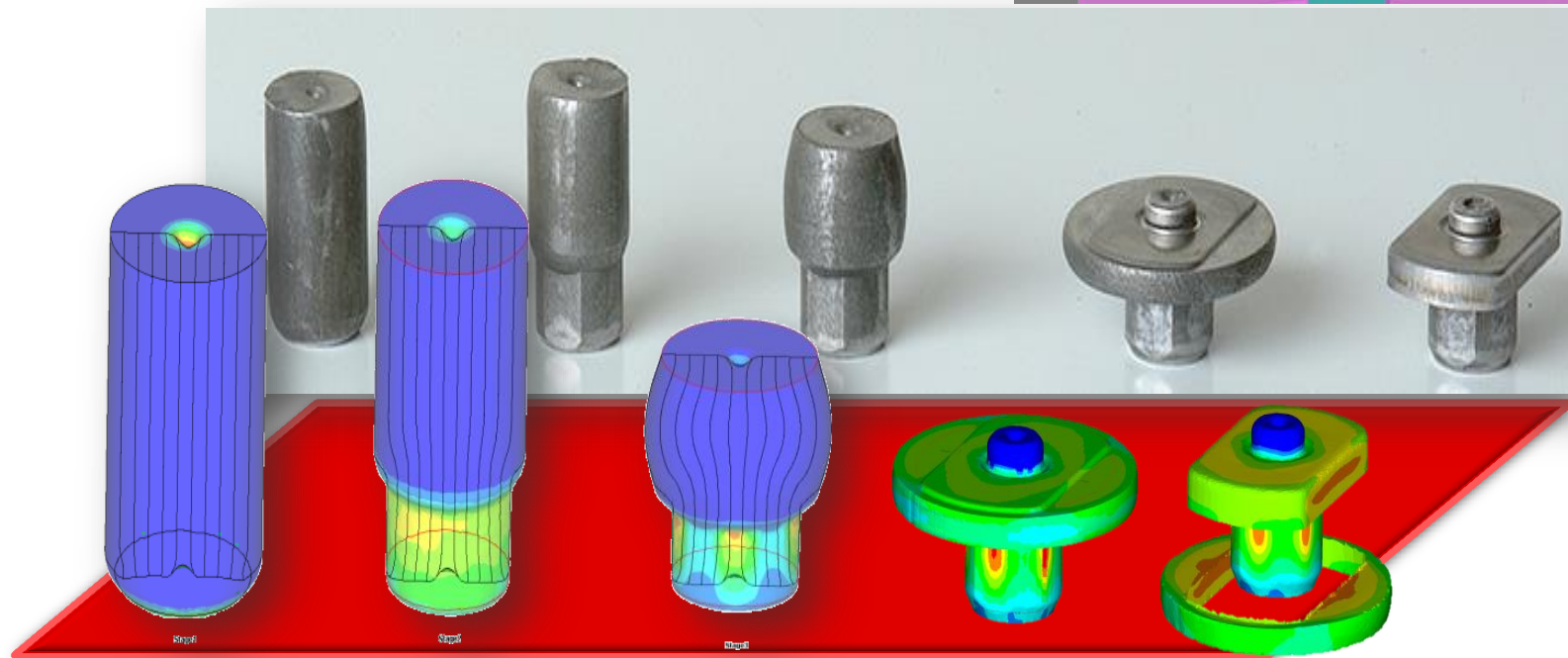
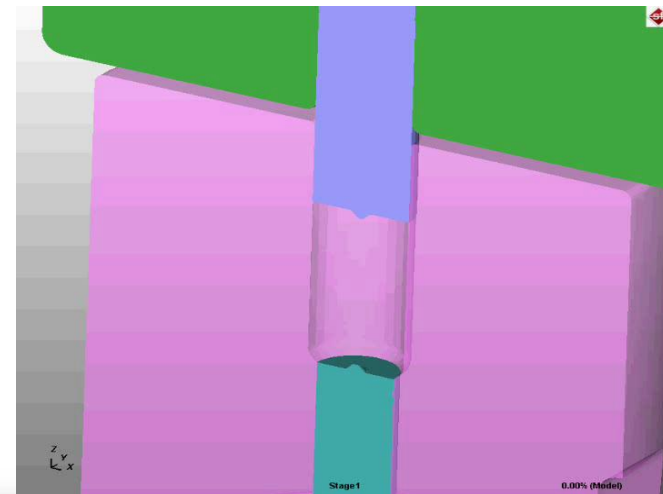


- FE有限元法+FV有限体积法
- 预测锻造缺陷
- 设备吨位预估
- 辅助优化模具设计
- 工艺参数优化
- 模具应力分析
- 简便的多工序连续分析
- 多窗口联动对比分析
- 2D结果转3D继续分析

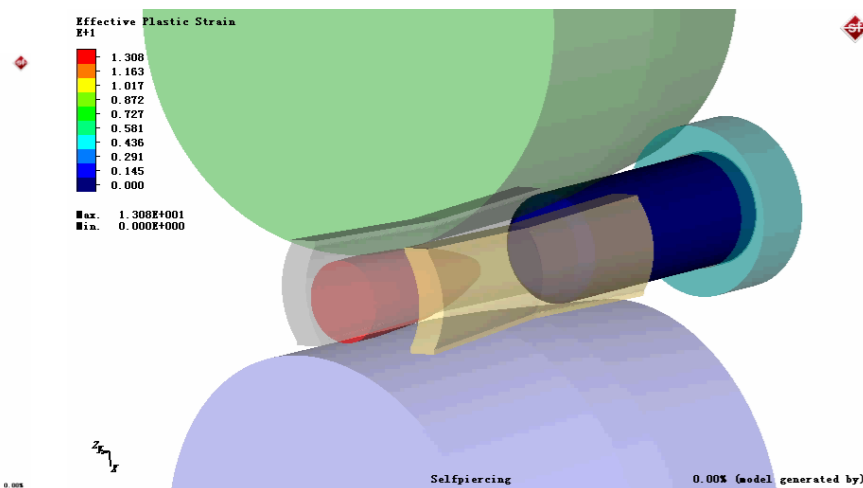
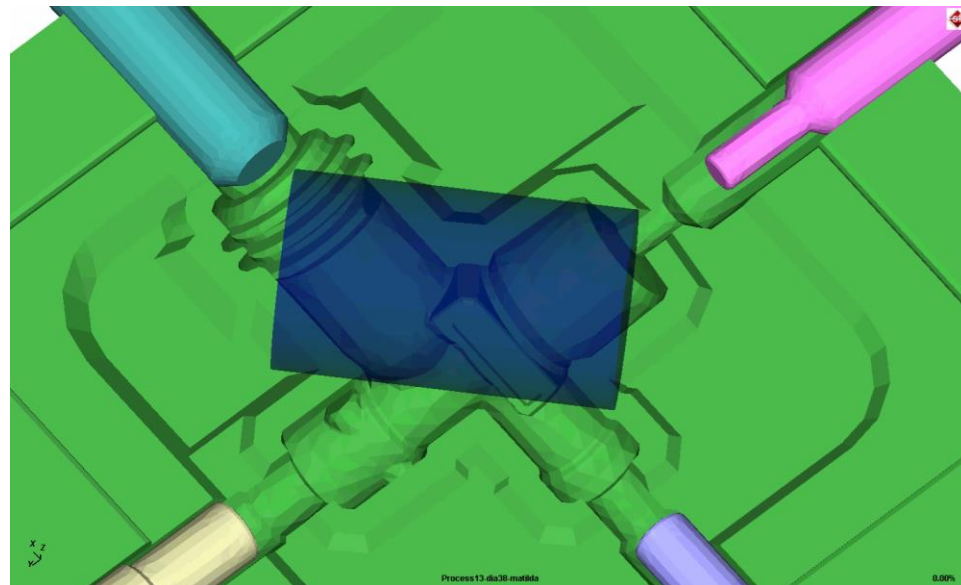
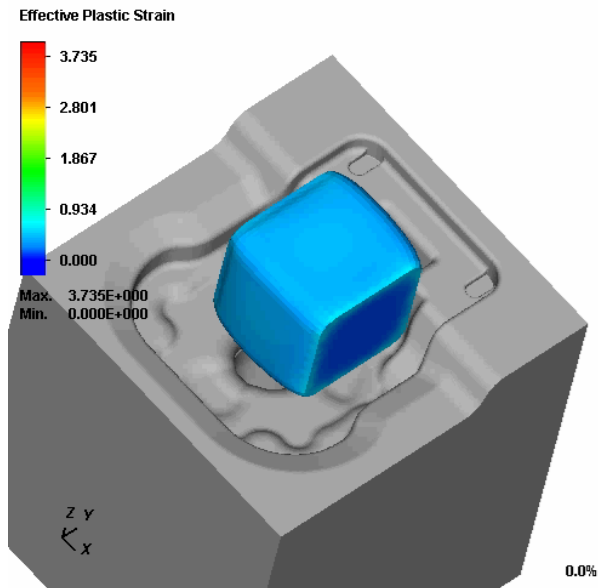


冷成形模拟分析

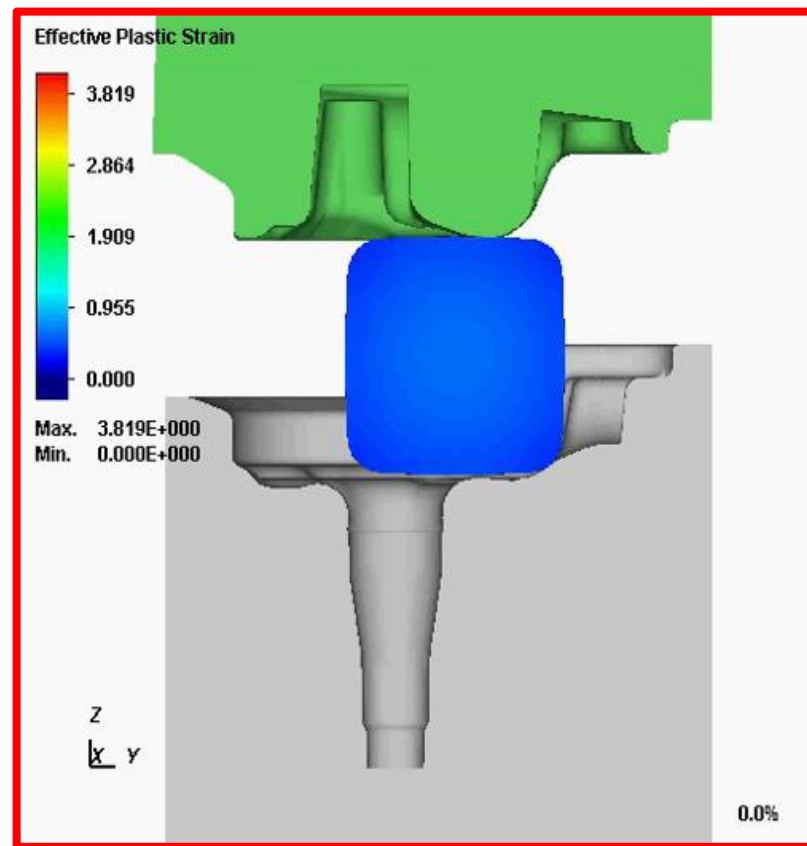
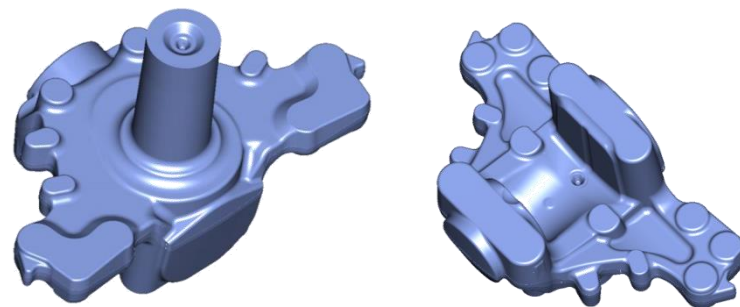
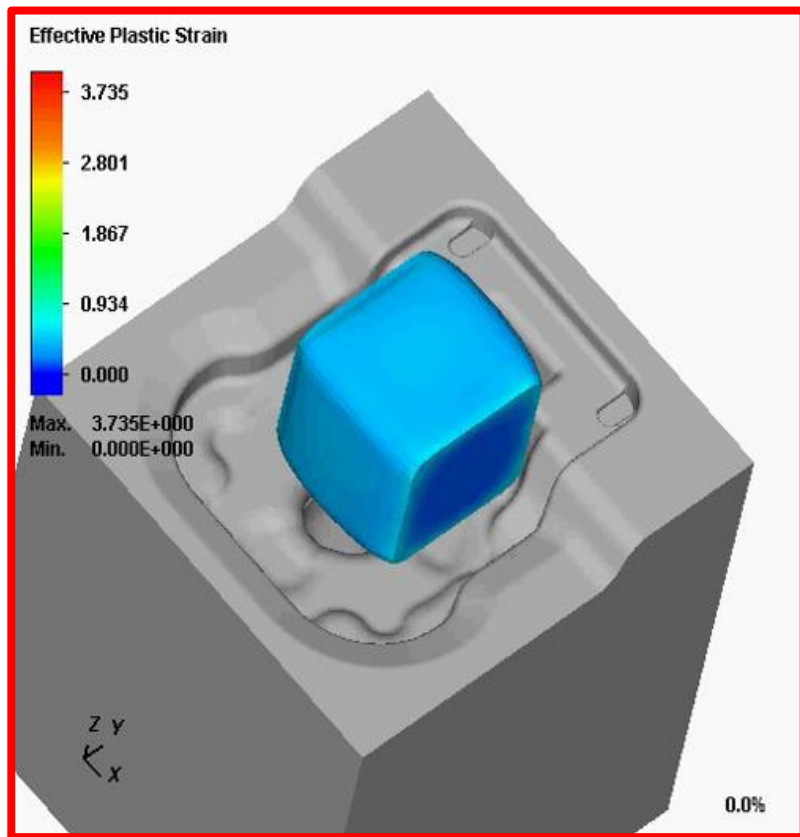
- ◆ 全自动过渡
- ◆ 2D-3D任意切换
- ◆ 集成2D和3D仿真
- ◆ 工艺成形性分析



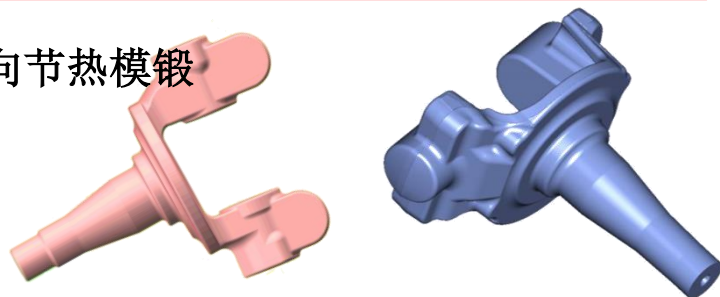
Simufact.forming 复杂材料流动



热加工工艺仿真

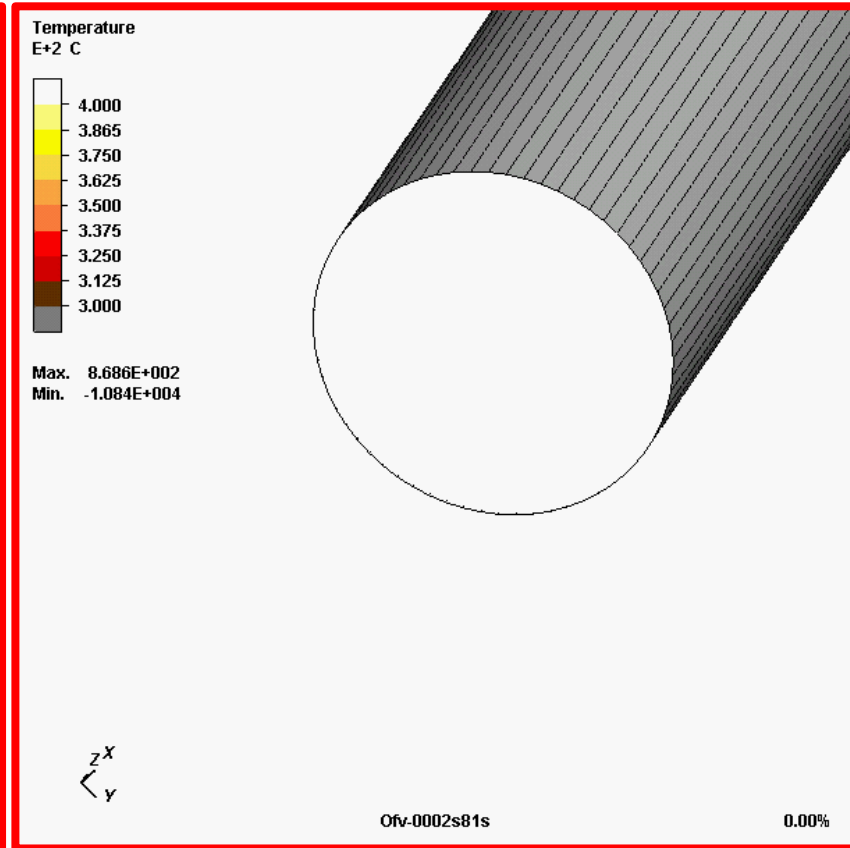
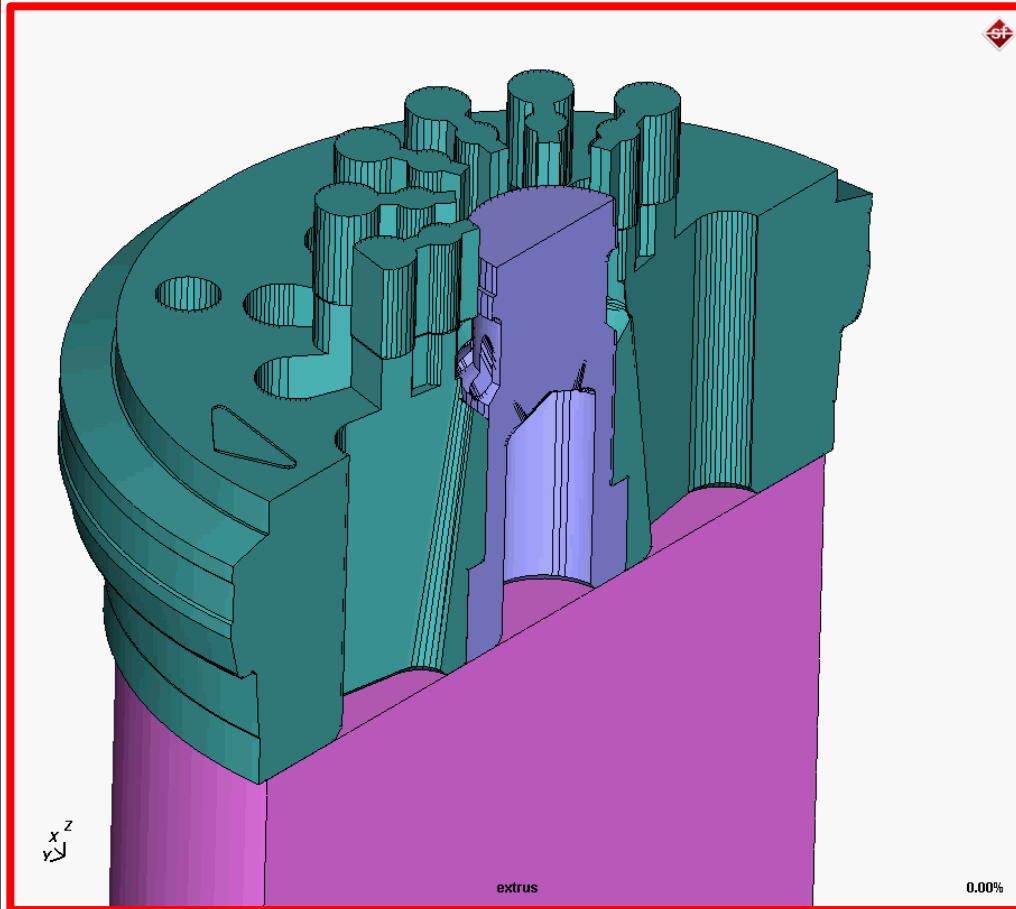


