CHAM

Pioneering CFD Software for Education & Industry

Flow in a Water-Cooled Electronics Box

PHOENICS Case Study – Electronics Cooling

Introduction

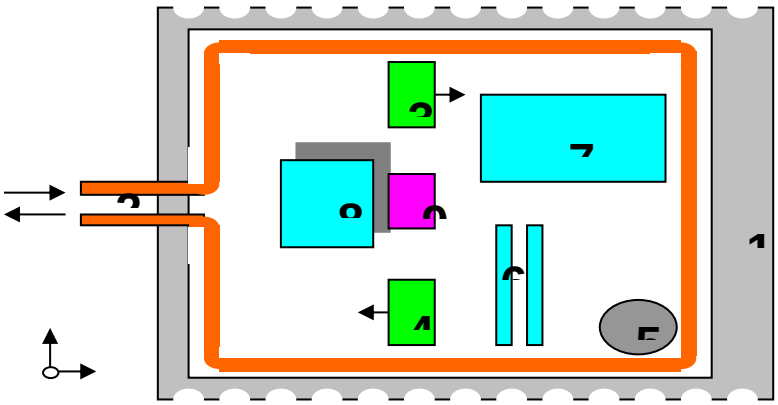
CHAM was approached by Norwegian technology development giant, Kongsberg Devotek AS, and requested to model its prototype design for a water-cooled electronics system housed in a finned aluminium box filled with air at 1 bar.

The problem considered

The pump supplying water to the cooling system can sometimes break down in that the water remains within the pipes but no longer circulates or cools. The system fails when one of the boards within the section labeled '8' reaches 75°C. The primary concerns for the customer are "Will the system fail and when? For how long can the system safely be operated after the breakdown? ".

Geometry and boundary conditions

The basic geometry of the system is simplified and shown in the figure below (viewed from above):



Coordinate system

The zero position is set at the outer lower left corner of the casing as shown in the figure. Zero z-position is at the bottom of the box. Gravity is pointing in negative z-direction.

Component 1 – Housing

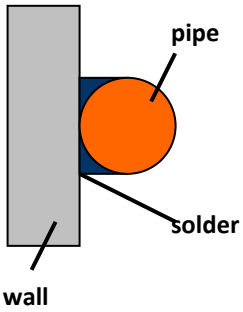
Material:	aluminium

Component 2 – Water Cooling System

Pipes:

Material:	copper

The pipes are soldered to the walls inside the box as shown in this figure (z-x-plane):



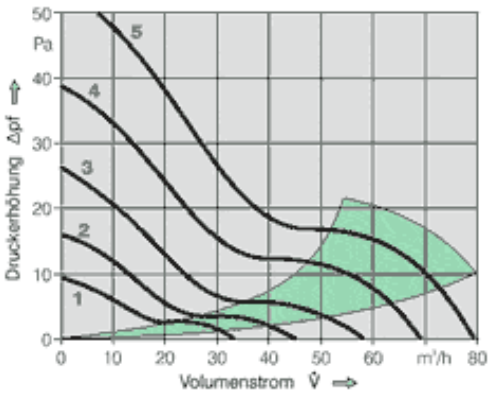
Cooling fluid:

Material:	water at 1 bar
Flow rate:	1 l/min
Fluid inlet temperature:	35 °C

Component 3 – Ventilation Fan

Dimensions:
diameter : 80 mm
mounted on the bottom plate

Operation conditions:
fan speed: 2050 rpm
direction of flow: positive x-direction
Pressure rise ("Druckerhöhung") as function of the volume flow rate ("Volumenstrom") as depicted for line 2.



Component 4 – Ventilation Fan

The same as Component 3 except that the direction of flow is in the negative x-direction.

Component 5 - Electrolytic capacitor

Material: Aluminium / Heat release: 0.5 W

Component 6 – two identical boards

Material: FR4 / Heat release: 5 W each

Component 7 – board

Material: FR4 / Heat release: 7.5 W

Component 8 – two identical stacked boards, with connector board

Material: FR4 / Heat release: 8 W each

Component 9 – power supply unit with voltage convertor

Material: Copper / Heat release: 22 W

Component 10 – ambiance

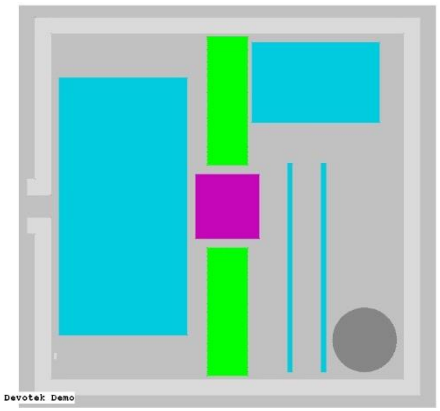
Air at 1 bar with a constant temperature of 33 °C is surrounding the box. The ambiance is enclosed by walls at 33 °C with emissivity of 1.

