

SWEDEMO

WP 2.1 Automated Sealing



AUTOMATED SEALING

- Project overview
 - Participants
 - Sealing methods studied
 - Project takes off
- Technical results
 - Simulations (FCC, Prodtex & Chalmers)
 - Application process and sealing gun (Swerea & Atlas Copco)

PARTICIPANTS



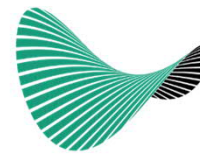
SAAB

CHALMERS

li.u LINKÖPING
UNIVERSITY

Prodtex



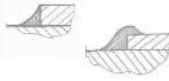


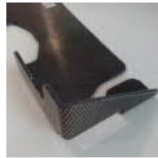


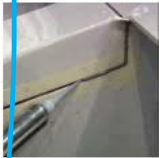

swerea|IVF



FRAUNHOFER CHALMERS
RESEARCH CENTRE FOR INDUSTRIAL MATHEMATICS

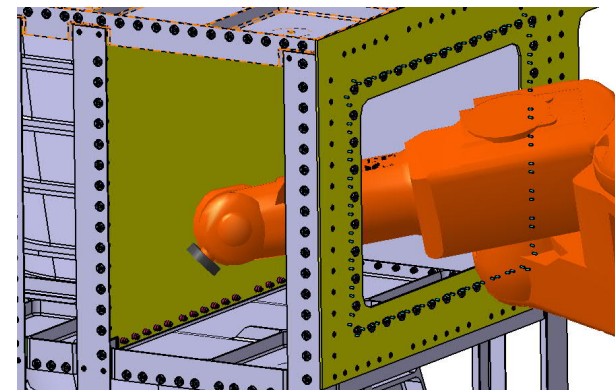
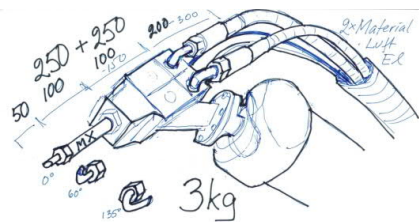
SEALING METHODS STUDIED

- We focused on tank sealing
- Fillet sealing and fastener sealing
- Polysulfide PPG PR-1776M B2
- Main challenges are access, low production rate and curing of sealant during application

| Sealing type | Edge Sealing | Interfay Sealing | Fillet Sealing | Aerodyna- mic Sealing | Fastener Sealing |
|--------------|---|---|---|---|---|
| |  |  |  |  |  |
| |  |  |  |  |  |
| Sealant | Epoxy | Polysulfide | Epoxy / Polysulfide | Polysulfide | Polysulfide |
| Surface | CFRP | Metal, CFRP | Metal, CFRP | Metal, CFRP | Metal, CFRP |

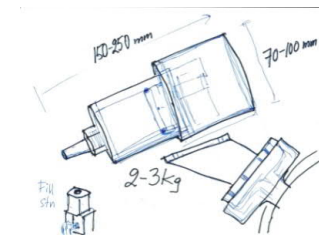
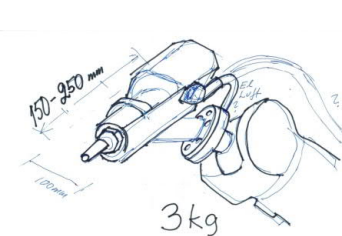
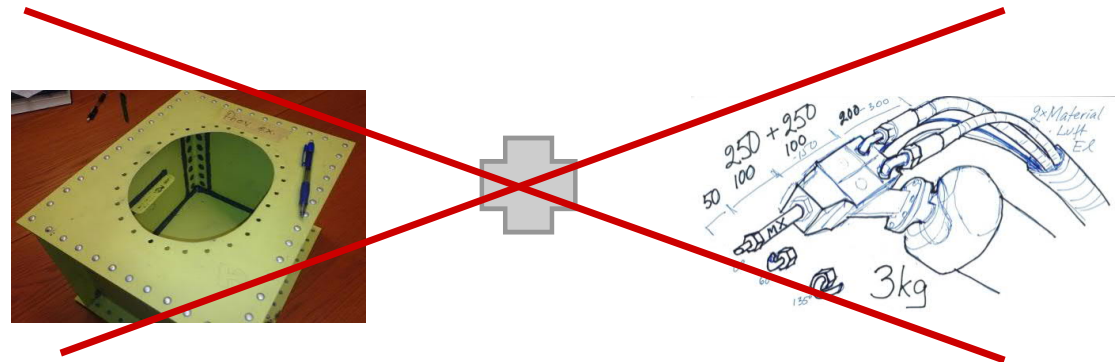
PROJECT TAKES OFF

- Swerea (today RISE) had made a pre-study to investigate potential
- Swerea characterized the material properties and Chalmers did initial reach studies
- An early concept was to pump and mix the sealant at the end effector



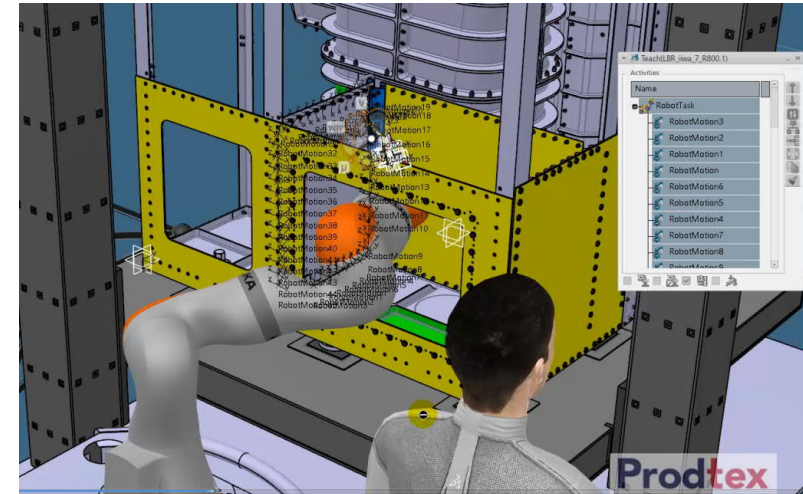
PROJECT TAKES OFF

- Already at the second live meeting we concluded that we didn't have room to pump sealant and mix "on the fly" and that we needed a very agile robot
- Renewed concept studies (Saab, Swerea & Atlas)
- Some of the most promising ones illustrated
- One was with an external fill station and one with prefilled Semkits