转向节热模锻



分流模挤压案例

分流模挤压



连杆热加工仿真案例

连杆热加工工艺链仿真



连杆热加工仿真案例

连杆热加工工艺链仿真



连杆热加工仿真案例

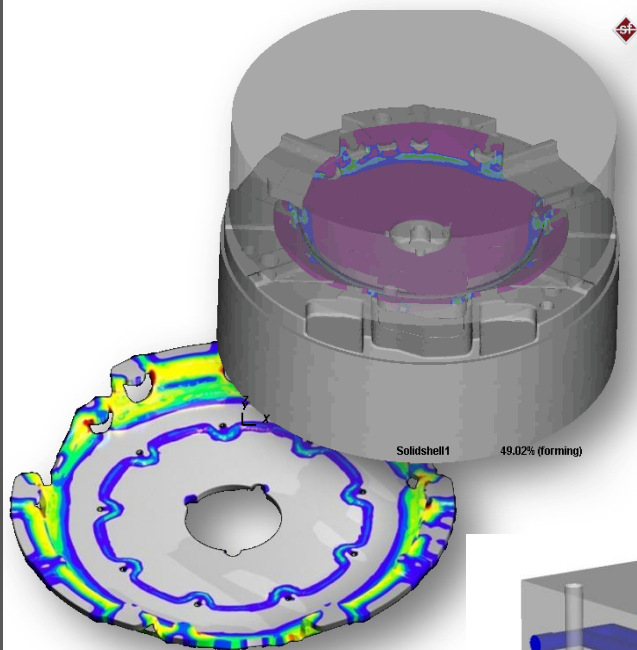
连杆热加工工艺链仿真



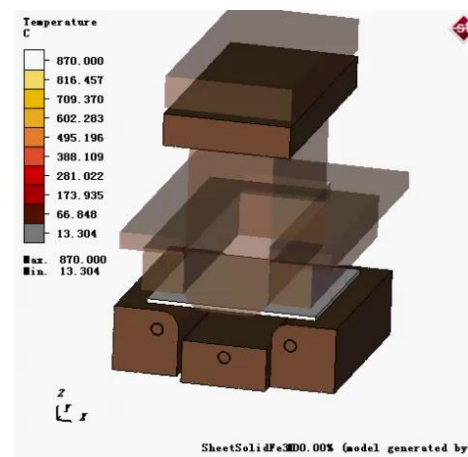
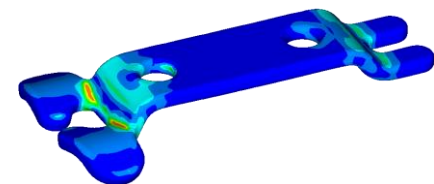
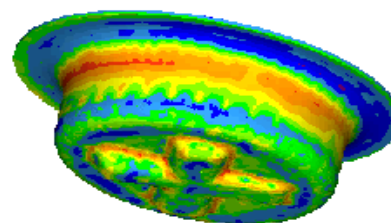
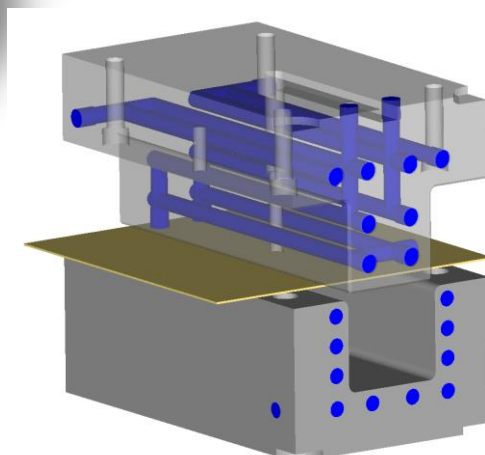
钣金成形工艺模拟

传统钣金冲压

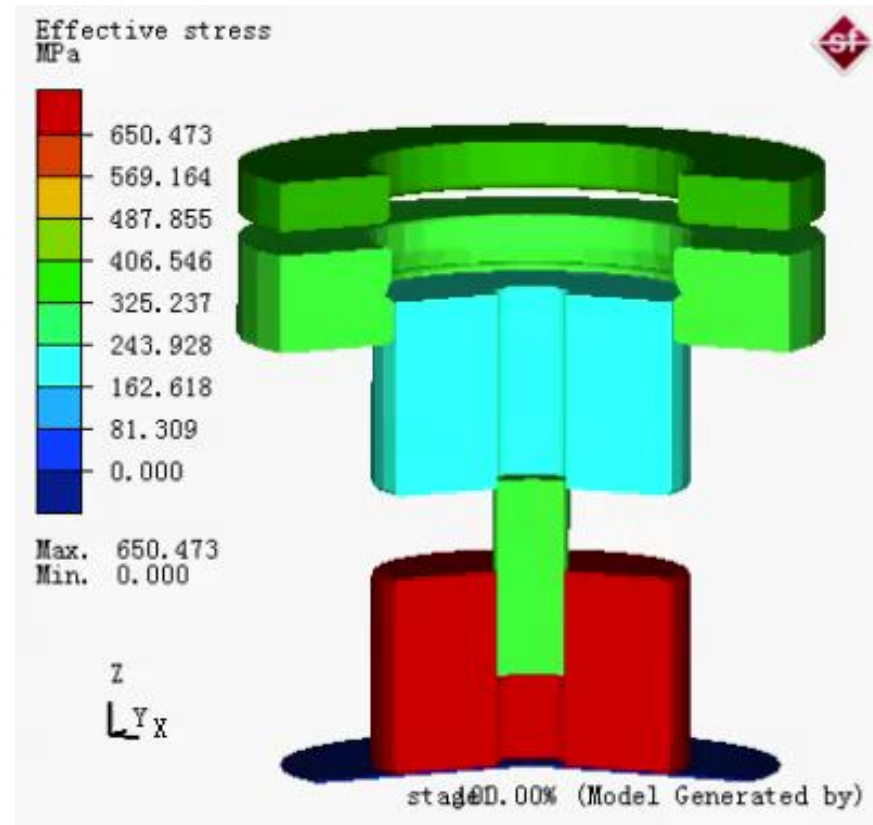
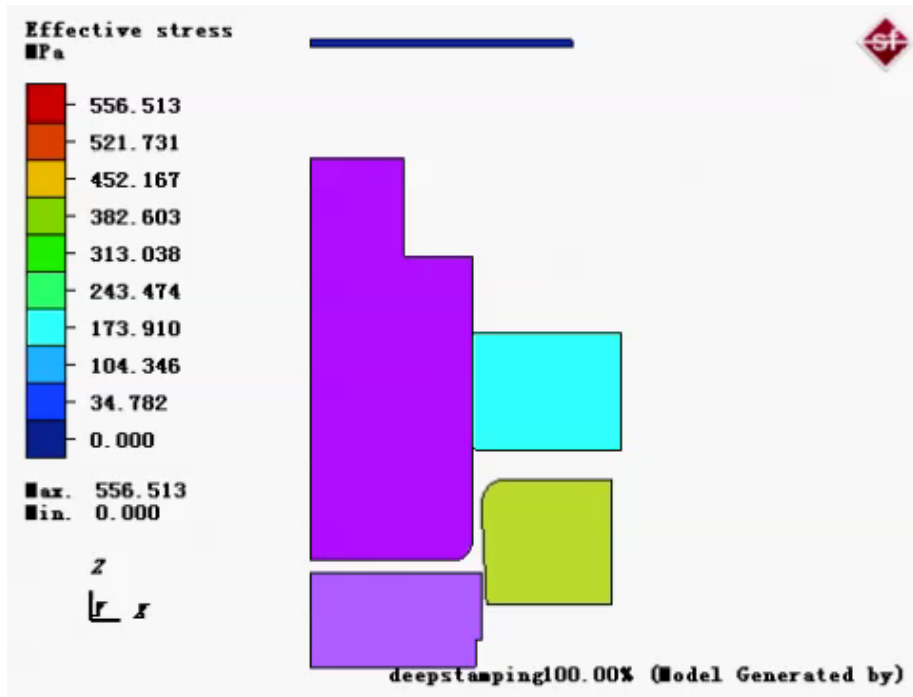
厚板冲压



热成形



钣金成形工艺模拟



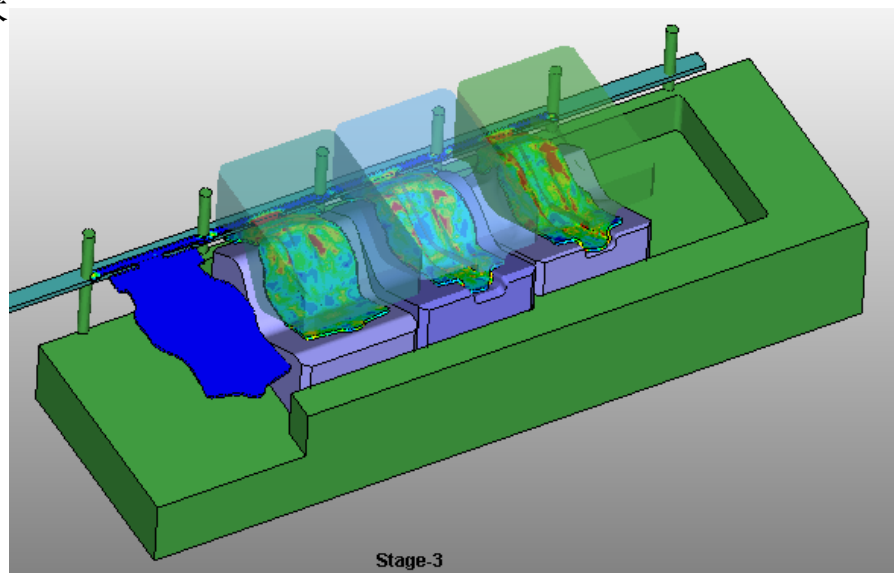
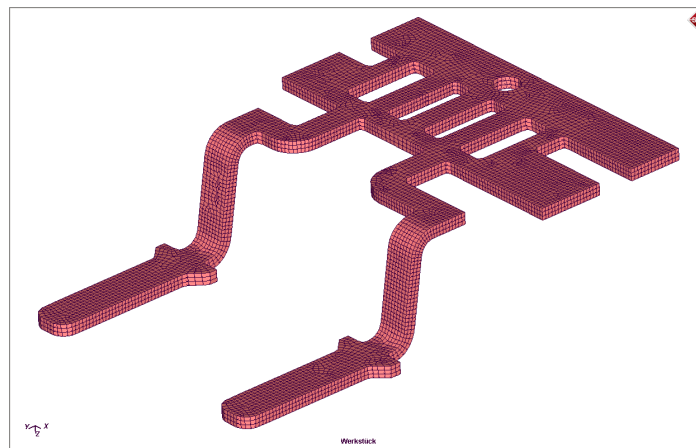
钣金成形工艺模拟

通用网格划分技术

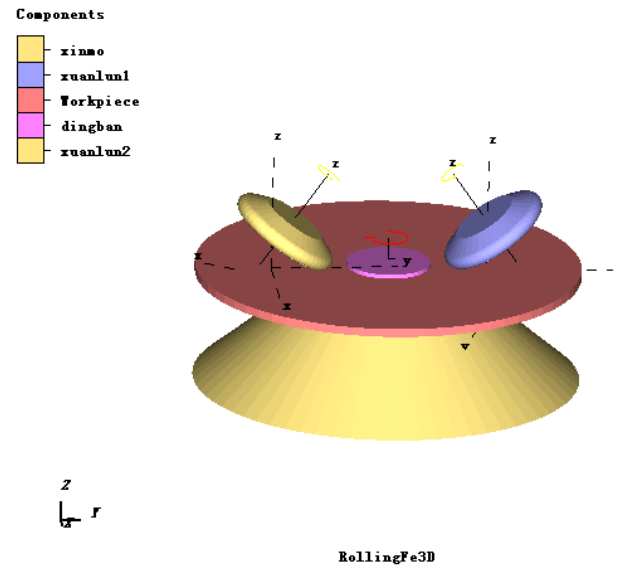
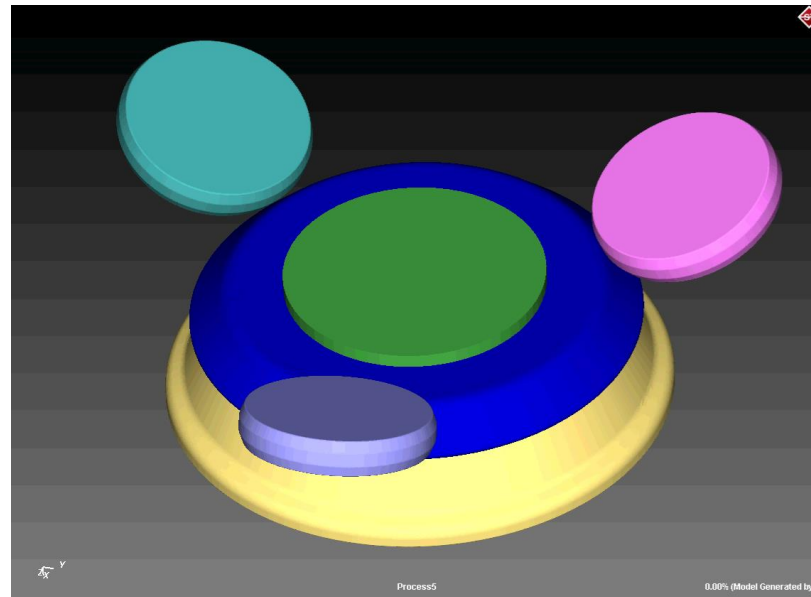
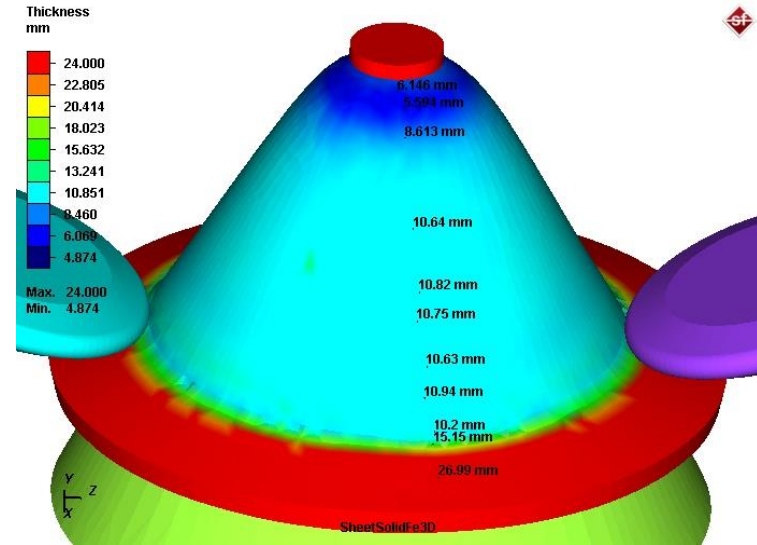
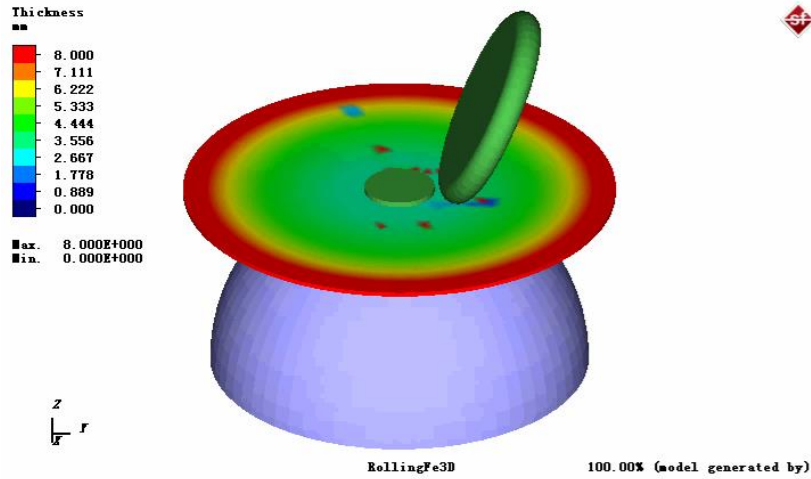
- 壳单元
- 表面三角形/四边形单元划分

其它网格划分技术

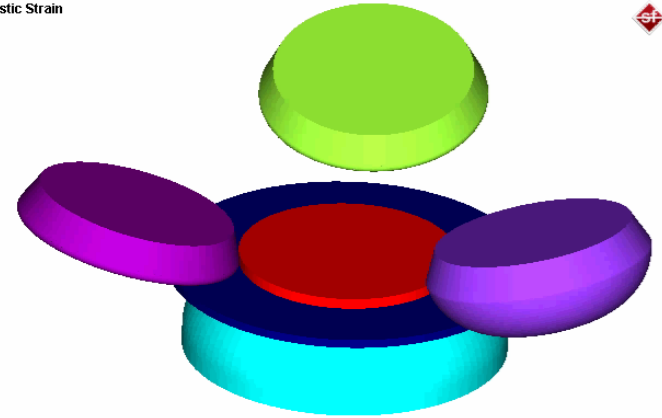
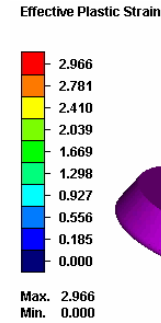
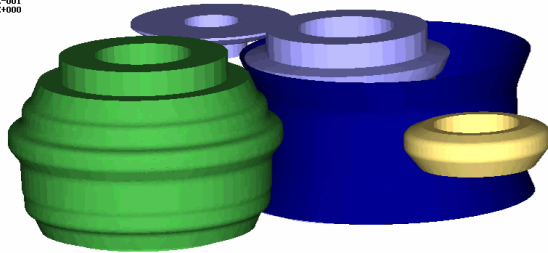
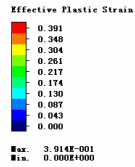
- 体单元
- 六面体和四面体单元
- 来自MSC和SimLab的四面体网格全自动划分技术
- Simufact自己开发:
六面体单元网格自动划分
- 实体壳单元