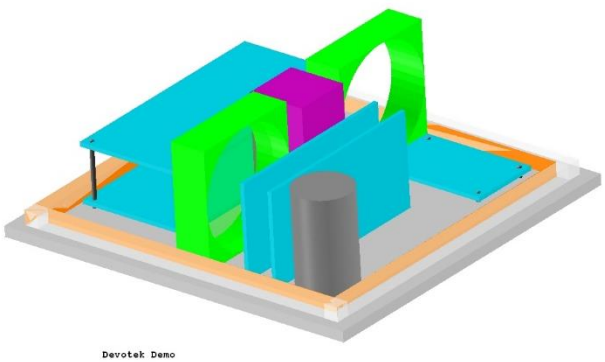
Material properties

Name	density [kg/m3]	heat capacity [J/kgK]	thermal conductivity [W/mK]	emissivity [-]
Copper & Solder	8930	382	399	0.76
Steel	7800	500	15	0.24
FR4	1938	878	17	0.9
Aluminium	2700	888	237	0.2
Filling of capacitor	1300	1250	0.2	-
Water	992	4177	0.631	-

The CFD model

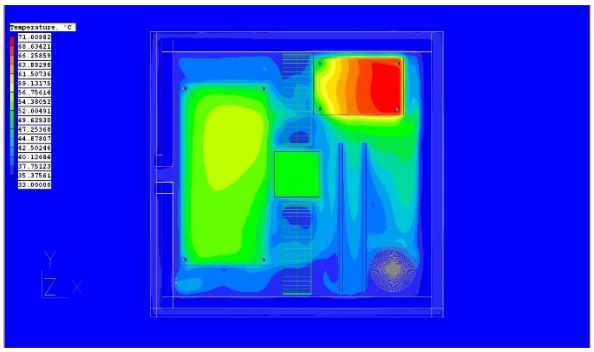
A CFD model was created using objects from the built-in library within PHOENICS based on the dimensional and operational data supplied by the client, as above.



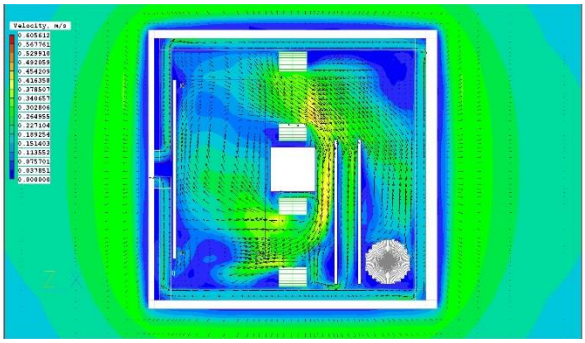


A relatively coarse mesh of 119 x 141 x 76 was applied. Given the nature of the geometric features, PARSOL, was not required. The IMMERSOL radiation model was activated with the LVEL turbulence model selected. The case was modelled transiently; a period of 5 minutes was considered comprising 10 time steps. The run time, on a 3GHz PC, was 12.7 hours.

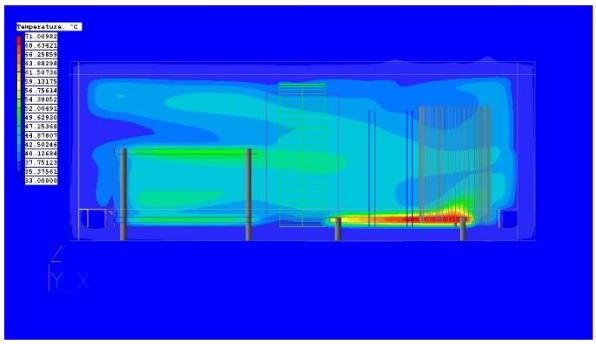
The images below show velocity and temperature results after 300 seconds, in plan and cross-sectional views throughout the domain. The geometry is shown in wire-frame for ease of viewing of the results.



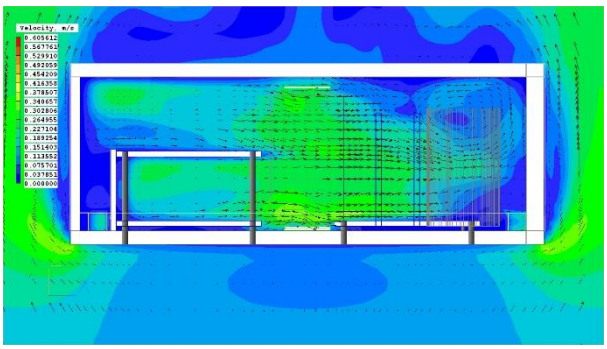
Temperature High Spot XY



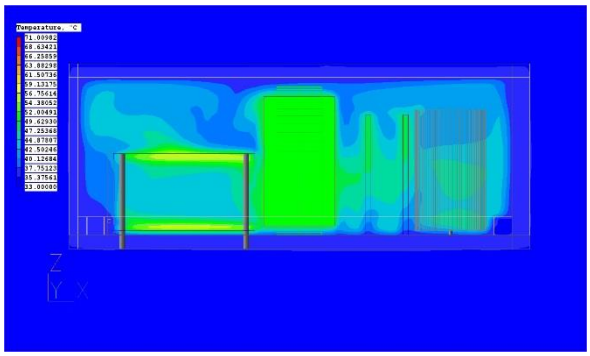
Velocity High Spot XY



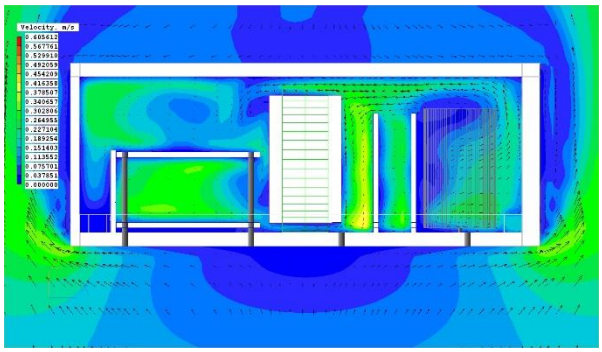
Temperature High Spot XZ



Velocity High Spot XZ



Temperature Centreline XZ



Velocity Centreline XZ

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