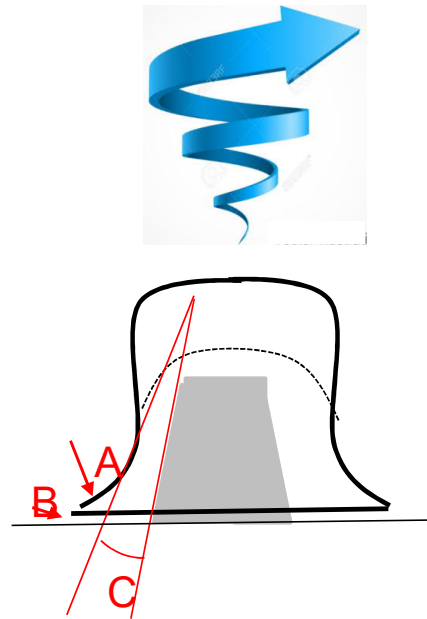
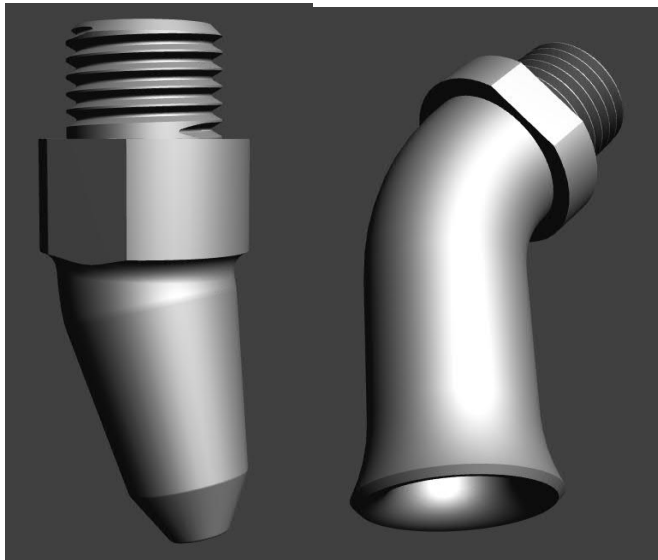
ROBOT CHOICE AND SEALING GUN PROTOTYPE

- Another department at Chalmers had a Kuka iiwa robot we could borrow and simulations (Prodtex) showed that it suited our task well
- Atlas Copco with simulation support from Fraunhofer Chalmers made the sealing gun prototype during the spring 2017
- We started testing the sealing gun during the fall 2017 at Swerea



SEALING PROCESS

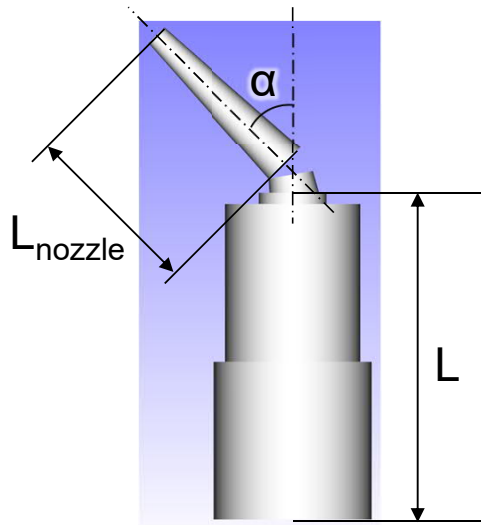
- Swerea developed the application technique for fastener sealing
- They also created the sealing nozzles and 3D printed them



