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# YOOMI – DEVELOPMENT OF SELF-HEATING BABY BOTTLE

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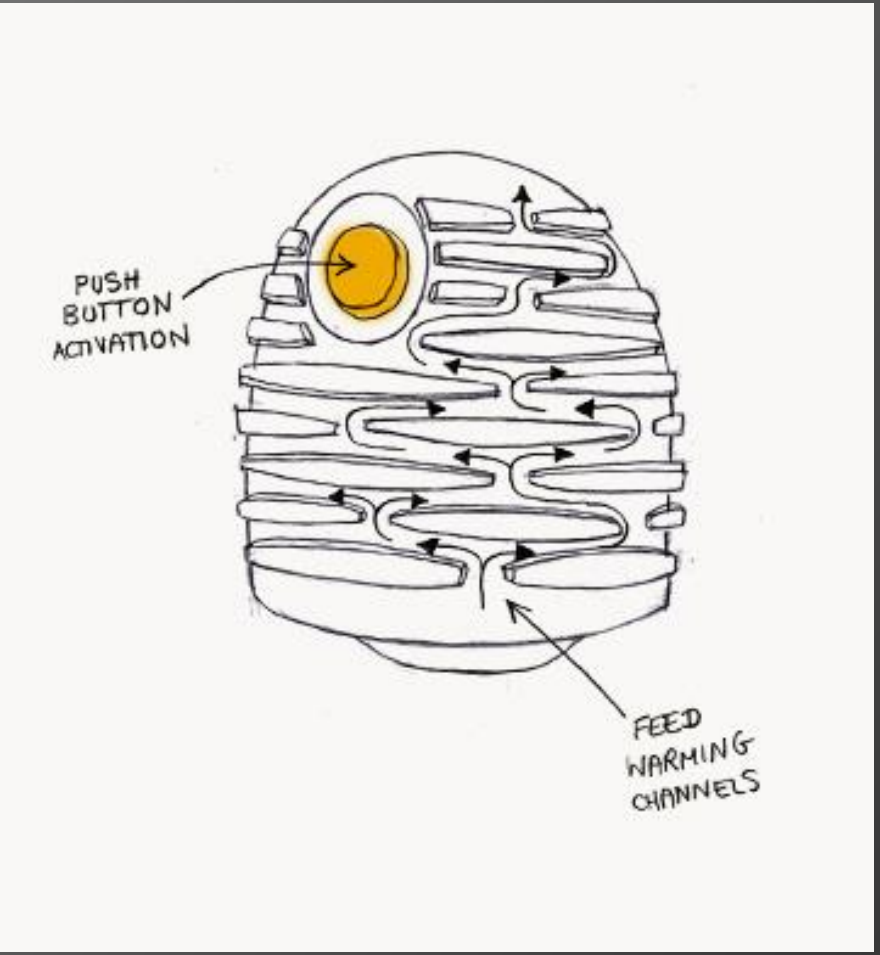
# yoomi - CFD in product development


yoomi - rechargeable, self-warming baby bottle warms baby's feed to the natural temperature of breast milk (www.yoomi.com)

- developed by Intelligent Fluid Solutions Ltd between 2007 and 2009
- manufactured by Feed Me Bottles Ltd
- entered the UK market in November 2009

# yoomi - CFD in product development




- Subcooled nature of sodium acetate mixture
- Mixture inside a warming unit with channels for the milk flow
- Solidification process releases latent heat
- Milk heated to the correct temperature - above 32$^{o}$C
- Warmer recharge in boiling water, a steam sterilizer or with microwaving

# yoomi - CFD in product development

Aspects of the design and overall warmer performance:

