

Radionica “Inovacije u inženjerskom projektovanju”

27-28. siječanj 2011, Rijeka

Virtuelna proizvodnja u inženjerskim aplikacijama

Prof. Dr Vesna Mandić

mandic@kg.ac.rs

Projektovanje novih ili modifikovanje postojećih proizvoda i procesa, tradicionalno se izvode na bazi iskustva tehnologa i eksperimentisanjem tipa **"trial and error"**.



**Praktična
potreba**

- projektno rešenje je daleko od optimalnog
- pojava unutrašnjih i spoljašnjih defekata
- prekomerni pritisci
- mali vek alata ili njegov lom
- neophodno reprojektovanje
- veliki troškovi



**Najmoćniji i najšire primenjivani “alat” za
numeričku simulaciju je**

METODA KONAČNIH ELEMENATA

FEM – Finite Elemental Method

DEFORM

FORGE

STAMPACK

SIMUFACT

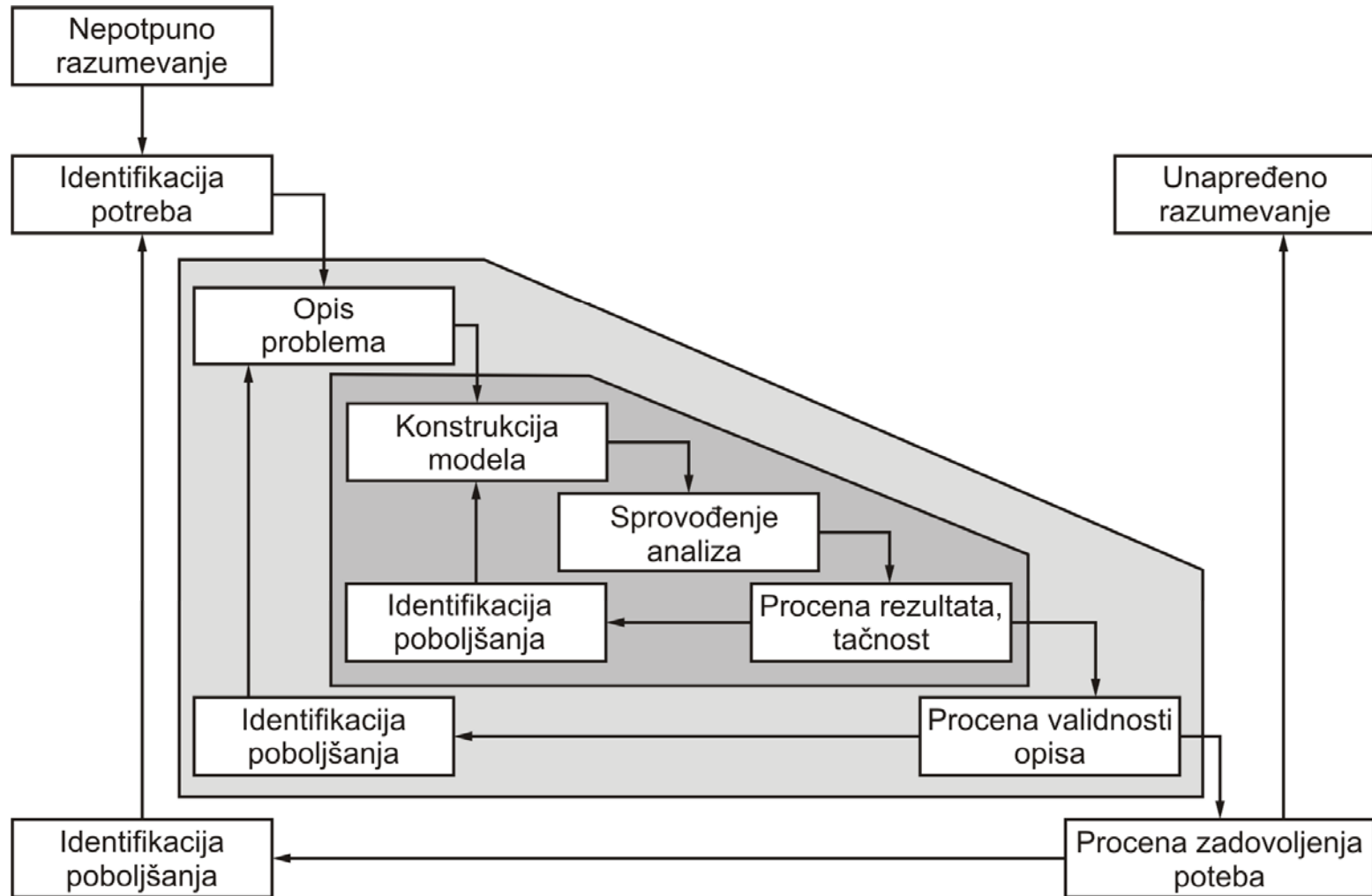
**MARC
AUTOFORGE**



**MSC
Superforge**

Qform

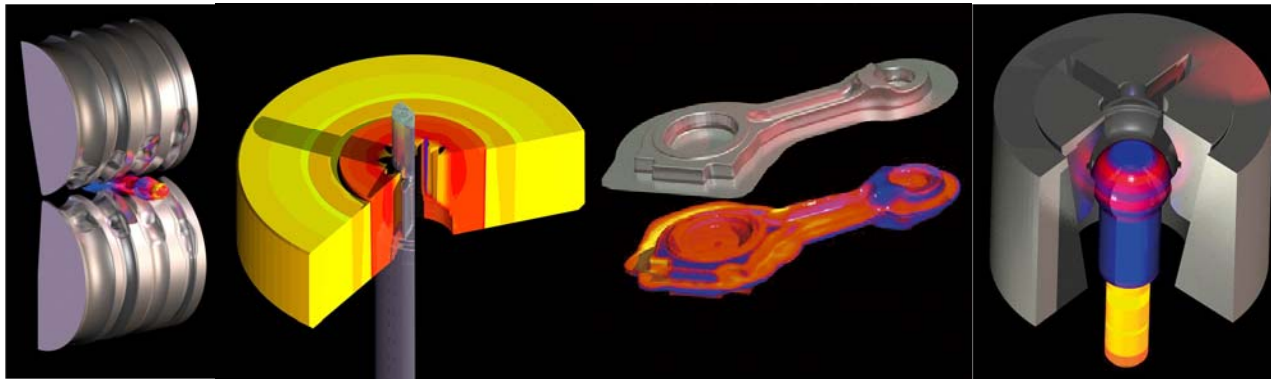
CAMPform



Projekat FE/FV analize procesa

Praktične i proverene numeričke simulacije procesa uključuju:

- projektovanje tehnoloških operacija procesa, uz procenu deformacionih sila, napona u alatima i međuoblika obratka
- predviđanje habanja alata i veka trajanja, i u tom smislu poboljšanje promenljivih procesa i projektovanja alata za prevenciju loma alata
- predviđanje i eliminacija defekata, kao što su preklopi, unutr. i spoljašnje naprsline
- istraživanje uticaja trenja na tečenje materijala
- procena osobina obrtaka i mikrostrukture, elastičnog ispravljanja i zaostalih napona.



Kovanje

- Zastava Kovačnica, Kragujevac
- FAD, G. Milanovac
- Zastava oružje, Kragujevac
- Petar Drapšin, Mladenovac
- Kovanje osovine veštačkog kuka

Istiskivanje

- Nissal, Niš (2 primera)
- Sloboda Čačak
- Studentski radovi (2 primera)

Valjanje

- Milanović inženjering, Kragujevac

Savijanje

- Promotor Irva, Kragujevac
- Metalac, G. Milanovac
- WEBA, Kragujevac
- Metalac bojleri, G. Milanovac

Duboko izvlačenje

- Metalac, G. Milanovac
- Metalac bojleri, G. Milanovac
- Budućnost, Bajina Bašta

Izvlačenje sa stanjenjem

- Tekuća istraživanja, Mašinski fakultet Kragujevac

Montaža:

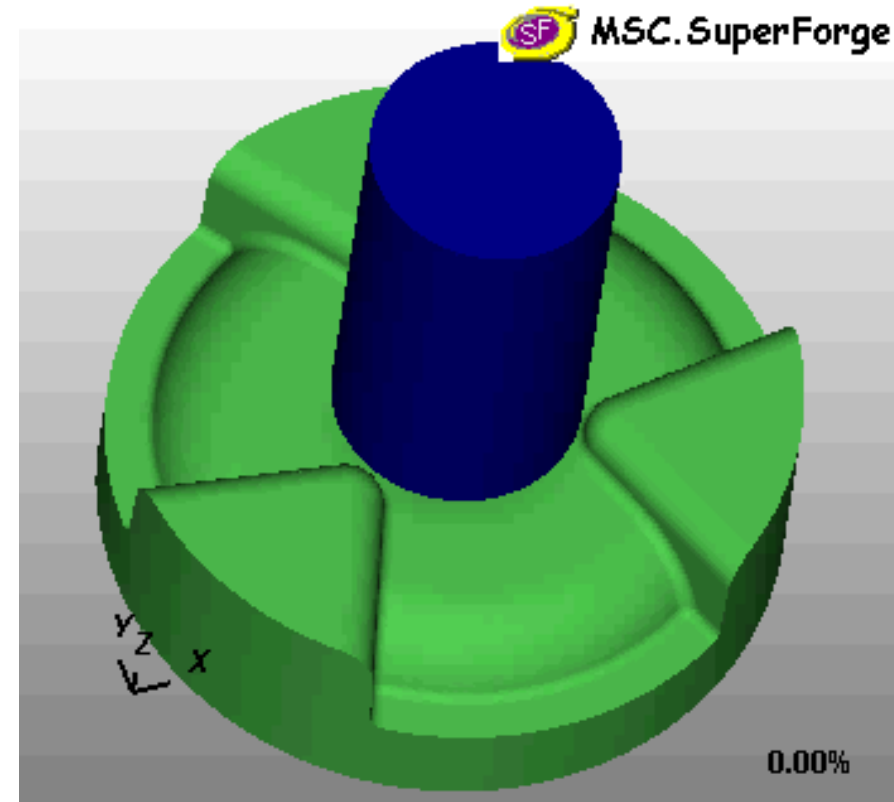
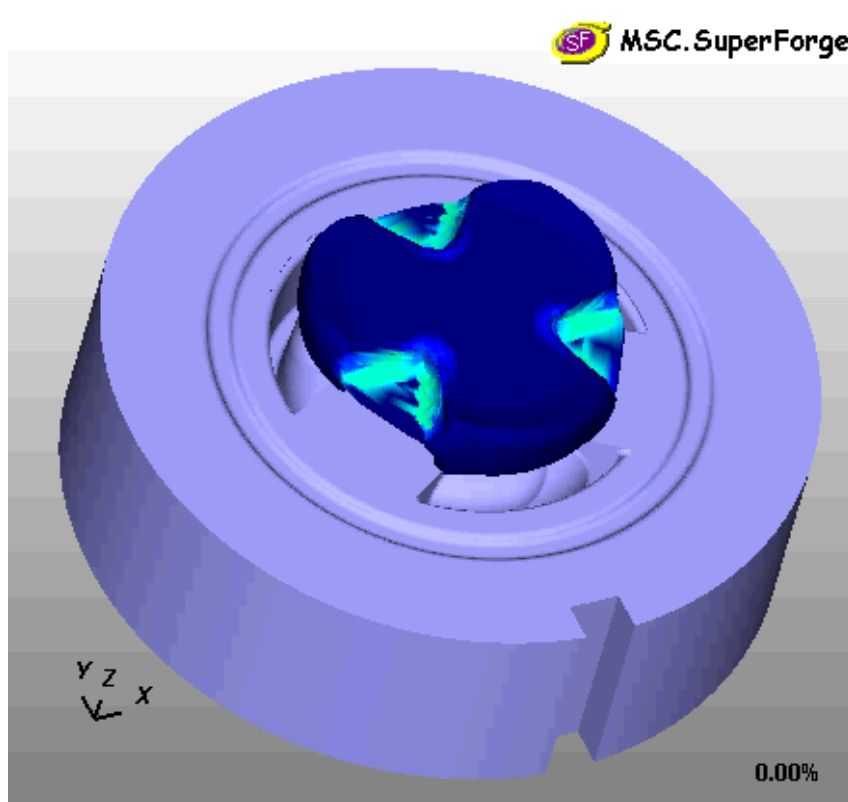
- FADIP, Bečej

Modeliranje procesa kovanja u dve operacije

CILJ: Optimizacija kovanja kanže, General Motors

PROBLEM: Netačnost otkovka i problem sa uravnoteženjem

REZULTAT: Vizuelizacija procesa i uvod u uticajne parametre za optimizaciju



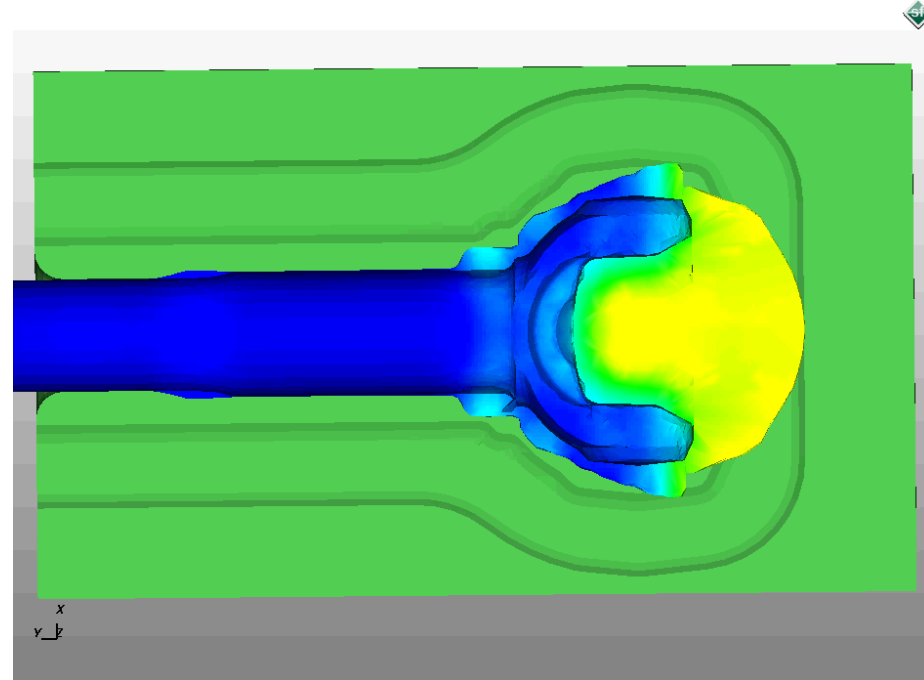
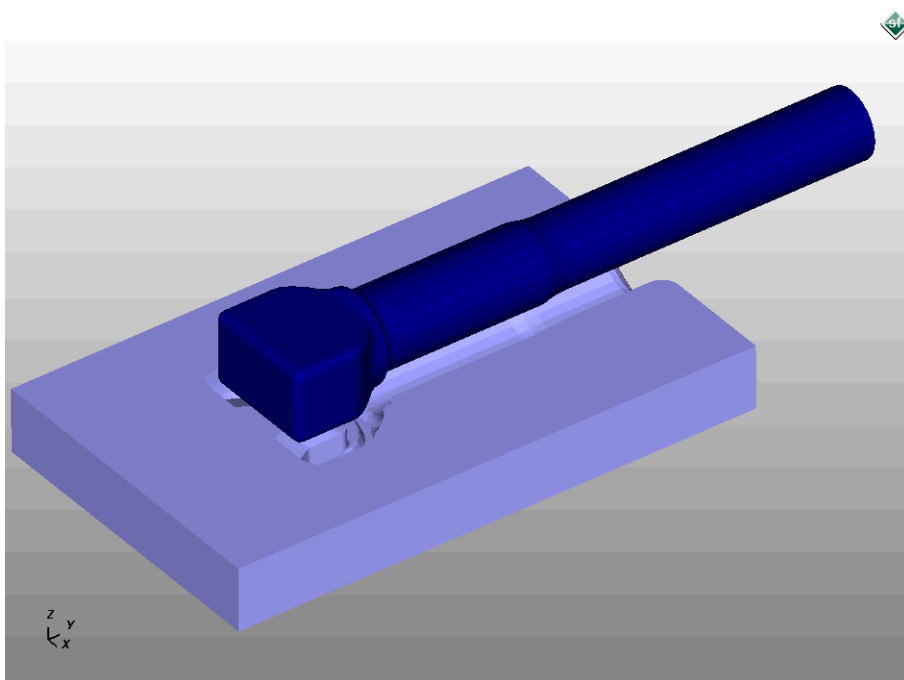
Projekat - Zastava Kovačnica, Kragujevac

