Thermo-fluid Numerical Simulation of the Crotch Absorbers' Cooling Pinholes for ALBA Storage Ring

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Abstract

The ALBA Synchrotron Light Facility crotch absorbers, that remove the unused storage ring radiation, incorporate an internal cooling system composed by a number of parallel pinholes and by the corresponding stainless steel inner tubes inserted into each of them. Water flows in the resulting annular sections to evacuate the total heat power. Around each inner tube, a spiral wire is fixed along the whole length with a given pitch height in order to enhance the convection heat transfer. The influence of several design parameters on the absorber thermo-fluid behavior has been evaluated by means of the CFD soft-ware ANSYS CFX®. In particular, the wall heat transfer coefficients, *h*, and the pressure losses, ΔP, through a single pinhole have been evaluated for a range of different flow rates and pitch heights. Moreover, some modifications of the end wall geometry have been simulated as well as the effect of reversing the flow direction inside the channels. Finally, the critical crotch absorber type 3 has also been simulated and the limiting pitch height-flow rate combinations have been found based on the available driving pressure of the cooling system.

Crotch Absorbers' Cooling Pinholes

Most of the synchrotron radiation generated by the bending magnets in the Storage Ring (around 95%) is absorbed in the crotch absorbers. For the critical crotch absorbers the maximum thermal power to dissipate is about 6.78 kW. For cooling by convective heat transfer, a 23 °C water flow circulates inside the absorber through a series of pinholes (see Figure 1). The effects of various design parameters on the performance of a single pinhole have been simulated such as the spiral wire pitch height, the flow rate, the direction of the flow and the end wall geometry.

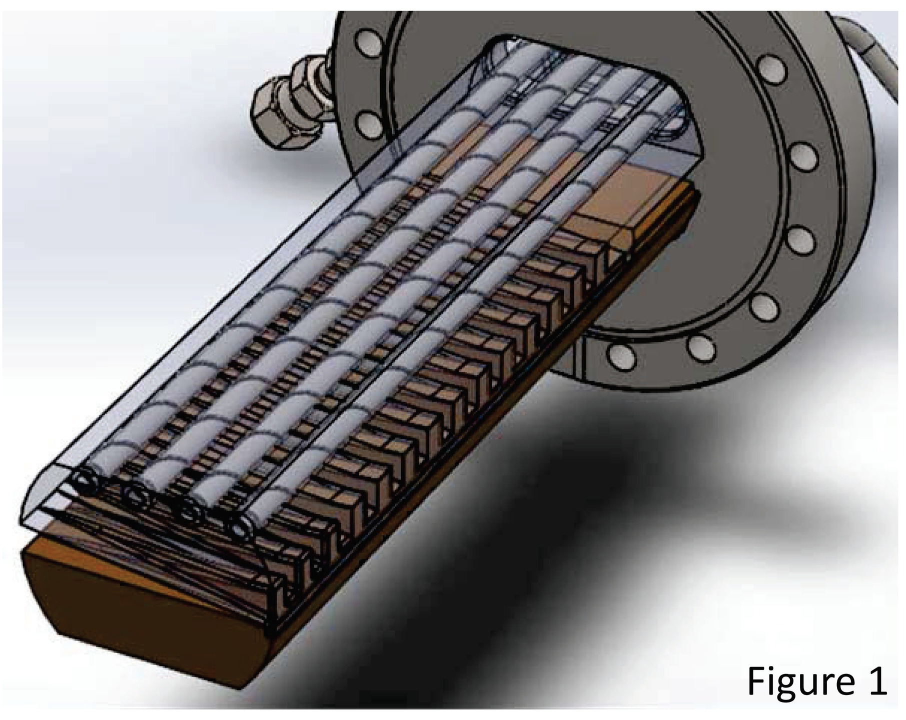


Figure 1

A detail of the spiral wire at the pinhole end wall and the two possible flow directions, forward and reverse, are presented in Figure 2. The simulation results indicate that the strongest flow perturbations and maximum velocities are found at the end of the pinhole (see Figure 3).