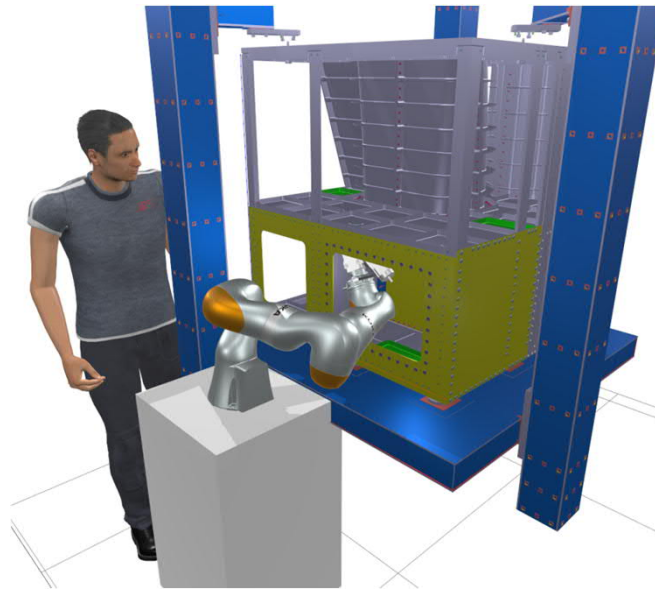
Robot doser 1

FRAUNHOFER-CHALMERS CENTRE

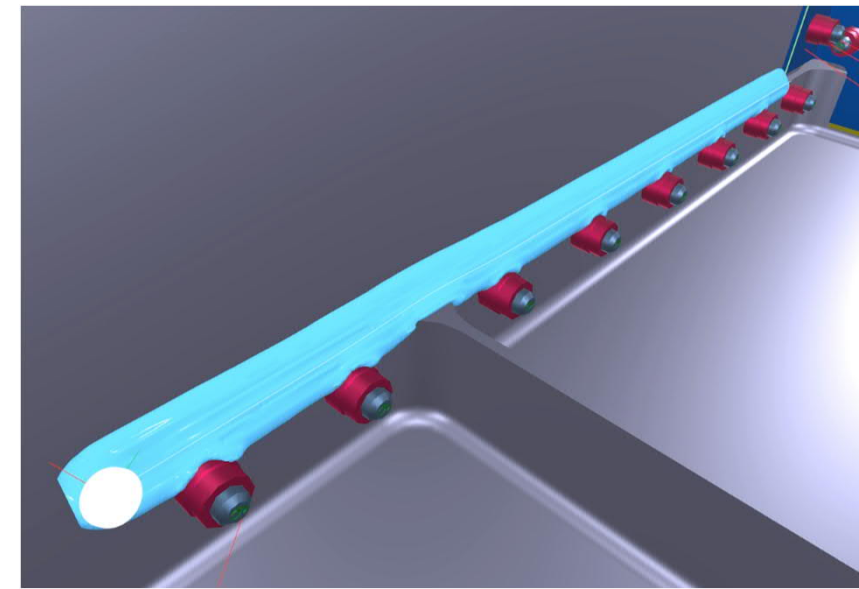
Optimizing of sealing gun



Automated path planning

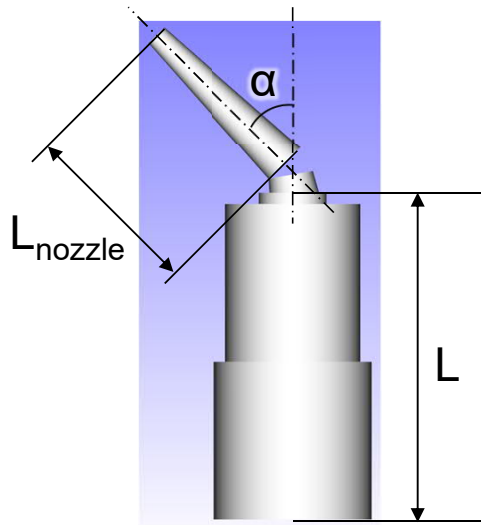


Simulation of sealant application

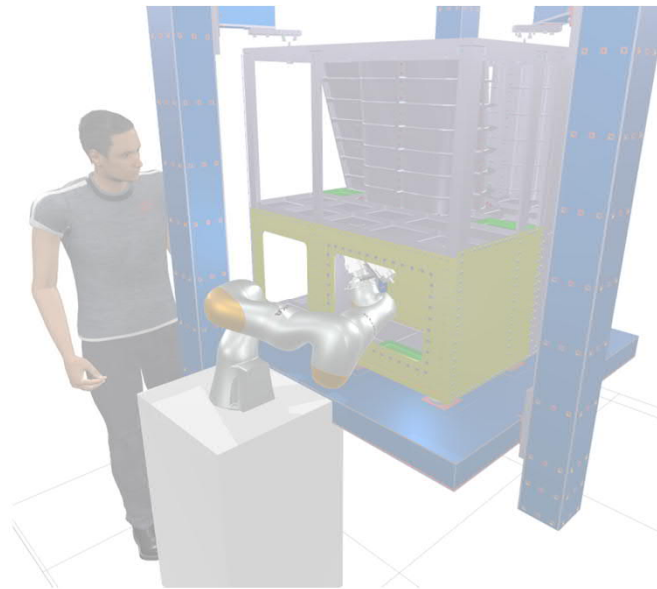


FRAUNHOFER-CHALMERS CENTRE