钣金成形工艺模拟



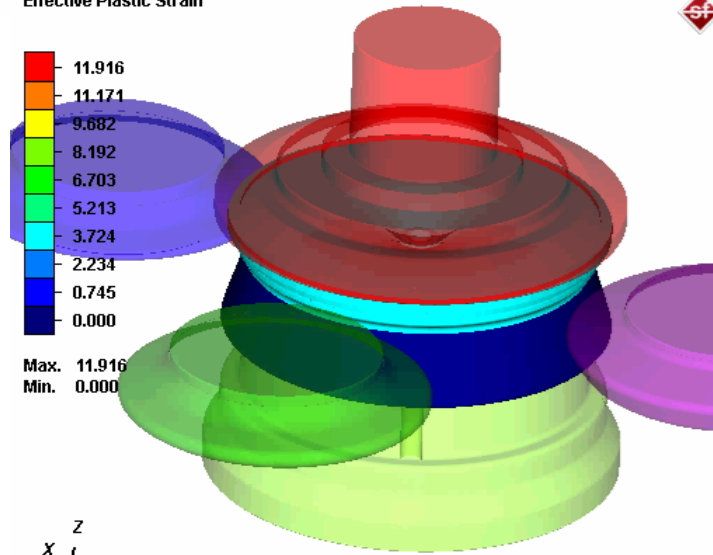
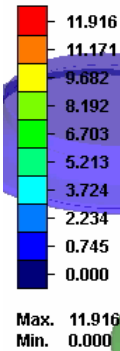
车轮滚型及旋压



z
y
x

SheetSolidFe3D-adz2-separation

Effective Plastic Strain

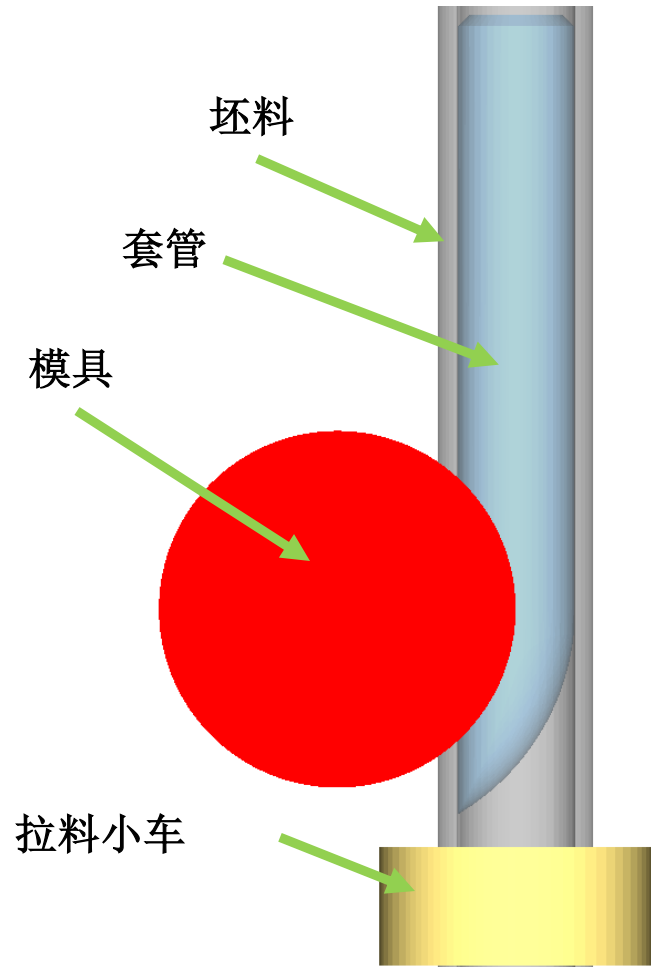
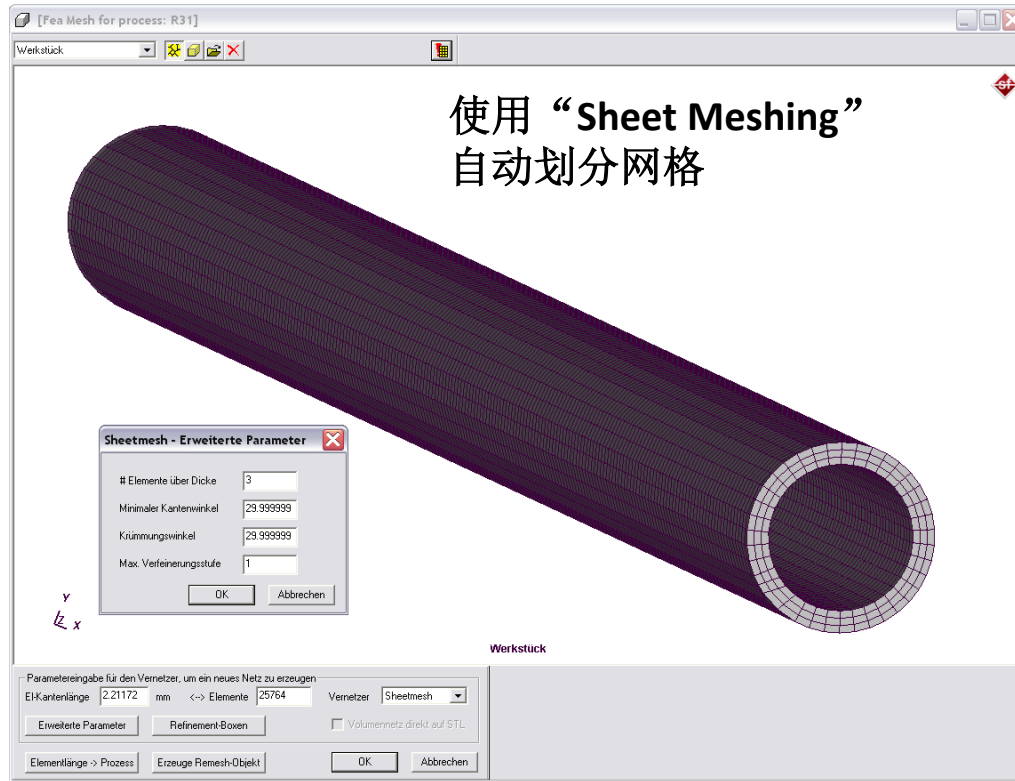


z
y
x

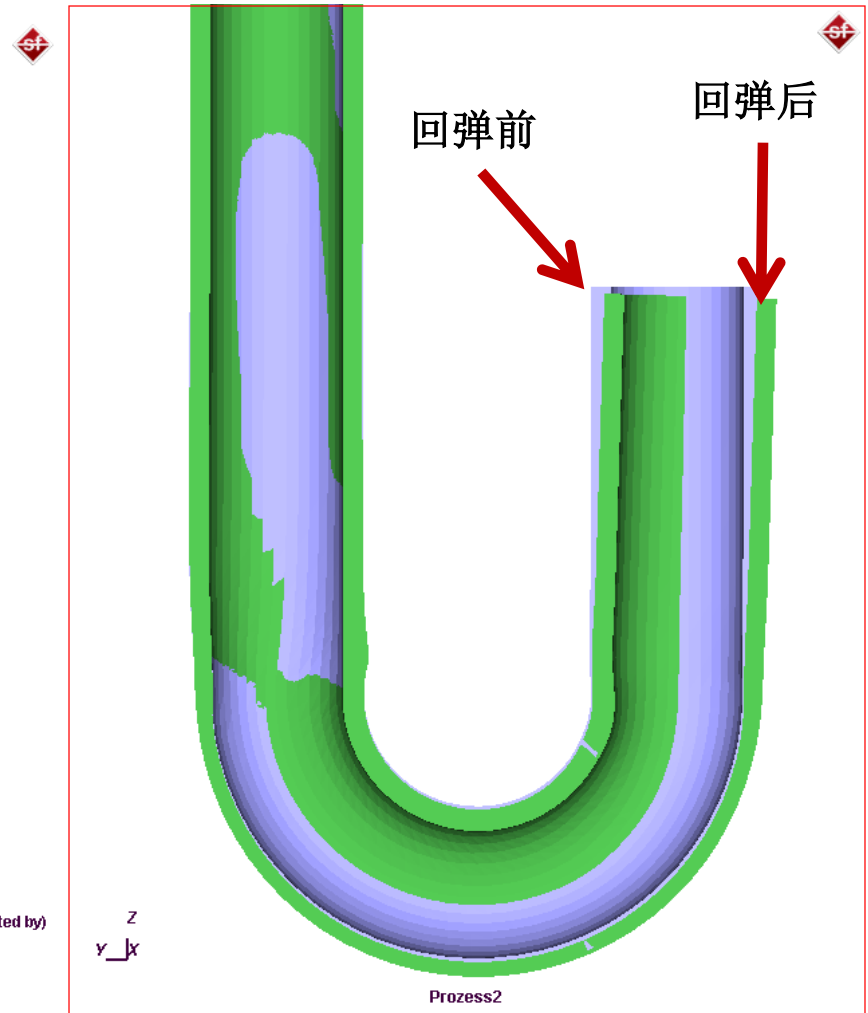
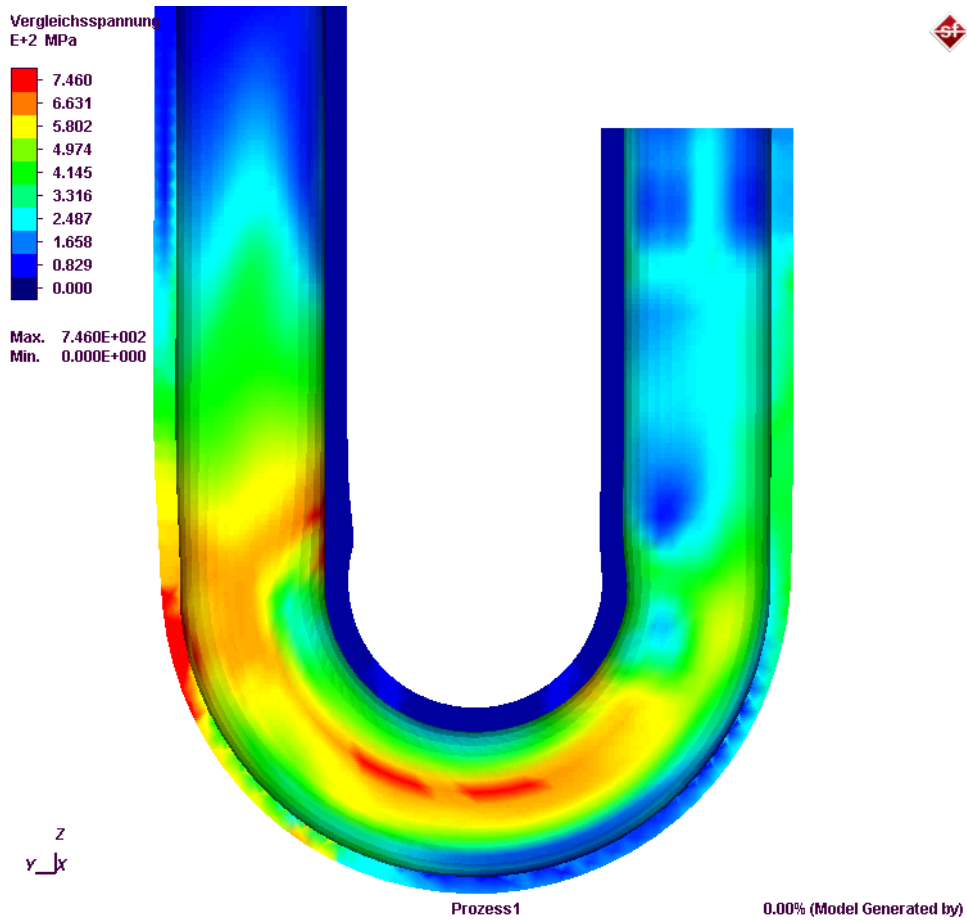
RingRollFe3D

100.00% (model generated by)

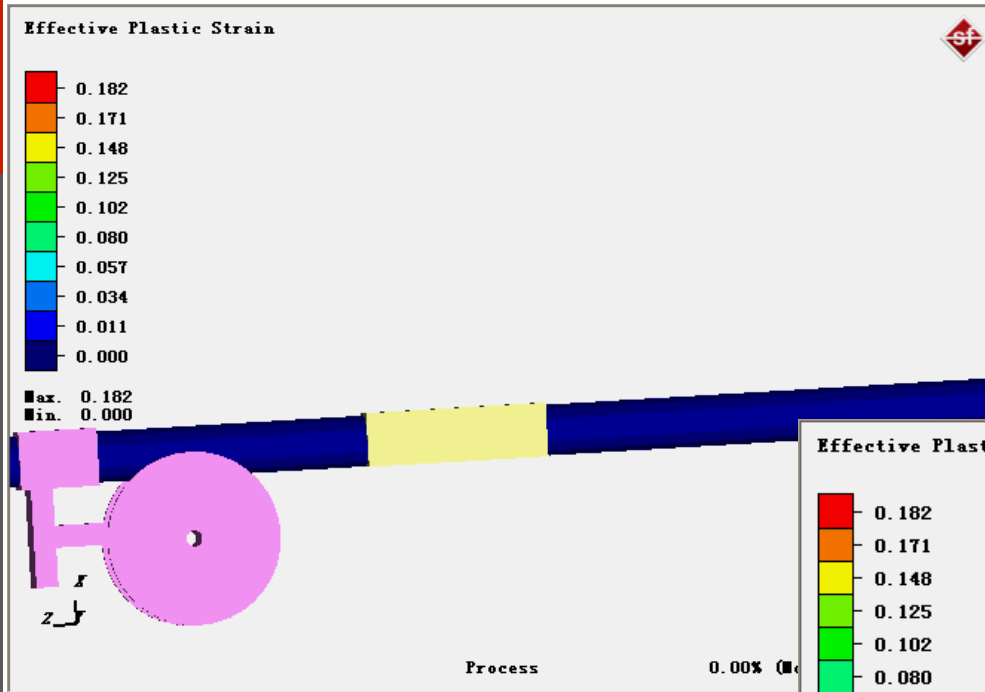
管材弯曲模拟



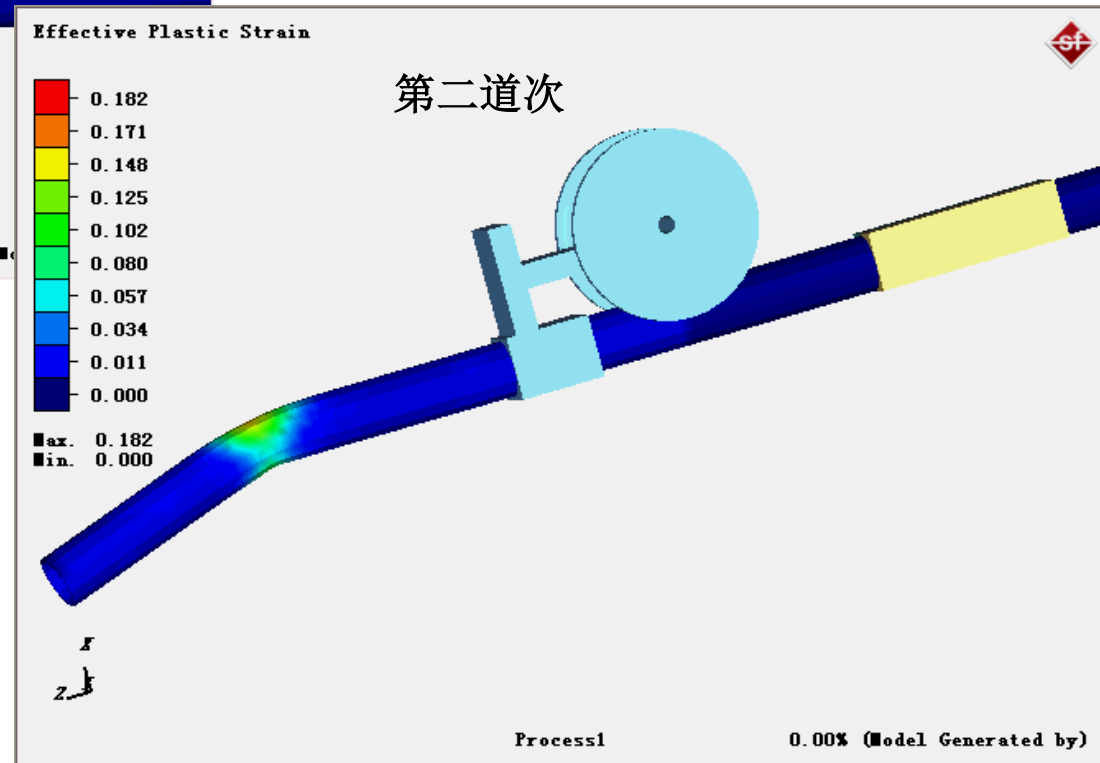
回弹预测



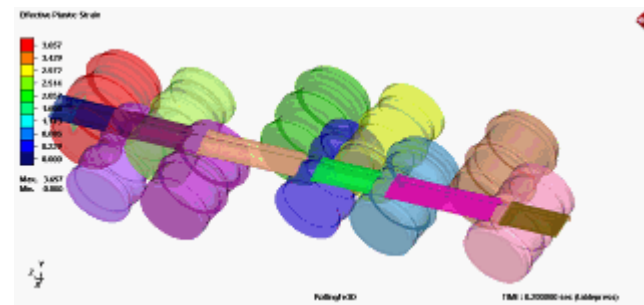
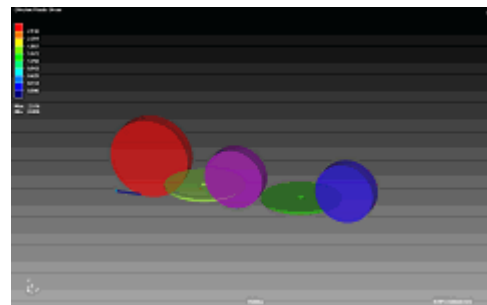
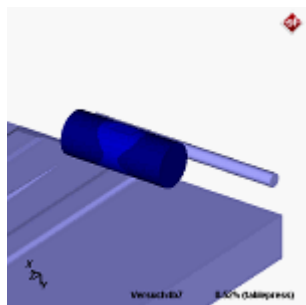
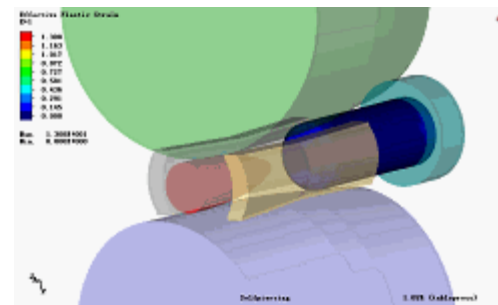
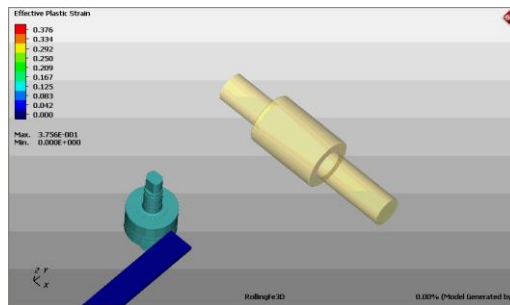
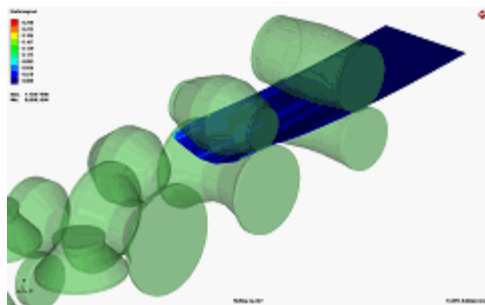
管材多道次弯曲



