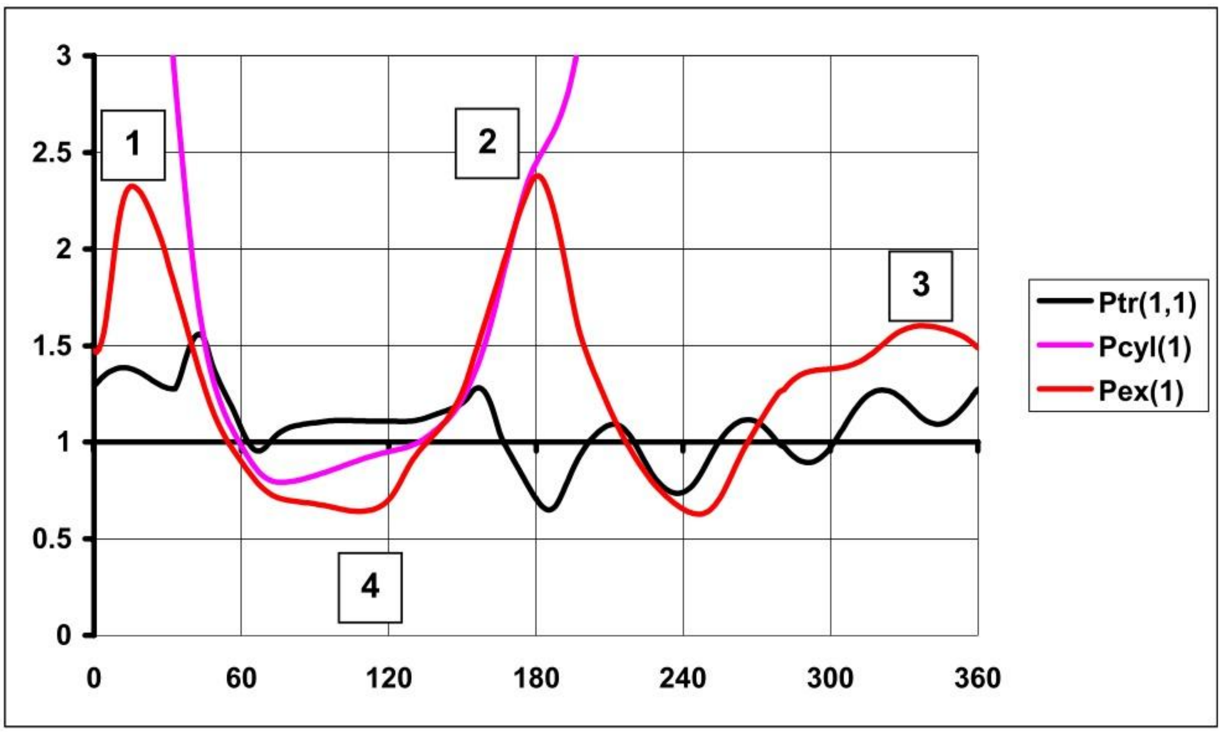
High Power Two Stroke Design – Postscript

After reading the previous articles in this series, it's easy to get lost in all the details. Below are excerpts from two papers that summarize what we are trying to do with pipe and port design. The first is by Neels van Niekerk. The second is the only publically available computational flow dynamics (CFD) analysis I'm aware of for a high performance, tuned pipe engine.

Pipe Pulse Design



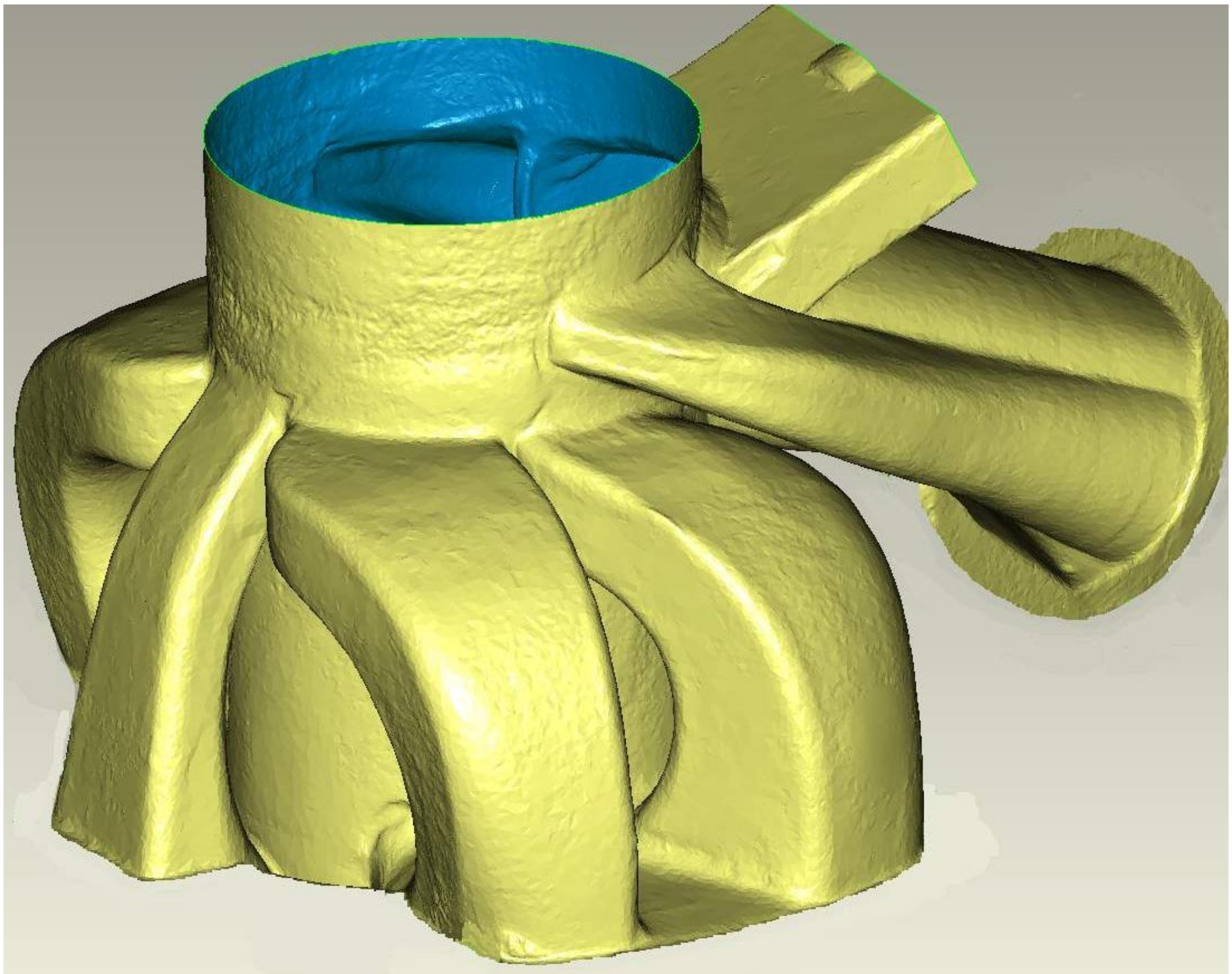
I think a successful design of a pipe combines the following:

- The obvious, that pressure pulse 1 must be reflected to arrive just before Ex-port closure 2
- There must be a suction pulse 4 during the transfer open period

The tricky bit in order to get really high suction and plugging pulse values, pressure pulse 2 which is reflected from the ex-port must again be reflected from the reverse cone to arrive just before Ex-port opening 3. This will then get reflected in back down the pipe and travel just in front of the new pulse 1, combining with it to increase its amplitude and thus the amplitude of the suction and plugging pulses.