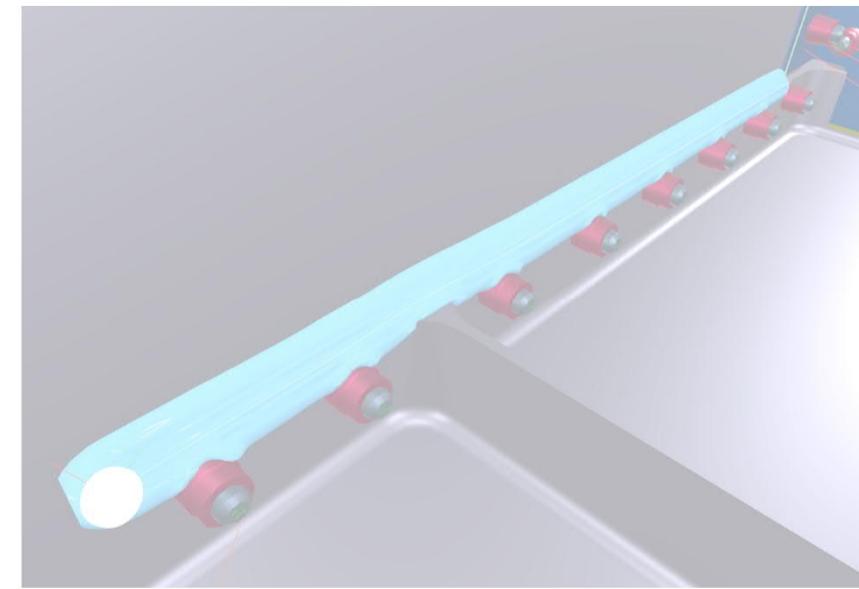
Optimizing of sealing gun



Automated path planning

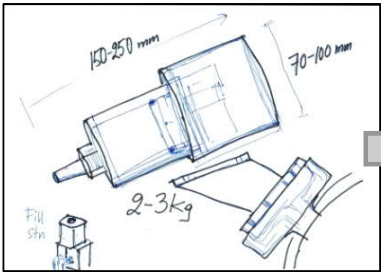


Simulation of sealant application

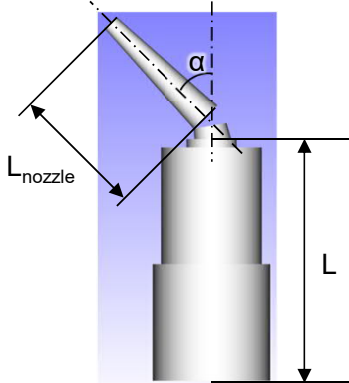


OPTIMIZING OF SEALING GUN

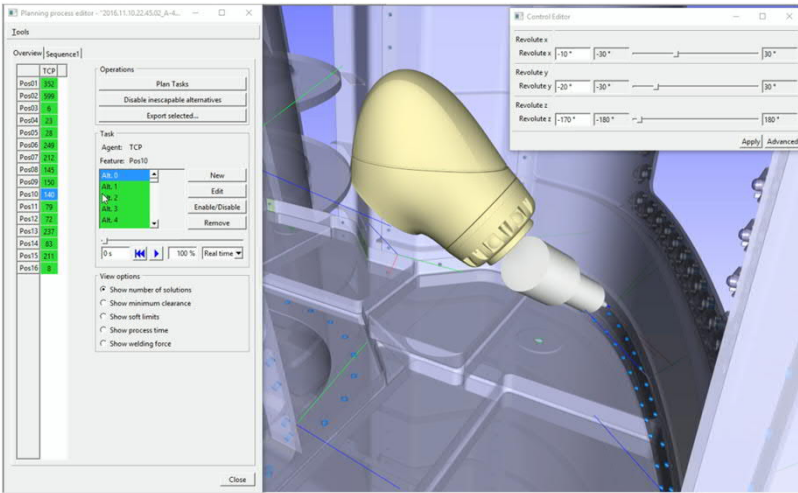
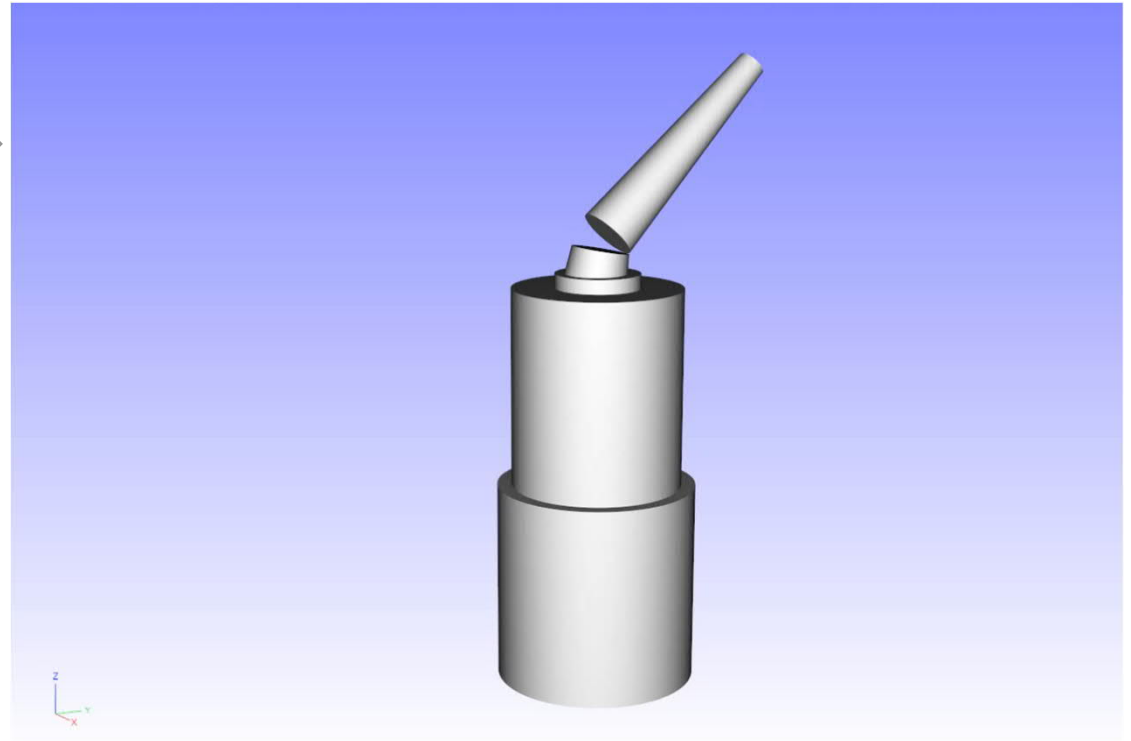
Concept