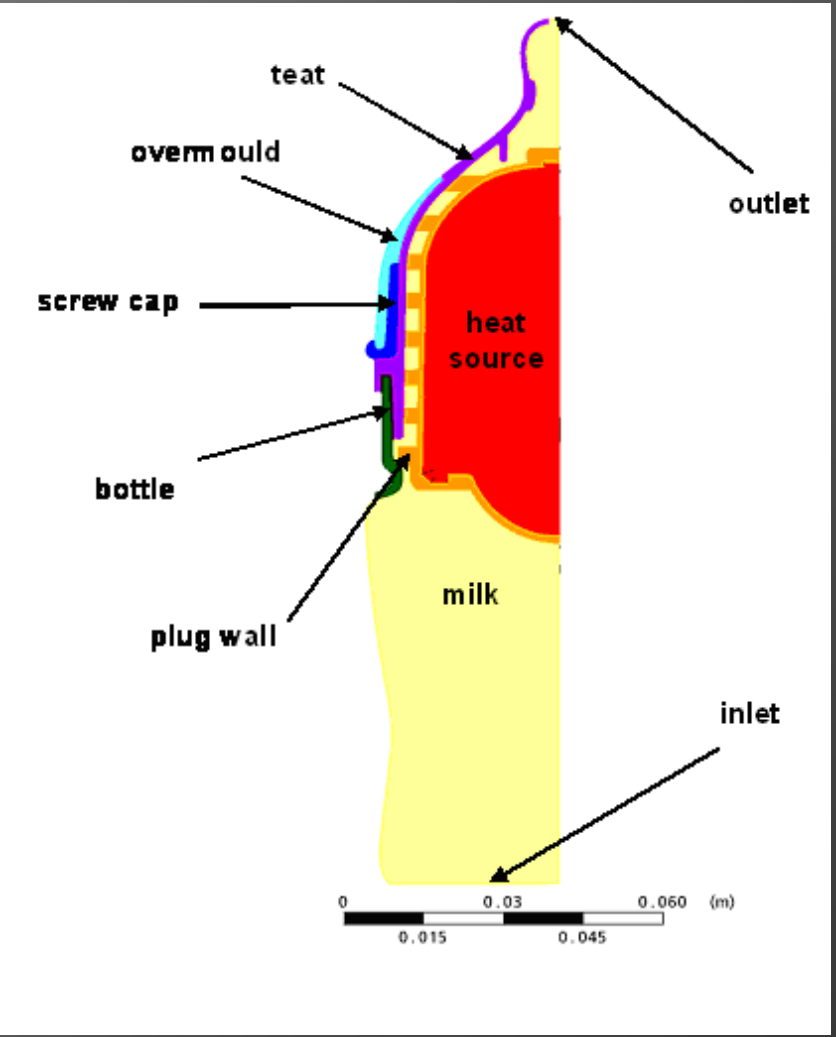
- pressure drop in the feed flow
- feed temperature at the first drop (200 ml/min)
- feed temperature at the steady drinking speed (20 ml/min)

# yoomi - CFD in product development

Technical challenge - designing a warmer to heat the milk (5 to 32°C) for the first drop flow rate and to maintain steady-flow conditions

- initially sluggish milk flow with the milk first drop temperature of just 17°C
- utilisation of CFD modelling techniques to improve the design, reduce the development time and costs
- ANSYS simulation software