Modeliranje procesa kovanja u dve operacije

CILJ: Optimizacija do dostizanja dimenzione tačnosti otkovka

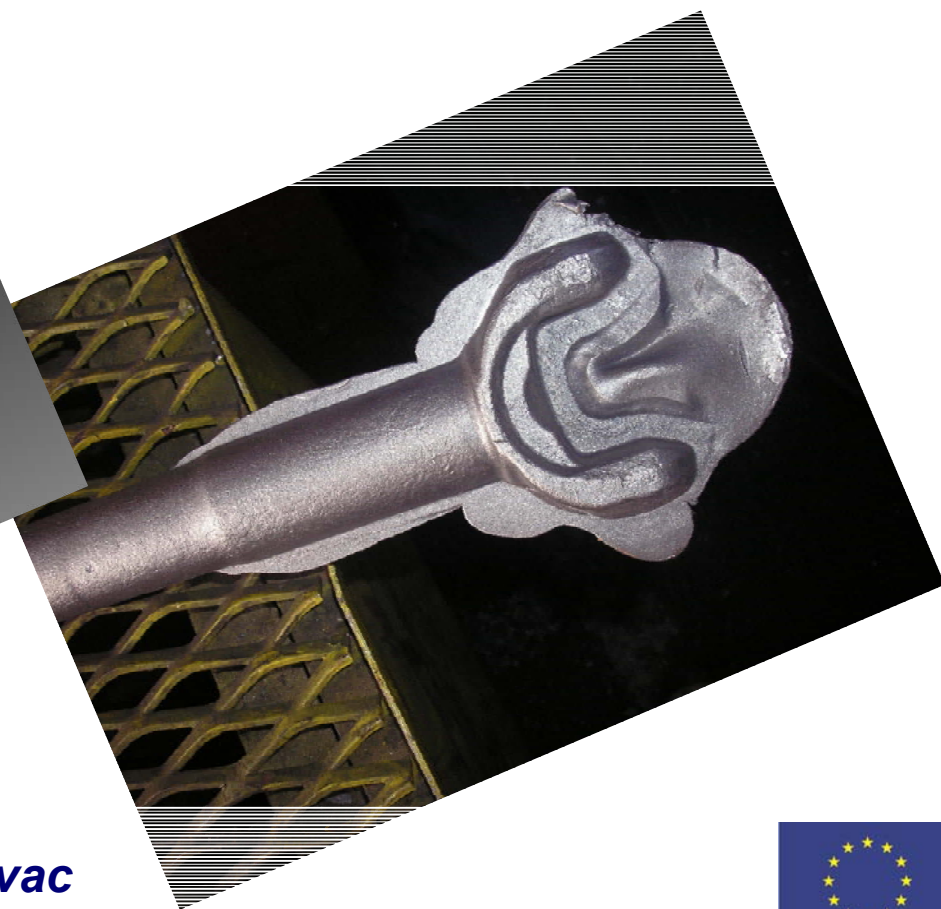
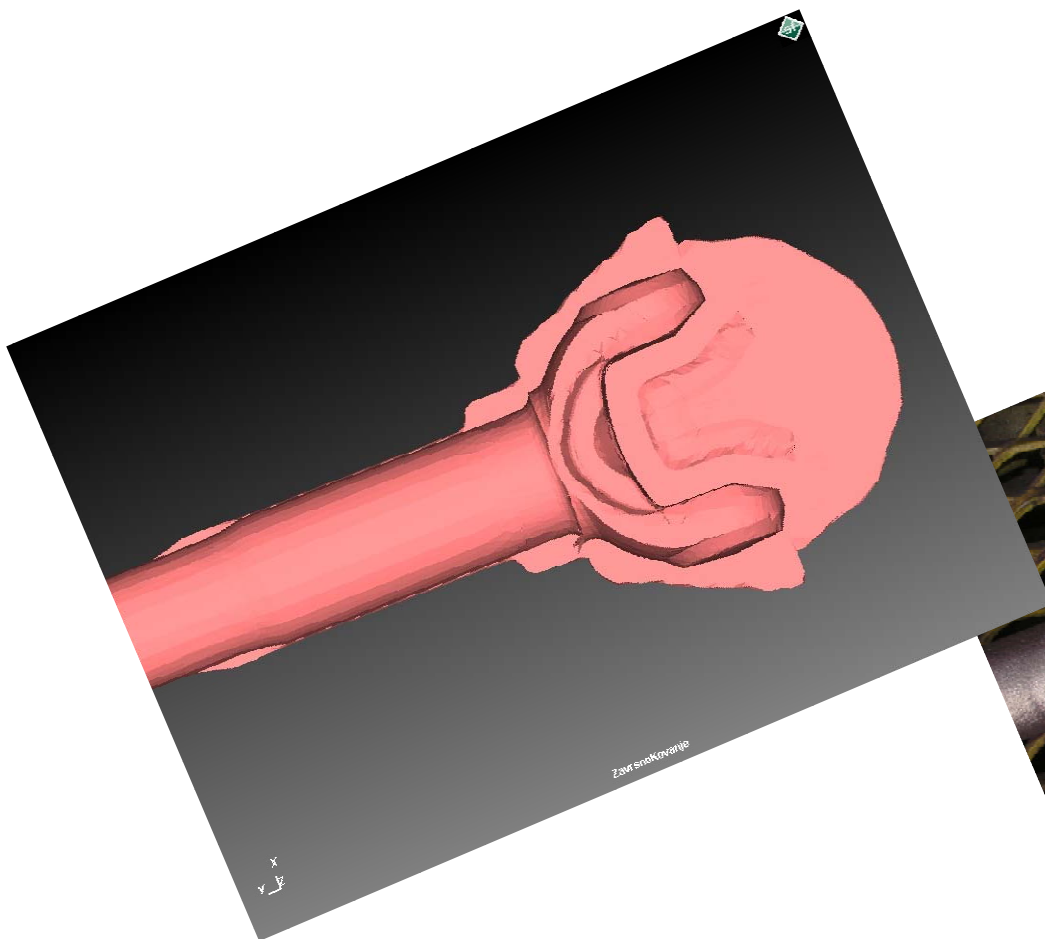
PROBLEM: Netačnost otkovka – nepopunjavanje alata

REZULTAT: Popunjavanje lata i tačnost otkovka - modifikovan pripremak i oblik u prethodnom kovanju



Projekat - Zastava Kovačnica, Kragujevac

Modeliranje procesa kovanja u dve operacije

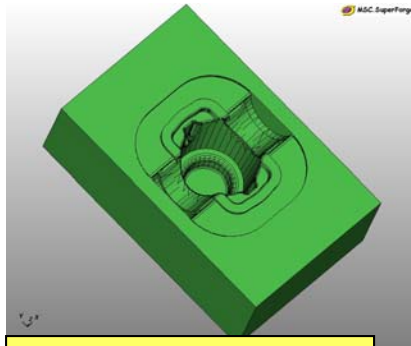


Projekat - Zastava Kovačnica, Kragujevac

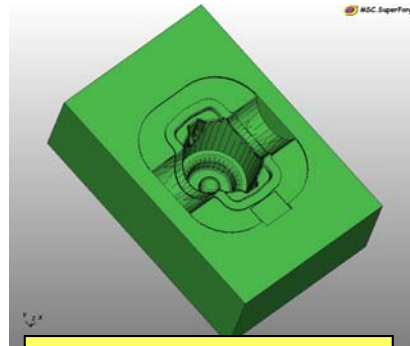
Modeliranje procesa kovanja u dve operacije

CAD modeli alata

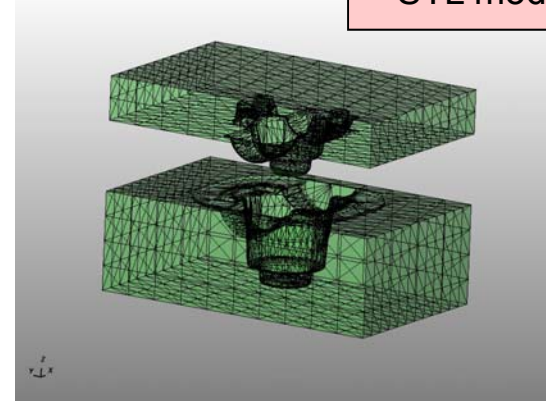
STL model alata



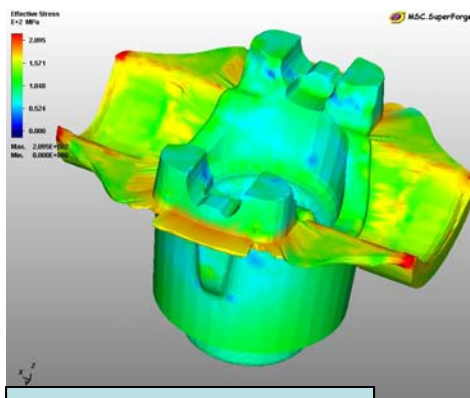
Pripremno kovanje



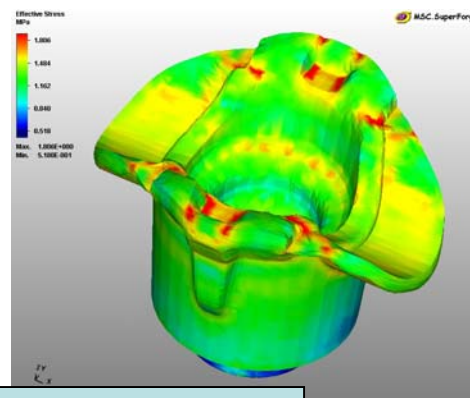
Završno kovanje



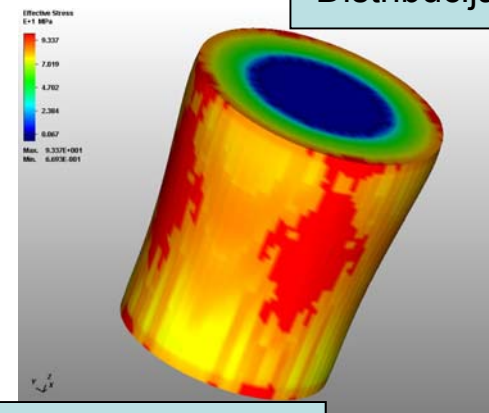
Distribucija napona



Završno kovanje



Pripremno kovanje

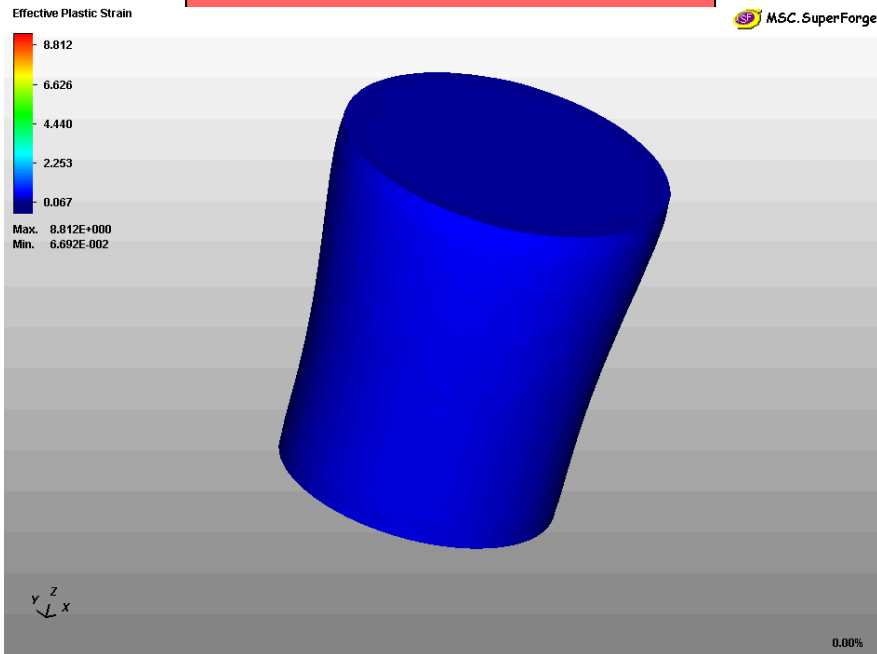


Sabijanje

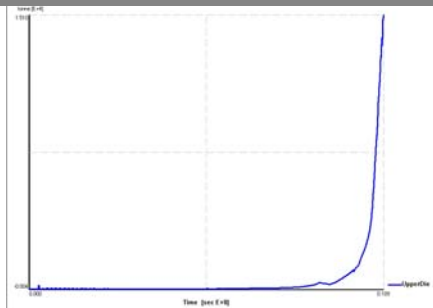
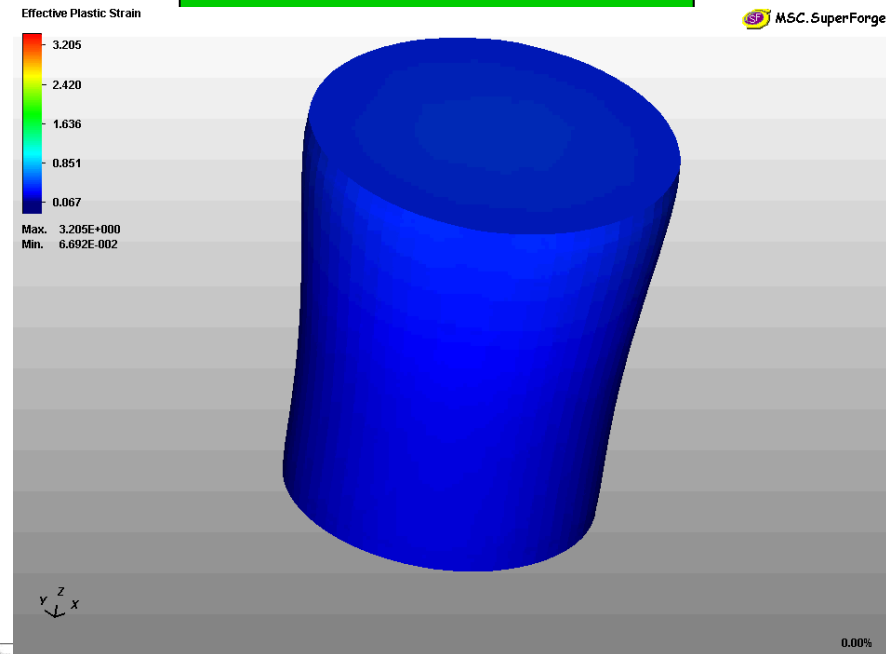
Projekat - Zastava Kovačnica, Kragujevac

Modeliranje procesa kovanja u dve operacije

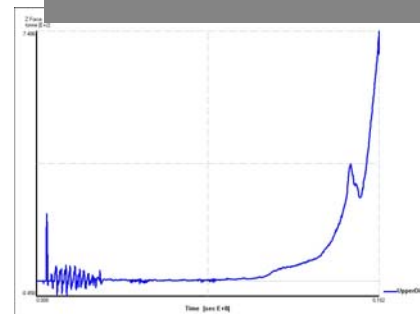
Preliminarno projektno rešenje



Predlog poboljšane varijante



Fmax = 9490 t



Fmax = 750 t

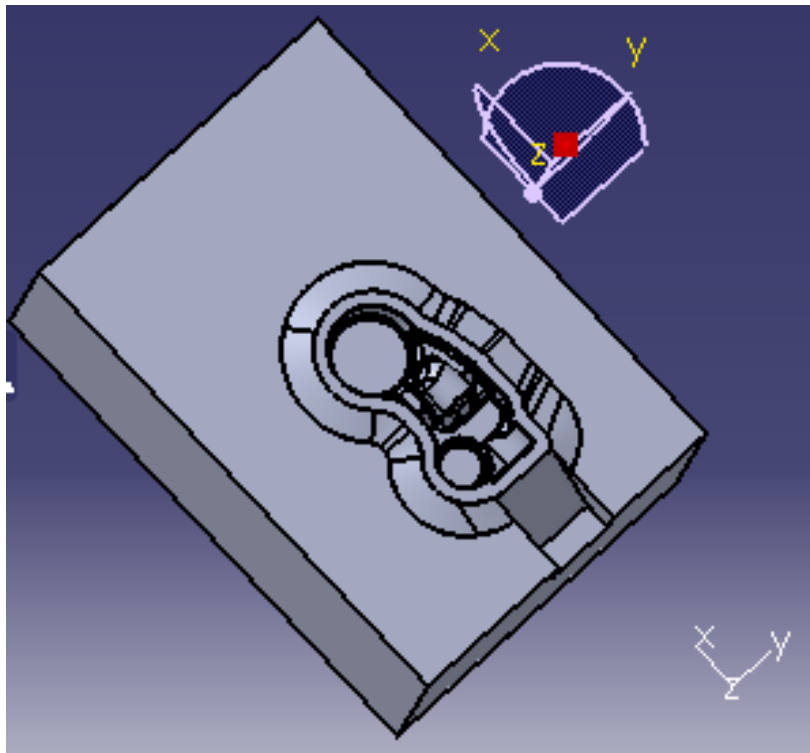
Projekat - Zastava Kovačnica, Kragujevac

Numeričko modeliranje procesa kovanja tela zgloba

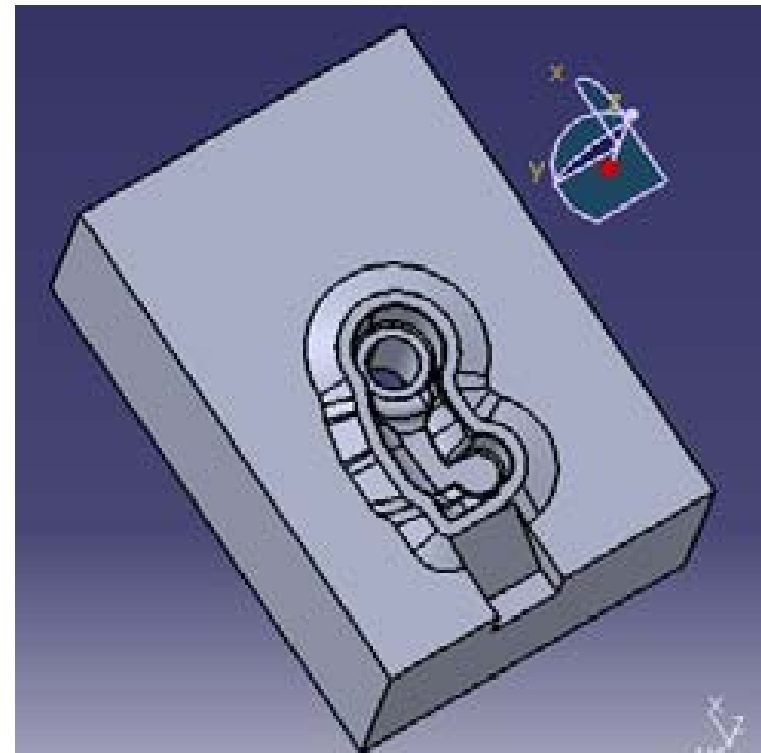
CILJ: Optimizacija procesa kovanja tela zgloba