第一道次



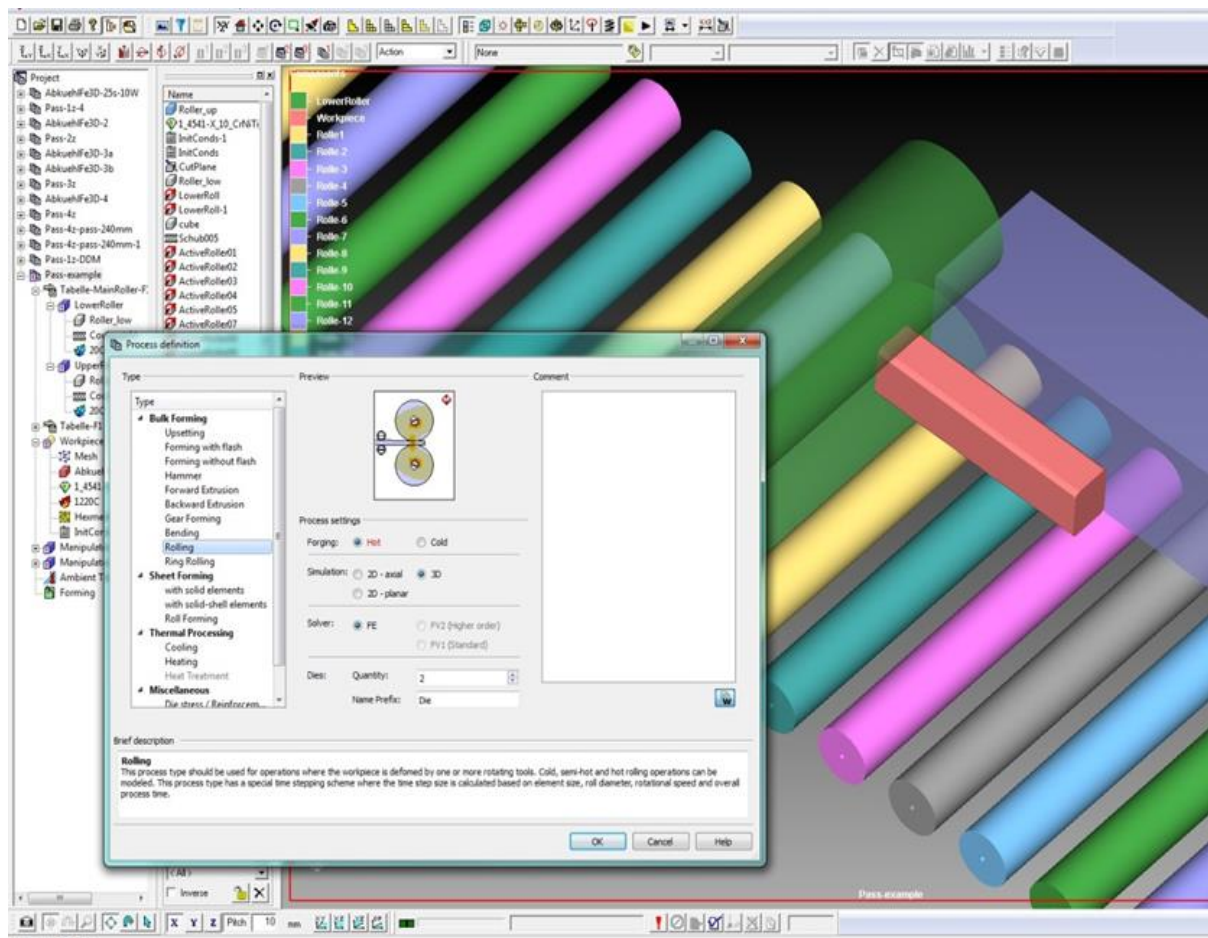
轧制成形工艺模拟



- 极易定义旋转运动
- 六面体、实体壳单元网格划分
- 多辊连轧仿真无任何限制
- 全开放的运动定义

轧制工艺仿真

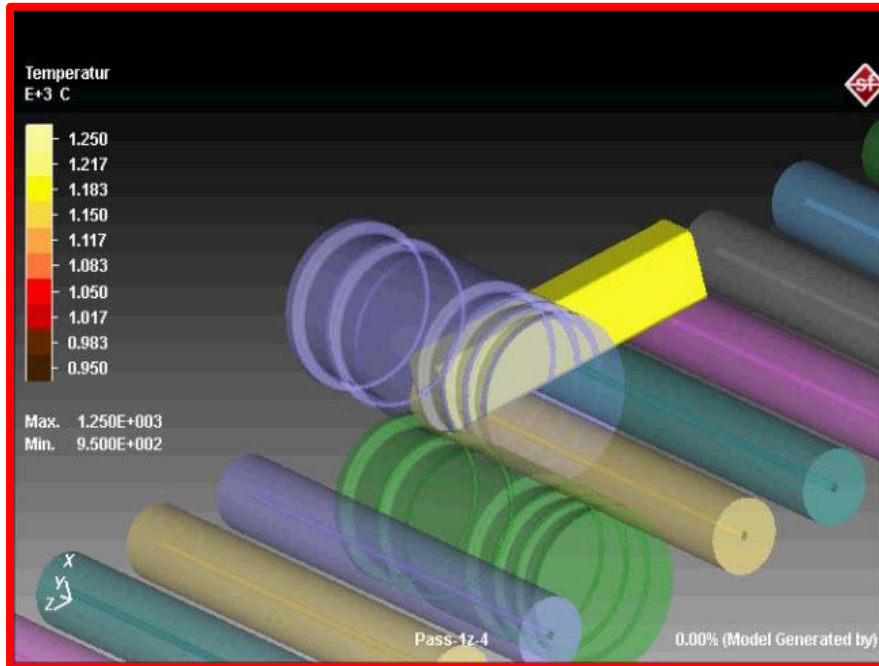
快速建模、极易使用的用户界面



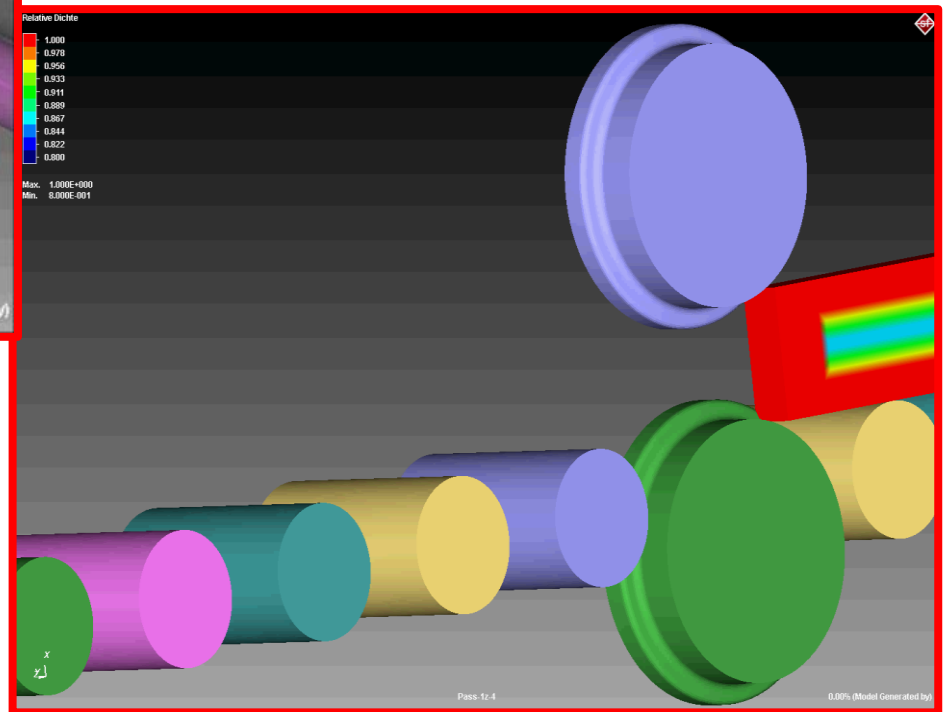
- ◆ 直观
- ◆ 灵活
- ◆ 模板 & 向导
- ◆ 高级模式
- ◆ 其它工艺仿真接口(铸态结构分析)

轧制工艺仿真

多道次铁轨轧制...

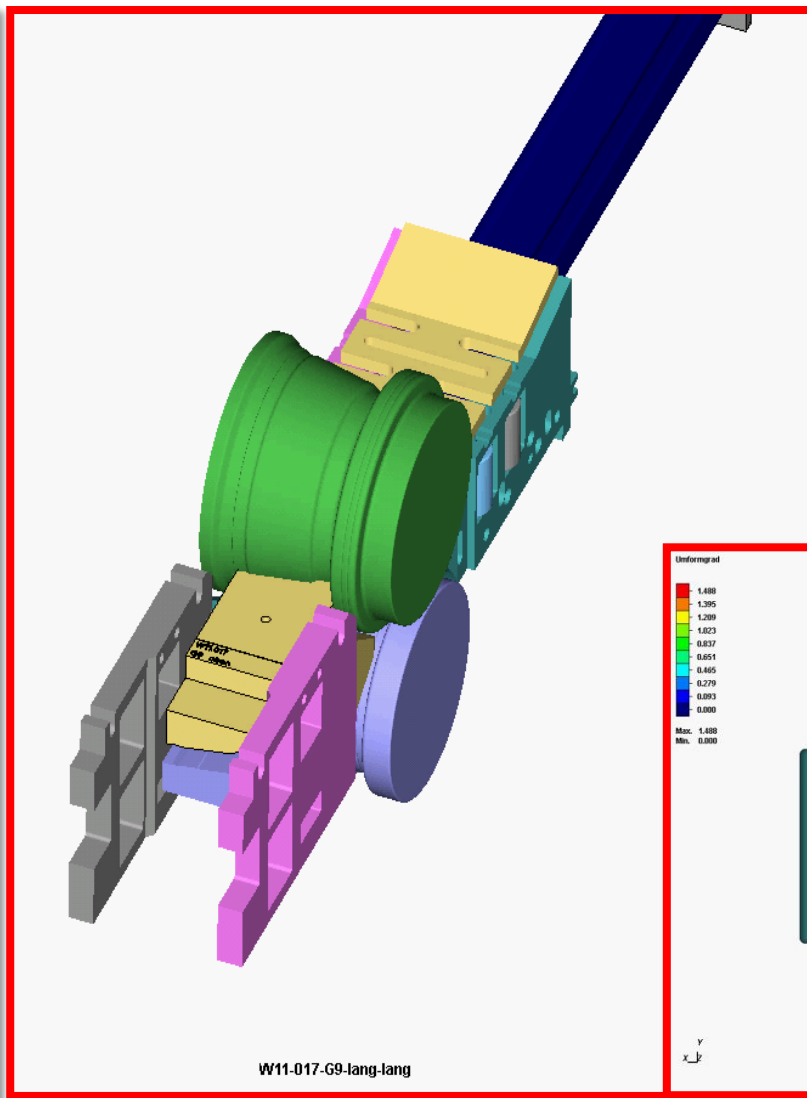
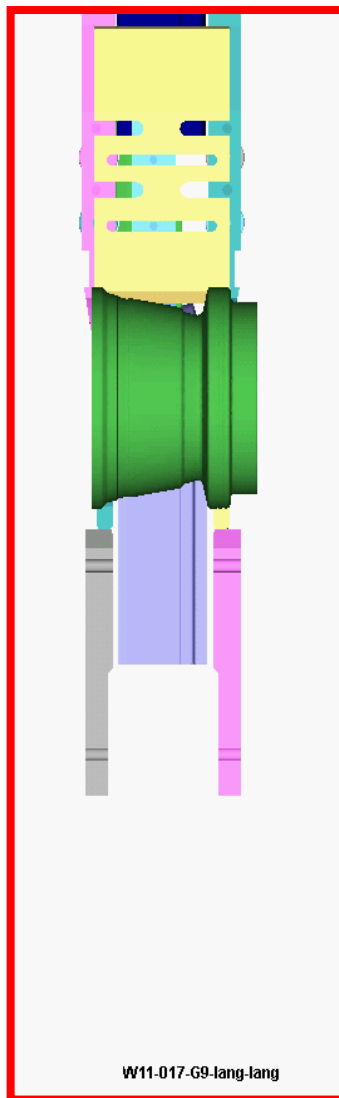


... 预测芯部缺陷 (孔洞闭合)

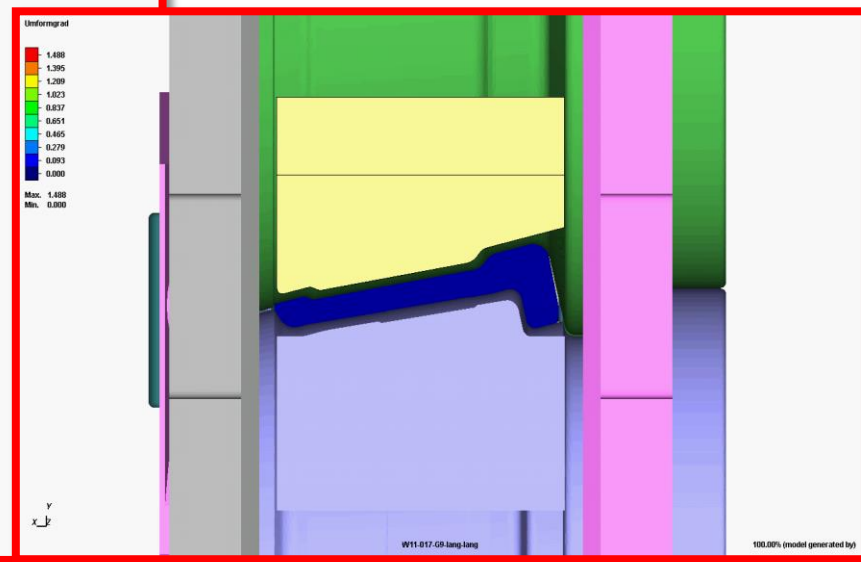


轧制工艺仿真

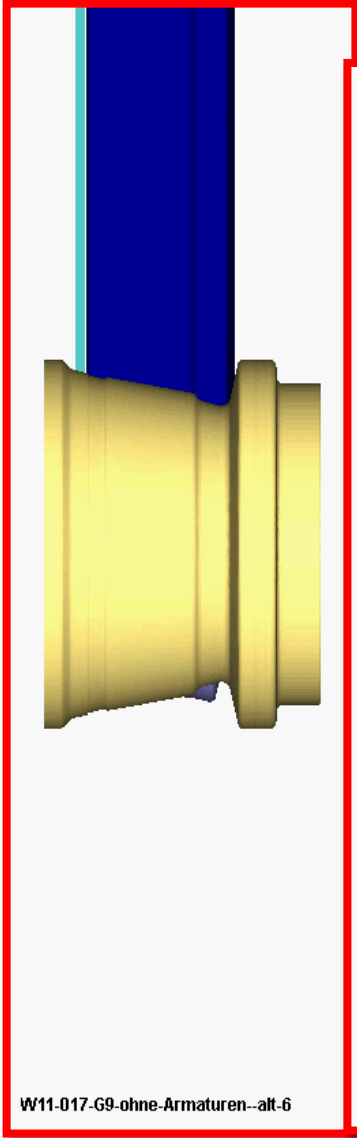
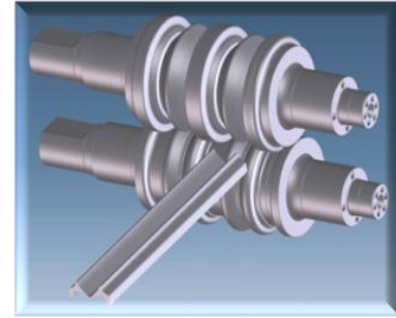
扭曲- 优化前