# yoomi - CFD in product development

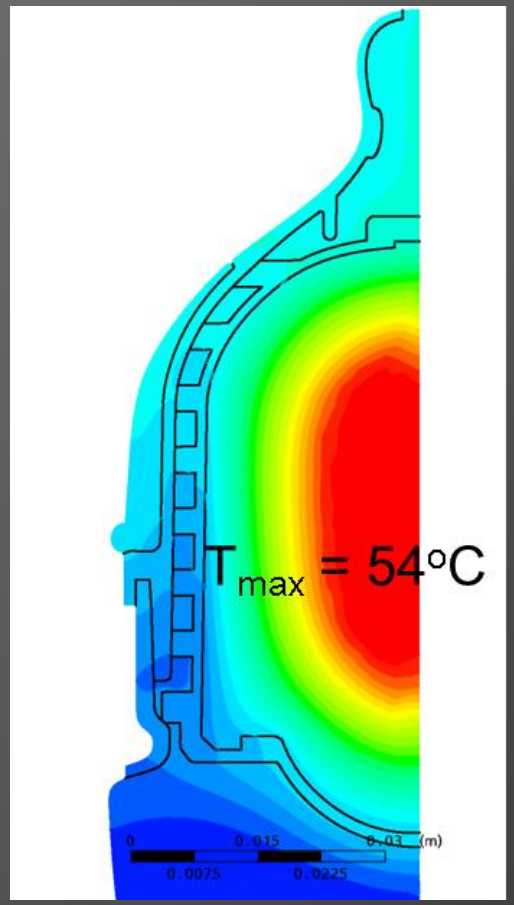


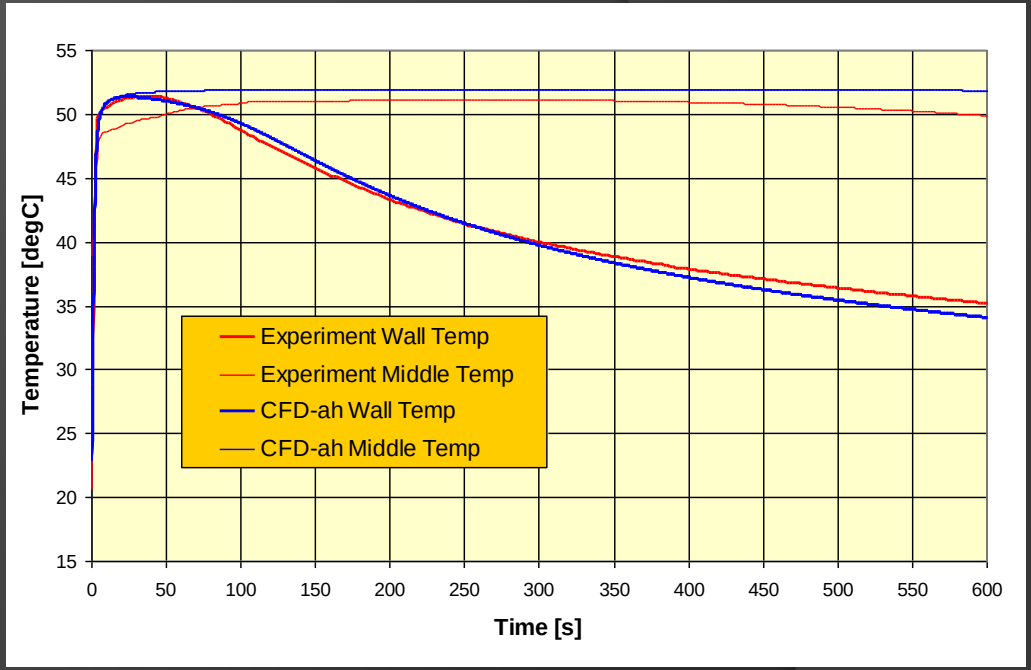

Modelling fluid and heat flow in such device is challenging:

- laminar flow of milk
- air flow in the opposite direction
- solidification process and heat generation
- thermal material properties of solid parts
- heat transfer (convection & conduction)
- flow stability

# yoomi - CFD in product development

Modelling of the solidification process of the sodium acetate mixture




- Speed of the solidification reaction limited only by the mixture temperature
- Development and calibration of the reaction model

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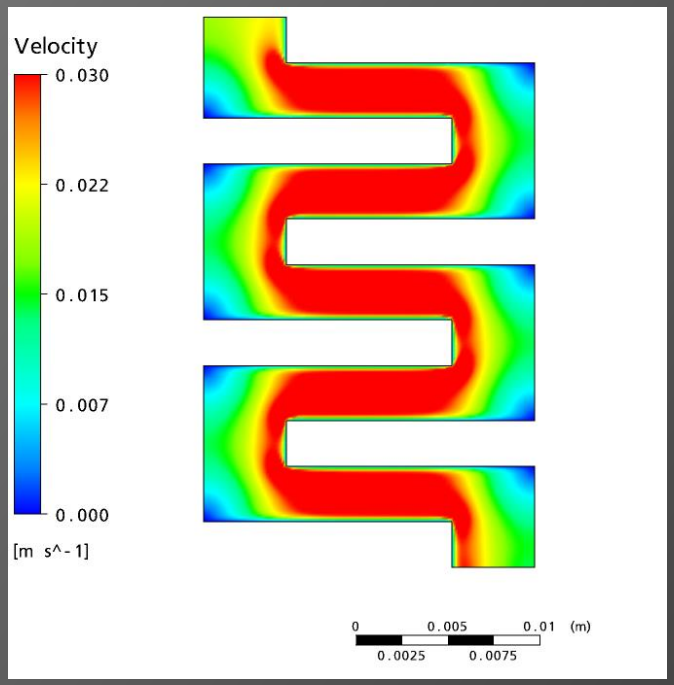


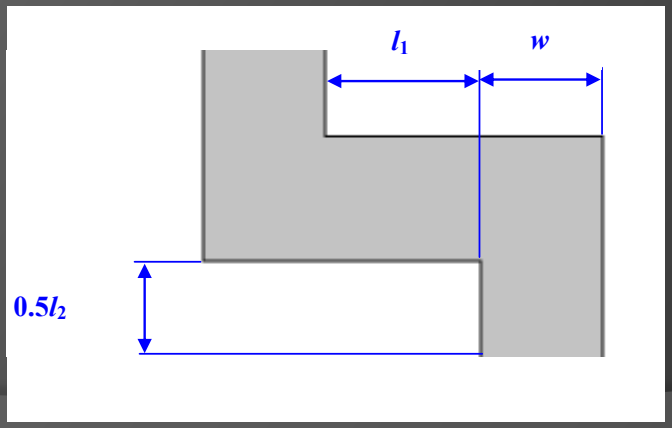


Heat transfer and pressure drop in the warmer channels:

