AUM

American University Of The Middle East

COURSE Project (25%)

Computational study of the flow characteristics through a Convergent–Divergent Nozzle

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I. Introduction

Projects for engineering students give an edge over the race of recruitment to work hard to ensure a good career. In spite of employment practices in recent times, students are progressively taking up projects to pad up their skill-set. Engineering projects help students to learn and acquire practical knowledge. Despite of theory concept they acquire, various industries also need to know their capacity to complete projects using their specific initiatives. Thus, we recommend students to realize engineering projects in their four years of engineering and try to present as many white papers as possible. Students who give importance to their course projects are expected to learn how to:

- Work in teams including multidisciplinary teams
- Build a major design experience based on the knowledge and skills acquired in the course work
- Build a major design experience incorporates appropriate engineering standards and multiple realistic constraints
- Apply both analysis and synthesis in the engineering design process, resulting in designs that meet the desired needs

In the design process, both creativity and criticism are essential. The followings are the seven steps that students should consider while designing their projects:

- Recognition of the need and identifying opportunities: Every project begins with recognition that needs improvement. These needs may be obvious or hidden to be revealed by investigation, surveys or research.
- Definition of the design problem: It is a major task requires gathering information about the problem.
- Definition of the design criteria and constraints: While the problem is being defined, the design criteria and constraints must be defined
  a. Design criteria are performance standards to be met by the design
  b. Design constraints are limitations placed on the designer, the final design or manufacturing process. *Examples of possible constraints include accessibility, aesthetics, codes, constructability, cost, ergonomics, extensibility, functionality, interoperability, legal considerations, maintainability, manufacturability, marketability, policy, regulations, schedule, standards, sustainability, or usability.*
  c. Risk analysis
- The design loop: design is a repetitive process of:
  a. Synthesis (Brainstorming - Generating new ideas)
  b. Analysis (Breaking ideas – find expected results)

c. Decision-making (Deciding the best alternative)

- Optimization: Design team must ask themselves if it is the optimum design. Optimum is the best design that can be achieved at reasonable cost. The proposed design is judged against the design criteria
- Evaluation: Design team should hold a design review to approve drawings and specifications before they are released. If an optimum design cannot be achieved, the design team might revise the problem definition, the design criteria or the constraints in order to achieve the optimal solution or prototype.

II. Project Description

I. INTRODUCTION

The increasing need for thermal comfort has led to a rapid increase in the use of cooling systems and, consequently, electricity demand for air – conditioning systems in buildings. Heat driven ejector refrigeration systems appear to be a promising alternative to the traditional compressor based refrigeration technologies for energy consumption reduction.

II. PROJECT SUMMARY (SCENARIO)

As a convergent-divergent nozzle has a lot of engineering application. The current project investigate the convergent-divergent nozzle at different operating conditions.

Group Size: 3 students

III. ABET Learning Outcome

- ABET (1-7), refer to the syllabus for the details
- Thermodynamics I Learning outcomes, refer to the syllabus for the details

Specific Learning Outcomes:

- Ability to apply theoretical knowledge in 'real work' project
- Ability to create mathematical model for a real power plant and recommend improvement of its performance.
- Ability to analysis outcomes in clear and concise manner

IV. Project Management & Deliverables

This project is divided into the following deliverables.

Deliverable 1: Project report:

This ME 510 project is intended to demonstrate students' ability to write a literature survey [Project Deliverable 1] to cover some points like,

- Ejector main parts,
- How does ejector work,
- Ejector applications,
- Ejector in a refrigeration system application in detail and provide,
  - Layout of refrigeration cycle without and without ejector,
  - How this ejector reduce the amount of demand electricity and by how much.

Useful links:

For Deliverable [1]

1. http://www.grimsby.ac.uk/documents/defra/tech-ejector.pdf
2. https://www.youtube.com/watch?v=0yK4Mzv7ei0
3. https://www.google.com.kw/search?q=refrigeration+cycle+with+ejector&oq=refrigeration+cycle+with+ejector&aqs=chrome..69i57j0l3.7519j0j7&sourceid=chrome&ie=UTF-8
4. https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1747&context=iracc
5. https://docs.lib.purdue.edu/cgi/viewcontent.cgi?referer=https://www.google.com.kw/&httpsredir=1&article=2052&context=iracc
6. http://www.ijsrp.org/research-paper-0714/ijsrp-p3138.pdf
7. https://pdfs.semanticscholar.org/8ce5/f16b25d39ade9b69576710d81d28212c63f2.pdf