This last point is only achievable with an Ex-port timing of roughly between 190 and 200 degrees which is why all GP-bikes use this value and use more and wider exhaust ports to obtain enough blowdown time area. With very small exhaust duration or very big exhaust duration this recombination is not possible as the timing is all wrong and only the classical pipe theory can be used.

Below is a picture of the Aprilia exhaust and transfer passages as an introduction to the next section.



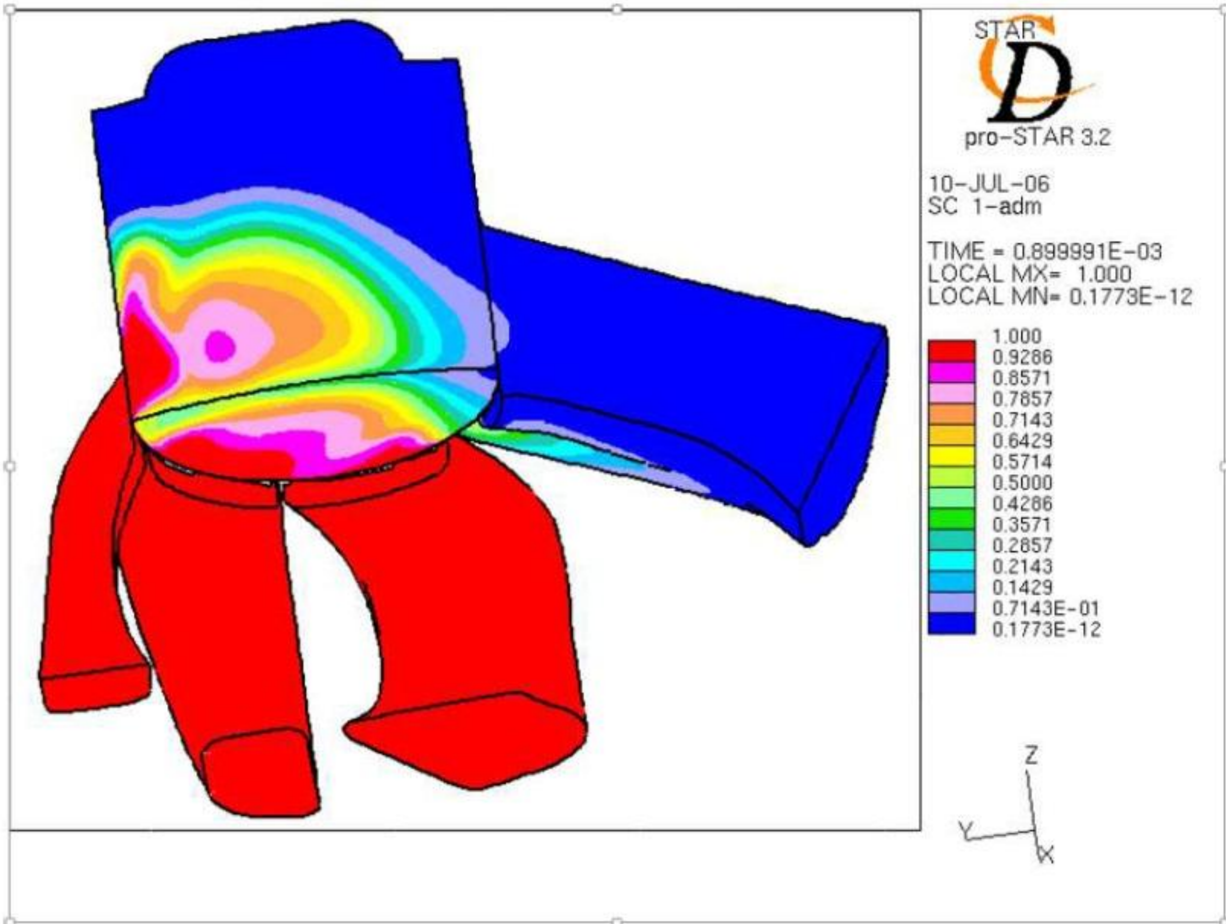
The following is an extract from the movie as shown by the PhD candidate VD Jimenez at CMT at the University of Valencia. It shows how the above pulses created by a tuned pipe influence the flows in the engine cylinder.

Notice how the red inflow from the transfers flows up the back wall of the cylinder and out the exhaust, pushing out the blue combustion products. This is encouraged by the low pressure pulse at 4 in the above picture. The high pressure pulse at 2 above then pushes the somewhat pure mixture in the pipe back into the cylinder. This is about as good as it gets in a two cycle. There are still some exhaust products in the cylinder at exhaust port closing, but the mixture is significantly supercharged. This engine develops 54 hp from a 125 cc cylinder. A 26 cc engine that was this highly developed would have around 11 hp at 13,000 rpm. Since the smaller engine could easily turn 18,000 rpm, you could expect over 15 hp.