PROBLEM: Nedovoljno popunjavanje alata

REZULTAT: Identifikacija uzroka problema – ručno pizicioniranje priprema – nestabilan proces

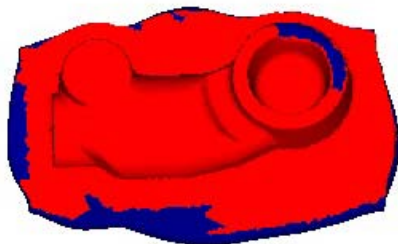


Gornji kalup

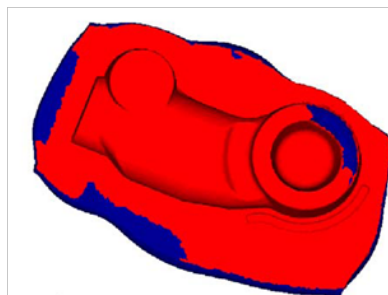


Donji kalup

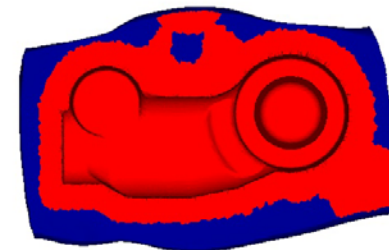
FAD, G. Milanovac (studentska praksa)



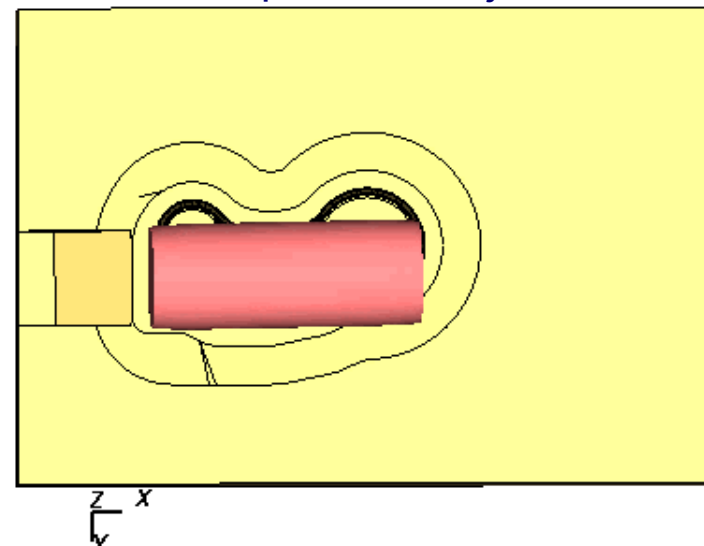
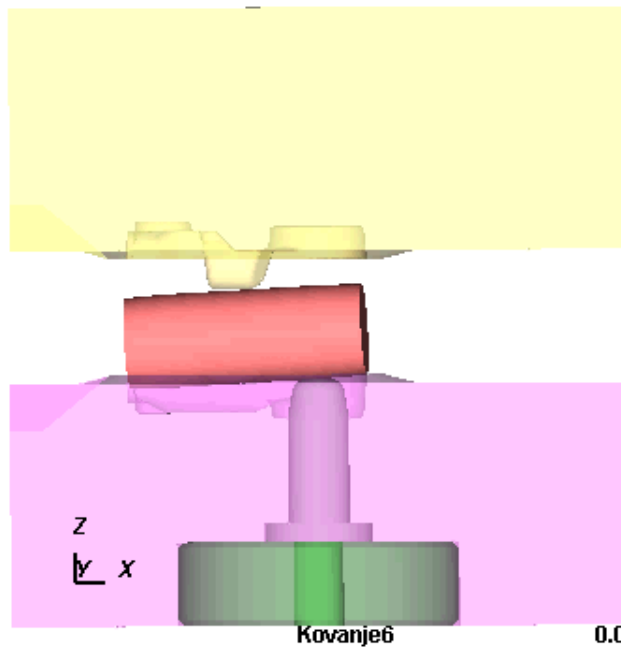
Nepopunjavanje
alata



Popunjavanje alata
sa kočnicom



Popunjavanje alata sa
modifikovanim
pozicioniranjem



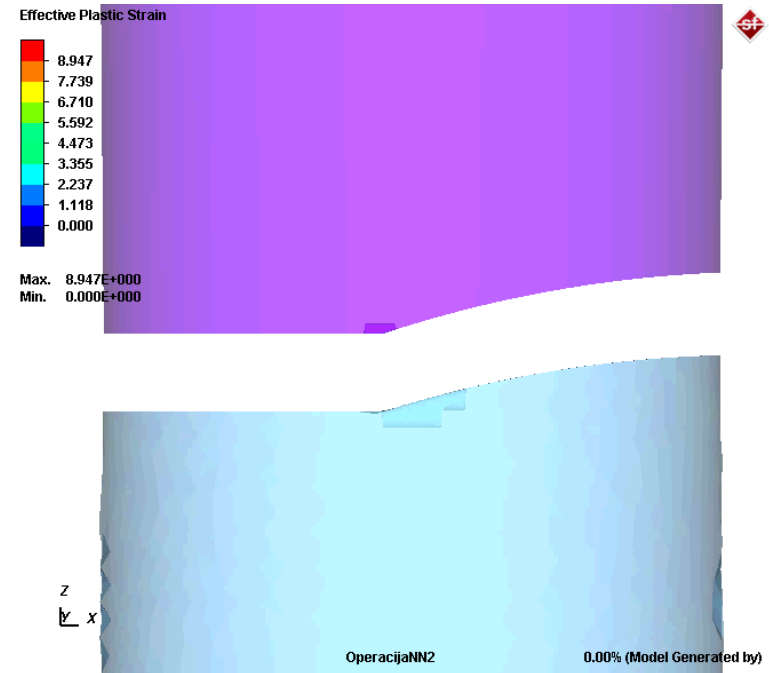
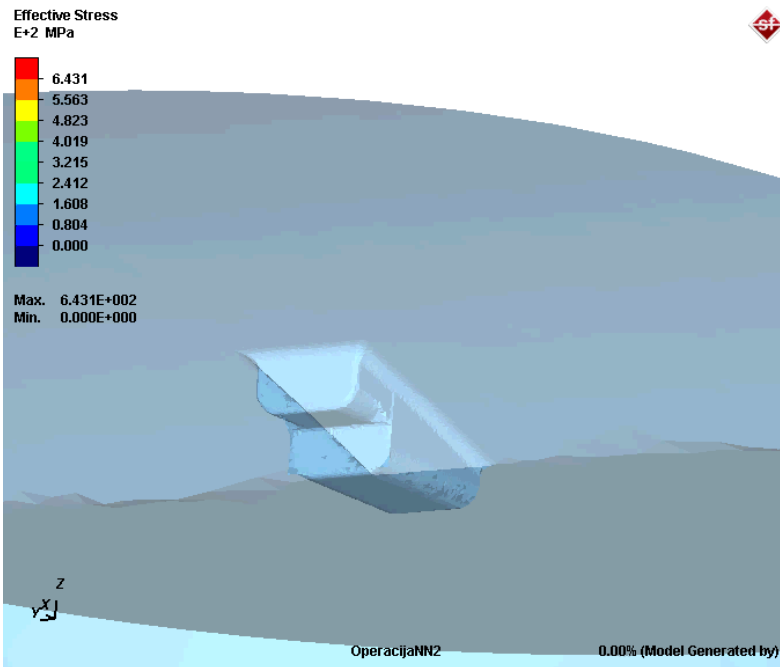
FAD, G. Milanovac (studentska praksa)

Modeliranje procesa hladnog kovanja primenom FE/FV numeričkih alata

CILJ: Optimizacija
 procesa hladnog
 kovanja - istiskivanja

PROBLEM: Tehnološko
 rešenje – prekomerni
 pritisci, mali vek alata

REZULTAT: Tehnološki
 postupak sveden na jednu
 operaciju kovanja, smanjena
 potrošnja materijala, pritisci
 dozvoljeni, vek alata produžen



Projekat – Zastava oružje, Kragujevac

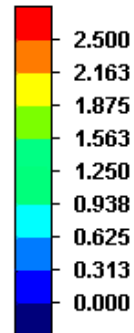
Die Contact



Max. 1.000E+000
Min. 0.000E+000



Contact Pressure
E+3 MPa



Max. 8.755E+003
Min. 0.000E+000



OperacijaNN2 0.00% (Model Generated by)

Die Contact



Max. 1.000E+000
Min. 0.000E+000



OperacijaNN2

0.00% (Model Generated by)



OperacijaNN2 0.00% (Model Generated by)

Projekat – Zastava oružje, Kragujevac

Toplo kovanje aluminijuma

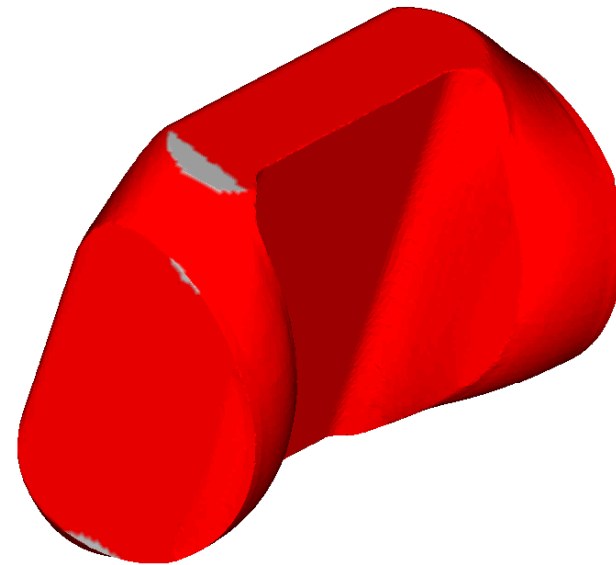
CILJ: Eliminirati defekte preklopa pri kovanju

PROBLEM: Defekti preklopa, tehnološki postupak

REZULTAT: Eliminirani preklopi, kovanje u 2 umesto 4 operacije, uštede u materijalu i energiji



Die Contact
 1.000
 0.500
 0.000
 Max. 1.000E+000
 Min. 0.000E+000



z
y
x

Kovanje12

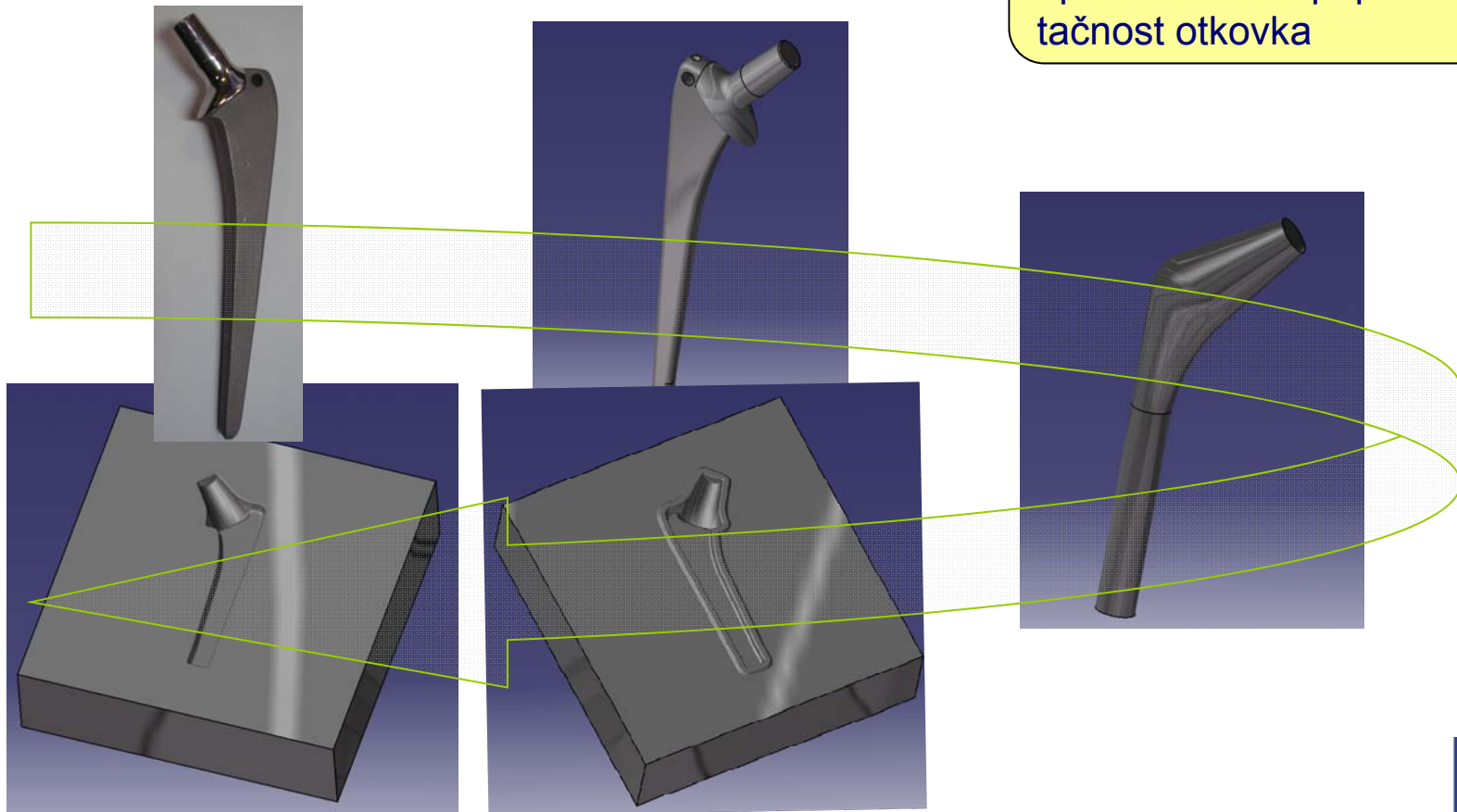
Projekat - Petar Drapšin, Mladenovac

Kovanje osovine veštačkog kuka

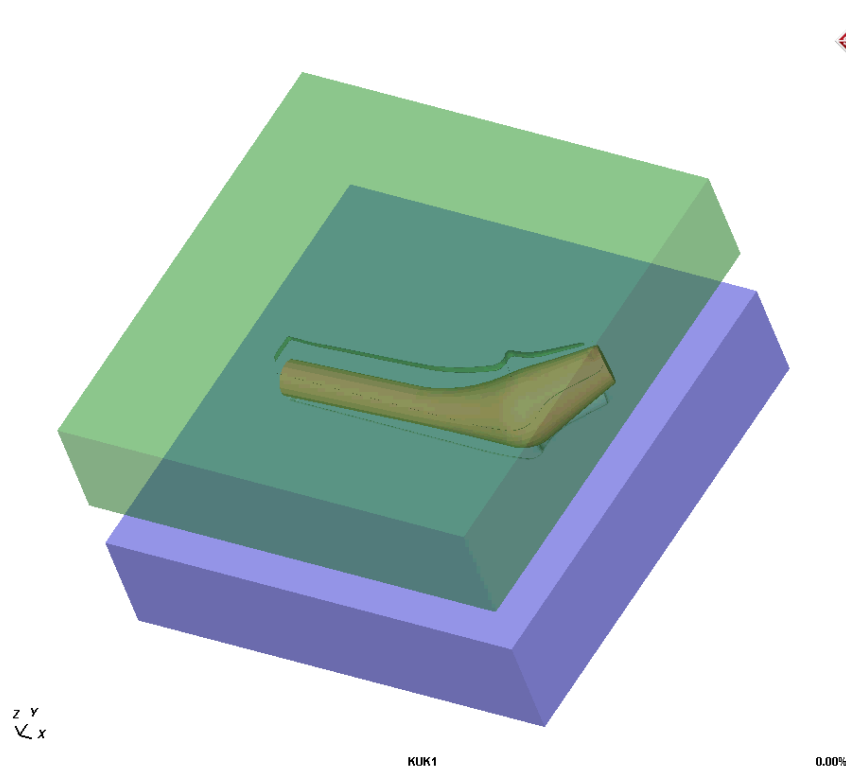
CILJ: Analiza procesa kovanja osovine kuka od titanijumske legure

PROBLEM: Veliki škart, defekti preklopa i netačnost otkovka

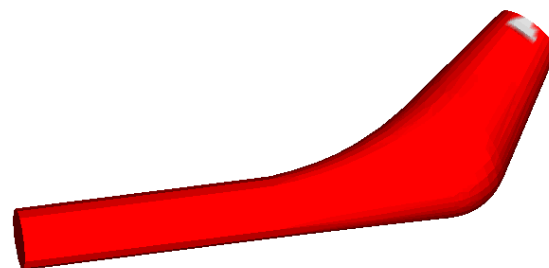
REZULTAT: Smernice za tehnološki postupak, optimalan oblik priprema, tačnost otkovka