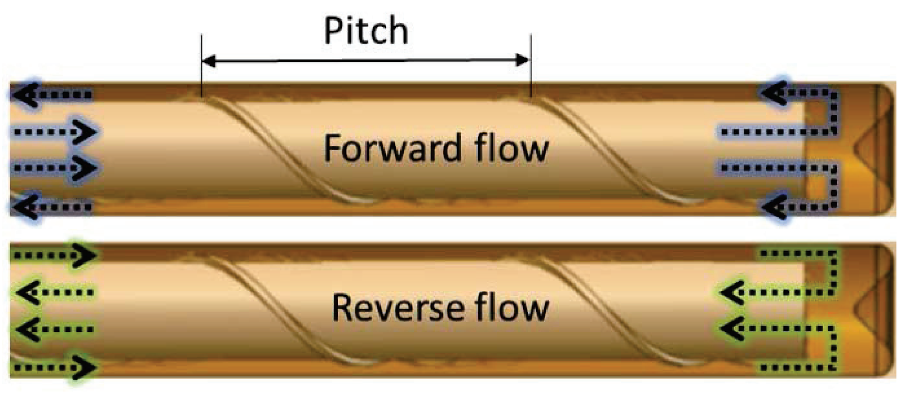


Figure 2

CFD Model

A mesh of about 1.5 M elements with good quality has been used for modelling a single pinhole. The total thermal load has been uniformly distributed along the contact wall surface with the fluid. At the inlet, the mass flow rate has been imposed ranging from 