Aprillia RSW125 Scavenging

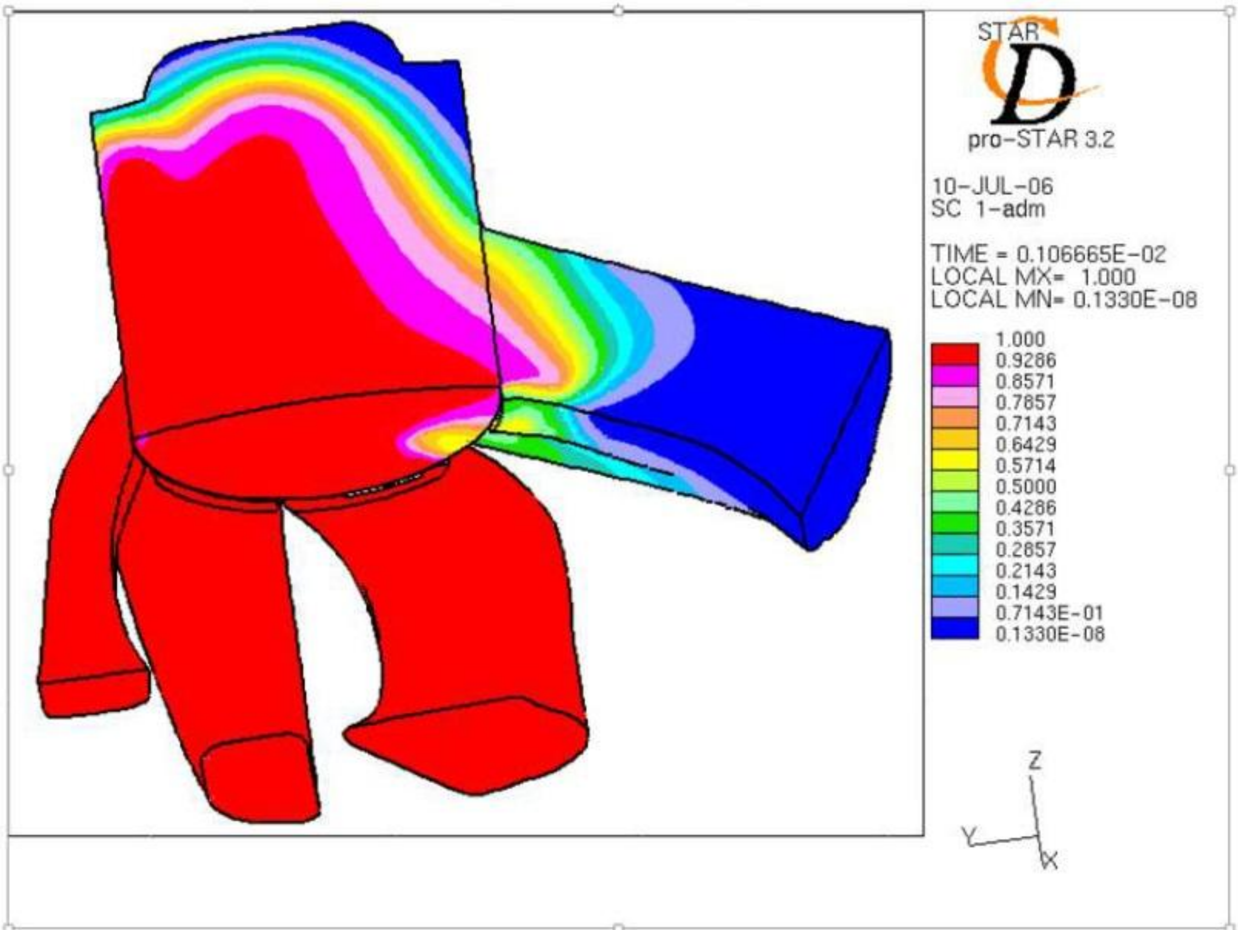
1. CMT own their own RSW125 and measured it fully to model in 1D and 3D
2. The rpm value working back from port duration and time seem to be around 12000.
3. Blue is burnt gas and red is fresh gas.
4. This is a single cycle event as it starts with uncontaminated charge in the transfer ports.
5. The interesting thing is how good the scavenging is; before the plugging pulse arrives the cylinder is close to a 100% scavenged. (fig 8)
6. The obvious next improvement would be to increase the delivery ratio to the point where the exhaust port is also filled with fresh charge so the plugging pulse is also fresh charge uncontaminated.
7. Not heating the fresh charge in the exhaust port duct should show the improvement as found by Jan Thiel.
8. It seems the shape and down angle of the Arillia port as developed by Jan Thiel on his flow bench not only promotes flow but also the lower turbulence tends to prevent mixing between the escaped fresh charge and the burnt gas.

59 degrees after exhaust port opening (transfer ports partly opened, blow down period has ended)