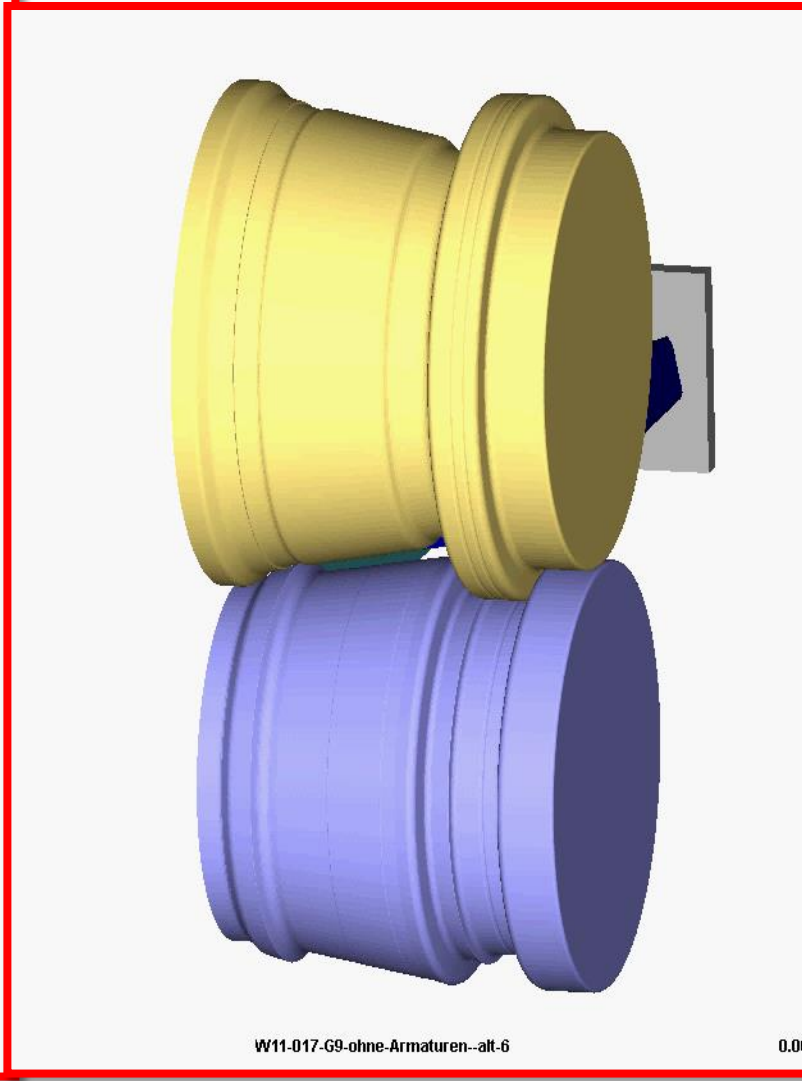
由仿真可以看出，扭曲
不仅和轧辊缝隙有关，
而且与后续矫形模具相关



轧制工艺仿真

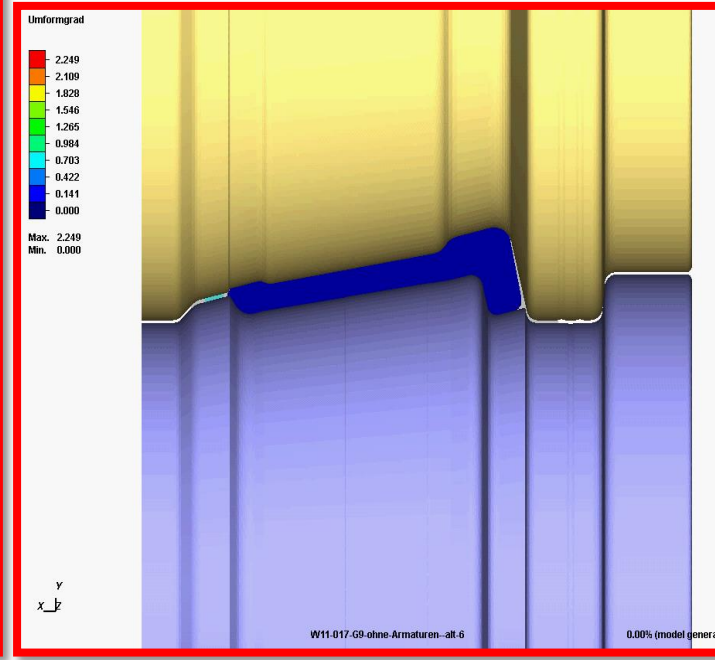


W11-017-G9-ohne-Armaturen--alt-6



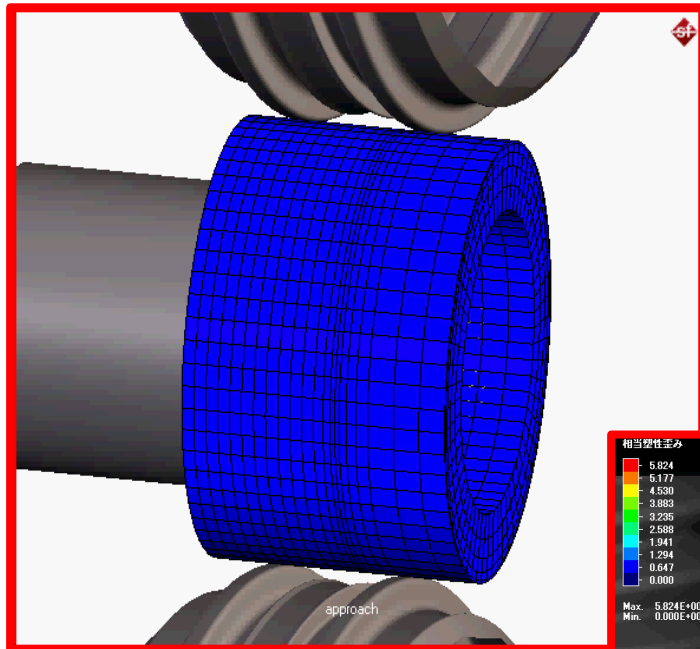
W11-017-G9-ohne-Armaturen--alt-6

0.00

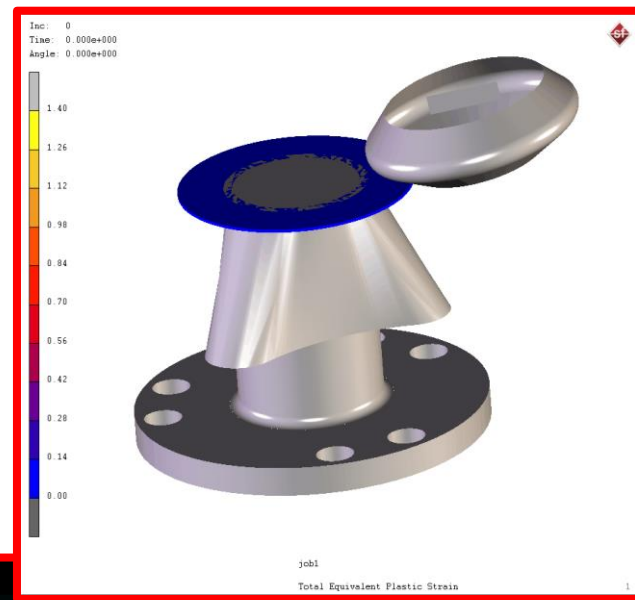


轧制工艺仿真

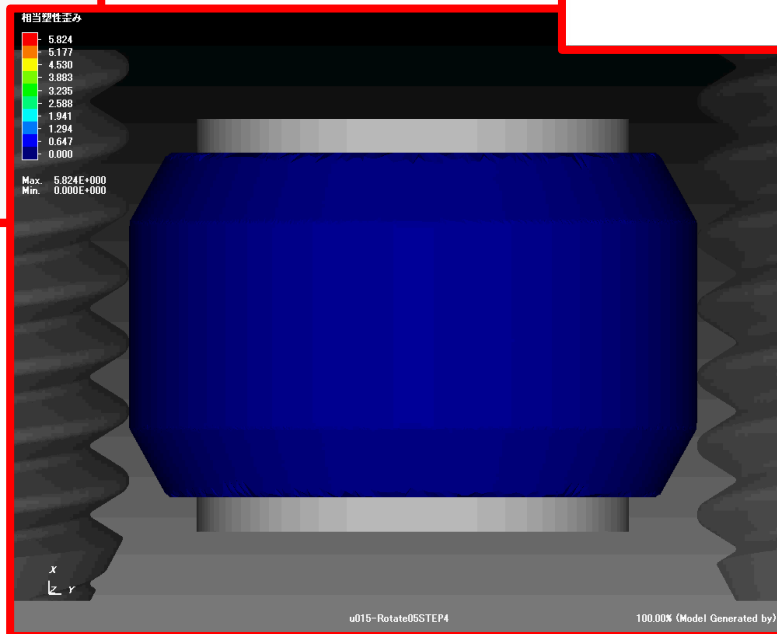
其它轧制工艺



辊轧...



非对称旋压...



搓牙...

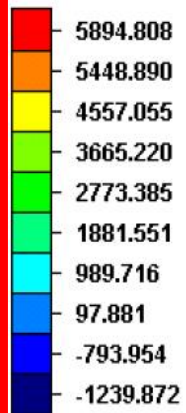
模具应力分析

问题: 模具损伤
凹模经常损坏



模具应力分析

Maximum Principal Stress
MPa

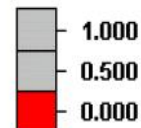


Max. 5894.808
Min. -1239.872

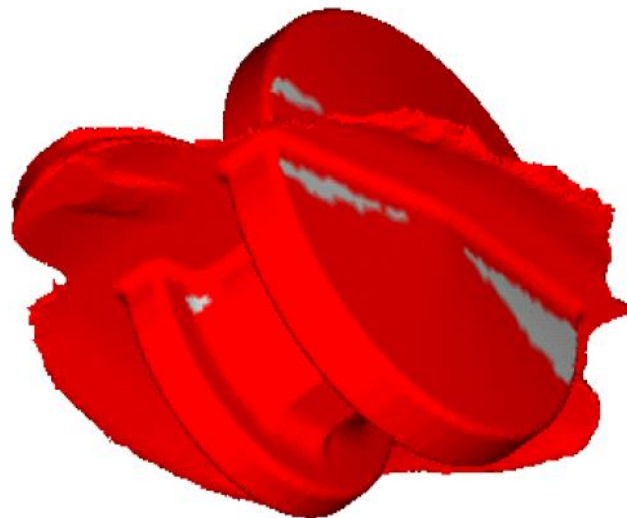


Finisher-DIESTRESS-BottomDie0.00% (Model Generated by)

Die Contact



Max. 1.000
Min. 0.000

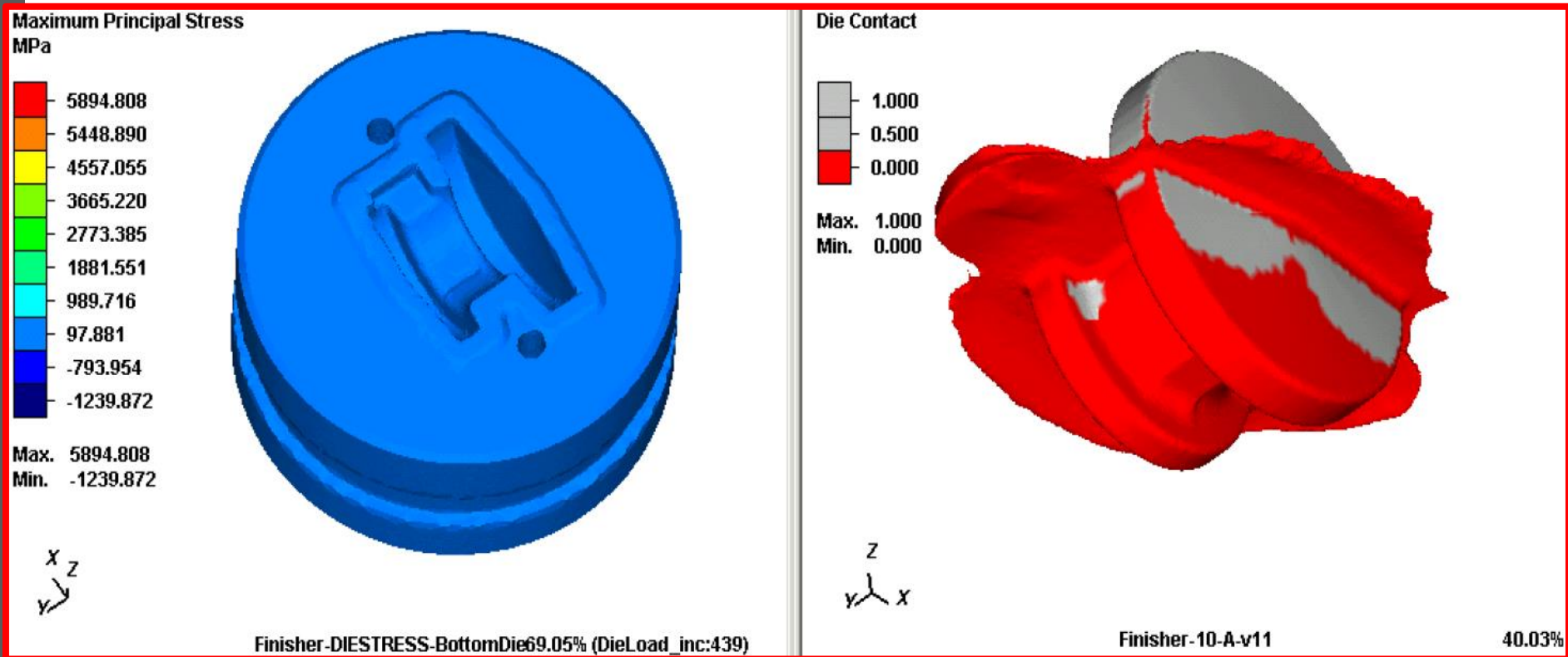


Finisher-10-A-v11

0.00%

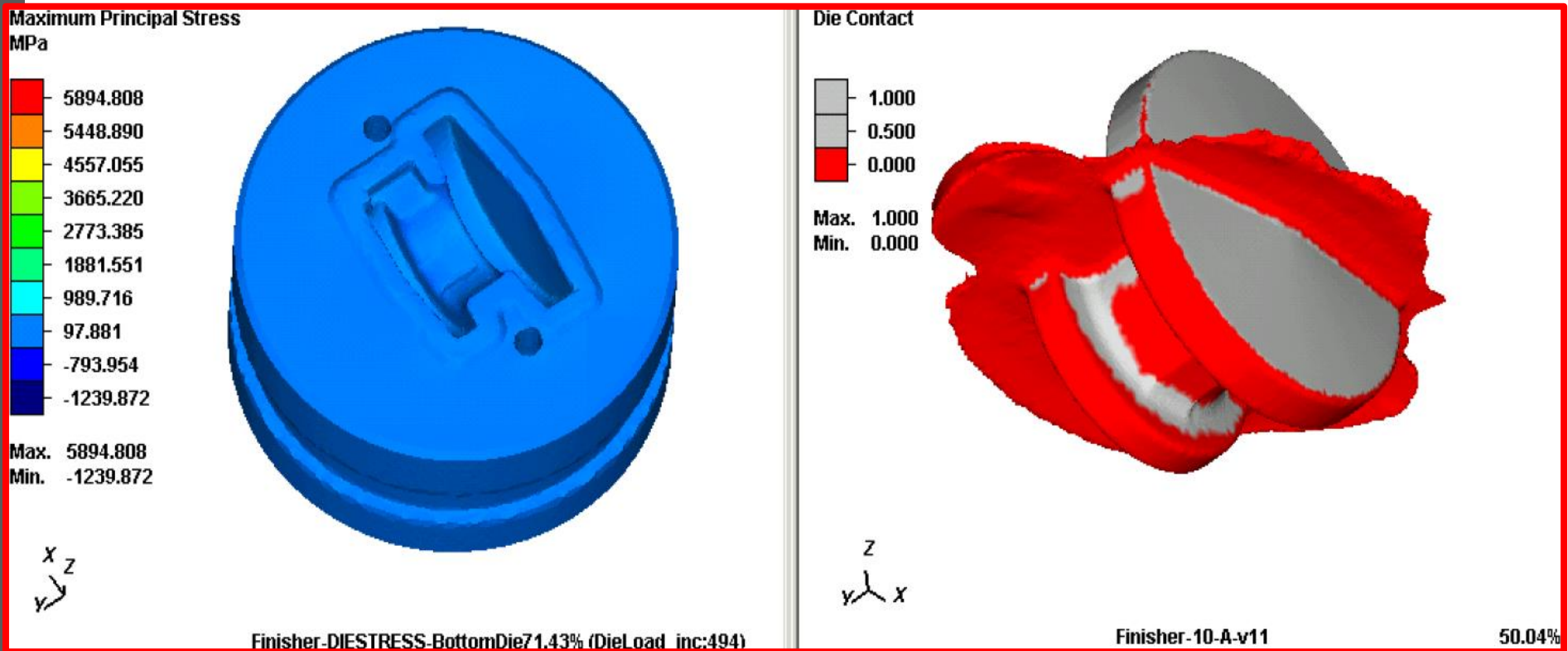
模具应力(左侧) 模具接触 行程 = 0%

模具应力分析



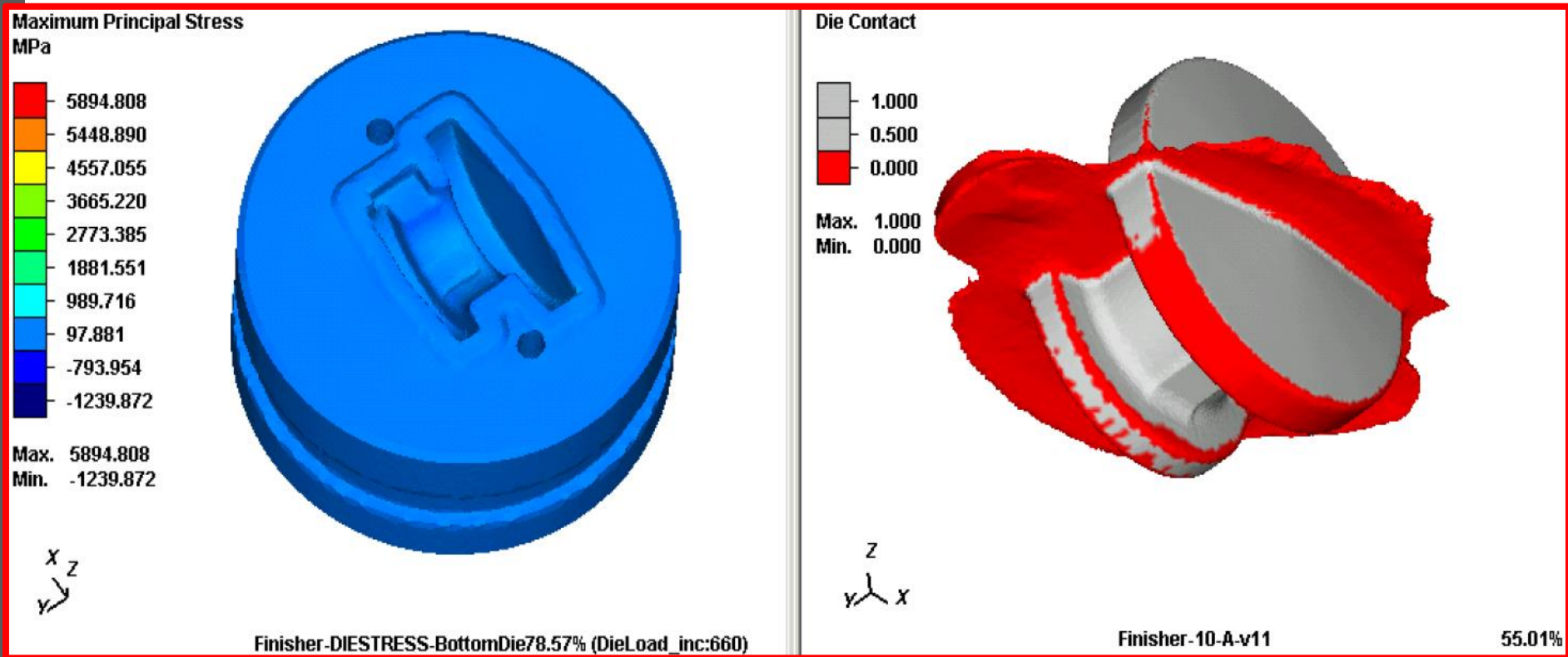
模具应力(左侧) 模具接触 行程 = 40%

模具应力分析



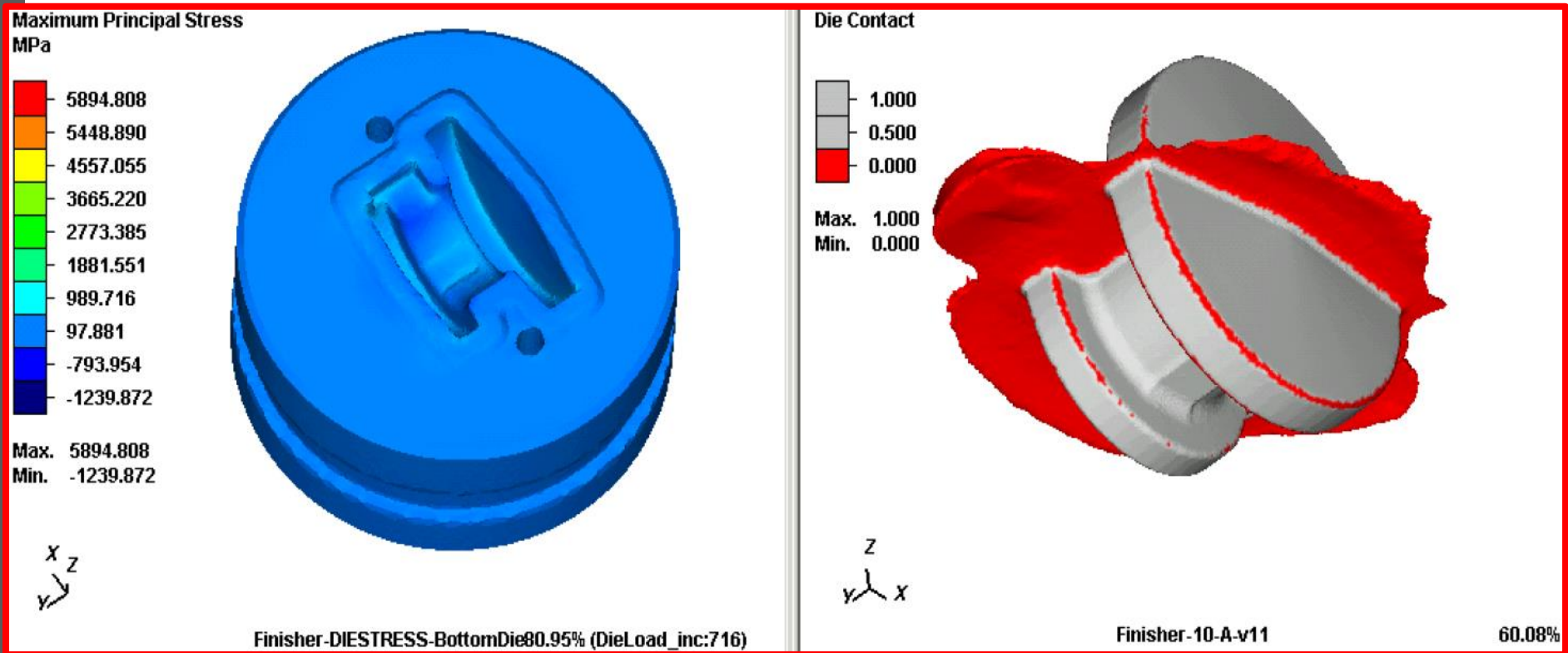
模具应力(左侧) 模具接触 行程 = **50%**

模具应力分析



模具应力(左侧) 模具接触 行程 = **55%**

模具应力分析

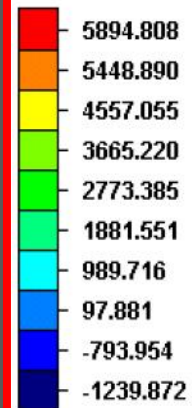


模具应力(左侧) 模具接触 行程 = 60%

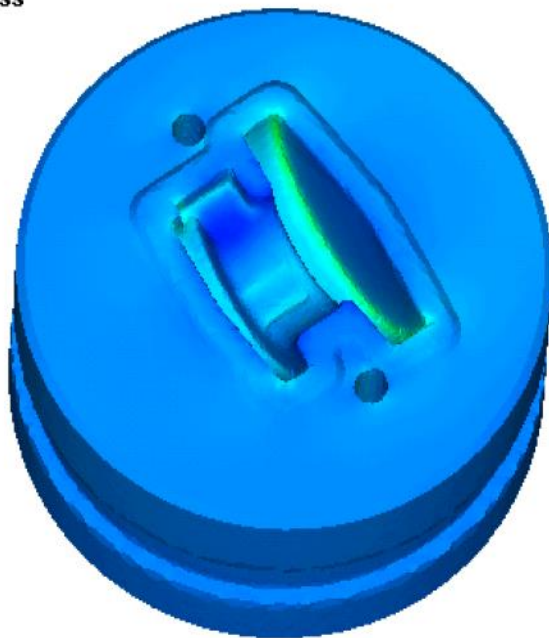
模具应力分析

模具填充完整

Maximum Principal Stress
MPa

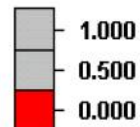


Max. 5894.808
Min. -1239.872

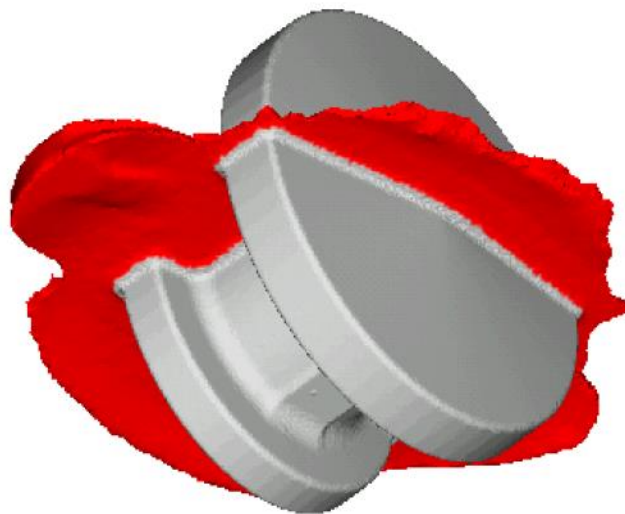


Finisher-DIESTRESS-BottomDie83.33% (DieLoad_inc:771)