Kovanje osovine veštačkog kuka

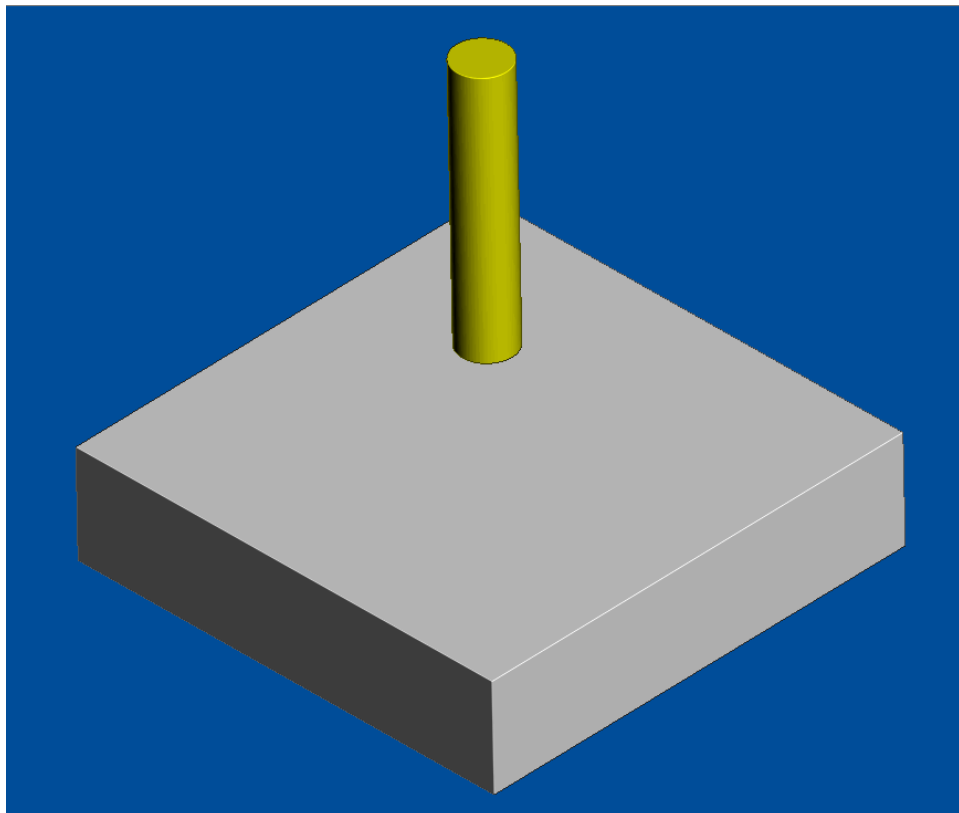


Proces kovanja



Kontakt između priprema i alata

Modeliranje mašiniranja alata za kovanje osovine veštačkog kuka



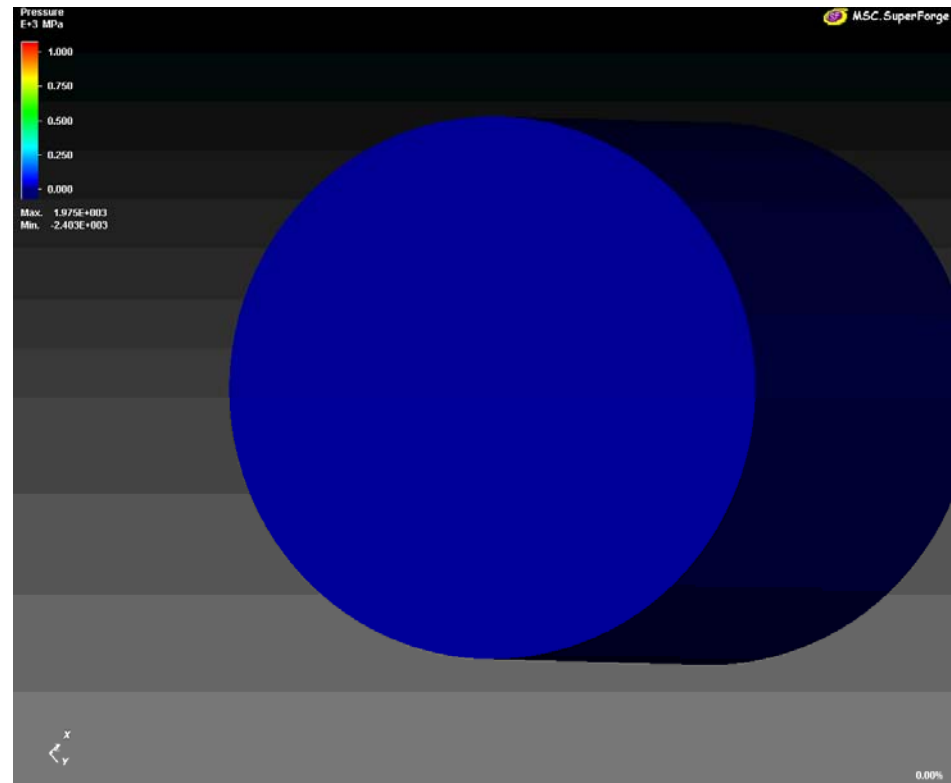
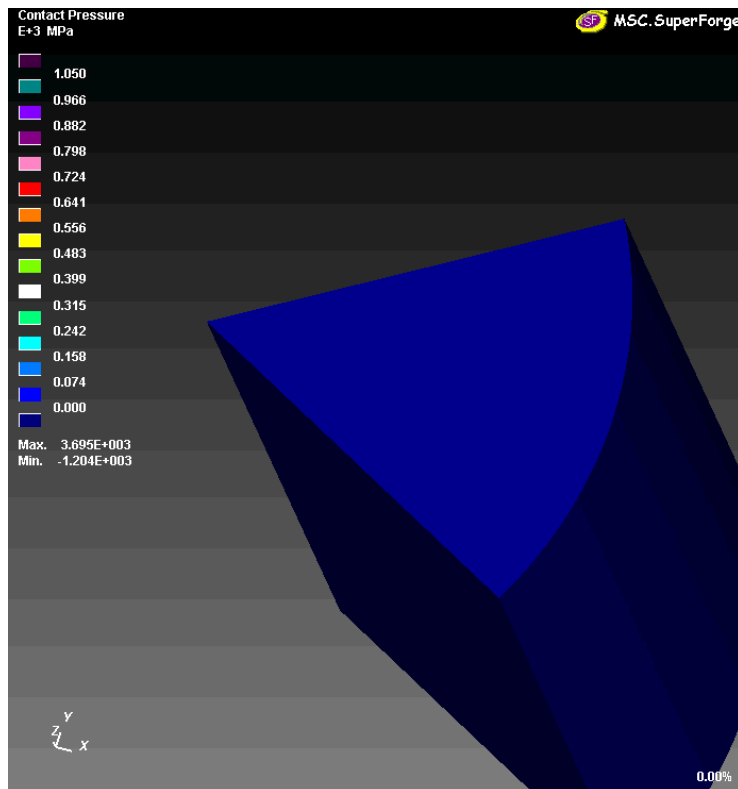
Simulacija izrade gravure alata (Delcam PowerMill)

Istiskivanje aluminijumskog profila

CILJ: Modeliranje istiskivanja Al profila i provera napona na alatu

PROBLEM: Prekomerni pritisci na mostu alata, problem kvaliteta profila u zoni svarivanja

REZULTAT: Uvid u ceo proces, naponi na alatu, pritisci u zoni svarivanja, procena kvaliteta



Projekat - Nissal, Niš

This project has been funded with support from the European Commission



European Commission

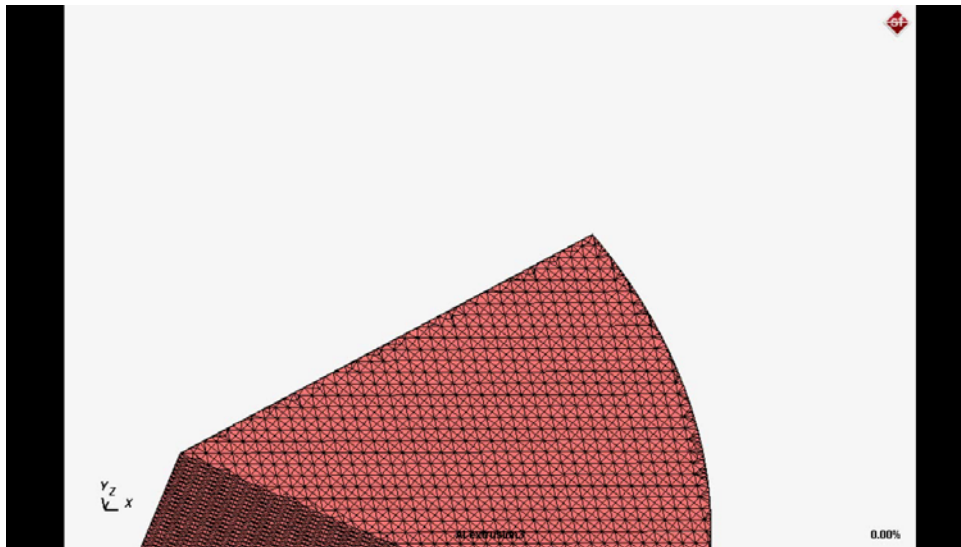
TEMPUS

Istiskivanje aluminijuskog profila

CILJ: Modeliranje
 istiskivanja Al profila i
 provera napona na alatu

PROBLEM: Prekomerni
 pritisci na mostu alata,
 problem kvaliteta profila
 u zoni svarivanja

REZULTAT: Uvid u ceo
 proces, naponi na alatu,
 pritisci u zoni svarivanja,
 procena kvaliteta



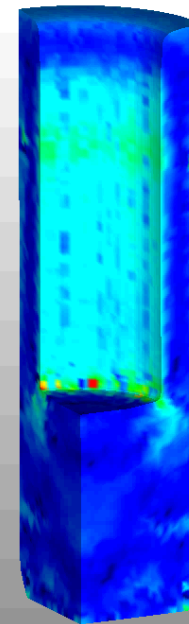
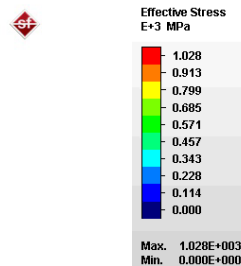
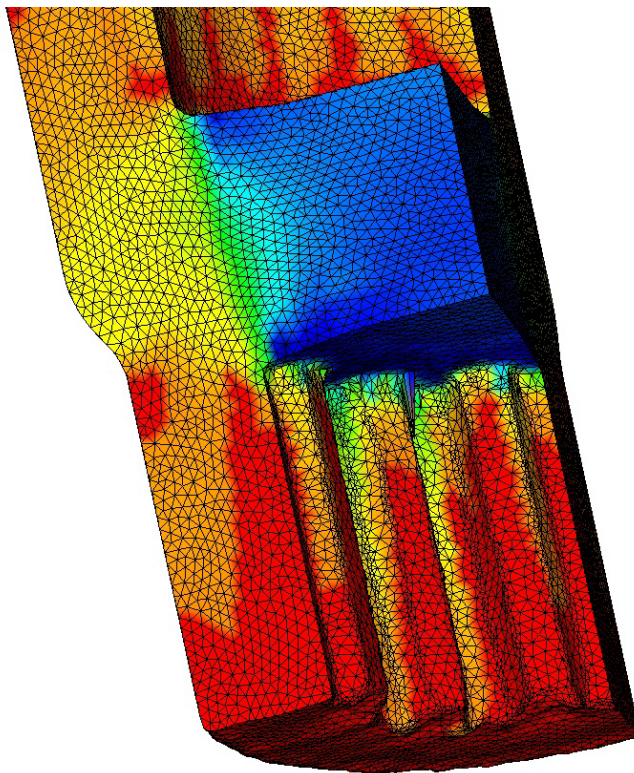
Projekat - Nissal, Niš

Modeliranje procesa višeoperacionog hladnog istiskivanja

CILJ: Analiza procesa kombinovanog istiskivanja, preporuke

PROBLEM: Naponi prednaprezanja alata, tačnost dimenzija dela, nestabilan proces

REZULTAT: Naponi u alatu u toku procesa, preporuke za upravljanje procesom, uticaji na tačnost dimenzija



TrecaOperacija3D-FV

0.00%

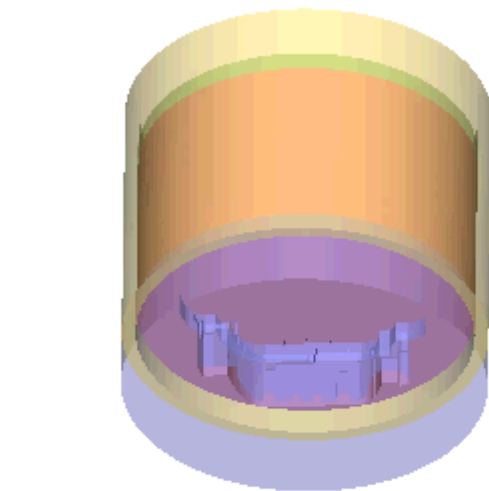
Projekat – Sloboda, Čačak

Istiskivanje aluminijumskih profila

CILJ: Analiza istiskivanja Al profila složene geometrije

PROBLEM:
neravnomernost brzina isticanja i defekti savijanja profila

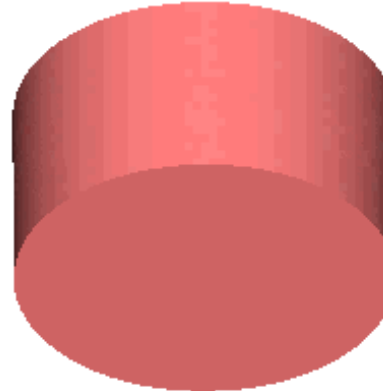
REZULTAT: Uvid u ceo proces, distribucija izlaznih brzina, mogućnost korekcija



$\bar{x}$
y

Istiskivanje

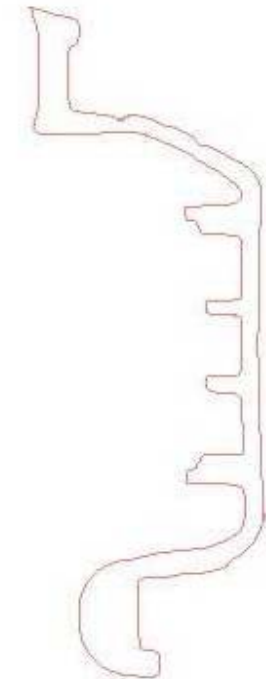
0.00%



$\bar{x}$
y

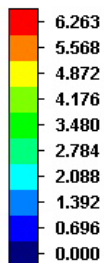
Istiskivanje

0.00%

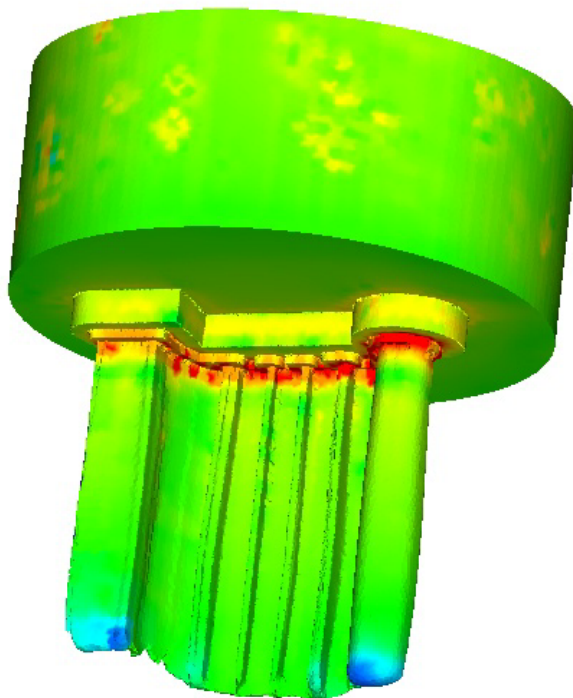


Istiskivanje aluminijumskih profila

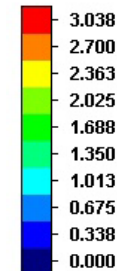
Effective Stress
 E+1 MPa



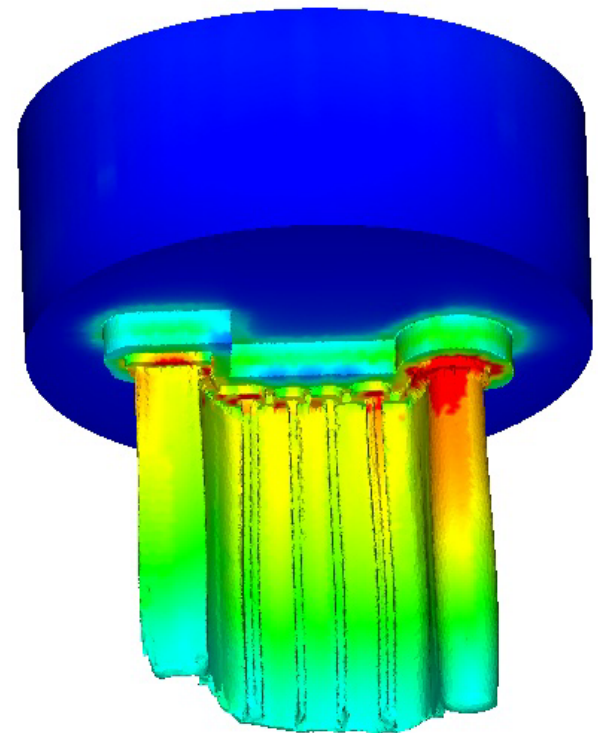
Max. 6.263E+001
 Min. 0.000E+000



Effective Plastic Strain



Max. 3.038E+000
 Min. 0.000E+000

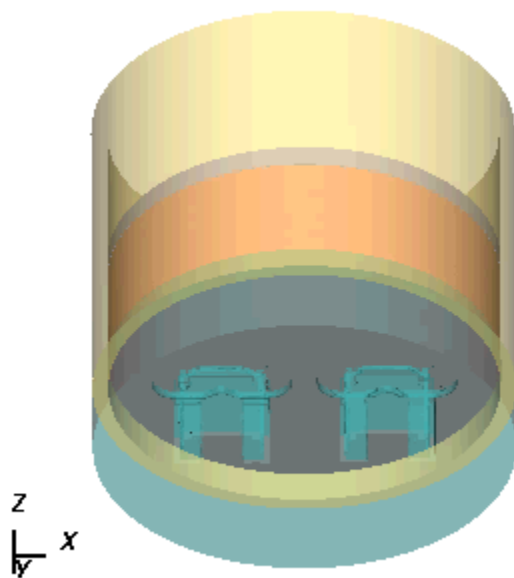


Istiskivanja aluminijumskih profila

CILJ: Analiza procesa i kvaliteta profila

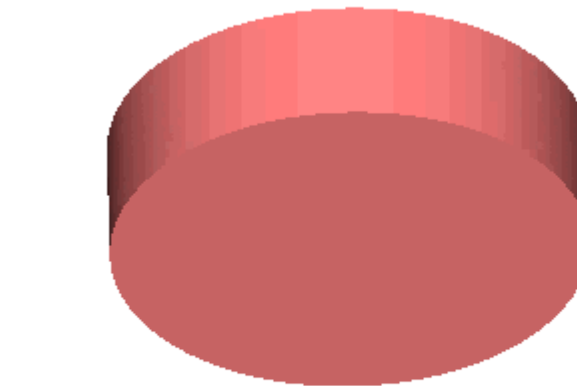
PROBLEM: Moguće krivljenje profila i pritisci na alatu