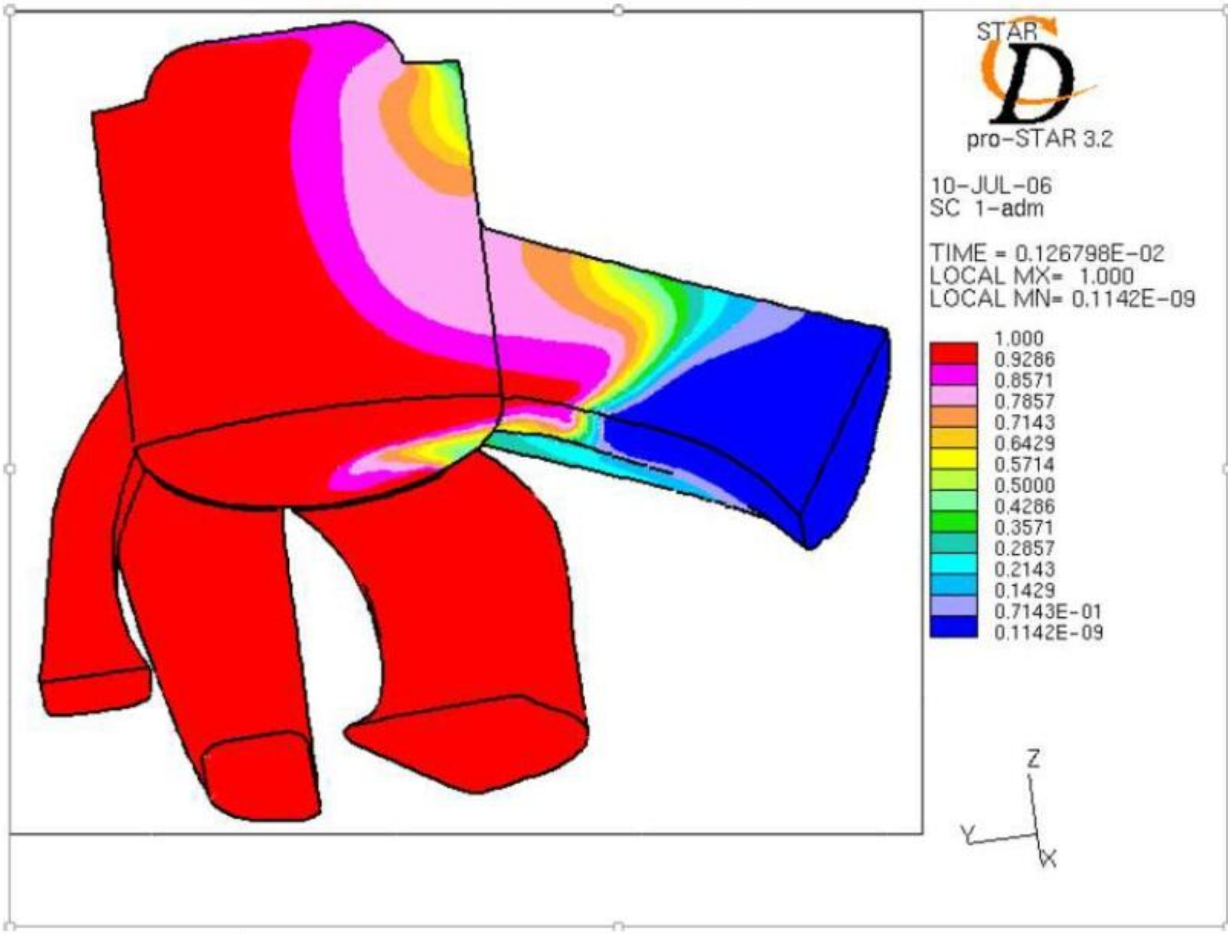


66 degrees after exhaust port opening

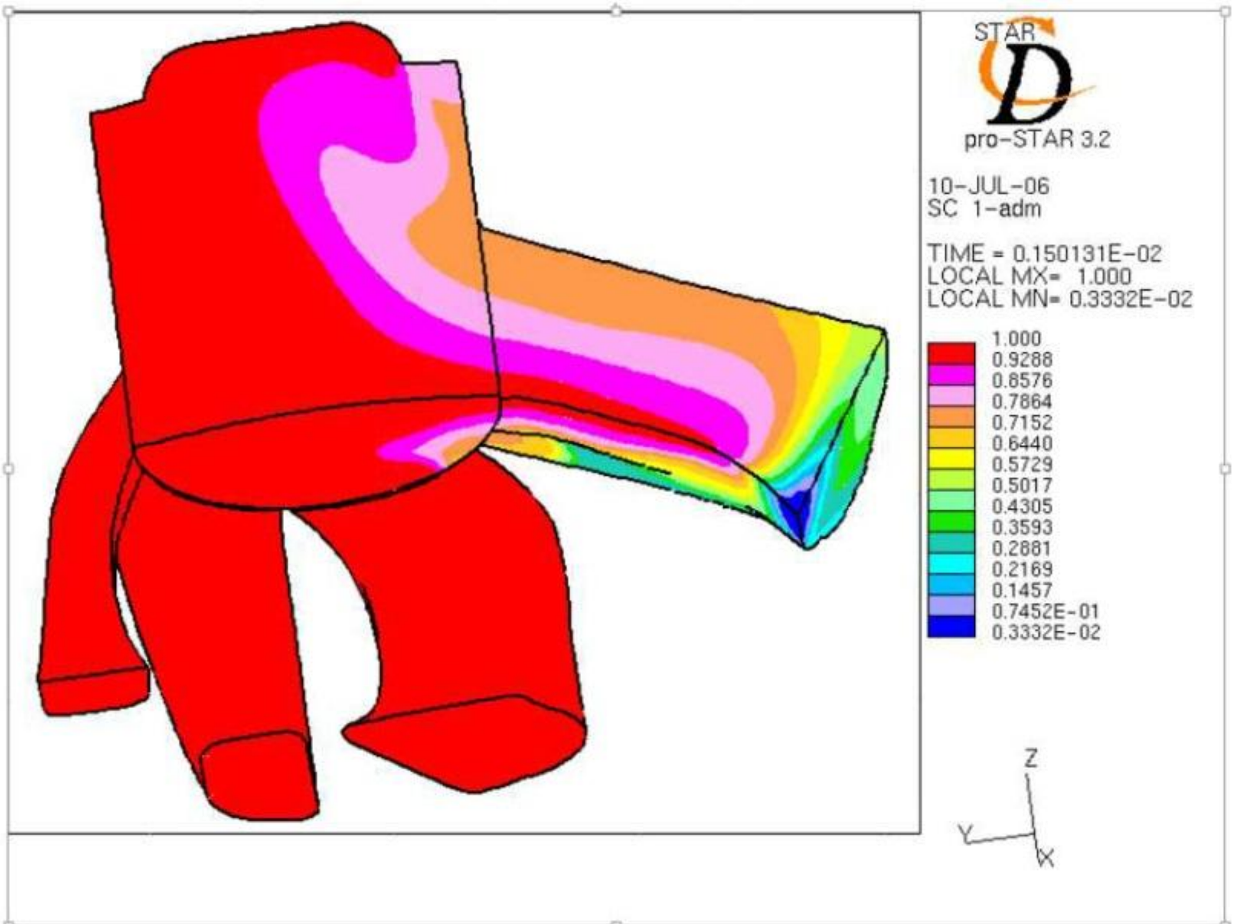
73 degrees after exhaust port opening



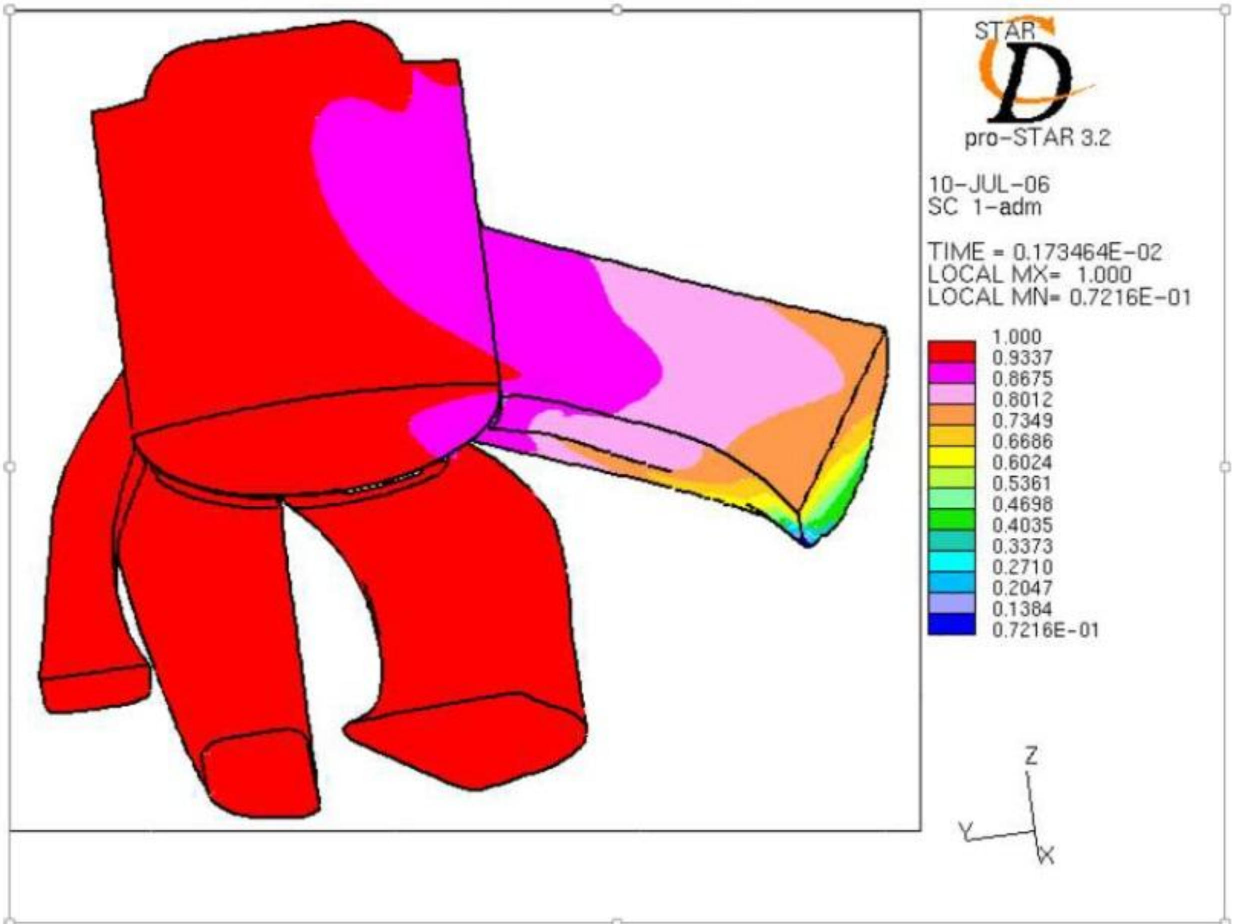