Parametric model

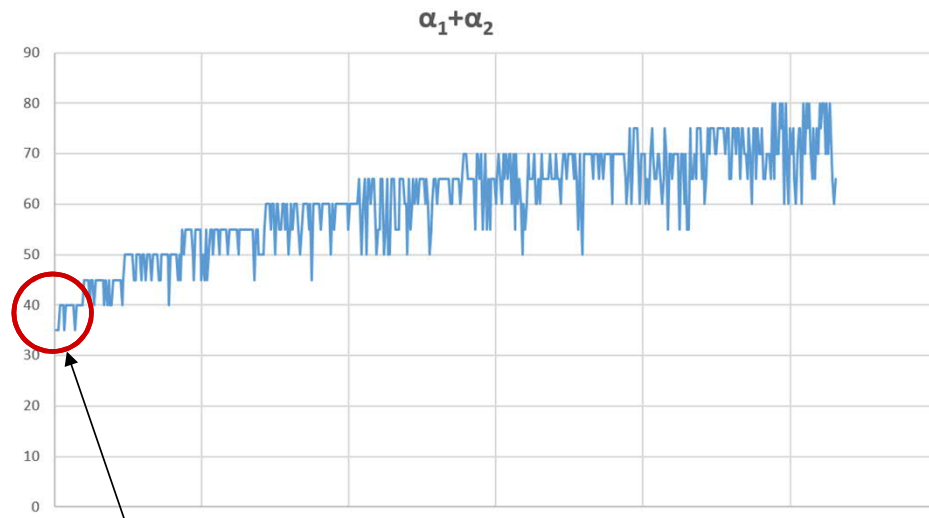
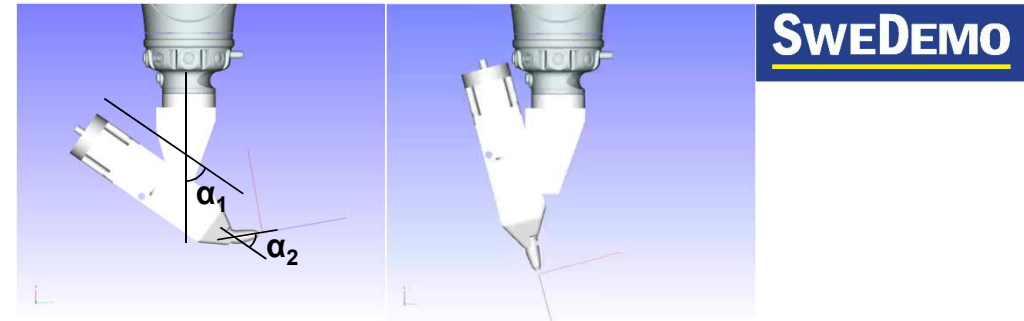


Automated reach study for 1000 design candidates



OPTIMIZING OF SEALING GUN

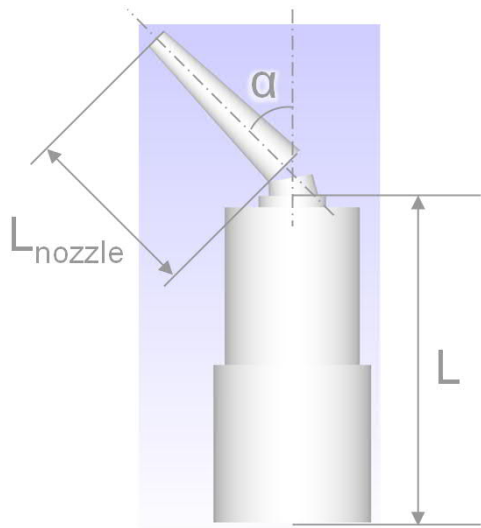
- Output from automated reach study



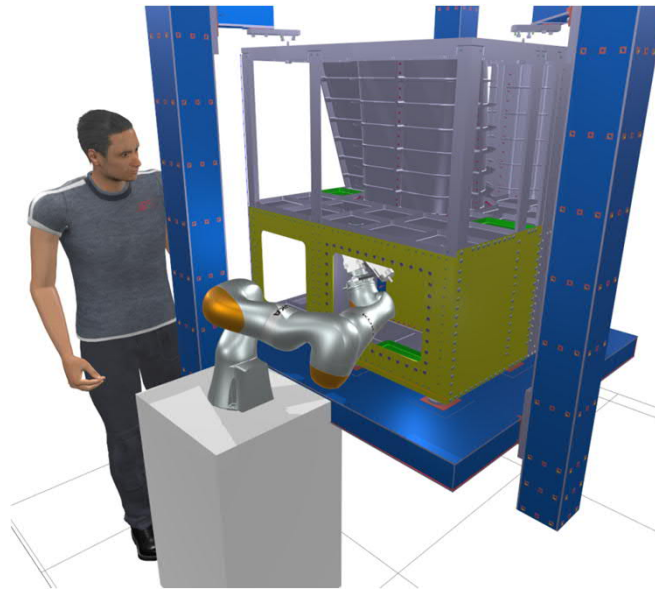
Most reached positions for $\alpha_1 + \alpha_2 \approx 35^\circ$