Deliverable 2:

Also, students should gain a knowledge of how they simulate supersonic flow in a convergent – Divergent Nozzle, shown in Figure 1(a), using ANSYS–Fluent. Then compare the obtained computational results with hand calculation results using table for isentropic flow [page 417] and Table for Normal shock wave [page 429]. In the simulation part which will be submitted in project

deliverable 2, student will simulate a uniform supersonic stream flow in C-D nozzle as shown in the Figure1 (b)

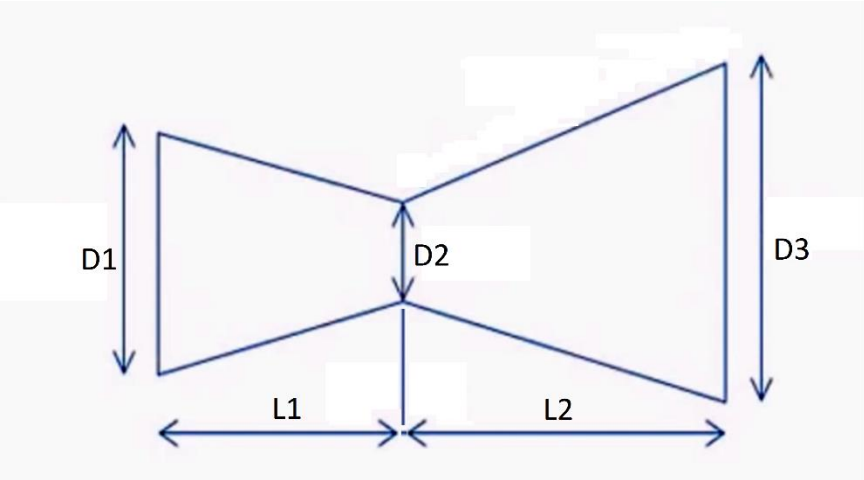


Figure1 (a): Convergent- Divergent Nozzle

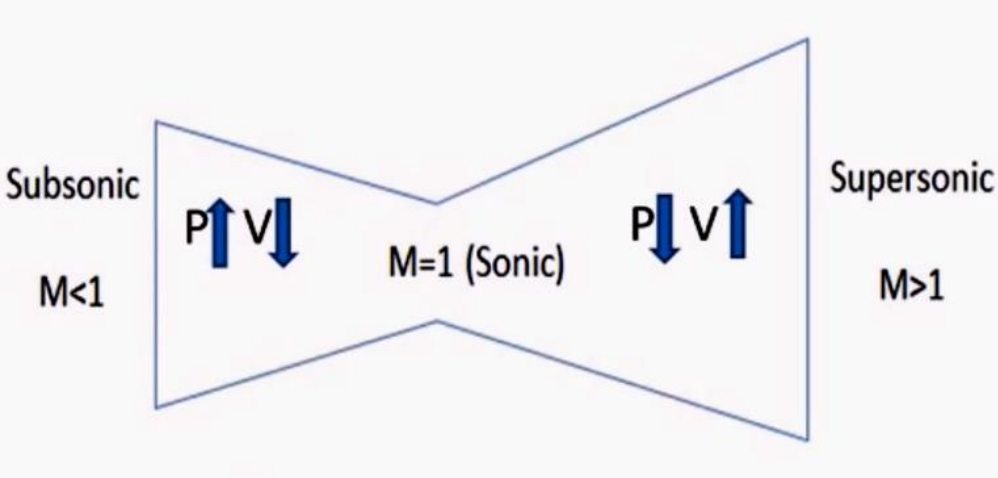


Figure1 (b): Convergent- Divergent Nozzle

The stagnation pressure p_t at the inlet is 101,325 Pa. The stagnation temperature T_t at the inlet is 300 K. The static pressure p at the exit will be changed as required. All boundary conditions and studies are indicated below. Mach number, pressure and temperature distribution along the nozzle axis should be calculated using FLUENT post processing.