- Milk travelling time or the channel distance were maximized
- Heat transfer coefficient correlation $h(x)$ and friction factor correlation $f(x)$
- Parametric model of the warmer channels

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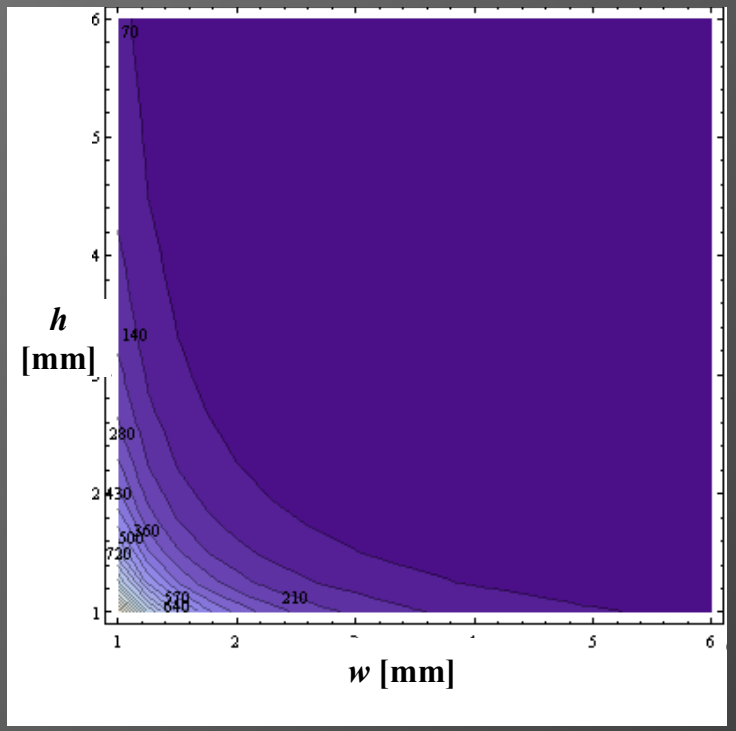


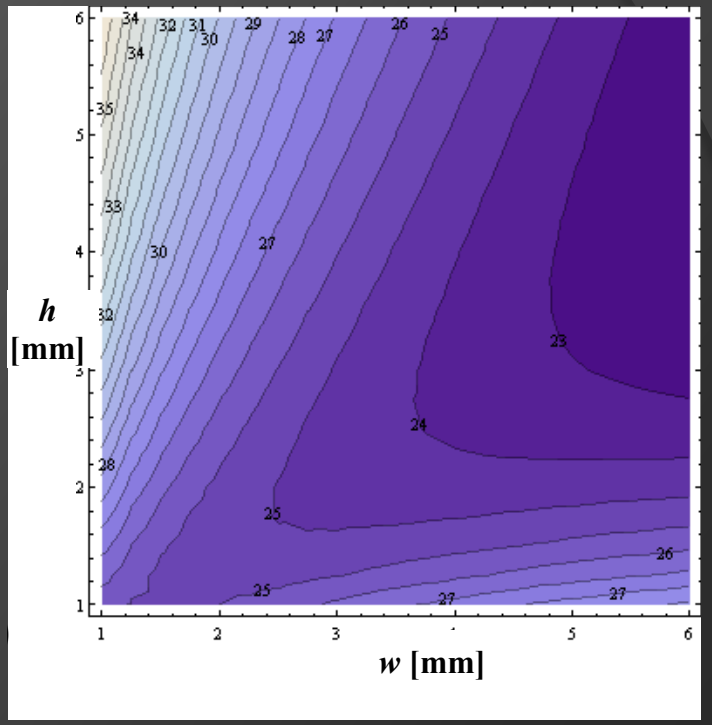


- Parametric space exploration of the warmer design - channel width *w* and height *h*
- Optimum channel design - pressure drop (left) and temperature increase (right) contour plots