FRAUNHOFER-CHALMERS CENTRE

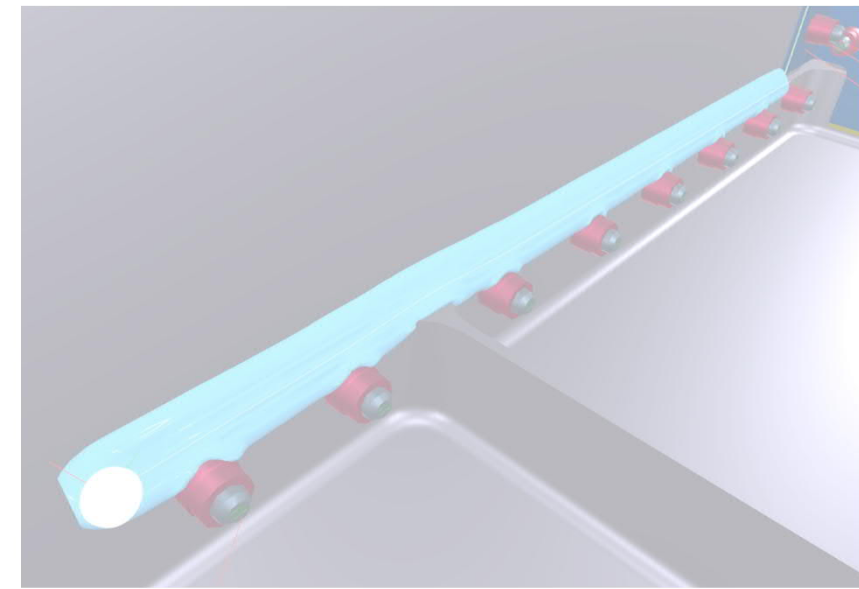
Optimizing of sealing gun



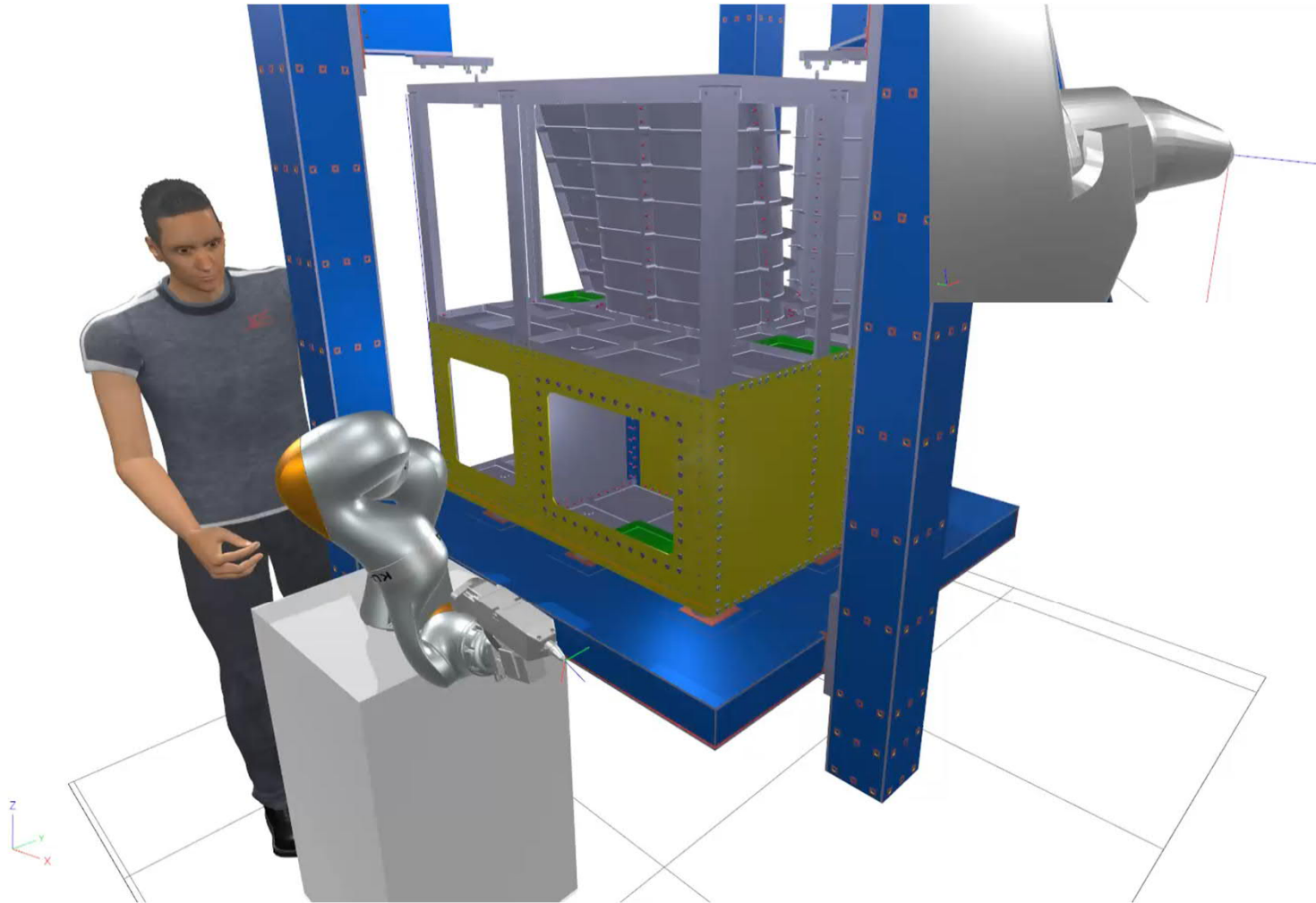
Automated path planning



Simulation of sealant application

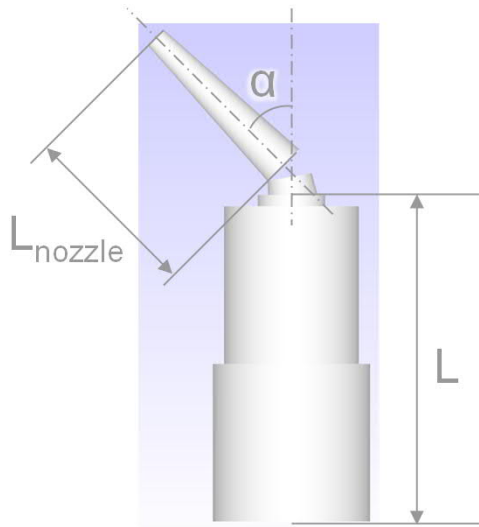


AUTOMATED PATH PLANNING - FILLET SEALING

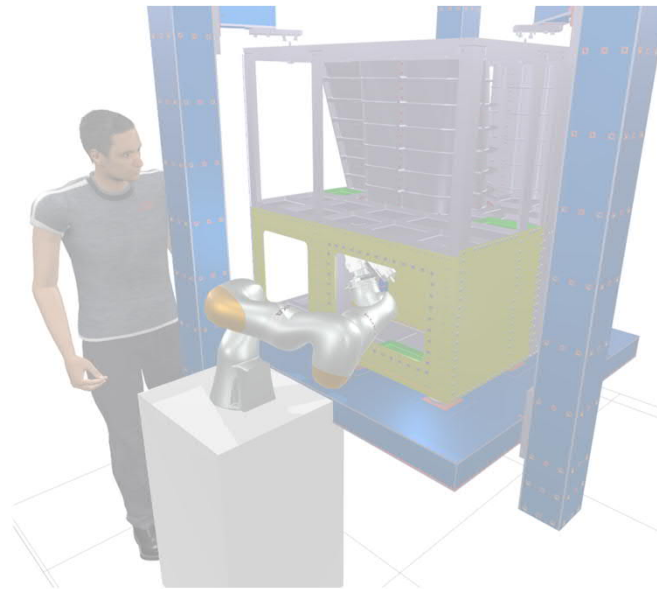


FRAUNHOFER-CHALMERS CENTRE

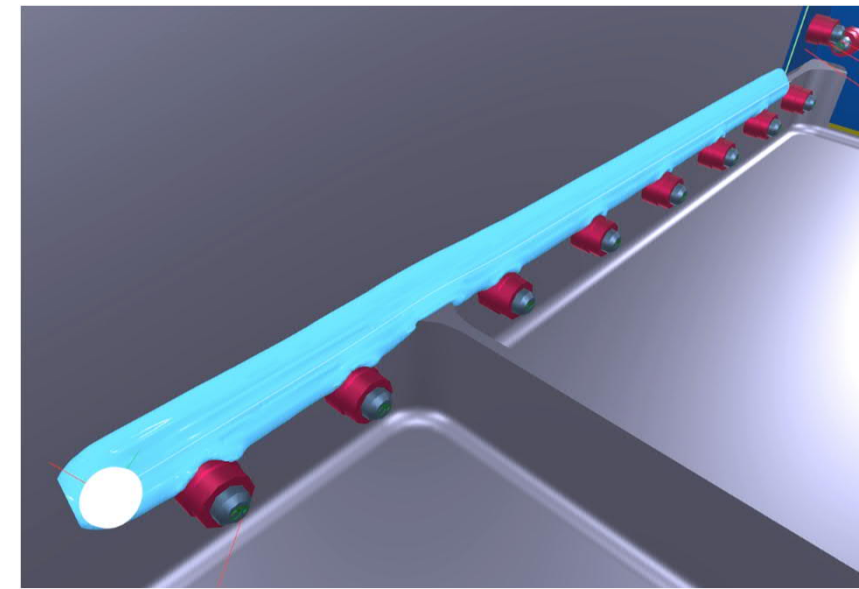
Optimering av verktygsdesign



Automatisk banplanering



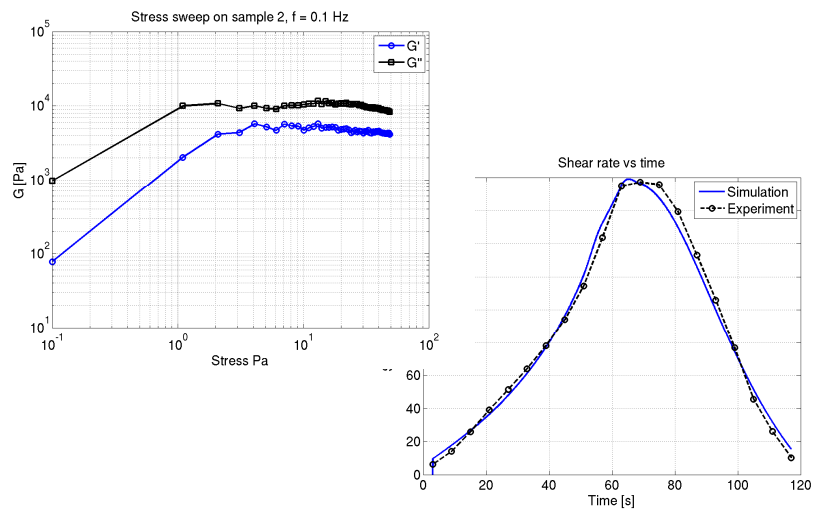
Simulation of sealant application



RHEOLOGY MODELING AND OCH SIMULATION

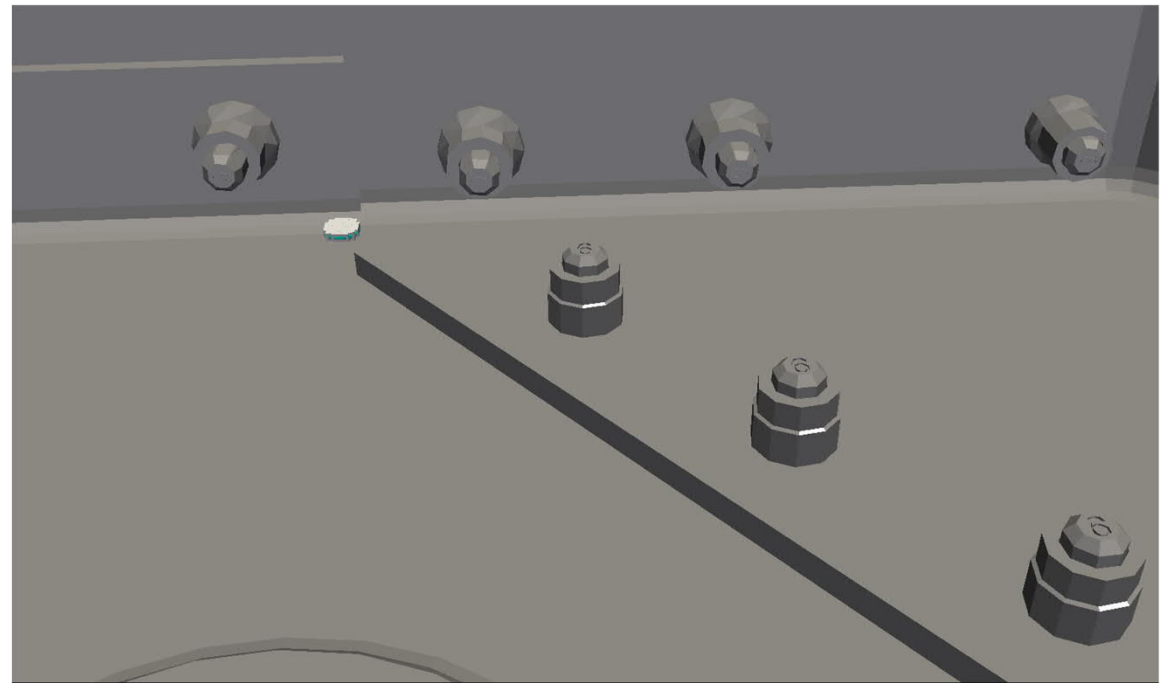
