

EG-M83 - Assignment 2: Laser Design Optimisation

This coursework assesses the following learning outcomes:

- The ability to apply computer-based models for solving problems in engineering and recognise the factors that influence model limitations (EA3m, SM5m).
- Demonstrate the ability to develop and apply a test strategy to produce an optimised design (D3m, D1)
- Demonstrate an understanding of the modelling process and the role of simulation in design (D7m)

1 Problem description

A manufacturer has developed a preliminary design for the housing of a laser. The schematic of the preliminary design is shown in Figure 1. The basic geometry is an aluminium tube positioned centrally in a finned aluminium extrusion. The extrusion is symmetric - a schematic of one quadrant is presented in Figure 2 and the dimensions are shown in Figure 3. There are 10 aluminium fins in each quadrant of the housing. Each fin has a thickness of 2 mm, and the air gap between each fin is also 2 mm.

The annular gap between the two parts is filled with helium at 35 Torr. The heat input into the annulus is 20 W per cm length and the spatial distribution of heat deposition is assumed to be constant.

Water flows through the central tube to transfer heat from the central aluminium tube to the outer heatsink. The water flow rate through the tube is 150 cc/min and the water inlet temperature is 293 K.

Air is blown between the aluminium fins, in the same direction as the water flows, at 1 m/s and 293 K in order to enhance the cooling of the laser. The system will operate at 293 K ambient air temperature.

The manufacturer has asked your R&D team to analyse the performance of the preliminary design under steady operating conditions and to suggest how the design might be improved.