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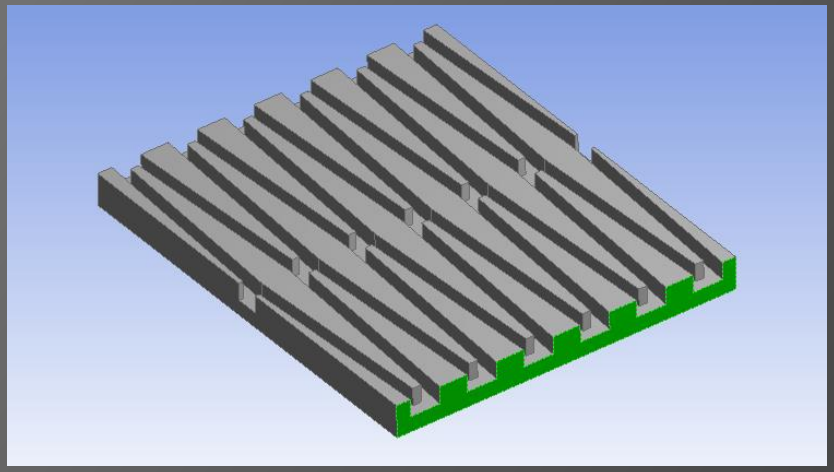
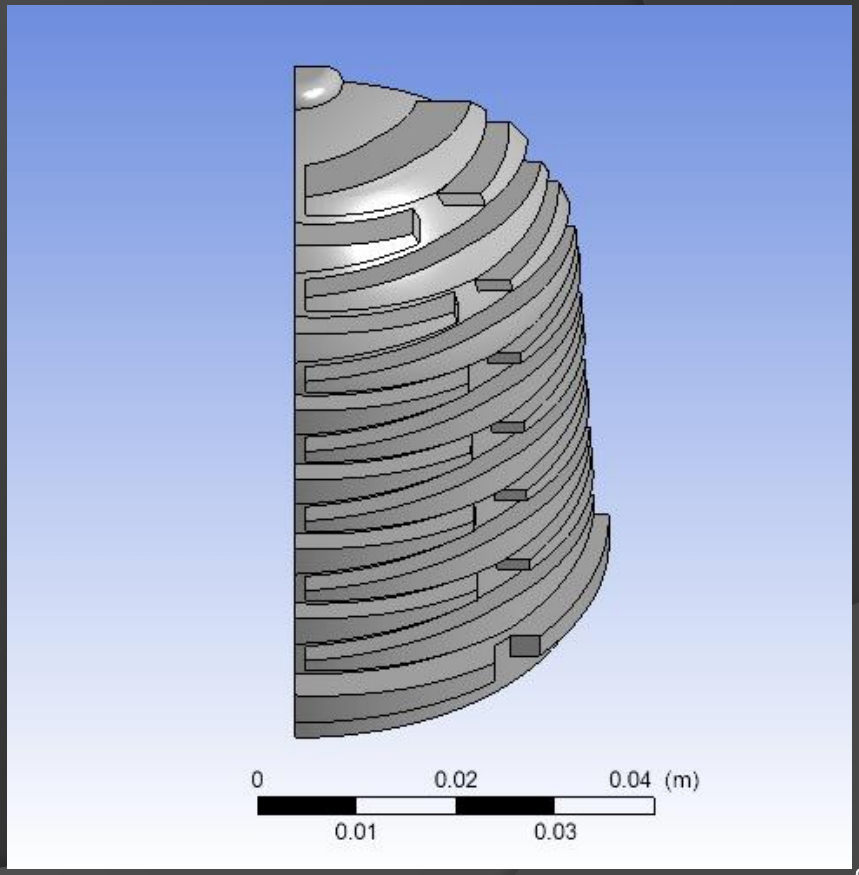


zig-zag channel of
the specific width $w$ and height $h$



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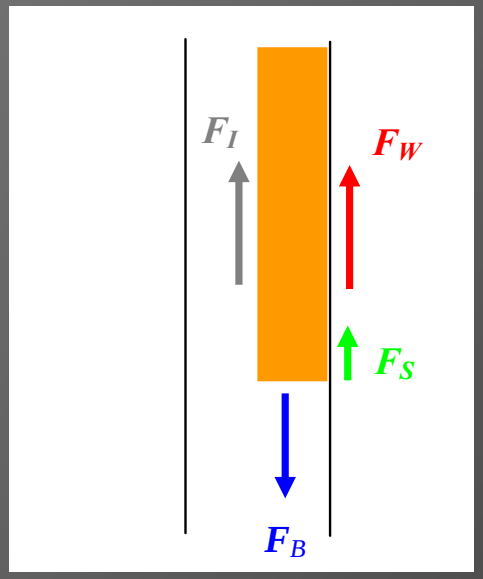