78 degrees after exhaust port opening



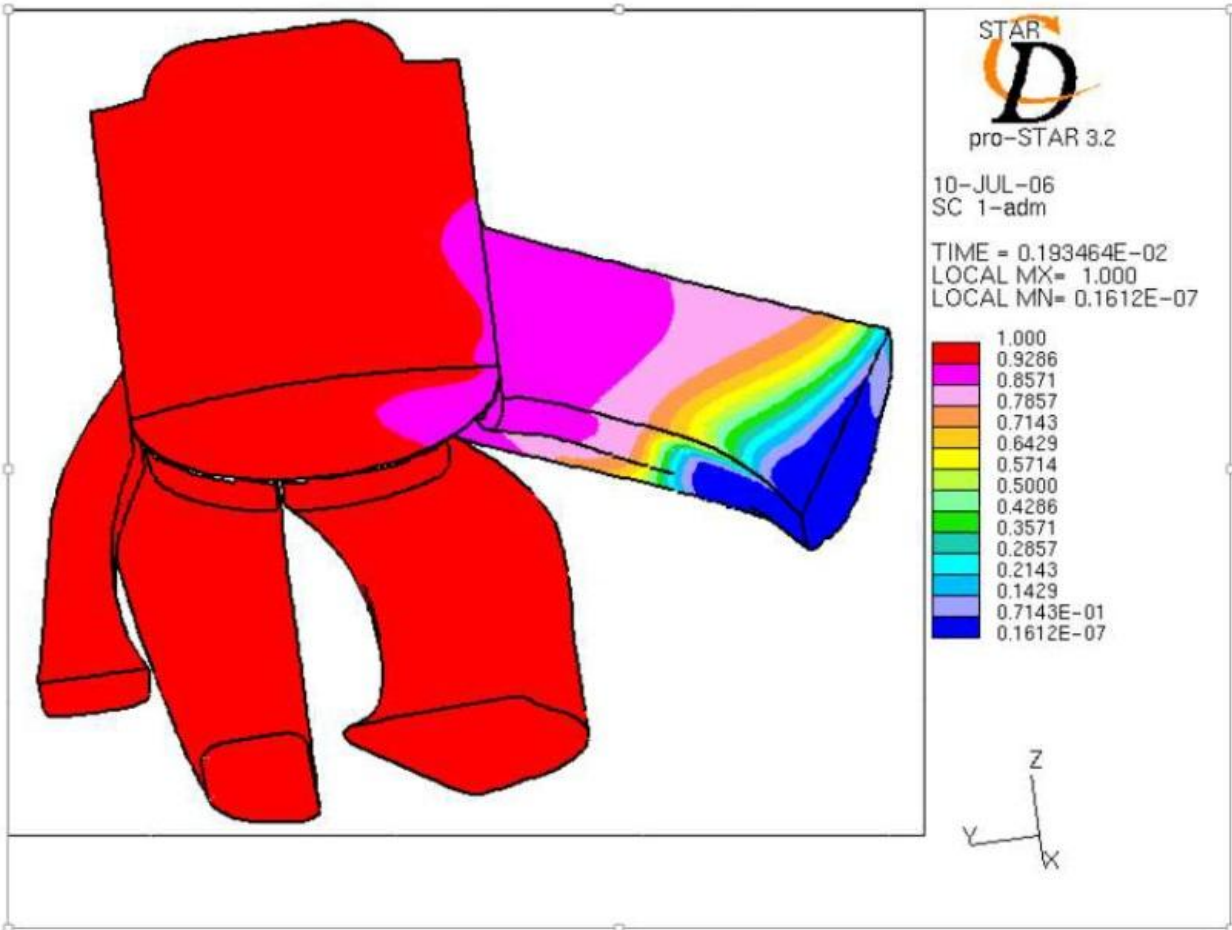
93 degrees after exhaust port opening (low pressure at the exhaust port, area 4 in the graph)