0.03 to 0.09 kg/s. At the outlet, the boundary condition has been set constant to a relative pressure of 0 Pa. The flow streamlines inside the pinhole for a reverse flow rate of 0.06 kg/s and a pitch height of 0.03 m are plotted in figure 3.

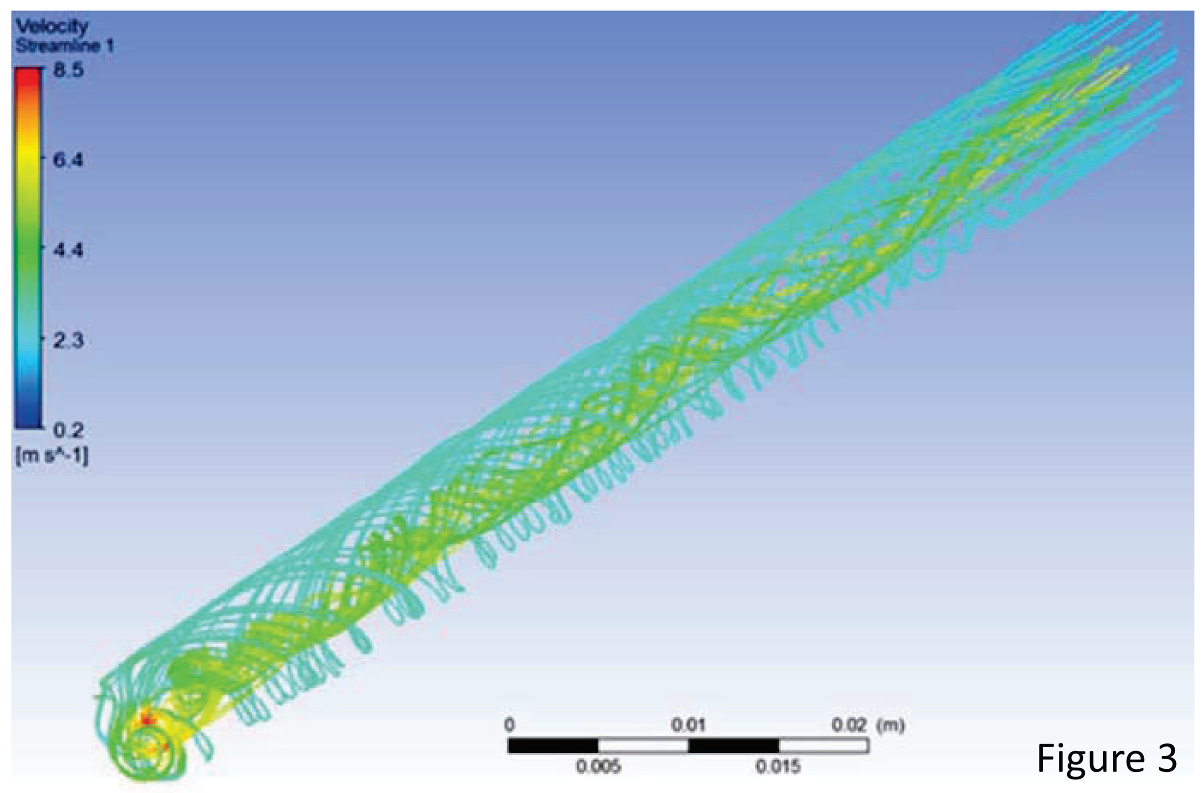
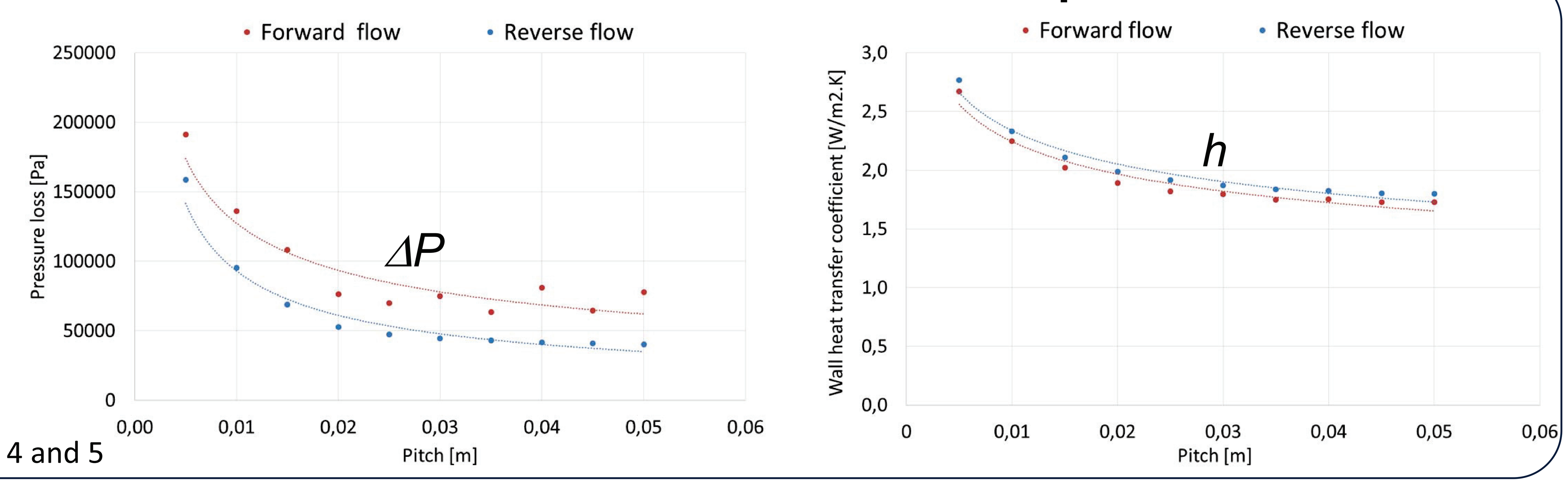