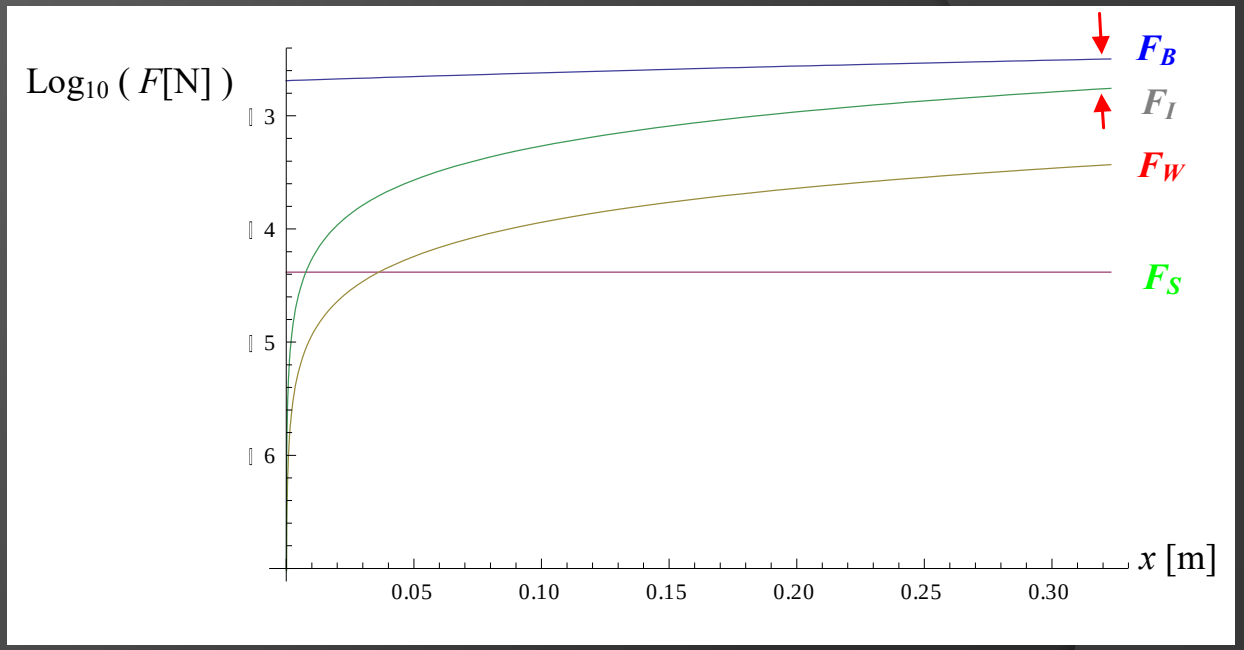


- Design optimisation process based on single-phase flow conditions
- A force balance analysis taking into account buoyancy force ($F_B$), wall friction ($F_W$), interphase drag ($F_I$) and surface tension force ($F_S$)

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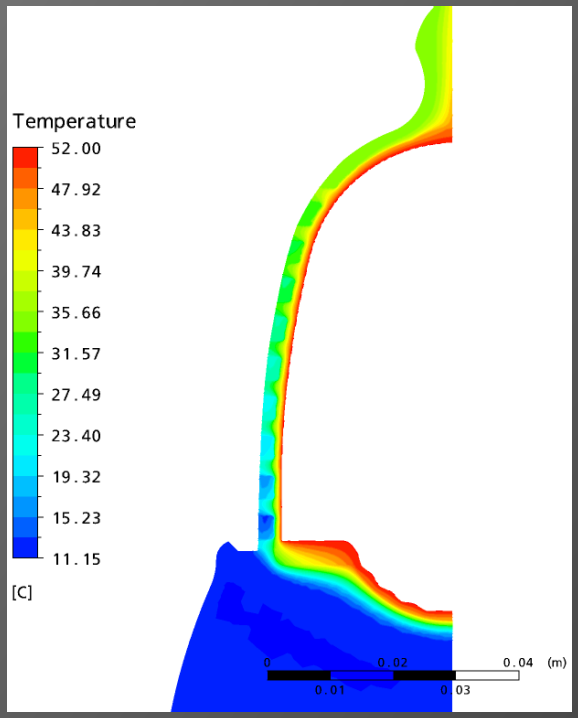