REZULTAT: Vizuelizacija procesa, temperatura, brzina, mogućnost proaktivnih korekcija alata



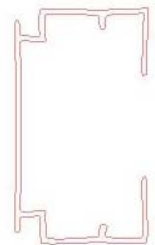
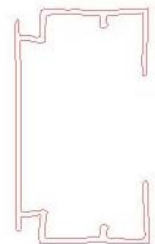
istiskivanje

0.00%

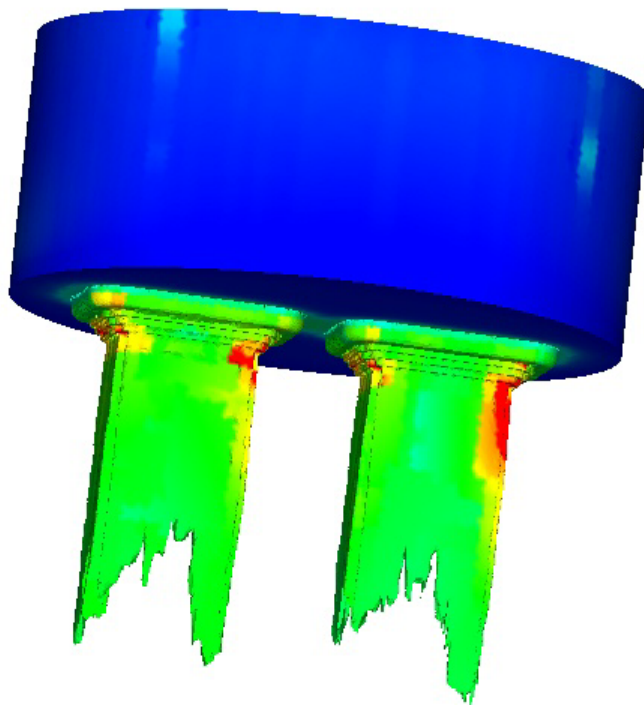
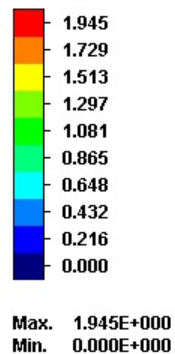


istiskivanje

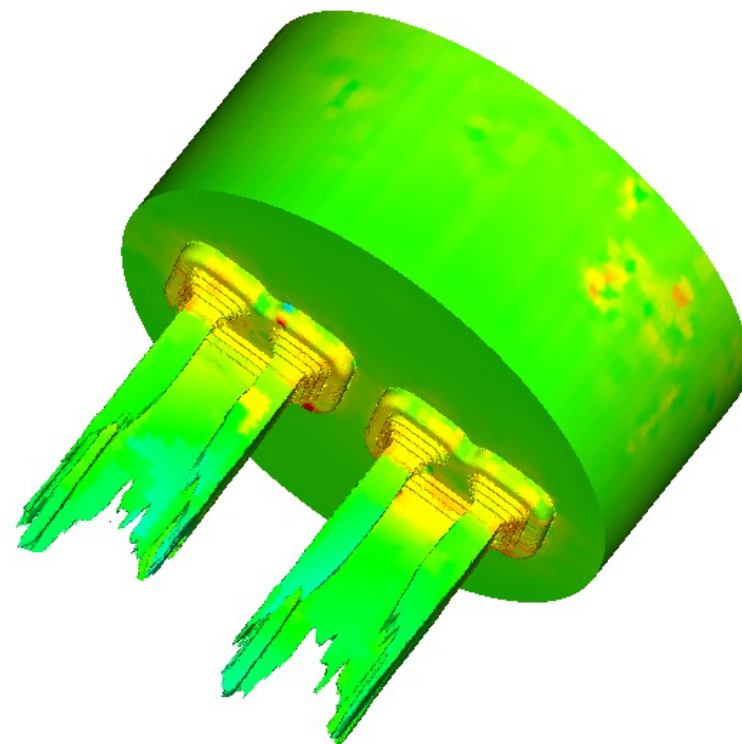
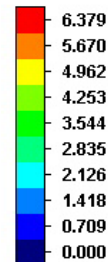
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Istiskivanje aluminijumskih profila



Effective Stress
E+1 MPa

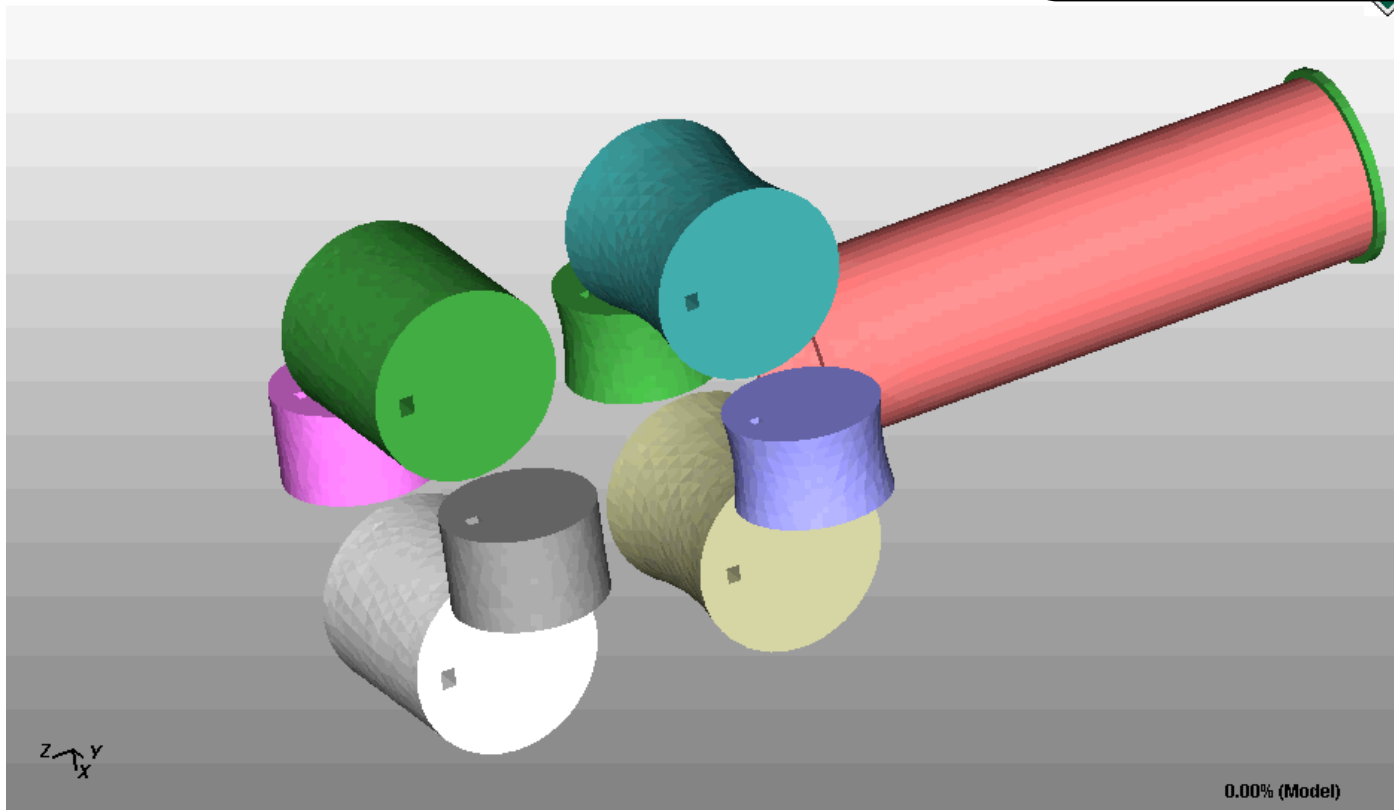


Simulacija valjanja bešavnih cevi

CILJ: Odrediti sile na valjcima na poslednja 2 stana, proveriti oblik profila

PROBLEM: Oblik profila zavisi od oblika valjaka, sile nepoznate

REZULTAT: profil dobar, određene sile na valjcima u toku procesa, kućište proizvedeno i isporučeno



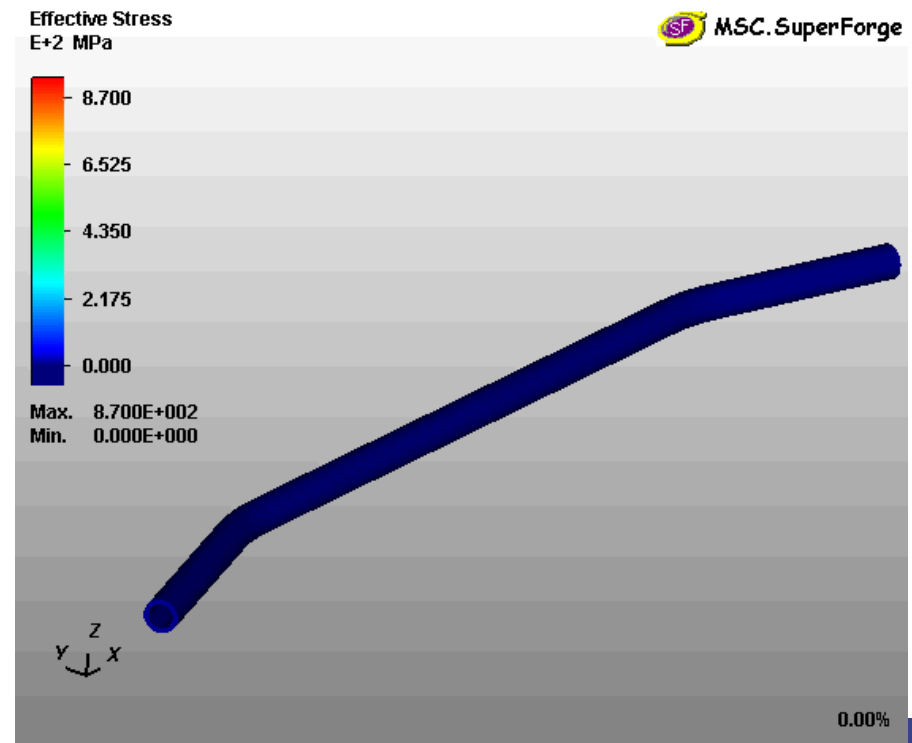
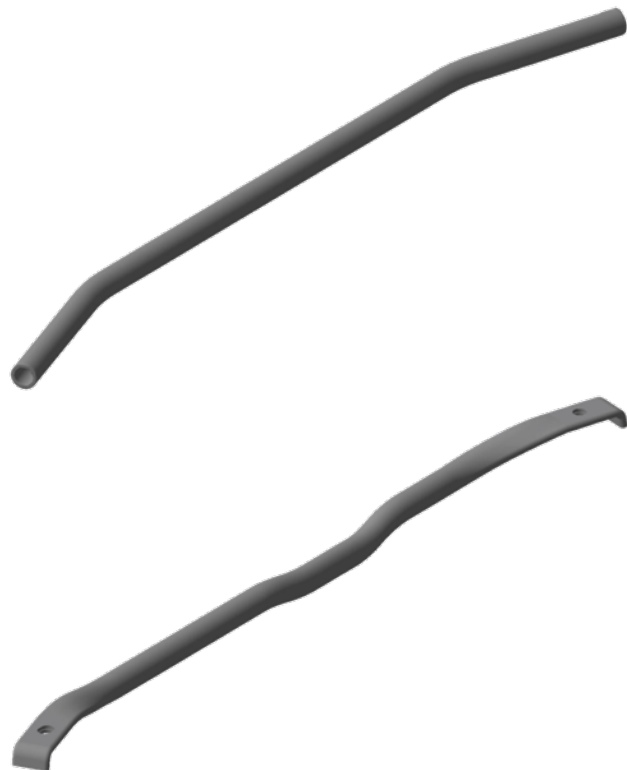
Projekat - Milanovic Engineering, Kragujevac

Modeliranje oblikovanja cevi

CILJ: Proveriti dimenzije i uglove cevi nakon oblikovanja

PROBLEM: Elastična povratnost nakon savijanja, netačnost dimenzija

REZULTAT: Utvrđena elastična povratnost, zone, i preporuke za modifikaciju alata



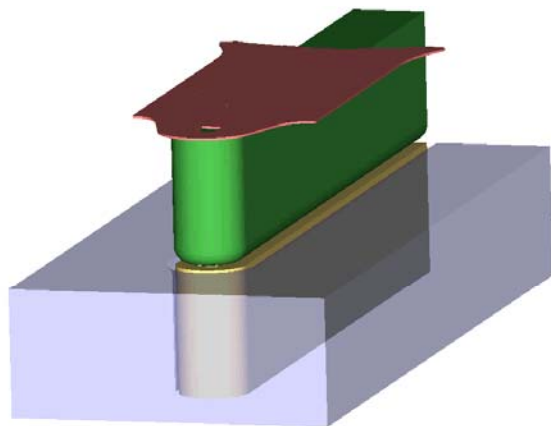
Projekat – Promotor Irva, Kragujevac

Reprojektovanje i analiza procesa obrade lima primenom reverznog inženjeringa i FE simulacija operacija dubokog izvlačenja i savijanja

CILJ: Analiza industrijskog procesa proizvodnje ručice K2

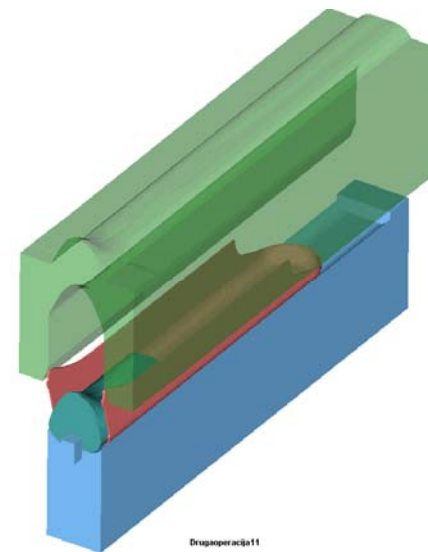
PROBLEM:
Nepostojanje tehničke dokumentacije

REZULTAT: Uspešan reinženjering celog procesa, procedura osvajanja novog proizvoda



Savijanje

0.00% (Model Generated by)



Druga operacija11

0.00% (Model Generated by)

Savijanje sa dubokim izvlačenjem - Metalac, G. Milanovac

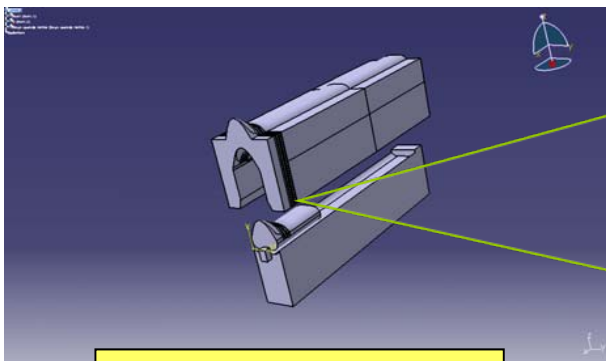
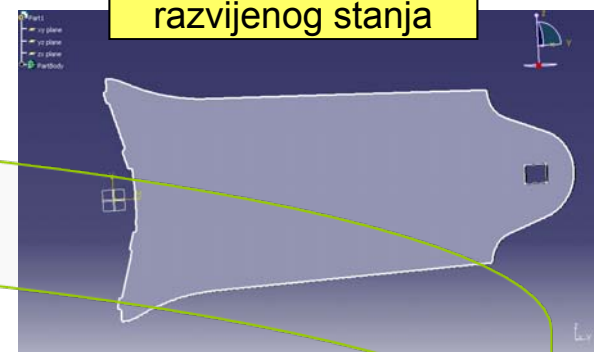
Fizički model ručice