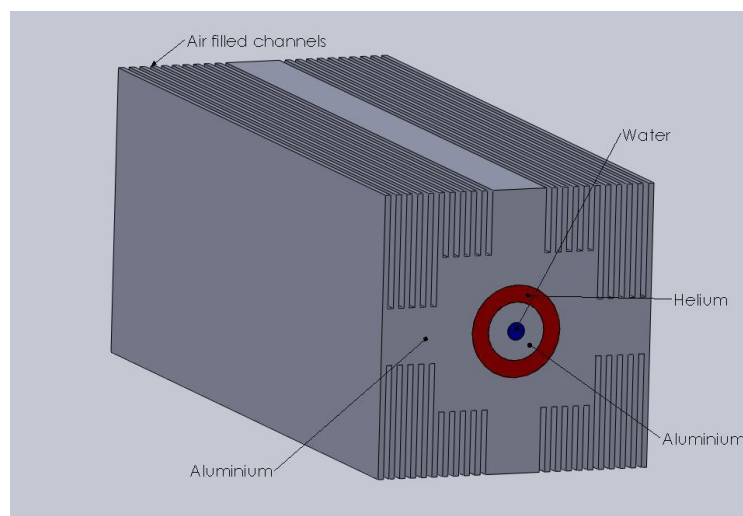


Figure 1 Schematic of preliminary 10 fin design

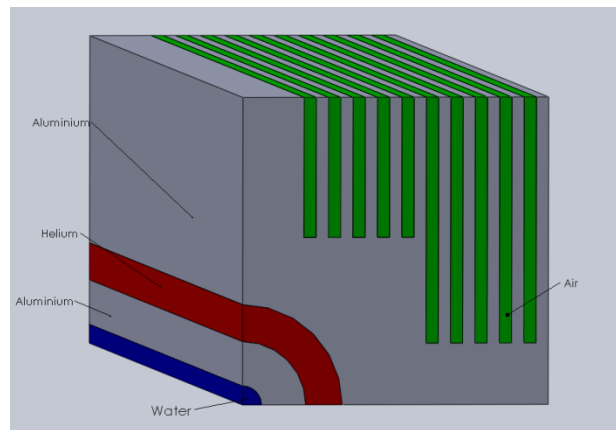


Figure 2 Schematic of one quadrant of 10 fin housing

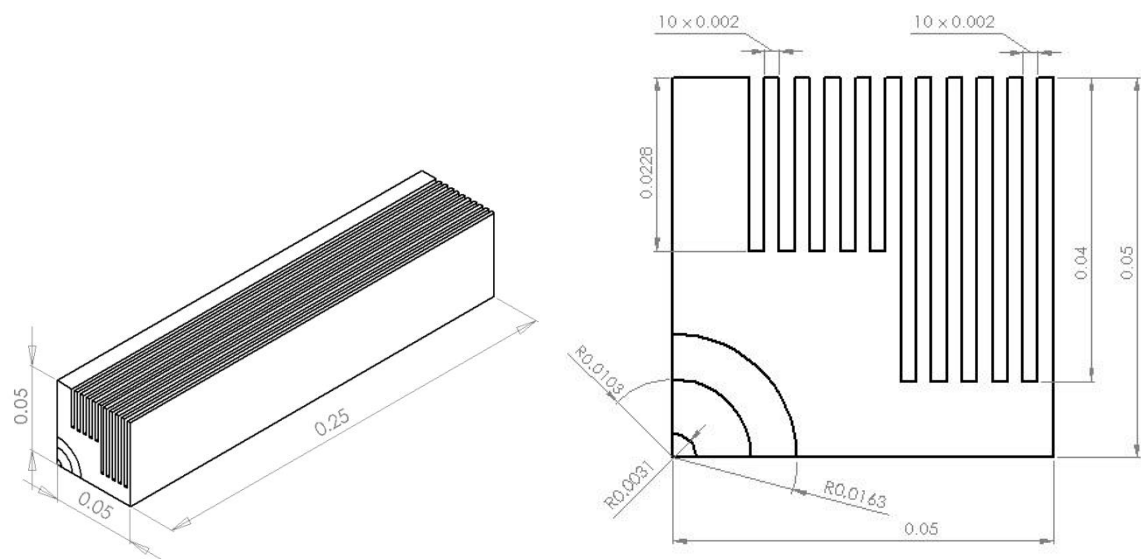


Figure 3 Dimensions (in m) of one quadrant of 10 fin housing

2 Coursework description

This coursework consists of the following steps:

1. Perform a simulation of the base design of the 10 fin laser housing as described in section 1 of this document. Use the guidance in the Workshop 2 handout to set up and run the model.

The report on this phase of work must include

- a. A description of the design problem
- b. Details of any assumptions/constraints in the simulation model
- c. The governing equations being solved
- d. Information about the mesh settings and mesh quality
- e. Plots of important results
- f. Values of
 - i. Maximum helium temperature
 - ii. Maximum outer wall temperature
 - iii. Maximum water temperature
- g. An analysis of the base design performance

(12 marks out of 80)

2. The manufacturer wants to optimise the design of the laser housing subject to the following constraints
 - a. Housing must be an extruded design
 - b. Maximum helium temperature ≈ 493 K
 - c. Water < 373 K

In addition the maximum temperature on the outer surface of the housing must be kept as low as possible, ideally < 318 K.

The manufacturer will consider making changes to one or more of the following design parameters if they can be shown to be beneficial to performance:

- a. **Outer** aluminium housing design, provided
 - i. It can be extruded
 - ii. The cross-sectional quadrant area must be within $0.05 \text{ m} \times 0.05 \text{ m}$
 - iii. Extruded length is 0.25 m
- b. Air flow speed and direction relative to the water flow
- c. Water flow rate
- d. Heat input

Use the simulation tools provided to optimise the design of the housing subject to the constraints. In doing this you should investigate how changes to **all** the design parameters, including changes to the outer aluminium housing design, influence performance.

Fully detail your methodology and findings in the report. Use the understanding you gain from the series of simulations you perform to analyse the system behaviour. The report must include a clear recommendation of an optimised process design for the manufacturer, together with all the design information that the manufacturer will require to implement it.

(40 marks out of 80)

3. In this section of the coursework you should consider the role of simulation in the engineering design process. Use examples from the guest research lectures to support your discussion.
 - a. Imagine you are a computer modeller that has been approached by a client with a product/process design problem. Following the preliminary meeting with the client, what are the main steps that you would follow to build up and test a simulation model for this problem?
 - b. What are the advantages/benefits of using simulation in the engineering design process?
 - c. What are the disadvantages/drawbacks of using simulation in the engineering design process?

(20 marks out of 80)

Marks will be awarded for report layout/quality. Reports should be no longer than 20 pages.

(6 marks out of 80)

The report should also include a link to a OneDrive folder containing your ANSYS Workbench files for the recommended optimised design. Please use your university OneDrive account to store these files. Note, if the model is contained in cw2.wbpj you will also need to upload the folder called cw2_files.

(2 marks out of 80)

You must also include a completed copy of the Coursework Cover Sheet form within your report.

The **report** must be submitted through the “**Assignment 2**” submission point on Canvas.

The deadline for submission is 16:00 on Friday 30th April.

Technical assistance with the software tools will be available in the online support lab, Monday 15:00-17:00, during term time.

This coursework is worth 80% of the final mark for EG-M83.

Individual written feedback will be provided by 17:00 on Friday 21st May.