Die Contact



Max. 1.000
Min. 0.000



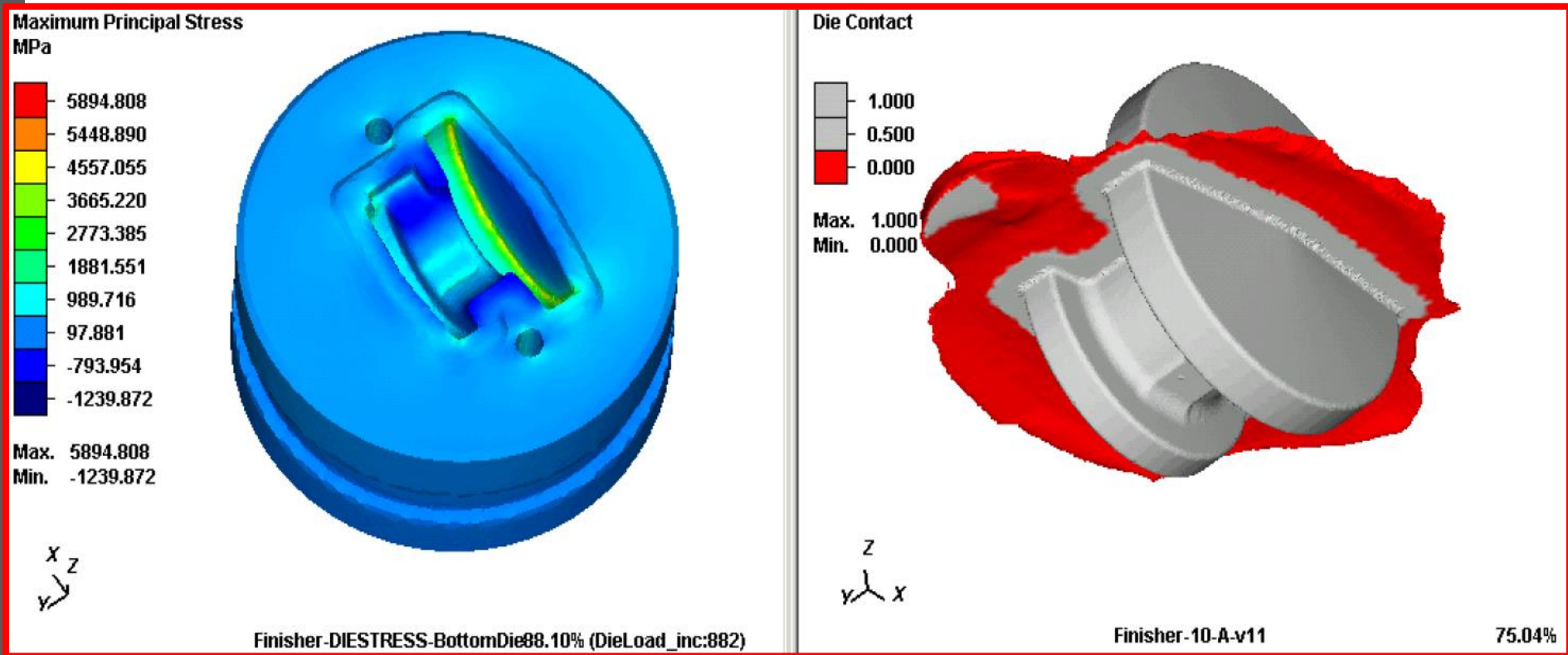
Z
Y X

Finisher-10-A-v11

65.05%

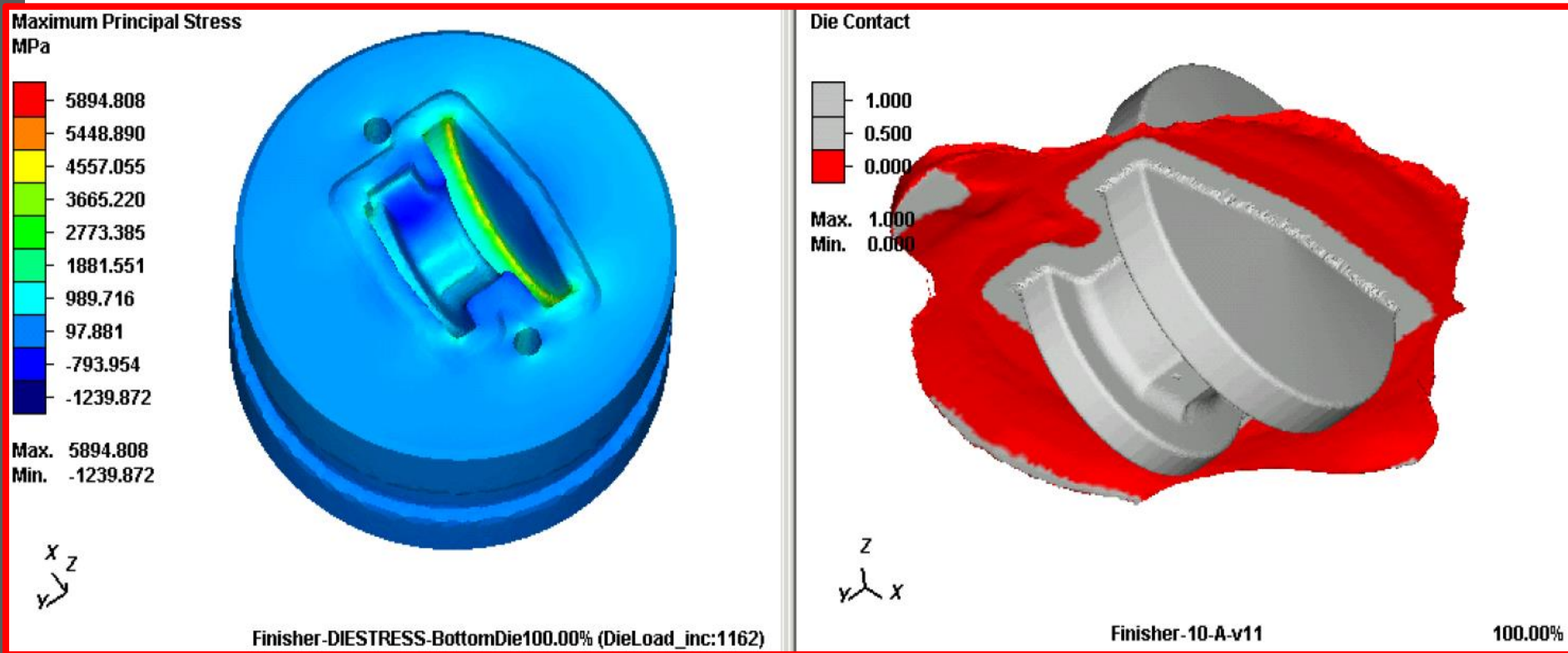
模具应力(左侧) 模具接触 行程 = **65%**

模具应力分析



模具应力(左侧) 模具接触 行程 = **75%**

模具应力分析



模具应力(左侧) 模具接触 行程 = **100%**

模具应力分析

从仿真结果可知，模具应力急剧增大的主要原因是：在进行到**65%**行程时，模具已经填充完整，如果继续下压**2mm**至下死点，将会导致较高的应力。

- ◆ 对现实加工过程进行虚拟仿真(模具损伤)

仿真软件所做工作!

- ◆ 但是: 什么原因导致这个问题? 如何解决?

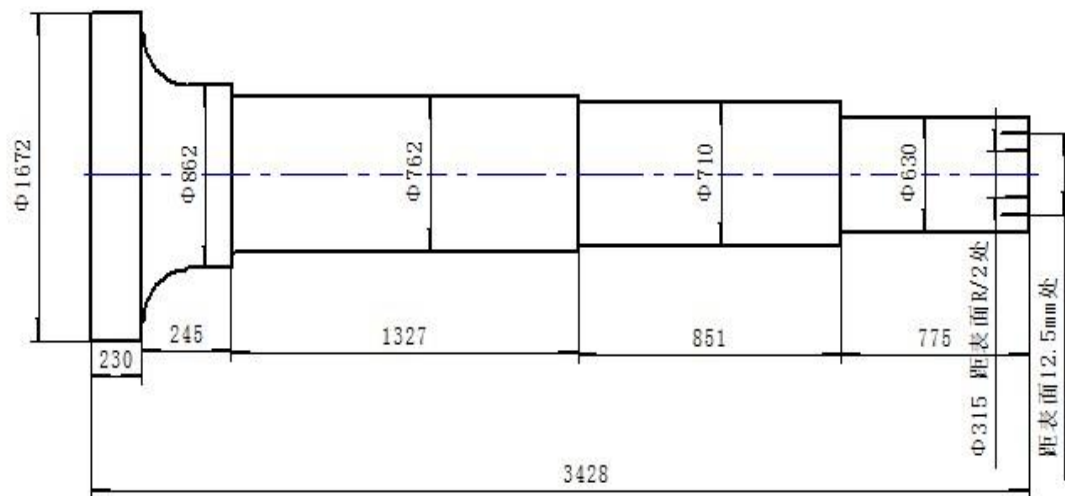
你需要完成的工作!

热处理工艺模拟

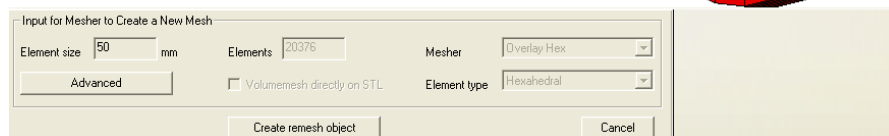
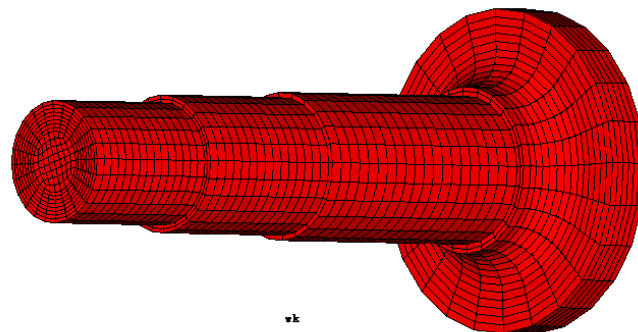
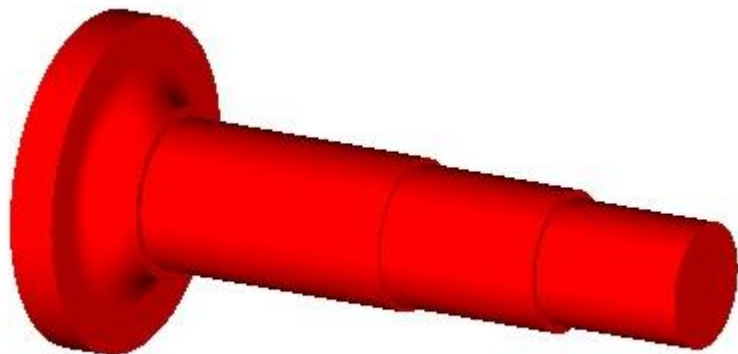
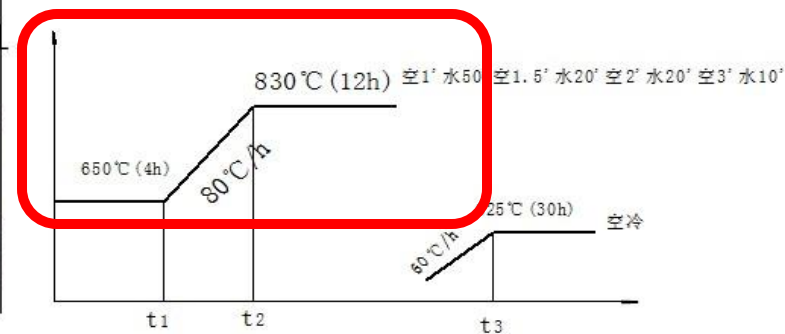
- 可对正火、退火、淬火、感应加热、感应淬火等典型热处理工艺进行仿真
- 按照实际热处理工艺开发的界面，极易使用，即使没有**CAE**软件使用经验，也能很快掌握使用
- 预置空气、水、油及常用淬火油属性，用户也可手动导入新的淬火介质



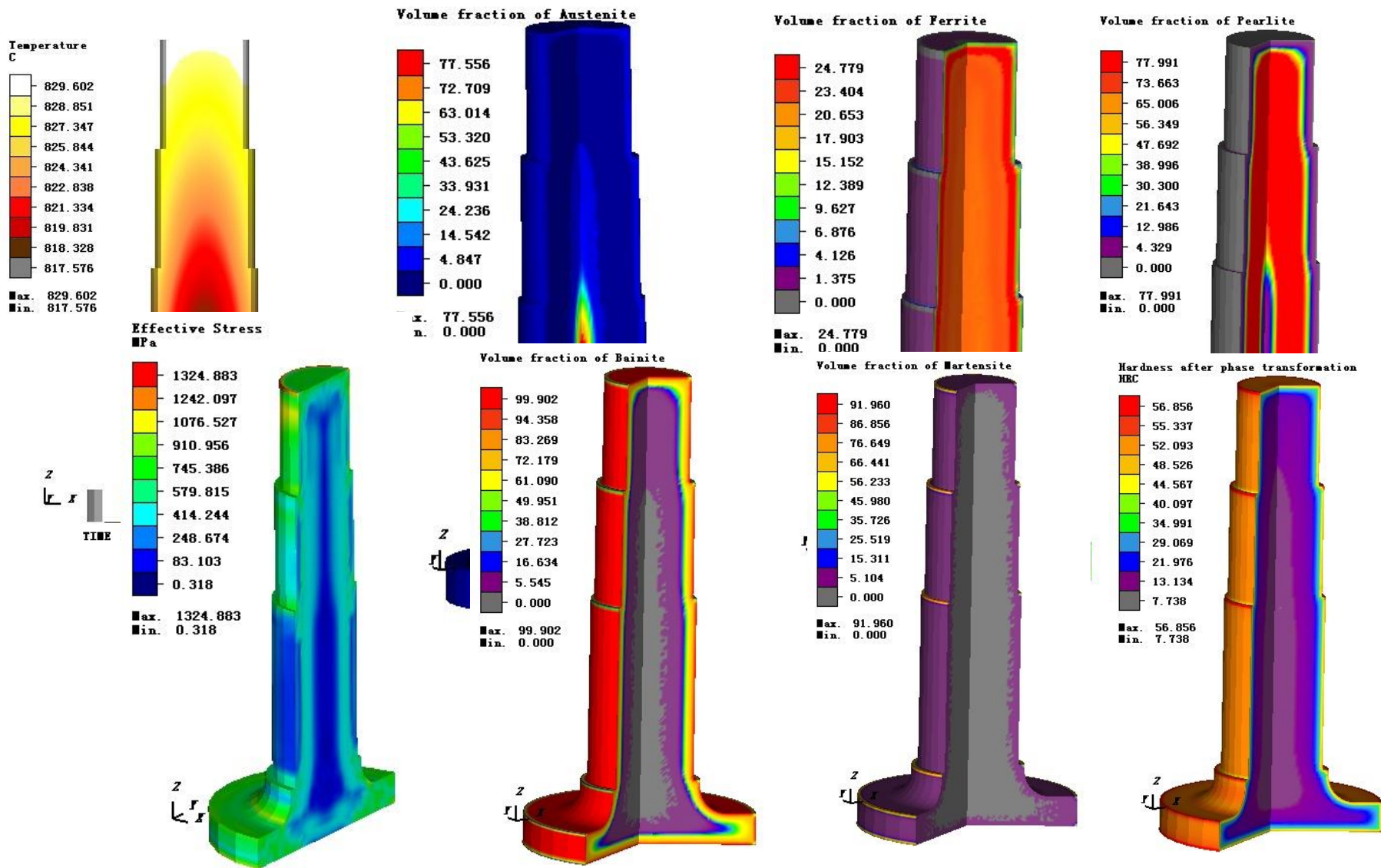
风机主轴热处理模拟



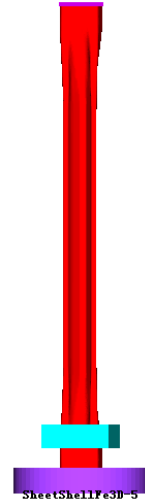
材料: 42CrMoA (42CrMo4)



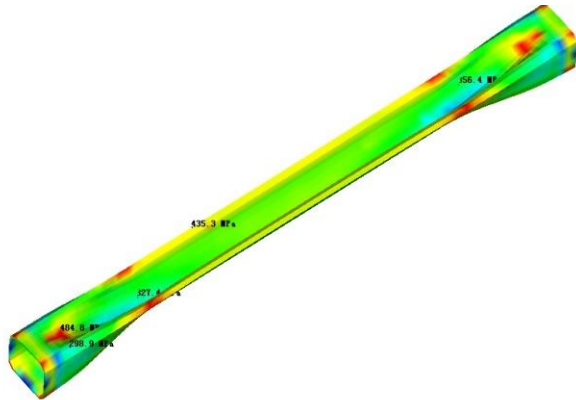
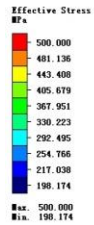
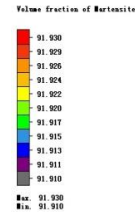
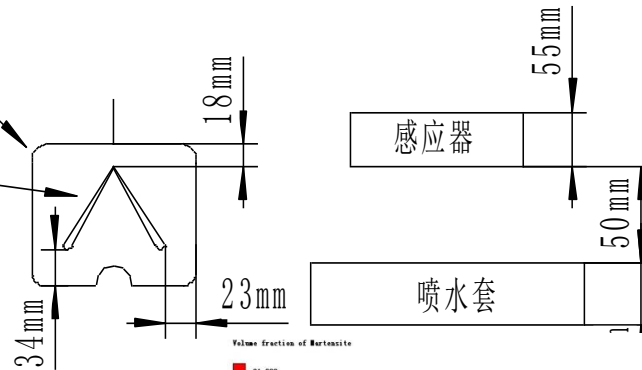
风机主轴热处理模拟



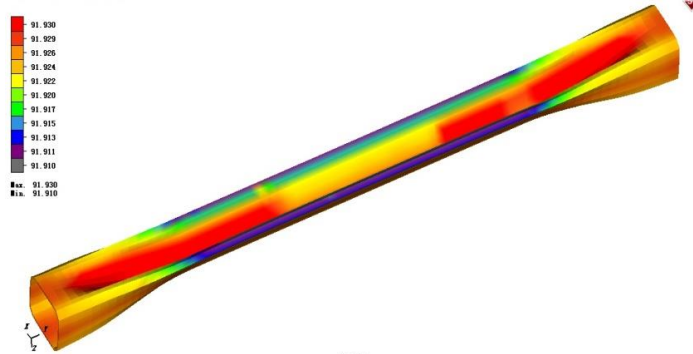
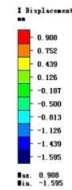
感应淬火工艺模拟