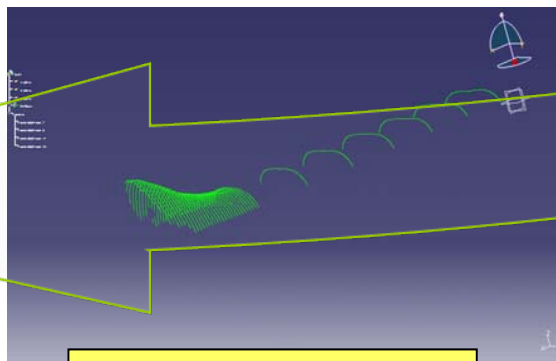
Skeniranje razvijenog stanja na CMM



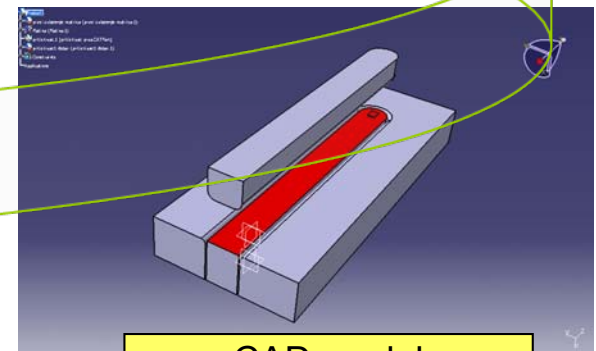
CAD model razvijenog stanja



CAD model alata za drugu operaciju



Oblak tačaka dobijen skeniranjem na CMM



CAD model alata za prvu operaciju

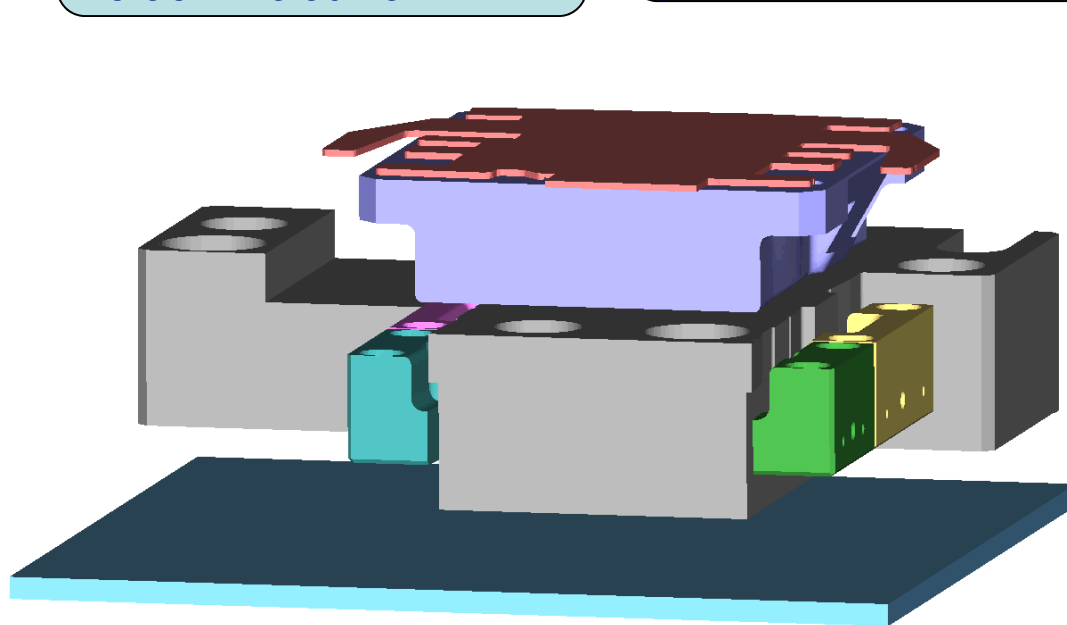
Savijanje sa dubokim izvlačenjem, - Metalac, G. Milanovac

Višeoperaciono savijanje lima u koračnim alatima

CILJ: Modeliranje procesa obrade u koračnim alatima

PROBLEM: netačnost dela zbog elastične povratnosti

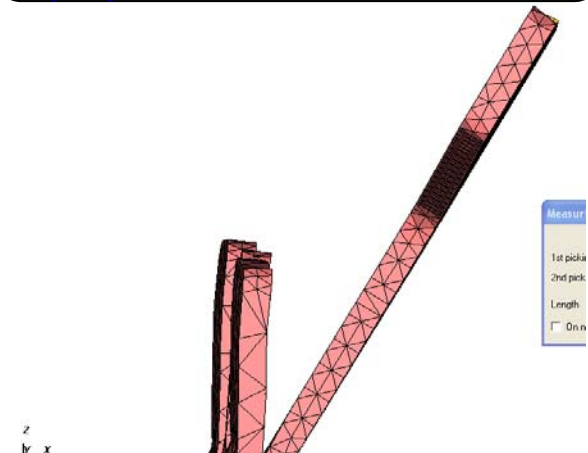
REZULTAT: Numerička procena elastičnog ispravljanja verifikovana na CMM



Savijanje1opFE-contact.tol-0.05mat

0.00% (Model)

Elastični alati, sa oprugama

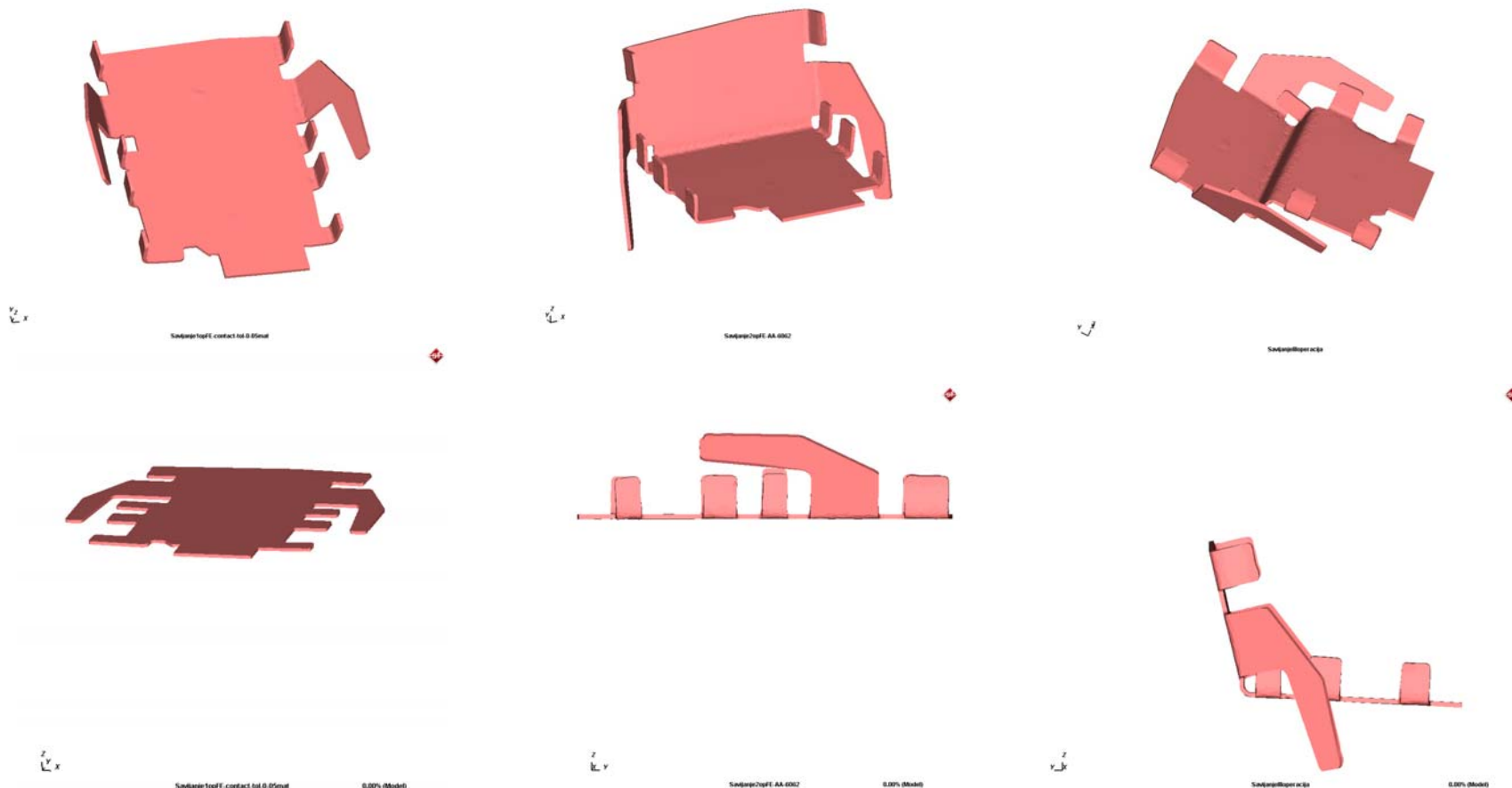


	X	Y	Z	
1st picking	-47.214422	-2316.0636	34.105024	Clear
2nd picking	-46.251715	-2316.1575	33.579911	
Length	0.962708	0.093952	0.525113	1.100626
☐ On node	Decimal	6	Unit	millimeter

Procena elastičnog ispravljanja

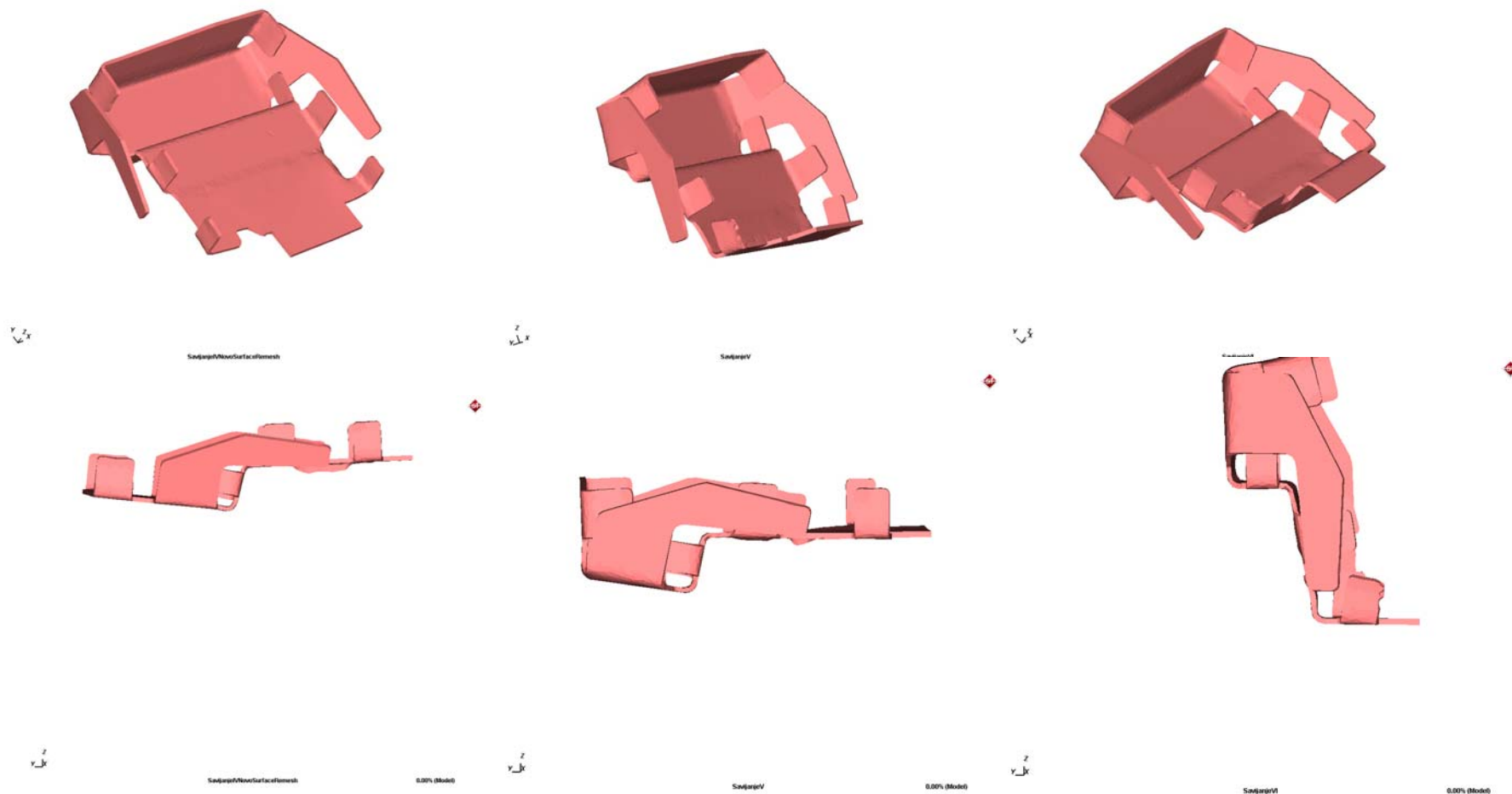
Projekat - WEBA, Kragujevac

Višeoperaciono savijanje lima u koračnim alatima



Projekat - WEBA, Kragujevac

Višeoperaciono savijanje lima u koračnim alatima



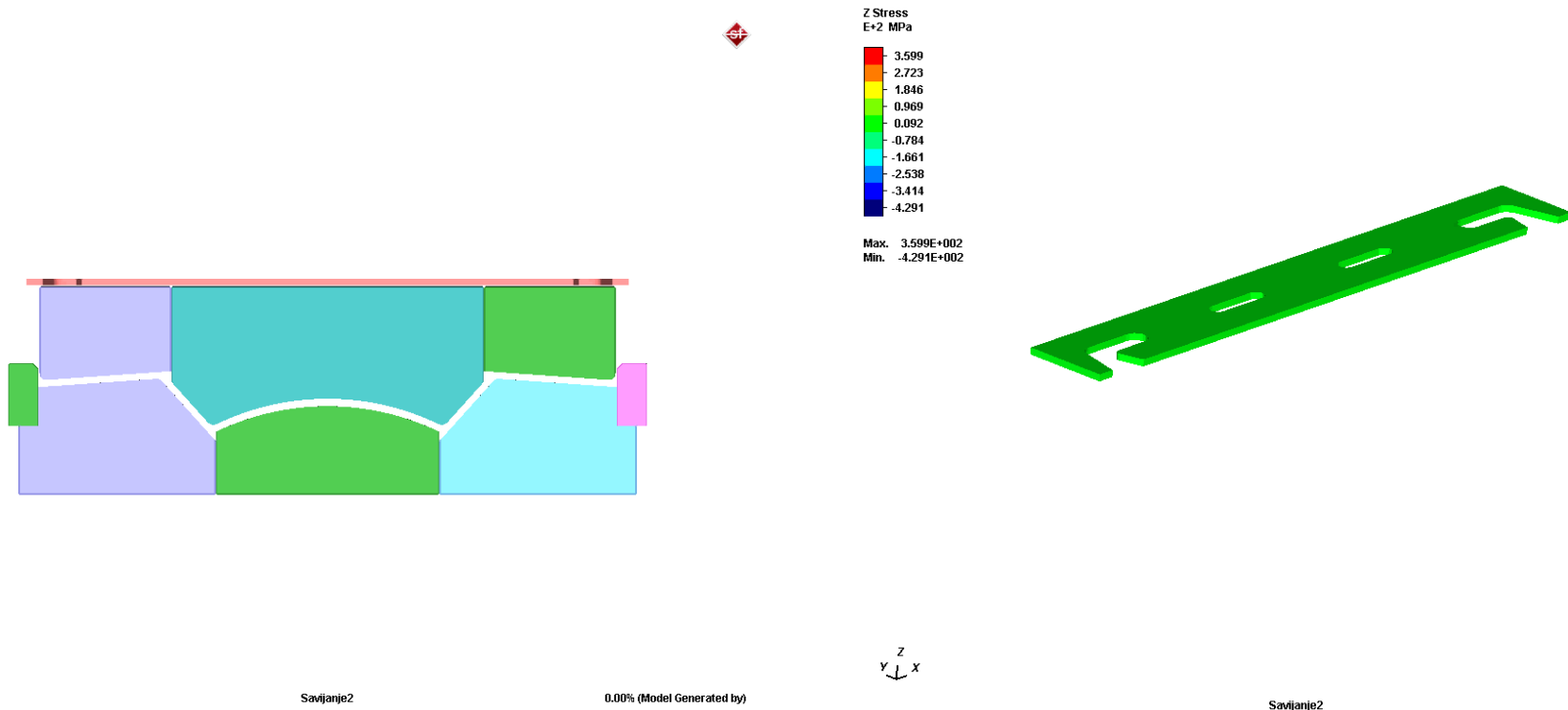
Projekat - WEBA, Kragujevac

Simulacija procesa savijanja lima na primeru nosača za bojler

CILJ: Procena elastične povratnosti

PROBLEM: Netačnost dela usled springback-a

REZULTAT: Proračun uglova nakon ispravljanja, predlog korekcije alata



Metalac, G. Milanovac (studentska praksa)