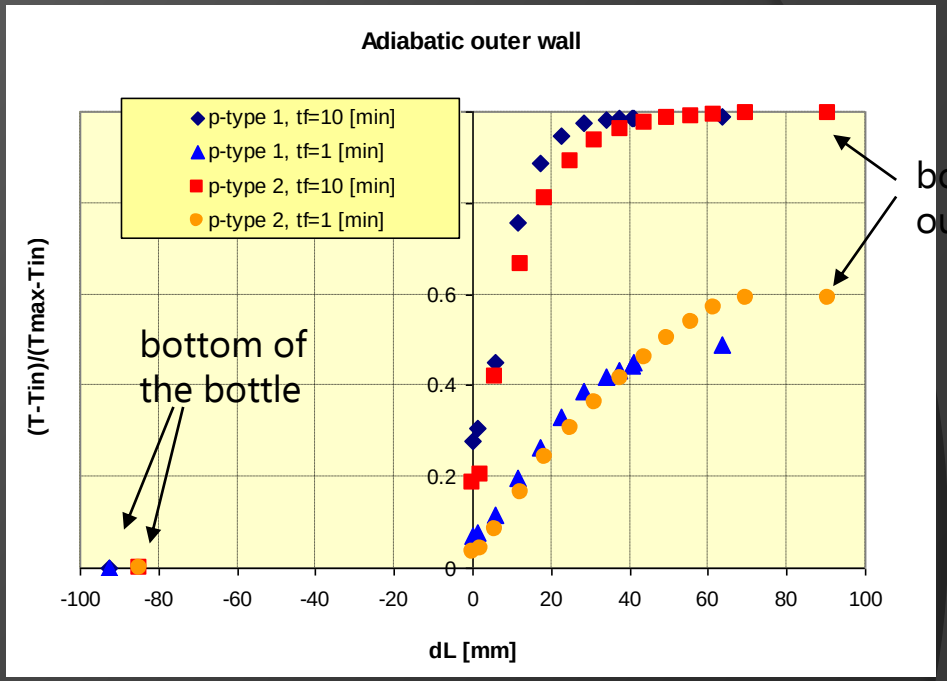


- CFD analysis to predict warmer's thermal behaviour
- Steady-state milk flow taking into account the milk volume only

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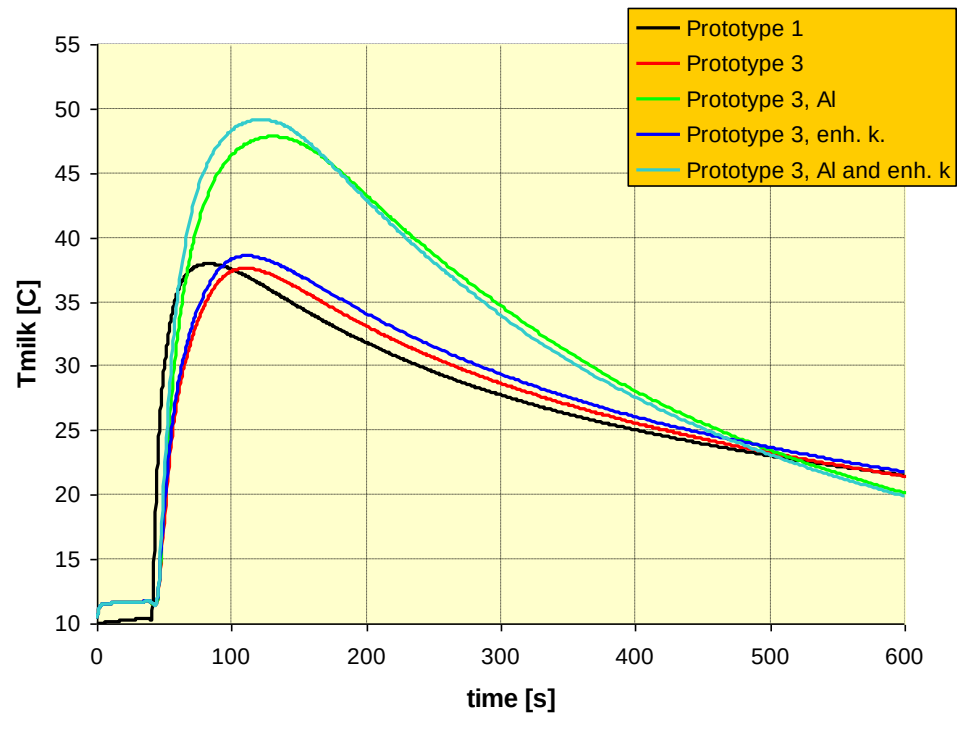


Warmer's thermal characteristics based on initial CFD simulations :

- milk temperature at steady drinking speed
- sensitivity to the material properties
- sensitivity to the milk flow rate and thermal boundary conditions

Significant over-prediction the milk first drop temperature

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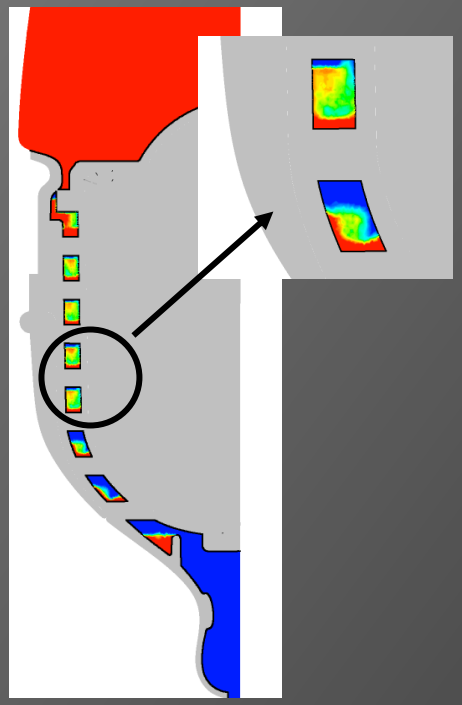