Figure 3

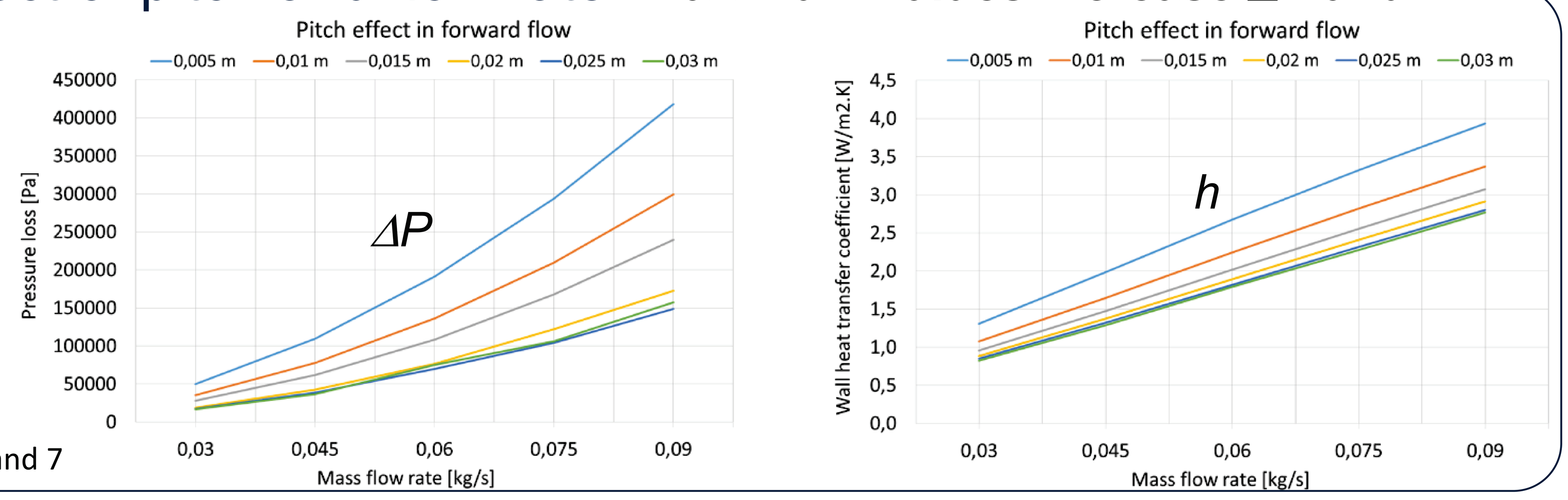
Simulation Results for Single Pinhole

- Effect of flow direction: **reverse flow has better performance**



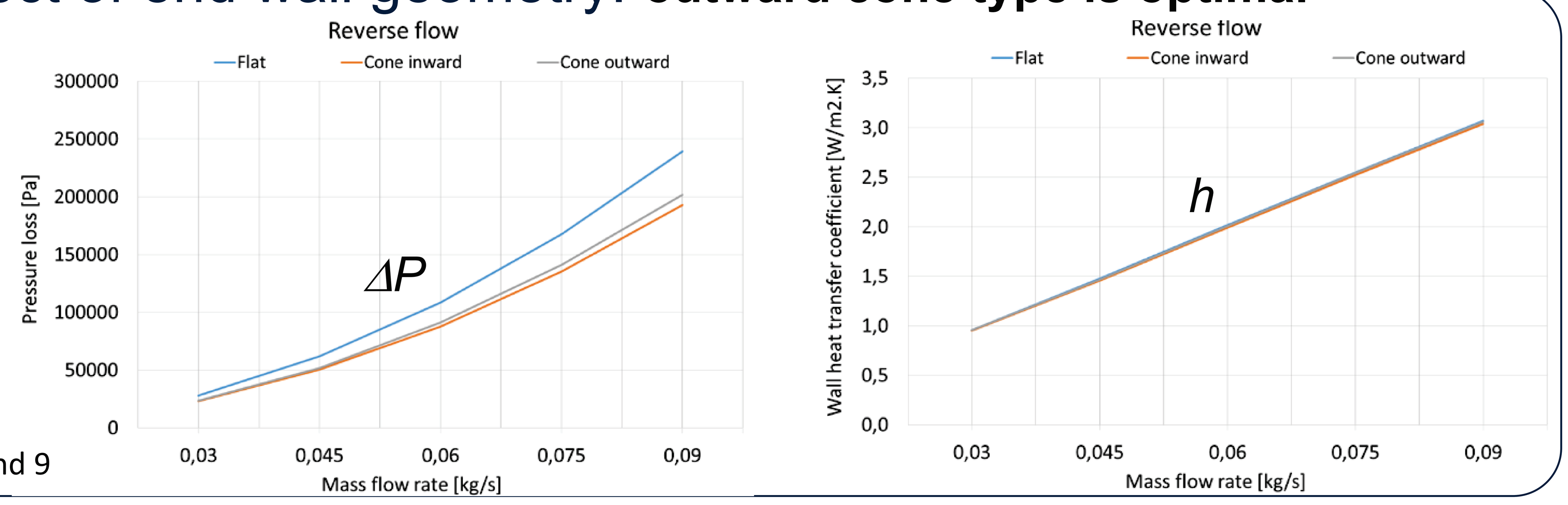
Figures 4 and 5

- Effect of pitch and flow rate: **maximum values increase ΔP and *h***



Figures 6 and 7

- Effect of end wall geometry: **outward cone type is optimal**



Figures 8 and 9

Simulation Results for Crotch Absorber Type 3

The wall temperature distribution indicates that maximum levels are found at the end walls of two pinholes located on the left (see Figure 10).