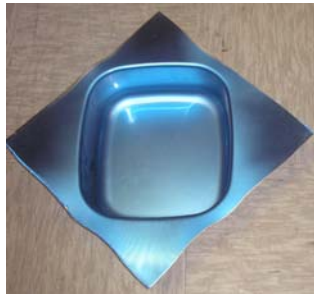
Duboko izvlačenje sudopere od feritnog čelika

CILJ: Ispitati mogućnost oblikovanja sudopere od feritnog čelika

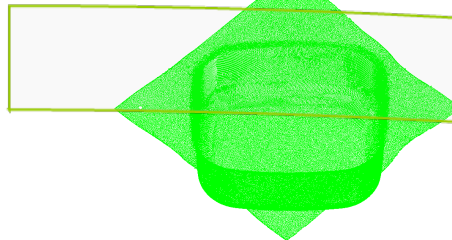
PROBLEM: nemogućnost oblikovanja sa istim parametrima i alatima kao inox

REZULTAT: Optimiziran proces u prvoj operaciji, preporuke za promena alata u drugoj

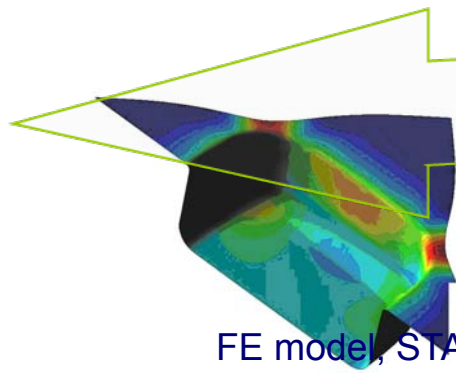
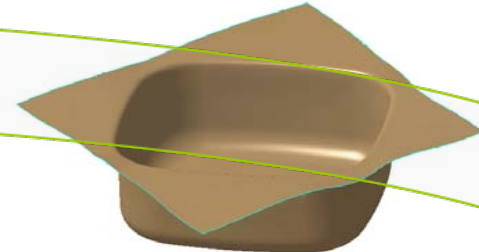
Proizvod



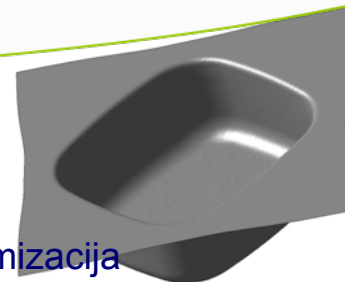
Reverzni inženjering, oblak tačaka, ATOS Ile



CAD model, CATIA



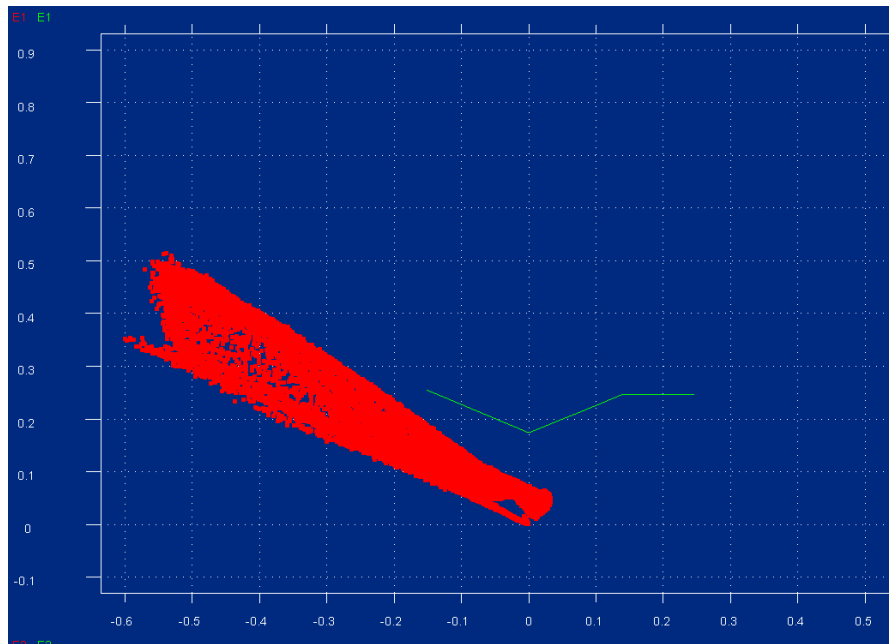
FE model, STAMPAK, optimizacija



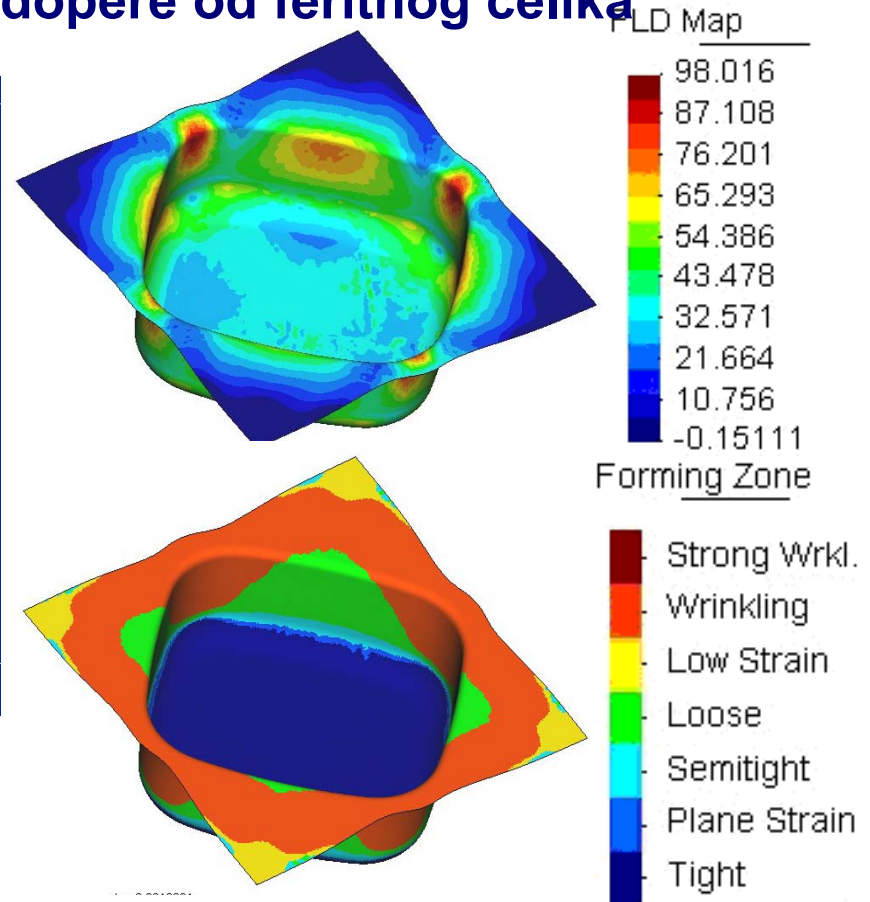
Projekat – Metalac INCO, Gornji Milanovac

This project has been funded with support from the European Commission

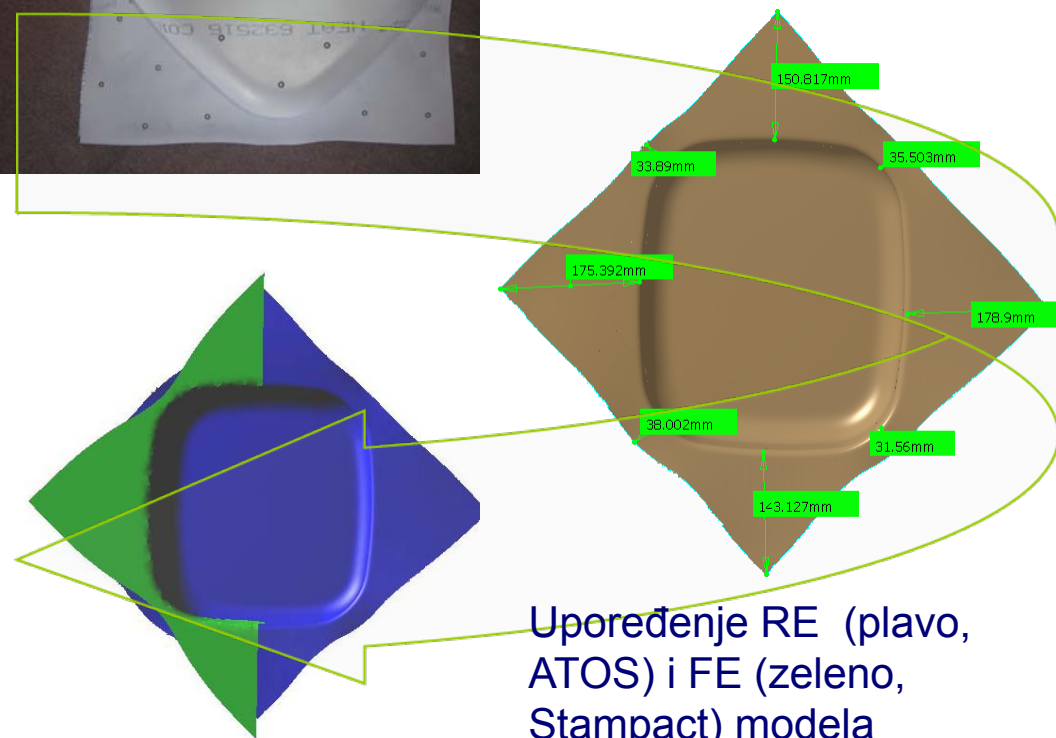
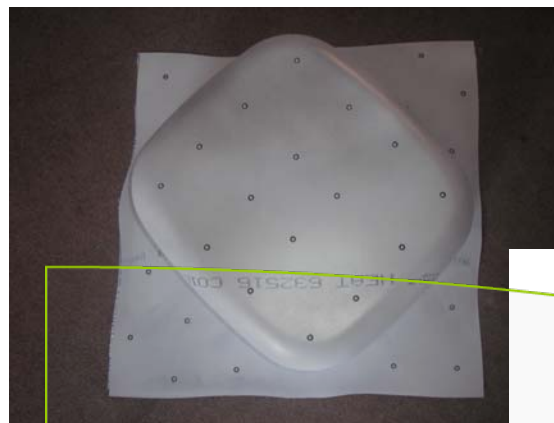
Duboko izvlačenje sudopere od feritnog čelika



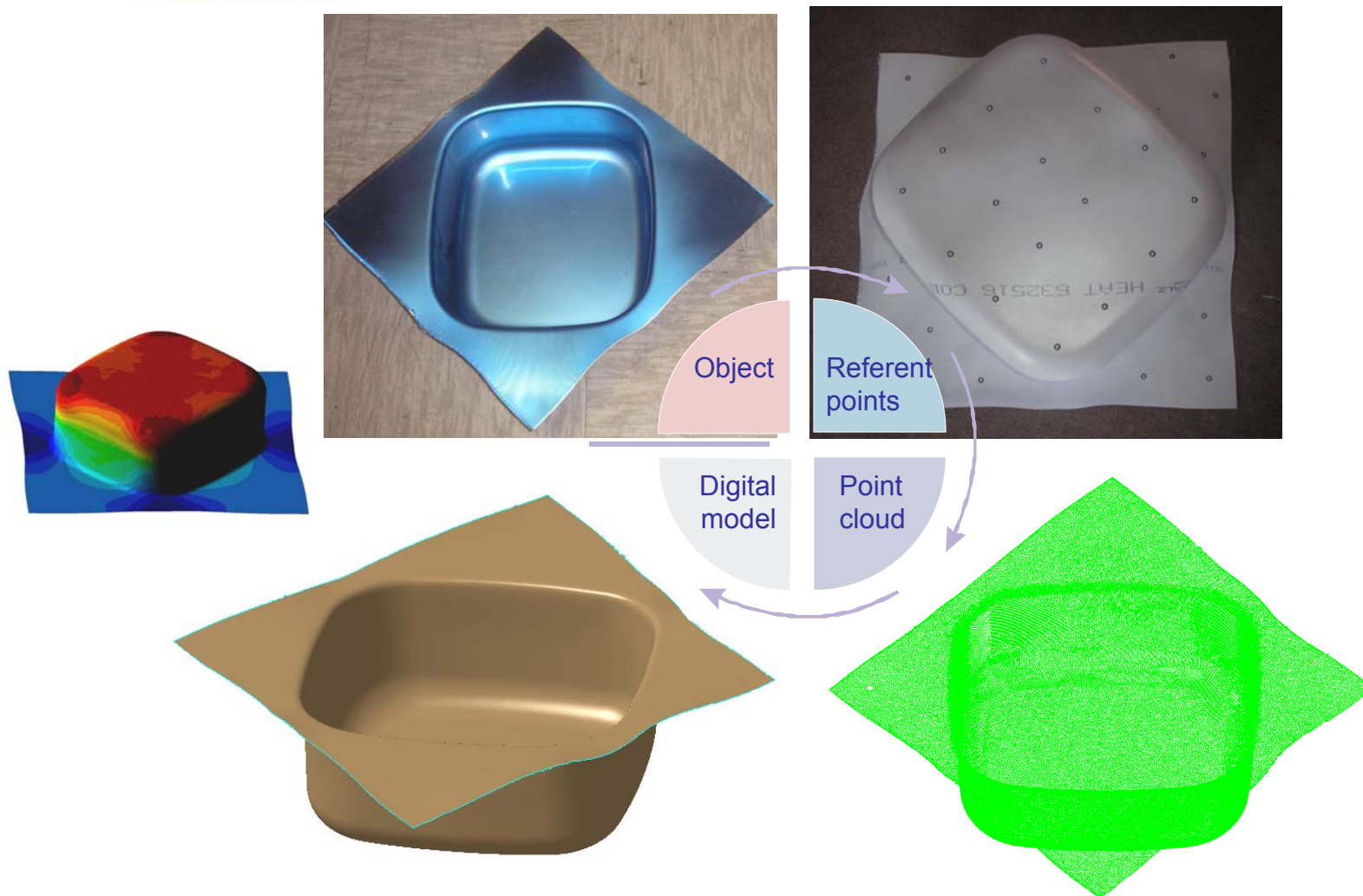
Dijagram granične deformabilnosti



Projekat - Metalac, Gornji Milanovac



Projekat - Metalac, Gornji Milanovac



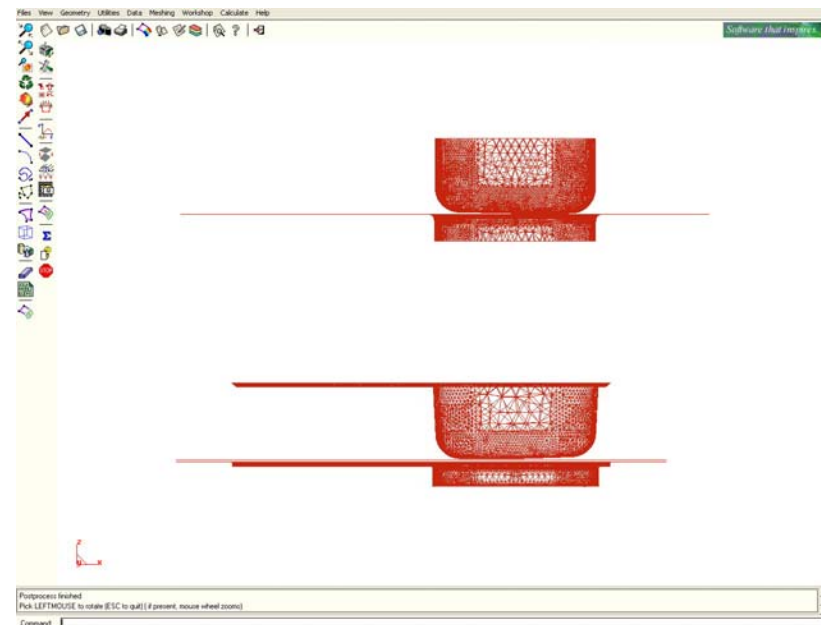
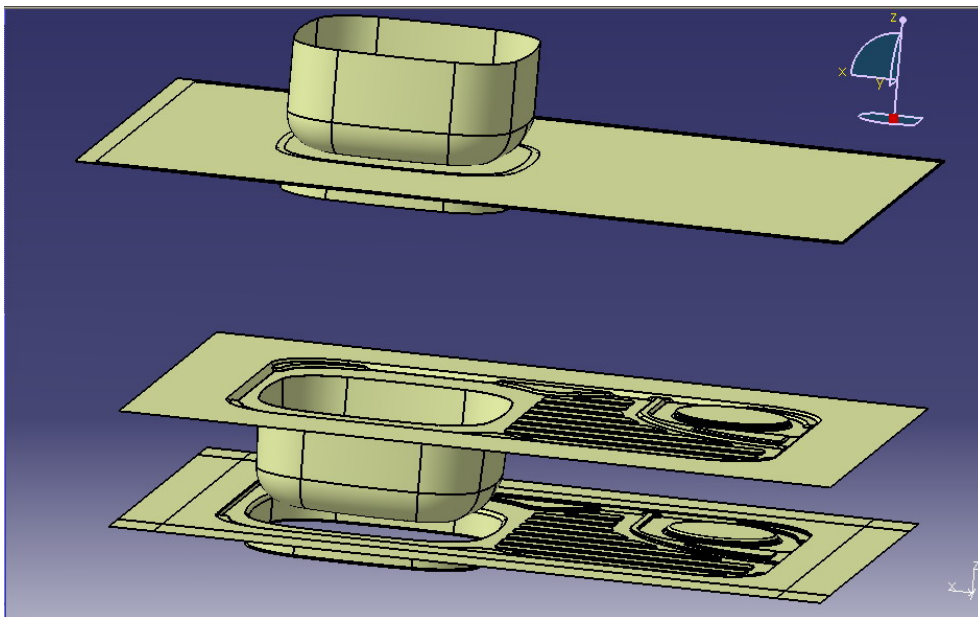
Projekat - Metalac, Gornji Milanovac

Duboko izvlačenje radnog dela sudopere

CILJ: Modelirati oblikovanje monoblok sudopere

PROBLEM: Nabori na obodu u I operaciji, balans sile držanja i podmazivanja

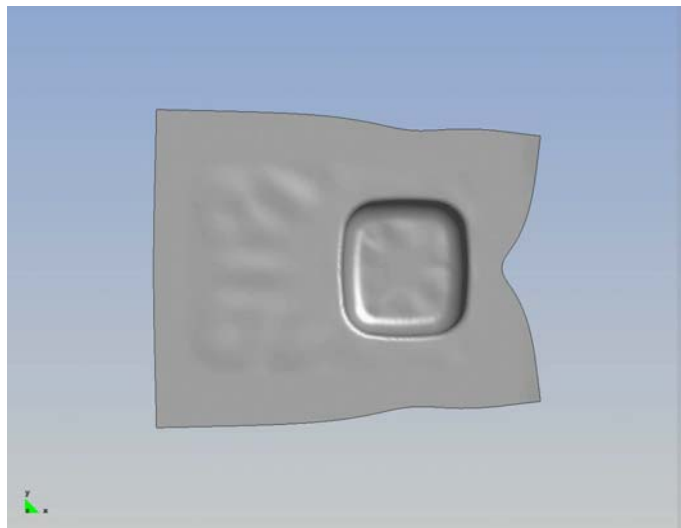
REZULTAT: ispitan proces i uticajni faktori, verifikovan industriksi proces, preporuke za eliminisanje nabora u I op.