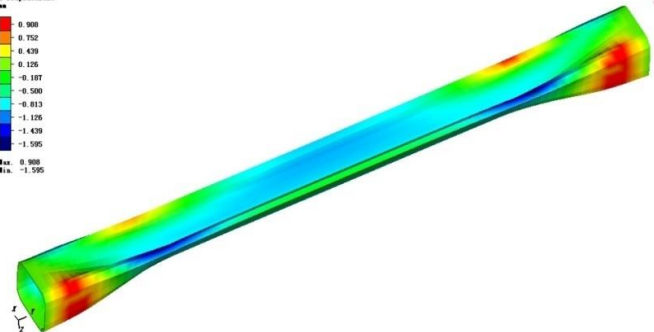
感应器
零件



heat-1



heat-1



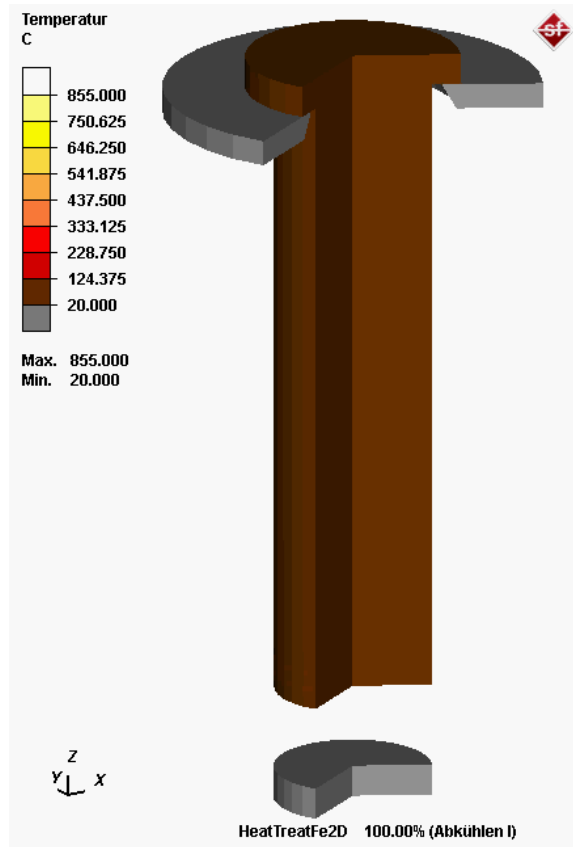
heat-1

相变模拟

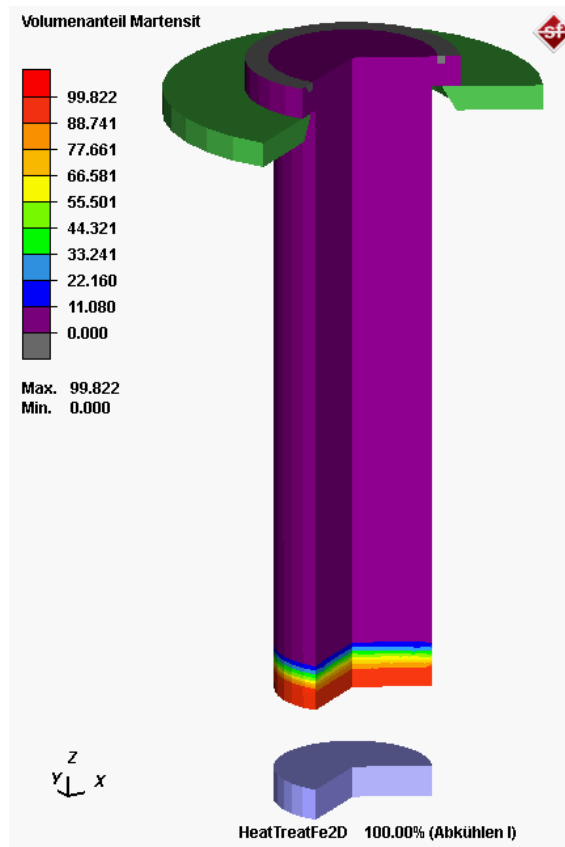
端淬试验

- 前端局部冷却
- 碳素钢

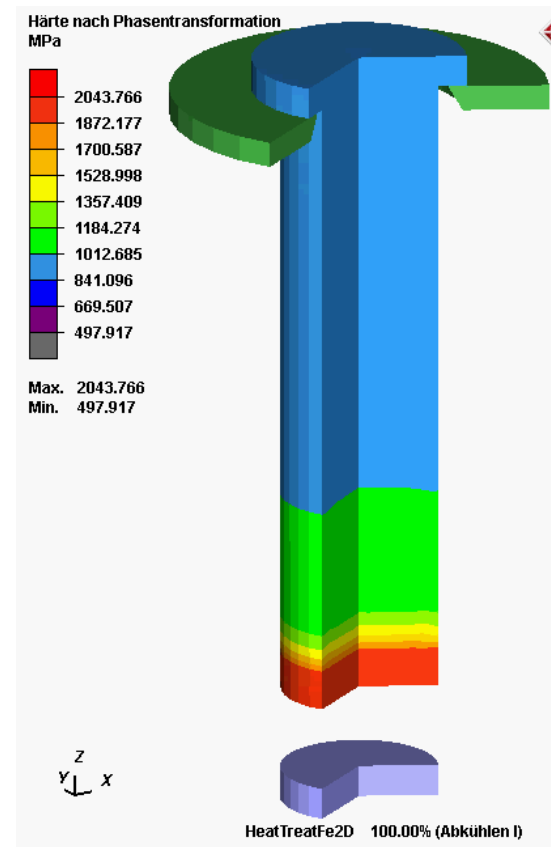
温度 [$^{\circ}\text{C}$]



马氏体体积份数 [%]



硬度 [MPa]

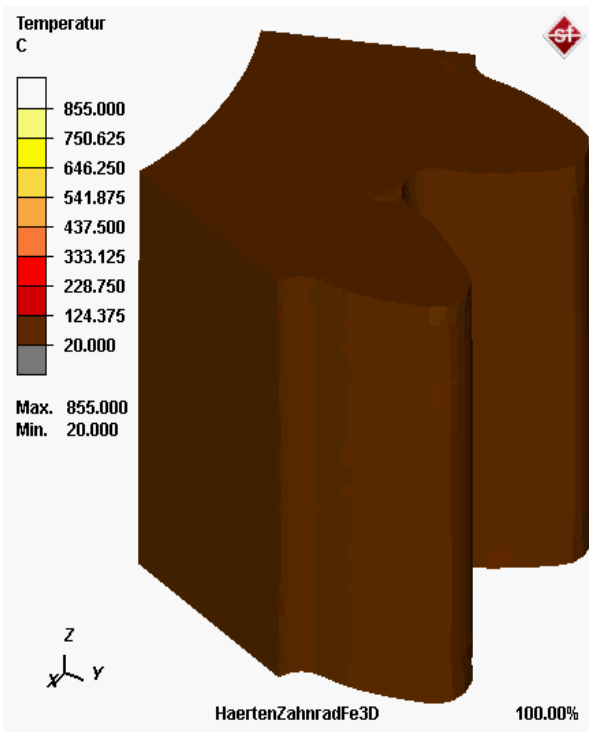


热处理仿真 (相变)

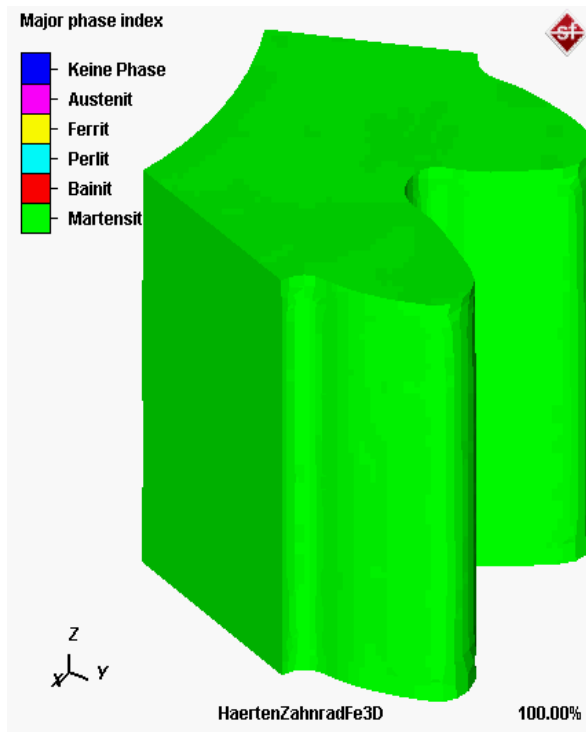
相变：齿轮强化

- 总体冷却
- 碳素钢
- 对称模型

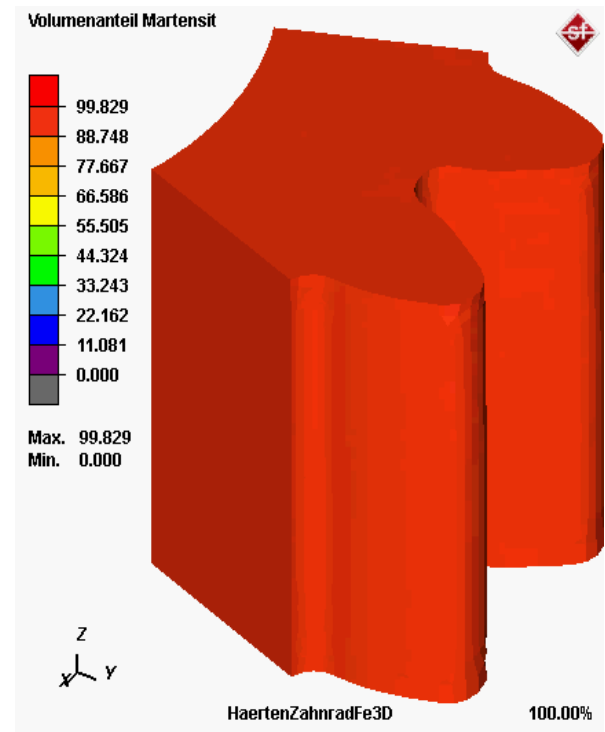
温度 [$^{\circ}$ C]



总体相成份



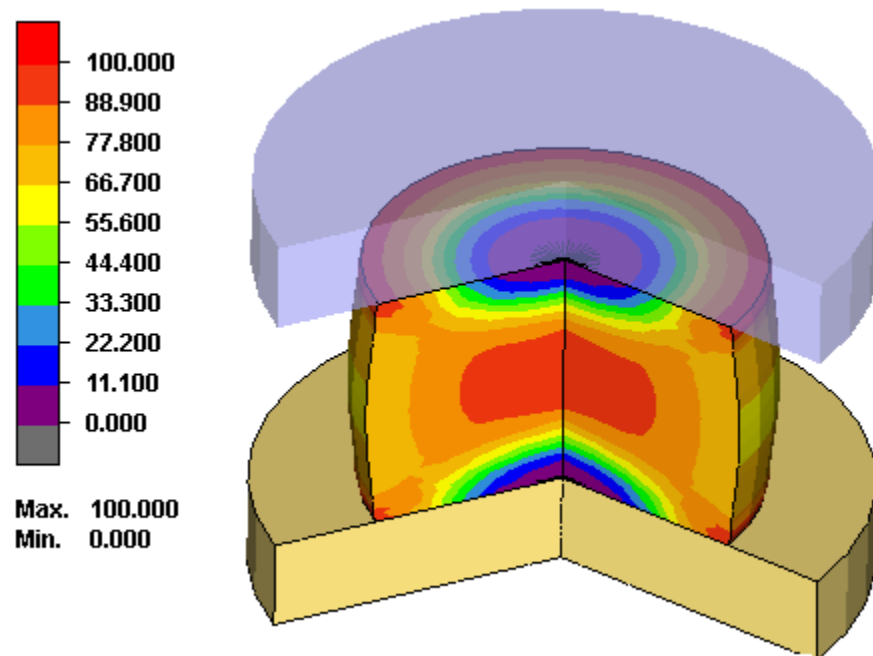
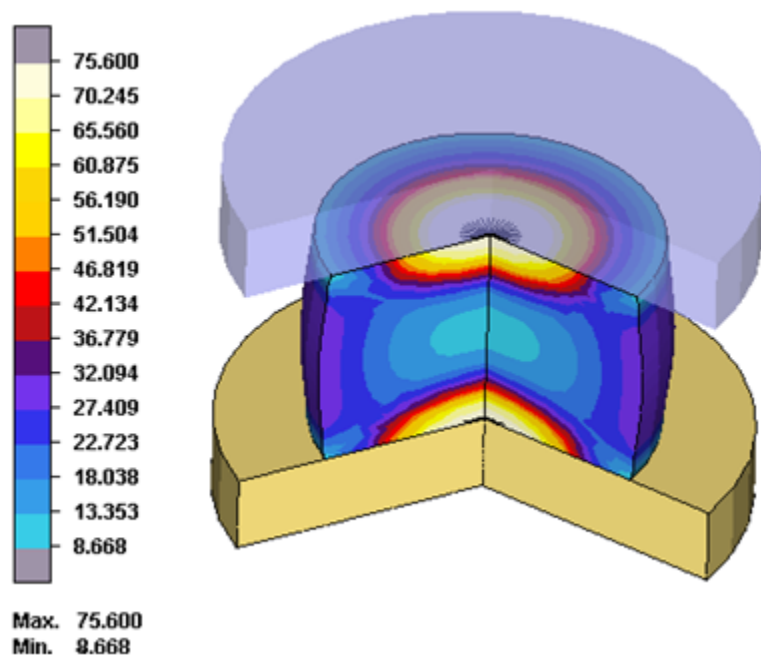
马氏体体积份数[%]



微观组织演变仿真

晶粒尺寸 [μm]

动态再结晶体积分数 [%]

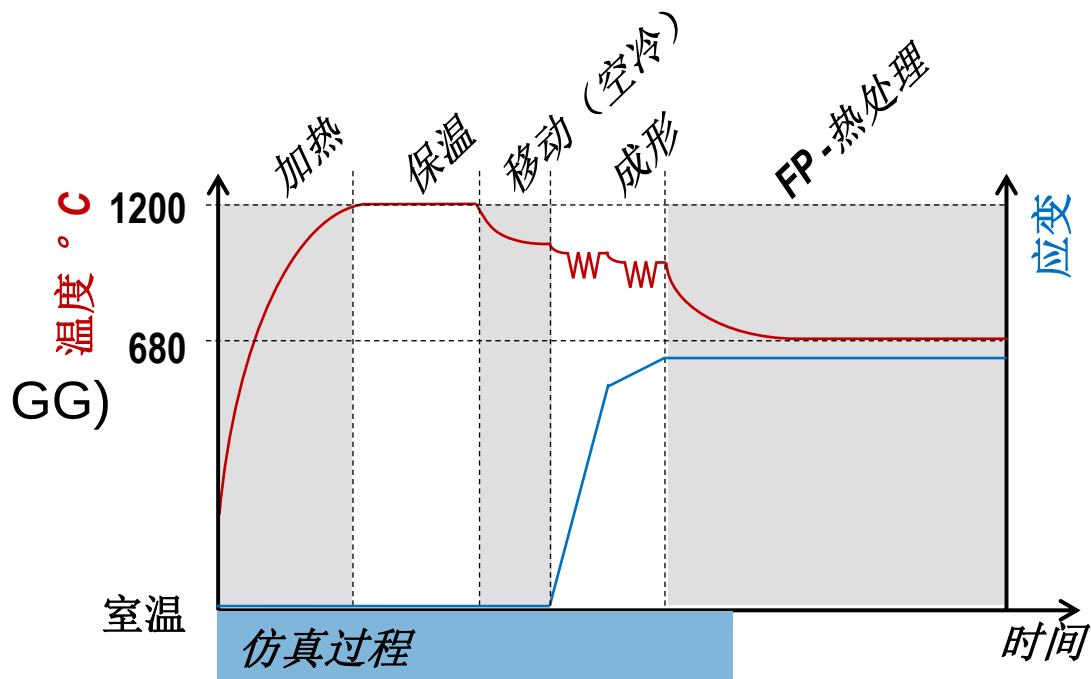


热处理仿真 (微观组织演变)

◆ 锥形齿轮工艺设计

— 成形工艺

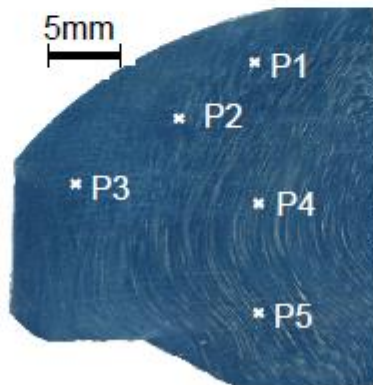
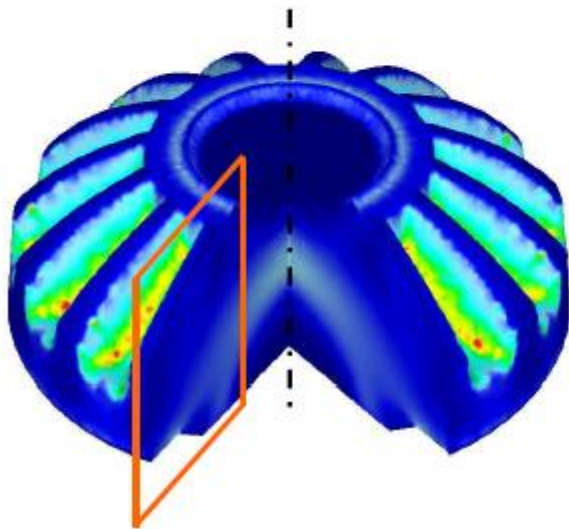
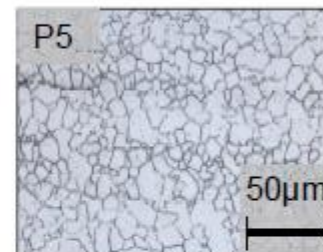
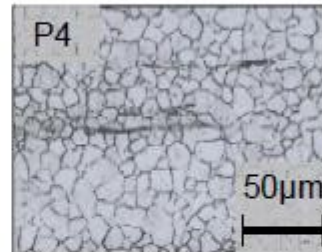
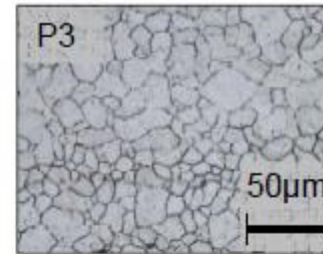
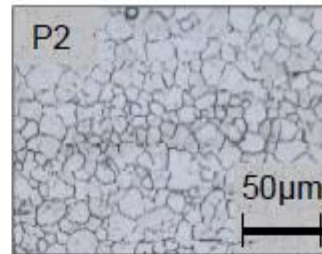
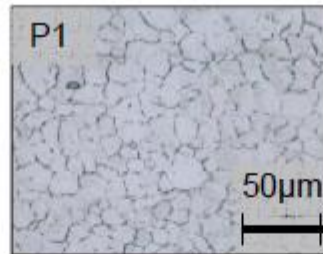
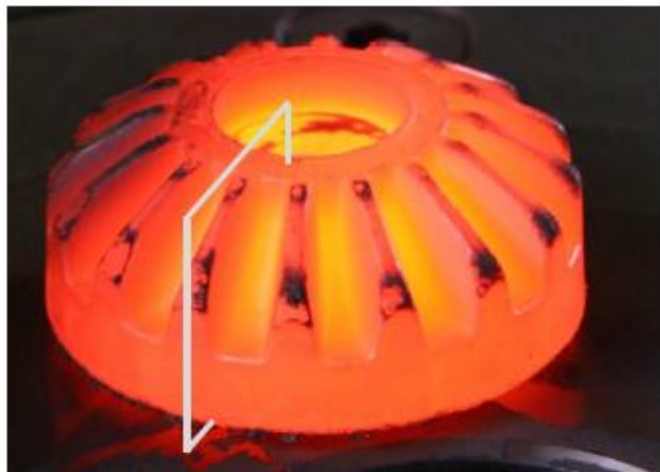
模具设计