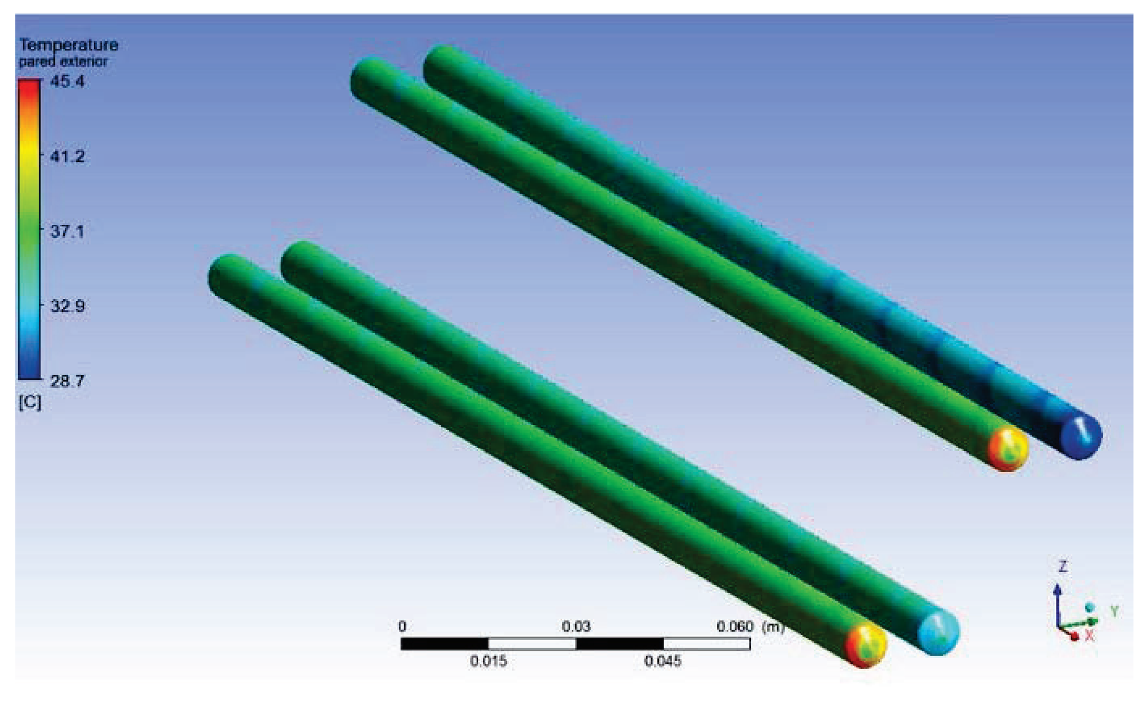


Figure 10

Pressure losses as a function of mass flow rate for different pitch heights are shown in Figure 11. Red area conditions are not possible due to insufficient driving pressure.

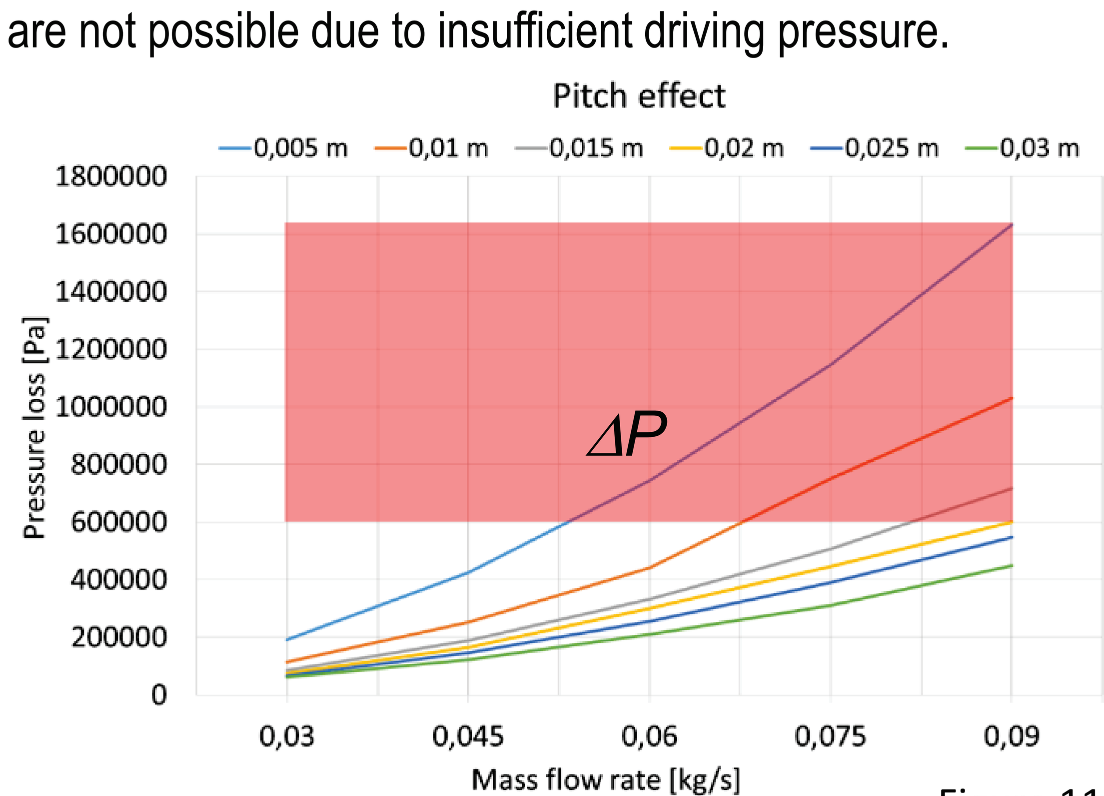


Figure 11