Rheology

- Material behavior characterization
- Study of rheology properties
- Choice of rheology model



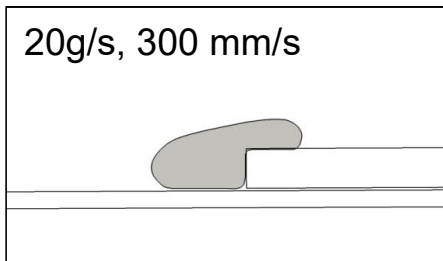
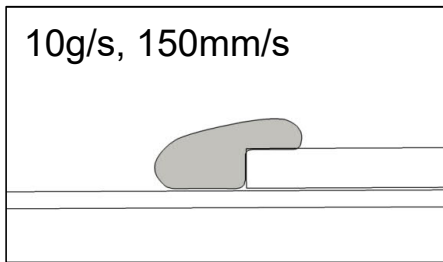
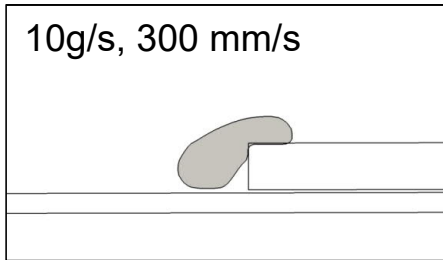
$$\lambda \frac{\nabla \tau}{\tau} + F(\tau)\tau = 2\eta S$$

Simulation



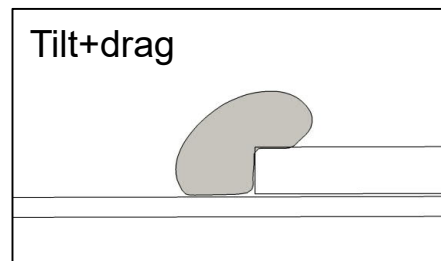
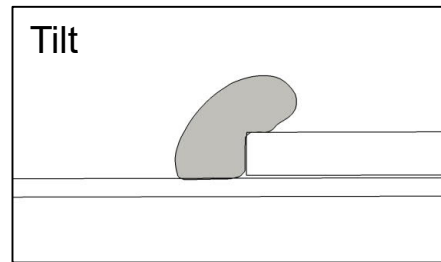
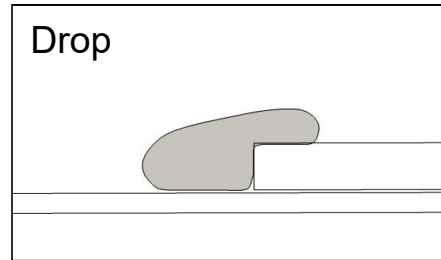
SIMULATION BASED PARAMETER STUDIES

Flow and speed



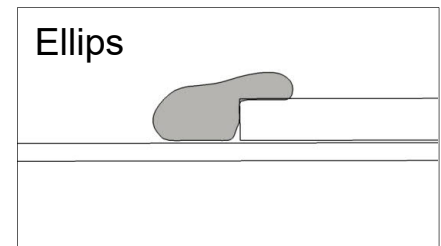
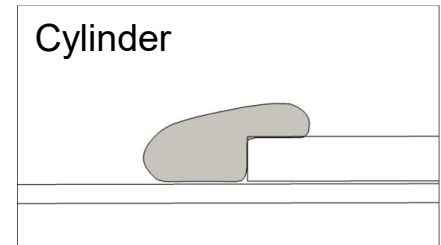
Same
volume flow

Application angle



Same
shape

Nozzle geometry



FILM FROM DEMO

<https://youtu.be/3gGNnL7-nW8>

TECHNICAL RESULTS

- Achieved in SWEDemo WP 2.1
 - We have in lab environment proved that automated sealing is possible
 - We have developed a working prototype with a simple control system
 - We have developed nozzles for fillet sealing and fastener sealing
 - We have simulated both sealing application process and geometrical reach in a test structure
 - We have made offline robot programs with IPS
 - We have studied collaboration between human and robot
 - TRL 5 at demo day 23rd of May 2018

SWEDEMO