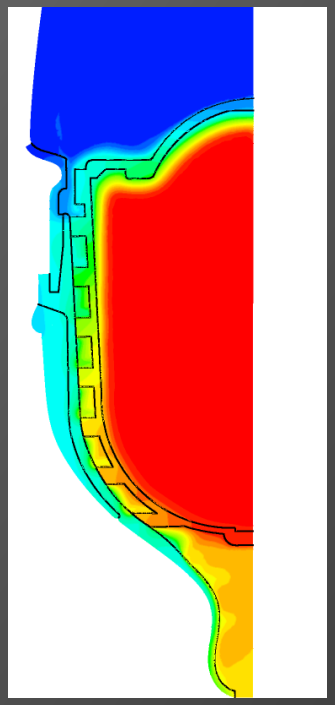

Accurate prediction of the first drop temperature and the pressure variation inside the channel:

- multiphase CFD analysis
- modelling of conjugate heat transfer through solid parts
- solidification reaction of the mixture

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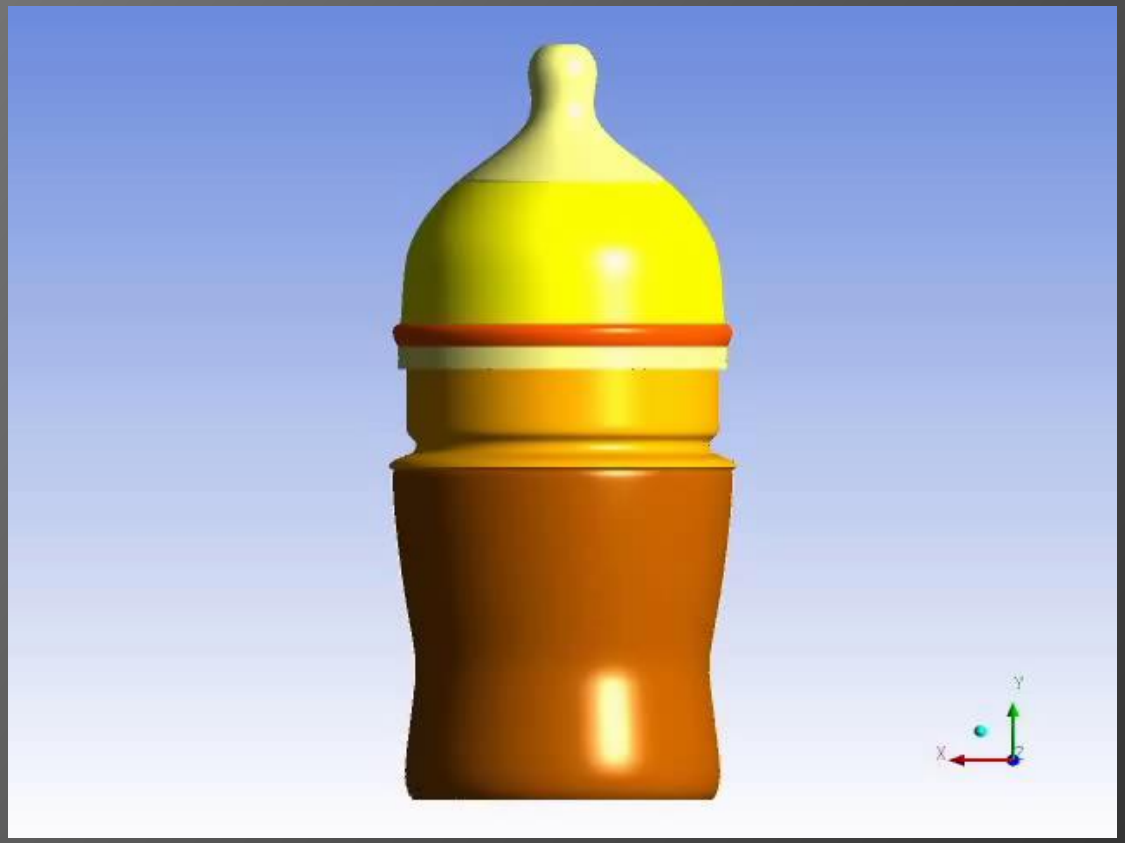

- Validation of the multiphase CFD analysis results
- Modelling of the warmer recharge process

# Thank you !

# Contact information

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