Model alata u Stampack-u

Projekat - Metalac, Gornji Milanovac

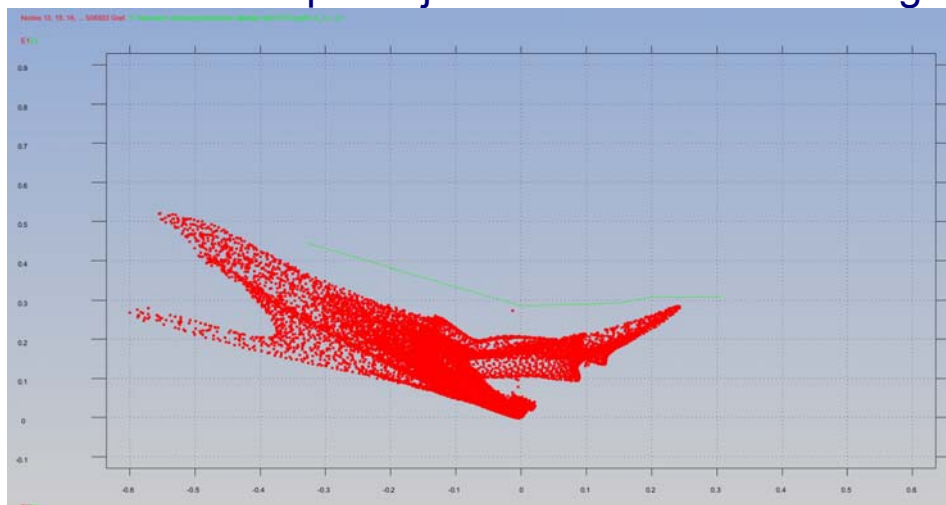




II operacija



Izgled komada posle II operacije



Dijagram
granične
deformabilnosti

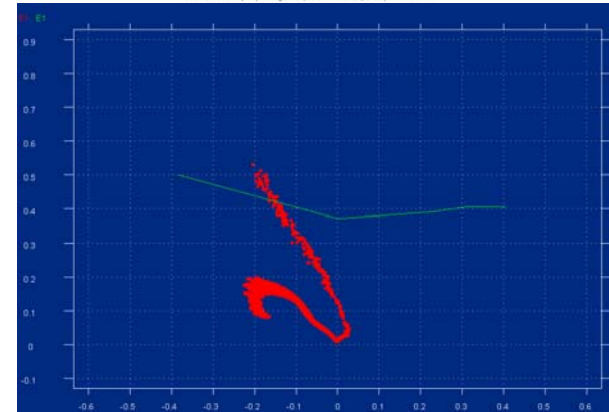
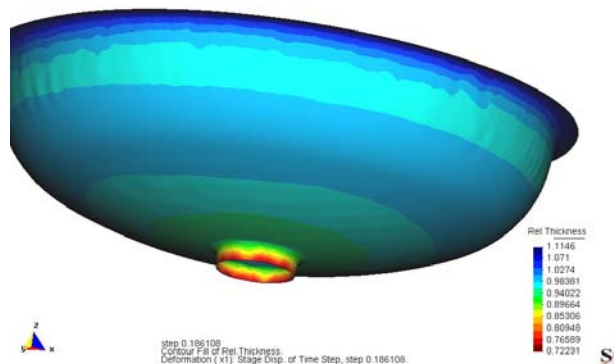
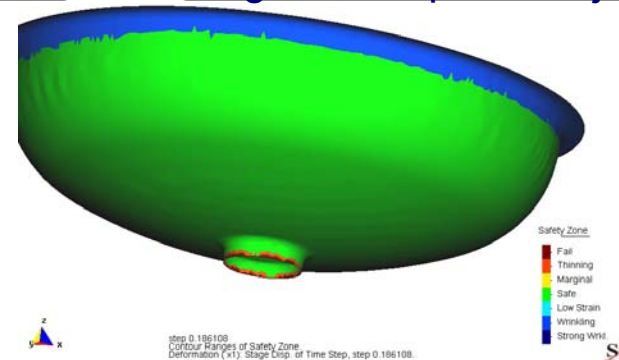
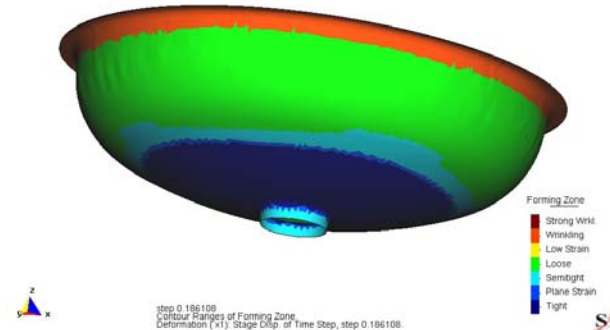
Projekat - Metalac, Gornji Milanovac

Duboko izvlačenje donjeg poklopca bojlera i provlačenje otvora

CILJ: ispitati mogućnost optimizacije procesa provlačenja otvora na poklopcu bojlera

PROBLEM: Na obodima provučenog otvora se pojavljuju naprsline

REZULTAT: Numerička procena verifikovala industrijski problem, mogućnost optimizacije



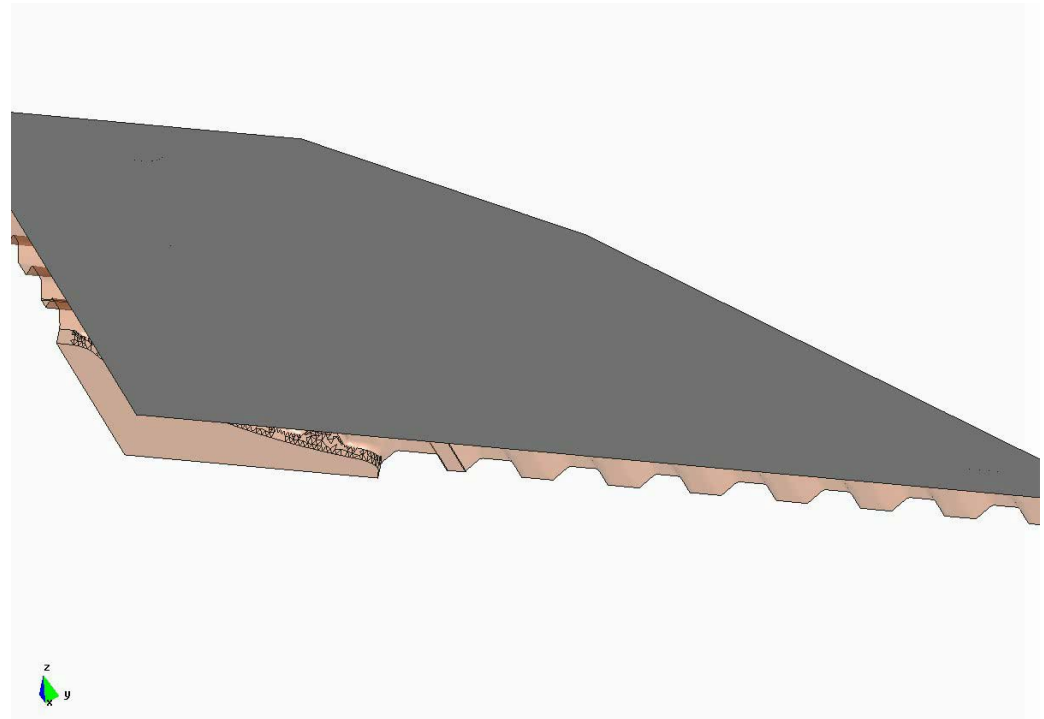
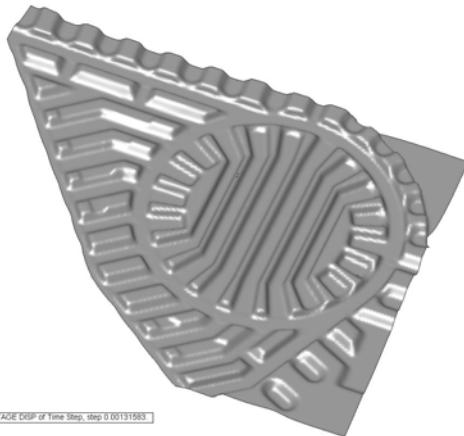
Probna simulacija – Metalac Bojleri, G. Milanovac

Simulacija dubokog izvlačenja razmenjivača toplote

CILJ: Simulacija oblikovanja lima ploča-stog razmenjivača toplote

PROBLEM: Moguća netačnost izvučenih žljebova, problem kod sklapanja i curenja

REZULTAT: Modeliran alat na osnovu RE, simulacija procesa, provera tačnosti žljebova i uklapanja, deformabilnost lima



Projekat - Buducnost, Bajina Basta

This project has been funded with support from the European Commission

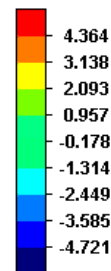
Simulacija dubokog izvlačenja sa stanjenjem

CILJ: Verifikacija eksperimentalnih rezultata

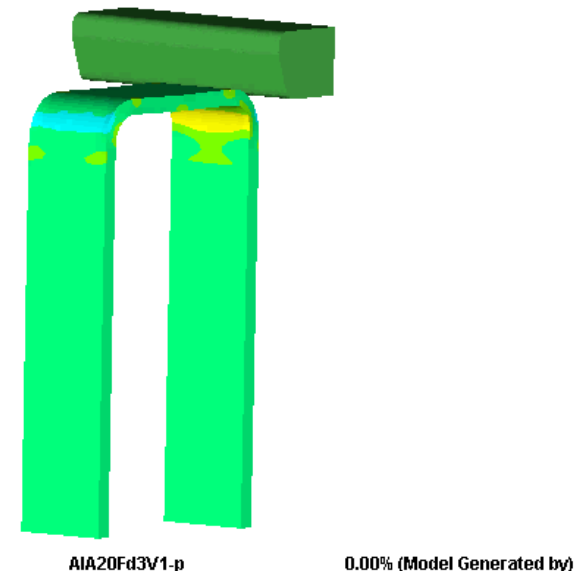
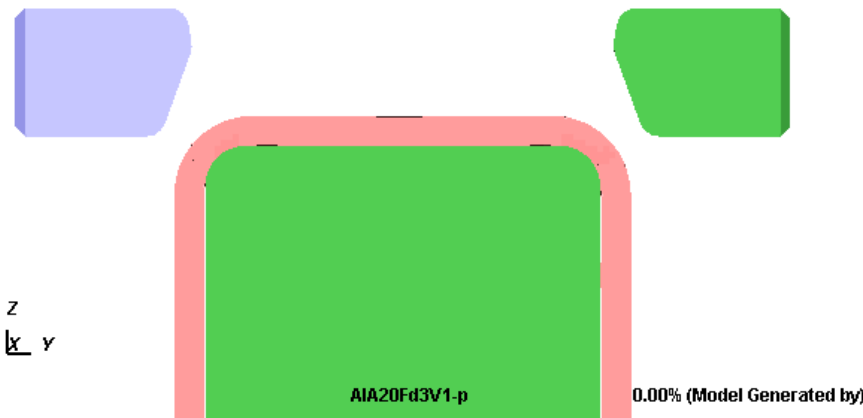
PROBLEM: Procena napona u zidu izvučenog dela, temperature i ost.

REZULTAT: Odlična verifikacija eksperimenata, napredna analiza procesa van opsega eksperimenta

 Z Stress
E+2 MPa



Max. 4.364E+002
Min. -4.721E+002

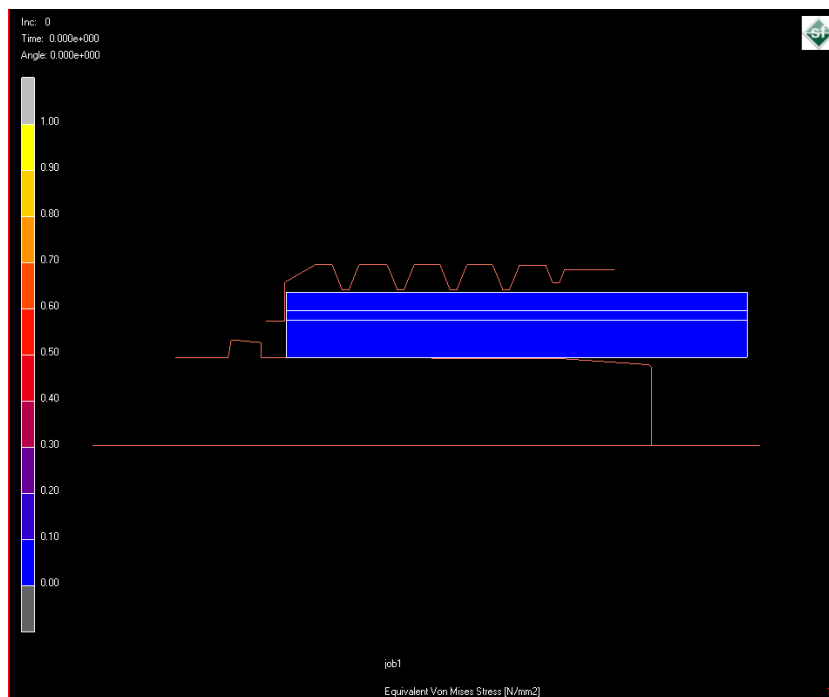


Simulacija montaže čaure za creva pod visokim pritiskom

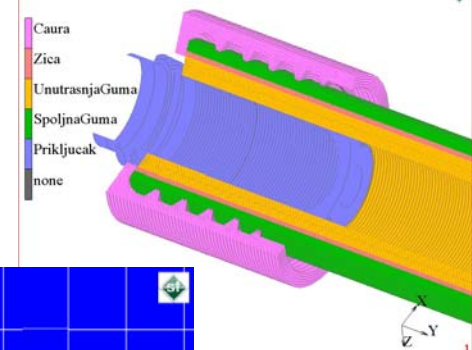
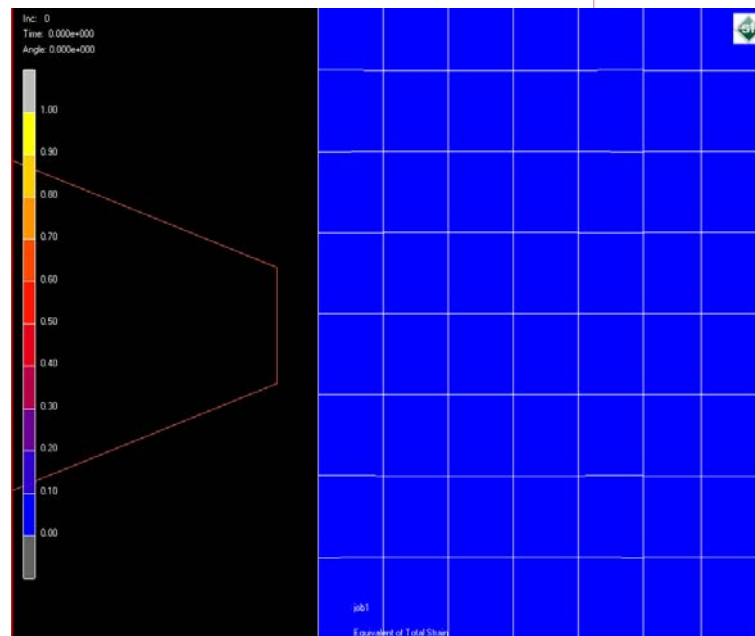
CILJ: Provera napona u gumenom crevu sa žičanim ojačanjem pri montaži čaure, sigurnost montaže na radni pritisak

PROBLEM: Curenje creva na delu čaure zbog velikih pritisaka fluida i loše montaže

REZULTAT: Provera creva na pritisak, deformacije, naponi, simulacija montaže čaure



Projekat - Fadip, Bečej



HVALA NA PAŽNJI



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