来源: IBF, RWTH Aachen

热处理仿真 (微观组织演变)

◆ 均匀且细致的晶粒组织分布

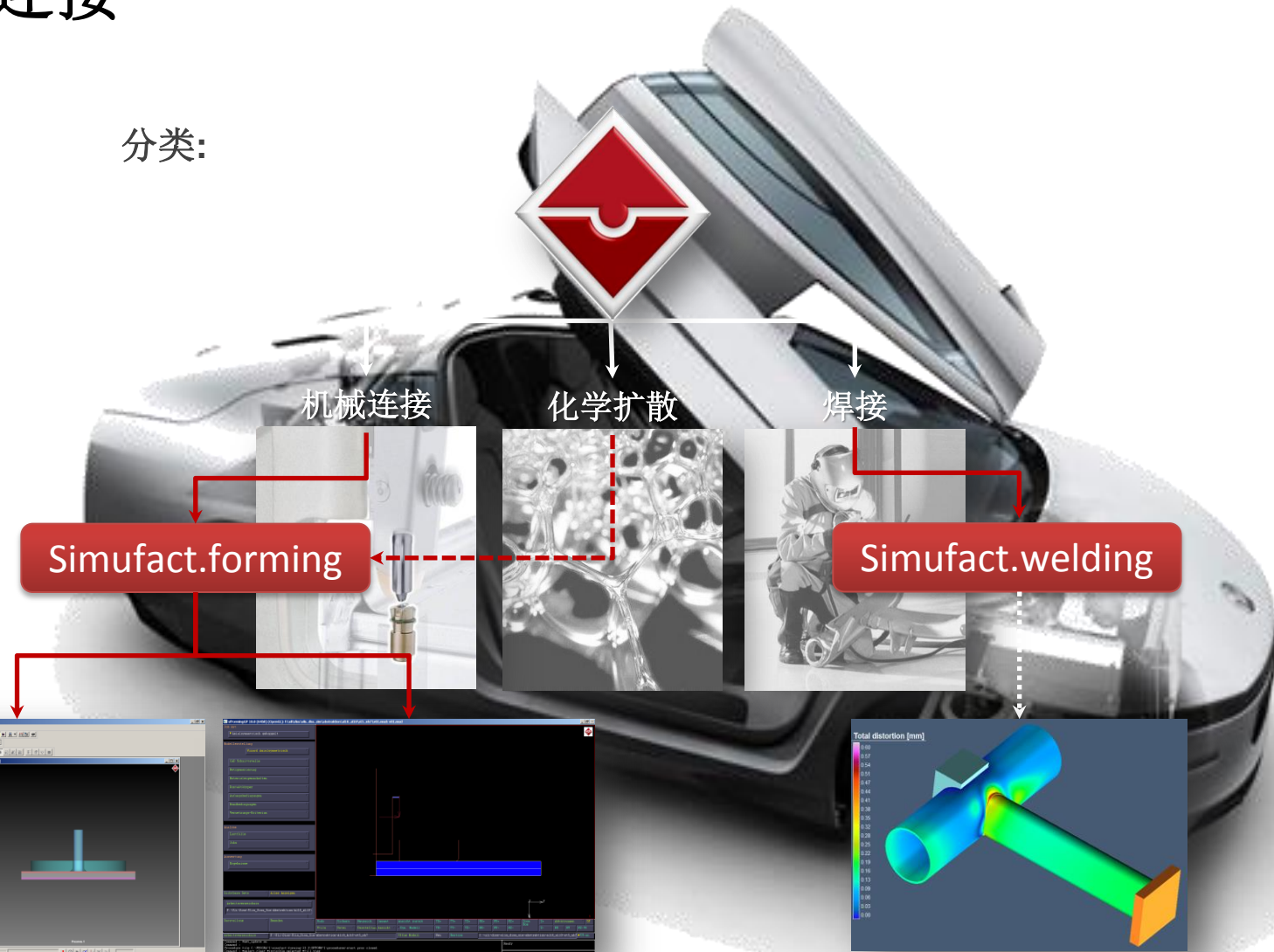


	Measured grain size in μm	Calculated grain size in μm
P1	12,3	13,6
P2	12,8	11,2
P3	12,6	10,2
P4	15,2	12,9
P5	14,2	13,4

来源: IBF, RWTH Aachen

机械连接

分类:

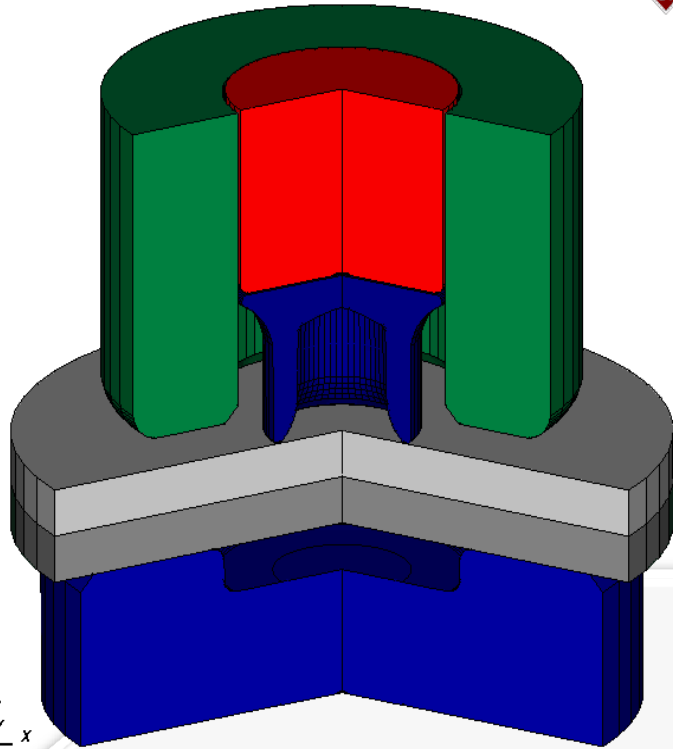


... 每种类型均有对应解决方案 ...

机械连接

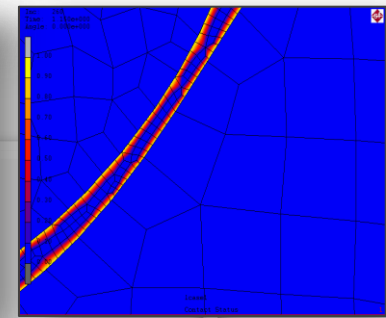
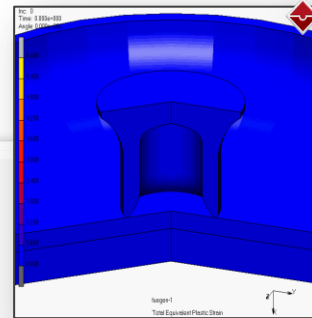
管状铆钉铆接

结合构件负载计算



潜在的:

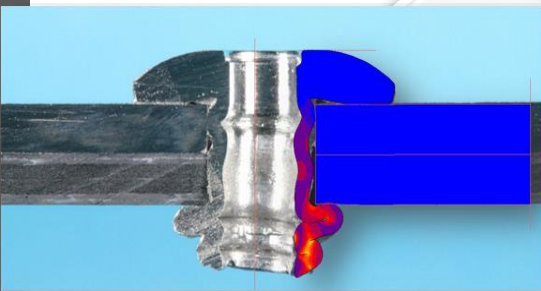
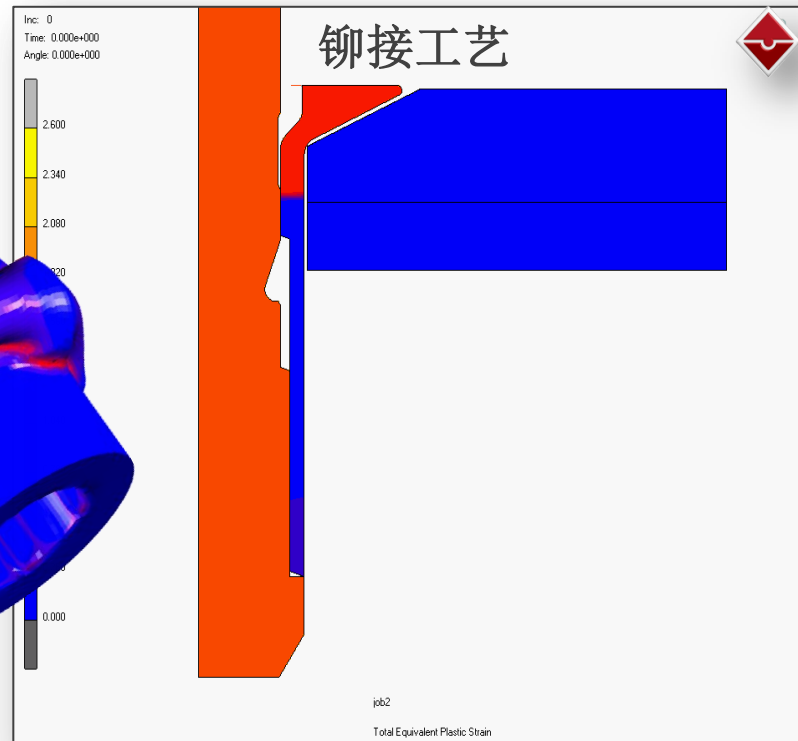
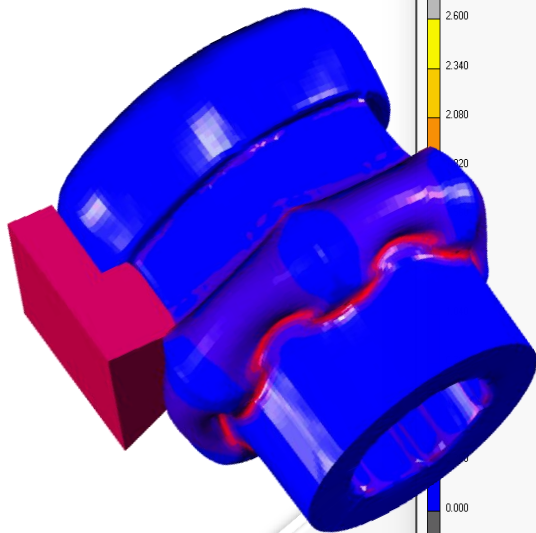
- ◆ 挤压铆接
- ◆ 穿透
- ◆ 剪切和拉伸校核
- ◆ 连接完成



机械连接

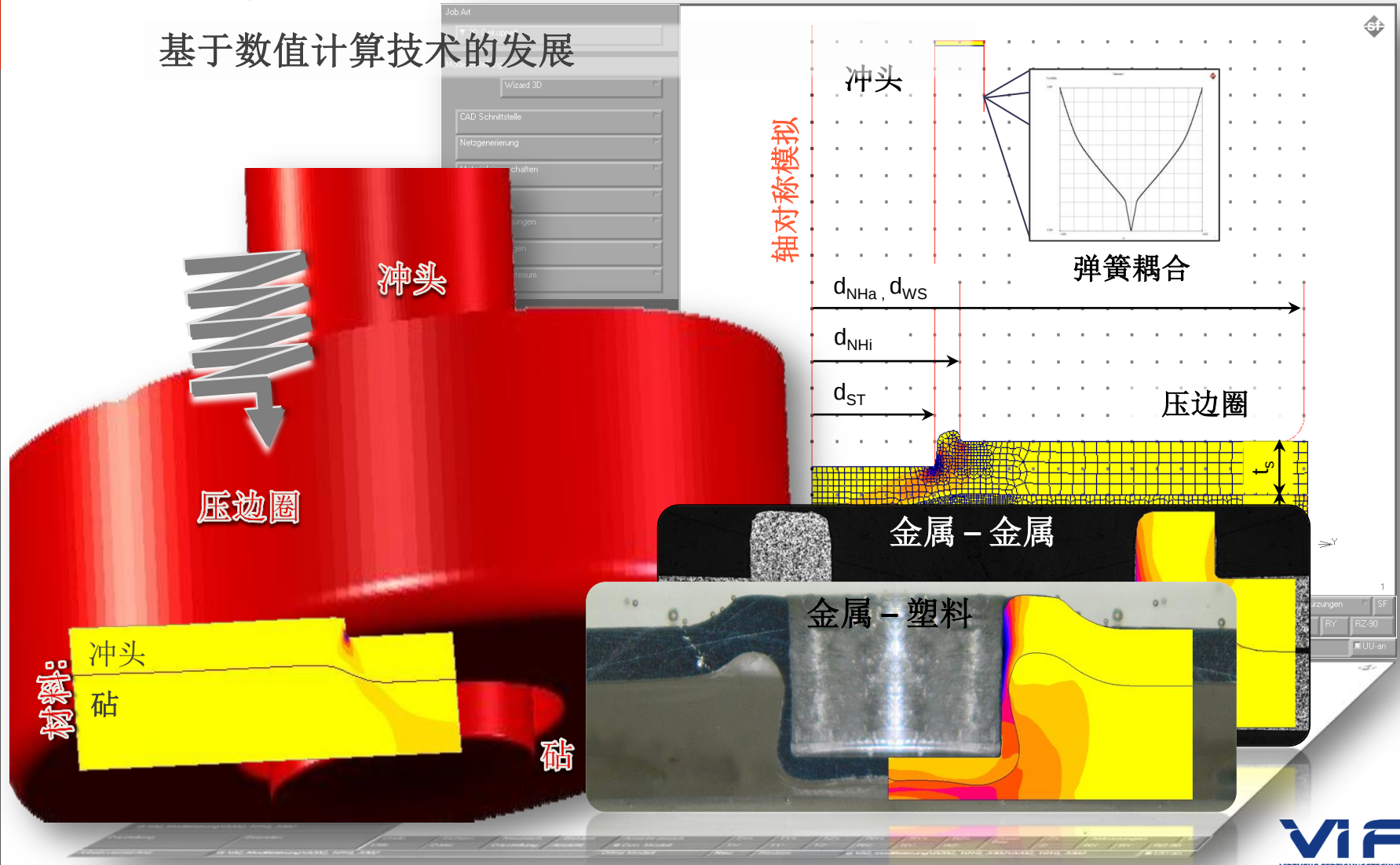
单面铆接

校验



材料

基于数值计算技术的发展



Simufact客户

Business partner → OEM`s



BOSCH



ThyssenKrupp VDM
ThyssenKrupp Steel



SALZGITTER
MANNESMANN
FORSCHUNG

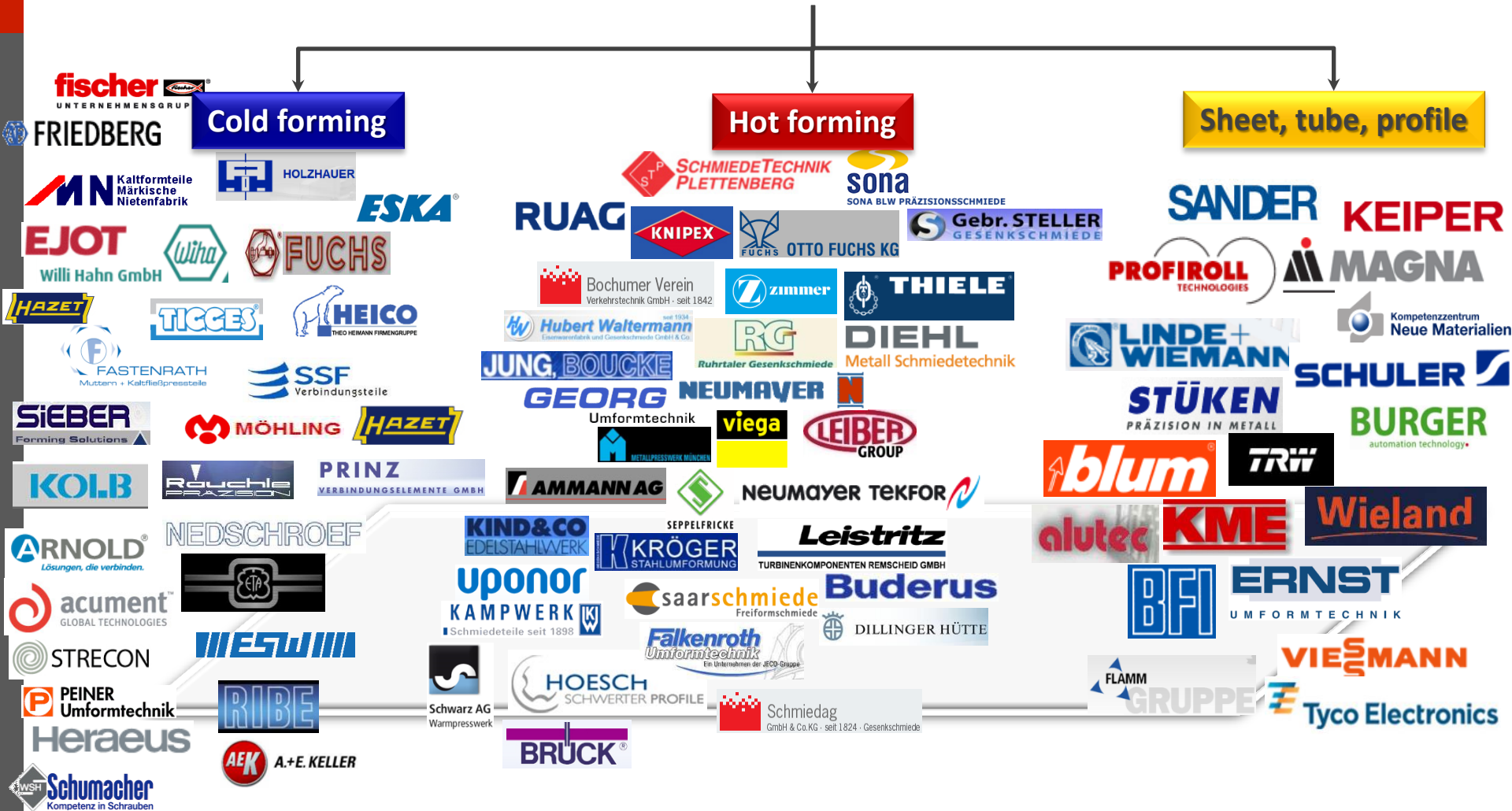


Siempelkamp



Simufact客户

Business partner



Simufact合作研发机构

Business partner → Research institution



Brandenburgische
Technische Universität
Cottbus



TECHNIK WIRTSCHAFT INFORMATIK
Campus Künzelsau
Reinhold-Würth-Hochschule



UNIVERSITÄT PADERBORN
Die Universität der Informationsgesellschaft

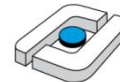
Hochschule Ostwestfalen-Lippe
University of Applied Sciences



Universität Stuttgart



Hochschule Aalen



Hochschule Osnabrück
University of Applied Sciences



UNIKASSEL
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Technische
Universität
Braunschweig



HELMUT-SCHMIDT-UNIVERSITÄT
Universität der Bundeswehr Hamburg



TECHNISCHE
UNIVERSITÄT
DARMSTADT



FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG

Thank You!

需要做详细了解，请联系：

西安细铭电子科技有限公司

联系人：王俐

电话：13359282259

邮箱：Liwang@ximingsoft.com