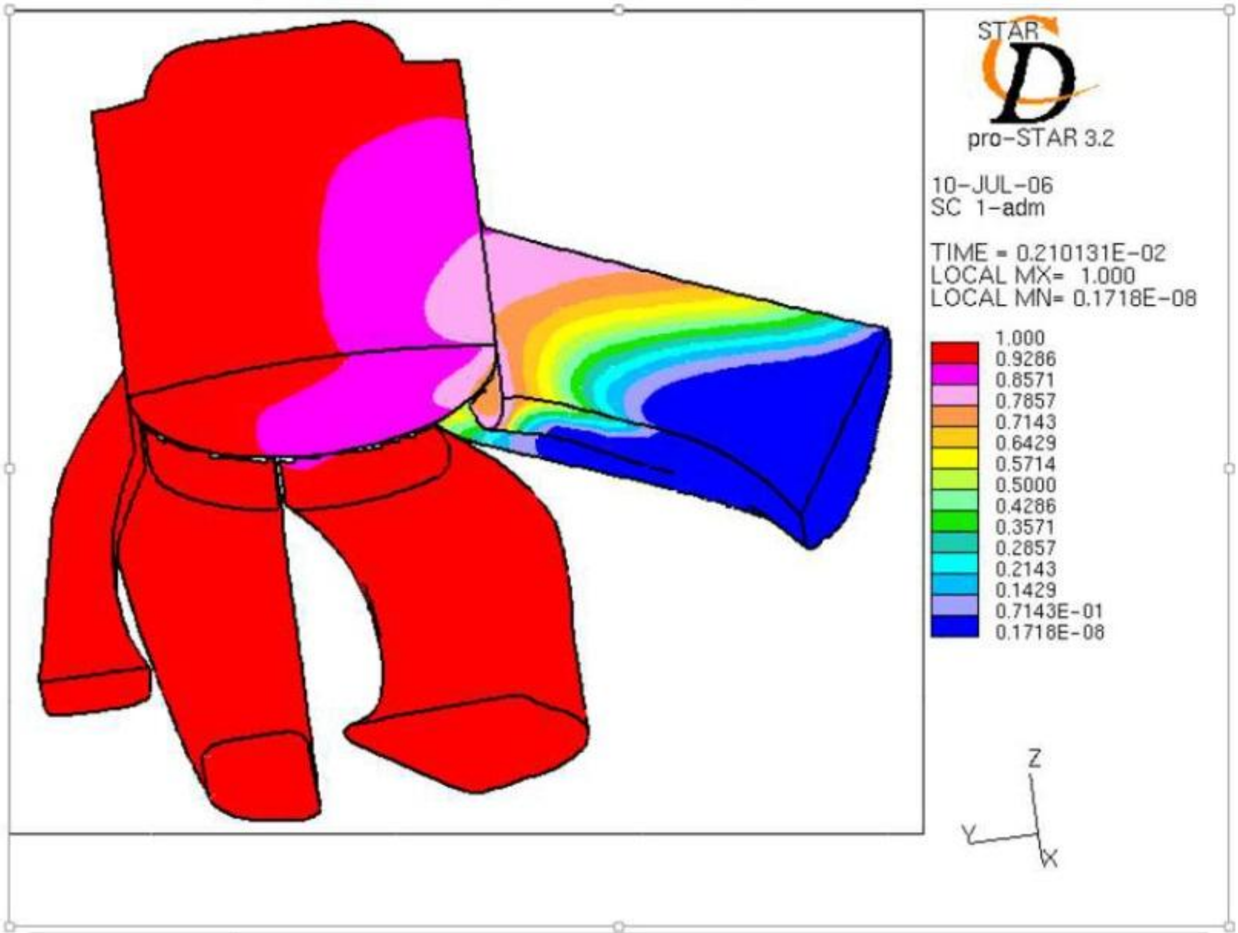
110 degrees after exhaust port opening



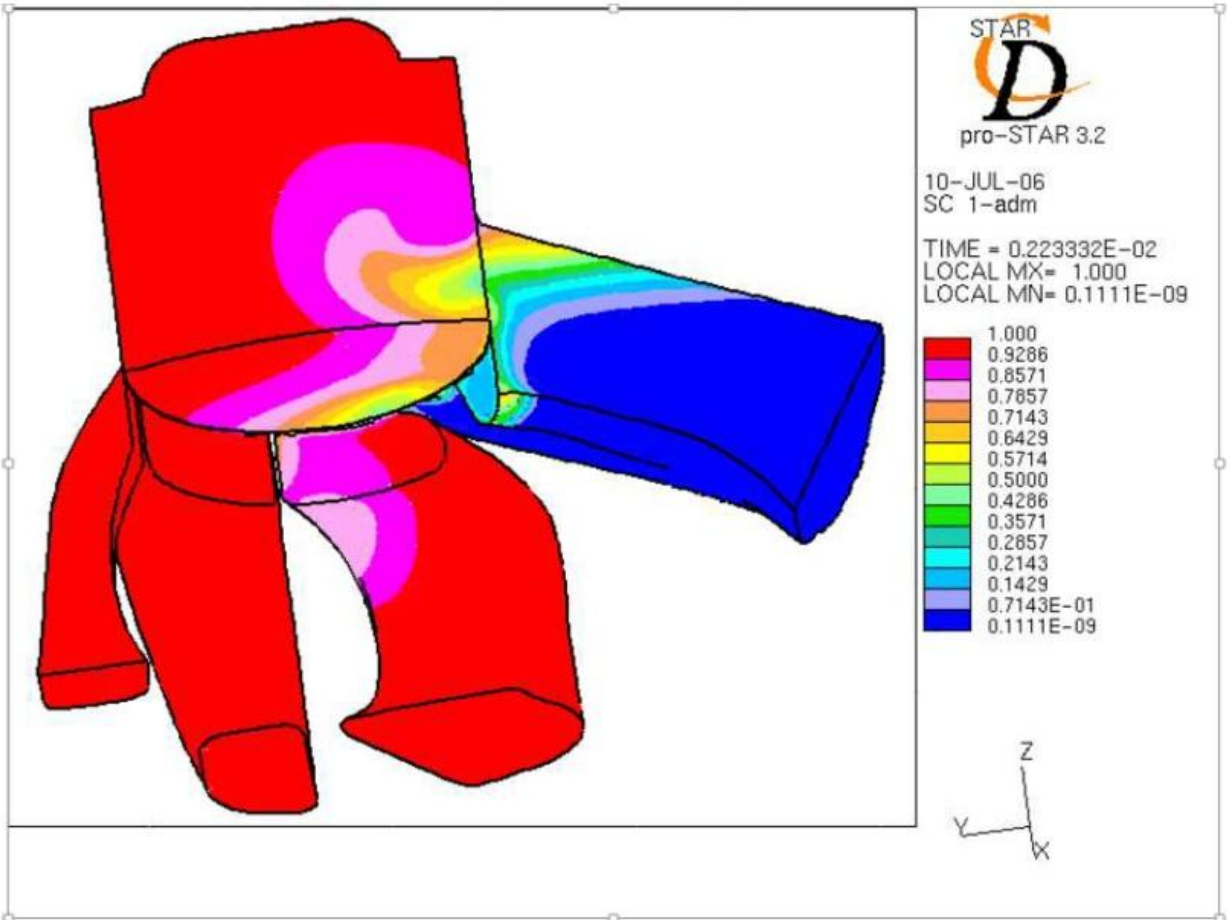
127 degrees after exhaust port opening



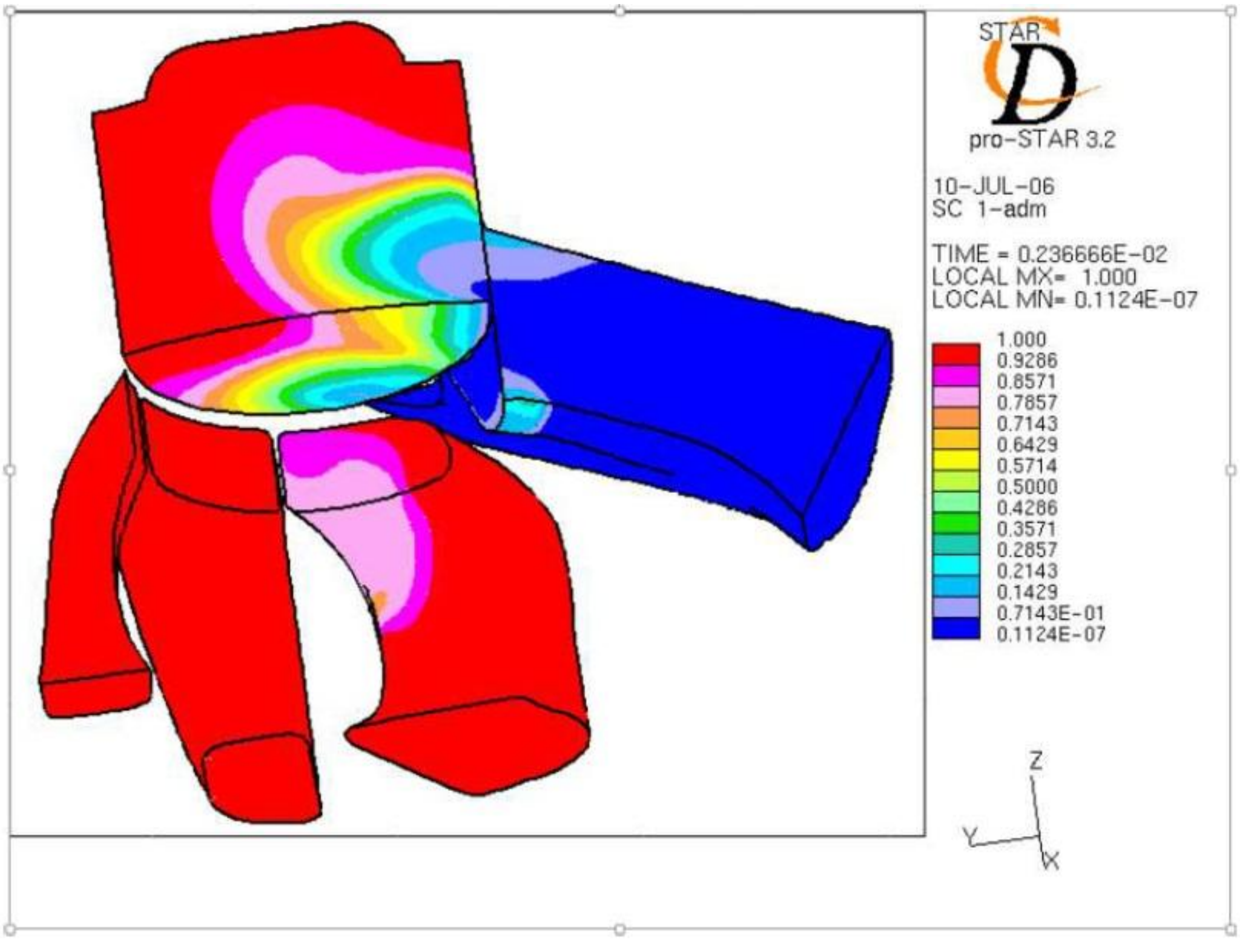
141 degrees after exhaust port opening



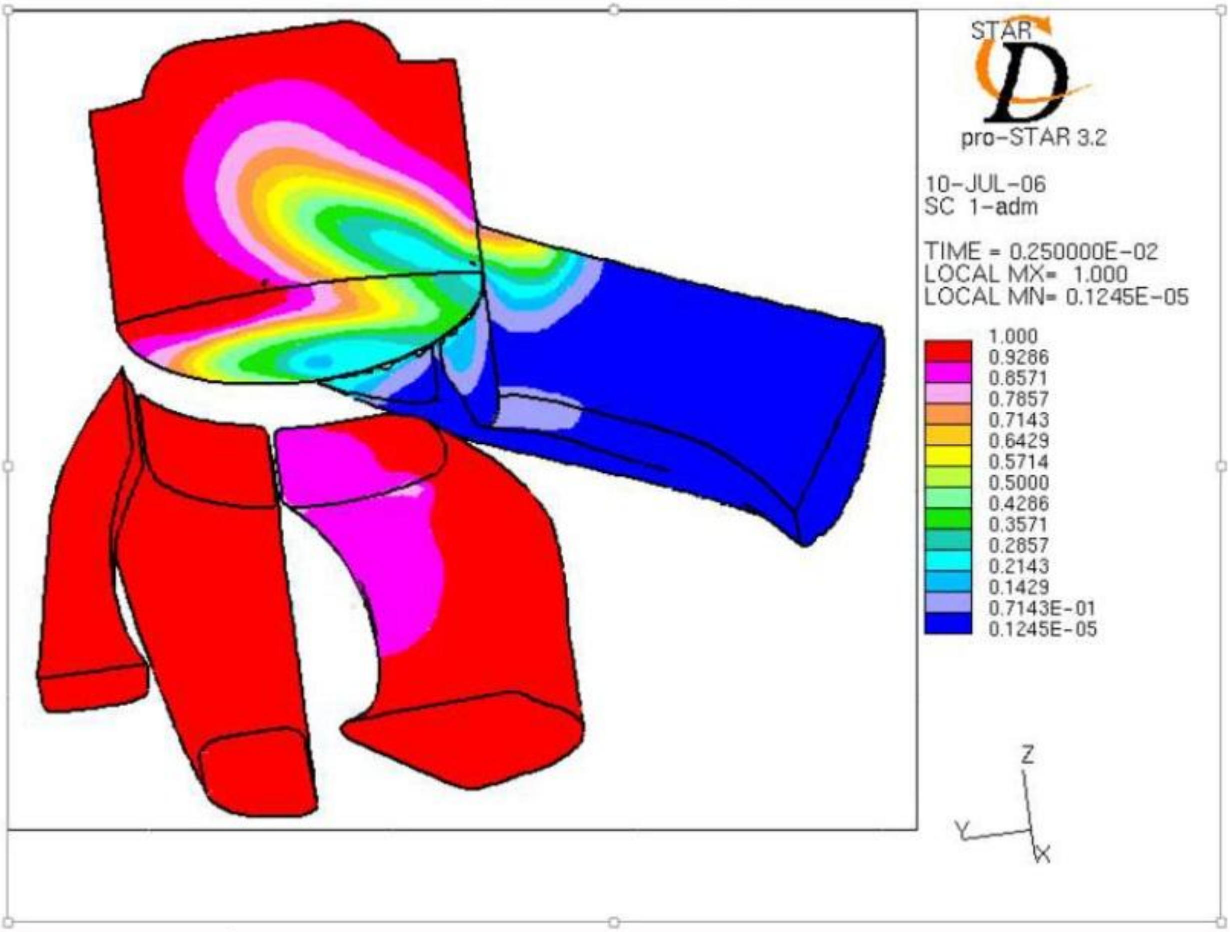
154 degrees after exhaust port opening



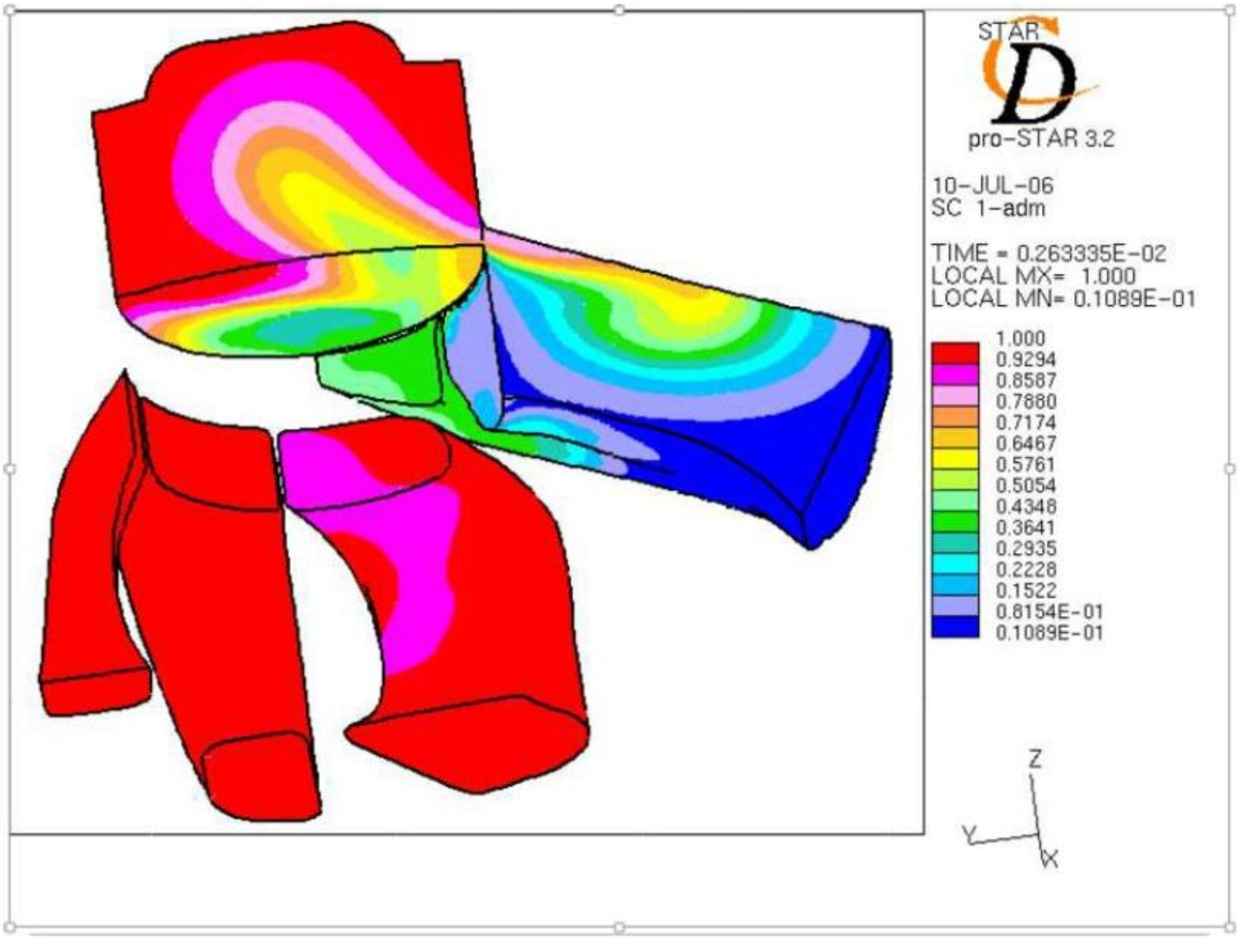
163 degrees after exhaust port opening (transfer ports closed, area 2 in the graph)



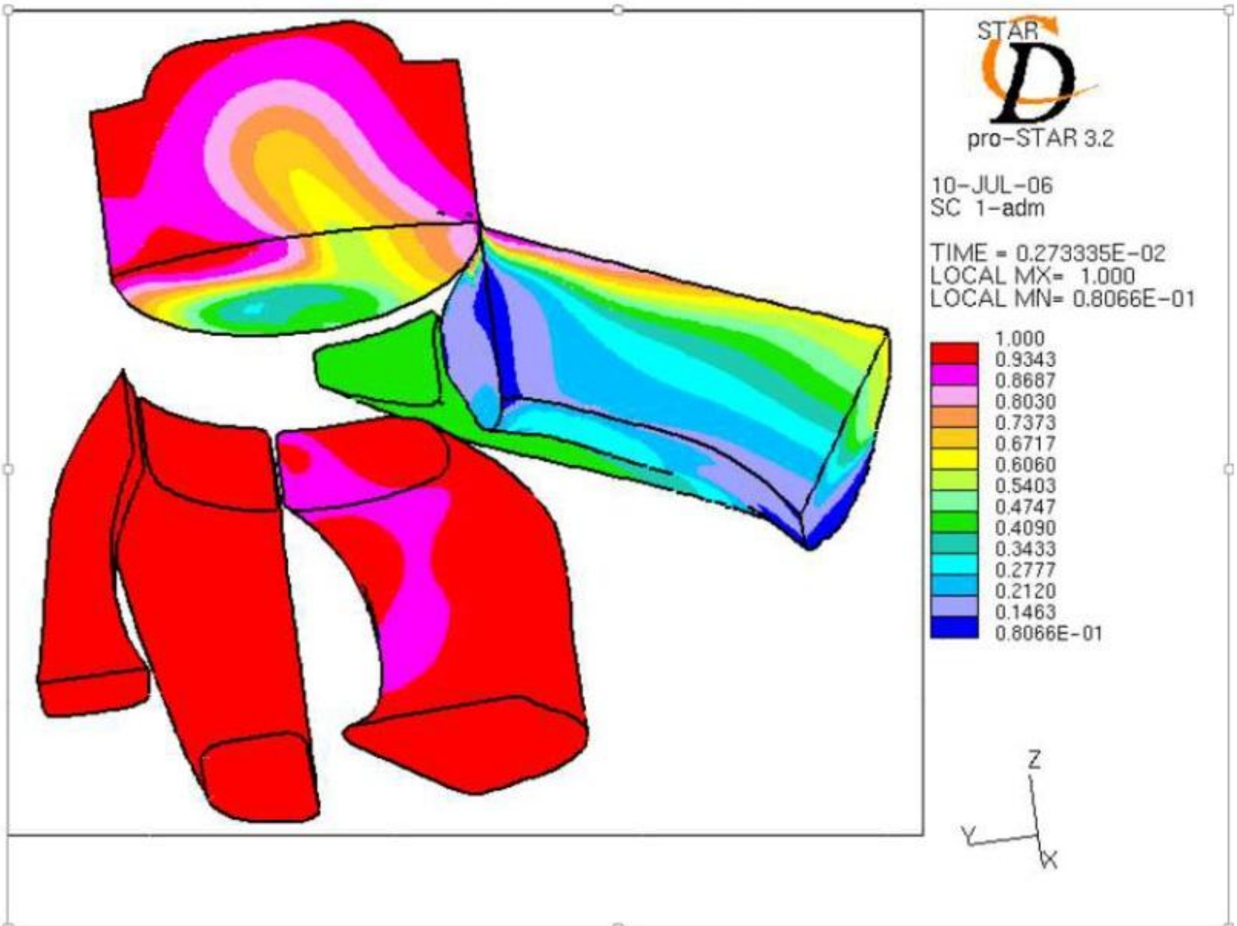
173 degrees after exhaust port opening



183 degrees after exhaust port opening



193 degrees after exhaust port opening (auxiliary exhaust ports closed)



200 degrees after exhaust port opening (main exhaust port closed)