Table [1]: Simulation boundary conditions

Parameter	Property / Value
Model	Inviscid
Fluid (Air)	Ideal Gas
Inlet pressure ▪ Gauge total pressure [Pa] ▪ Supersonic gauge pressure [Pa]	 101325 90000
Total Temperature [K]	300
Receiver Pressure [Pa]	(Variable, read below)

Required parametric studies

1. Study [1] - Mesh sensitivity study

Student should select at least three different levels of mesh

Dimensions

D_2=10 mm, D_1=2.5 D_2, D_3=3.5 D_2, L_1=2.5 D_2 and L_2 =6 D_2

Boundary conditions

Receiver pressure 80000 Pa

2. Study [2] - Effect of receiver pressure on the C-D nozzle performance

Student should select one mesh level from study [1]

Dimensions

D_2=10 mm, D_1=2.5 D_2, D_3=3.5 D_2, L_1=2.5 D_2 and L_2 =6 D_2

Boundary conditions

Receiver pressure 80000 Pa, 60000 Pa, 3000 Pa, 500 Pa

3. Hand Calculations:

- Students will select one case that has shock wave then,
- Calculate the cross-sectional area at shock wave location,
- Consider Mach number at the inlet equal to zero and then calculate the following,
  - Pressure, temperature and Mach number at throat, before shock, after shock and exit.
- Comparison between CFD and hand calculation results should be drawn including the percentage error **[this comparison must be written in table] as follows.**

CFD Calculations	Hand Calculations	Error%
Mach at throat **Before shock wave** Mach Pressure Temperature **After shock wave** Mach Pressure Temperature **At nozzle exit** Mach Pressure Temperature		$\left\lvert\frac{M_{hand\ cal} - M_{CFD}}{M_{hand\ cal}}\right\rvert \times 100\%$

Useful links

For Deliverable [2]

1. https://www.youtube.com/watch?v=P_jdywkbRQ4&list=PLJXyA7db7IC5XaJzntJd5WbTuXX1jaK_6&index=13&t=968s
2. https://courses.ansys.com/index.php/courses/compressible-flow-in-a-nozzle/
3. https://www.youtube.com/watch?v=XN8Xx_1L4Vw

Deliverable 3: Oral Presentation:

- The presentation duration is 10 minutes that is followed by 5-10 minutes of a discussion period. All presentations must be done using presentation software like MS PowerPoint. An electronic copy of the presentation and report must be submitted through Moodle (Turnitin) prior to the presentation due date. A rough structure of oral presentation is as follows:
    a. Introduction
    b. Project Overview and Project Statement (Explanation of project goals and aims)
    c. Steps and methods involved in the project
    d. Representation of final product (Prototype, creative product, simulations or research product exc.)
    e. Reflections of the project on students` learning
    f. Conclusion and Future Remarks
    g. References

V. Turnitin

Turnitin is a web-based solution that lets AUM faculty and AUM students check written work for improper citation or misappropriated content. You may be assigned a username and a password to be able to upload your assignments online, when and if requested. If you face any technical problem, please contact IT at AUM.

VI. APA Style

AUM adopts the APA writing style for all its academic programs. AUM students need to use this style for their assignments. The following web site is of value for students:

http://owl.english.purdue.edu/owl/resource/560/01/. Students are also encouraged to visit the AUM Writing Lab to receive help and guidance on all APA-related questions.

VII. Academic Honesty and Integrity Assurance

One of the signs that the course material has been properly understood is honesty when accomplishing the assignments. Lack of academic integrity (e.g. plagiarism, copying another person's work, the use of unauthorized aids on examinations, cheating, facilitating acts of academic dishonesty by others) will not be tolerated. Therefore, if students include ideas, sentences, or other material that are not theirs in their work, they must properly quote the source(s). Students are encouraged to consult with the instructor if they have any questions on the issues of academic integrity or technical formatting of the references.

Upon suspicion and doubt of the authenticity of the work submitted, the Instructor has the right to ask the student to verify her/his work. This can be done through, but not limited to, repeating the work, oral examination or discussion, alternative or similar on spot class assignment, pop quiz, or any other action deemed necessary. If the student fails to prove the authenticity of the work, then the Instructor will apply the academic misconduct rules as mentioned in the AUM Student Handbook which may include awarding the work a zero grade.

Students are expected and encouraged to be honest and to maintain the highest standards of academic integrity in their academic work and assignments at the University. Any act of Academic Dishonesty may result in severe consequences for violations range from zero grades given for the assignments, failing the course, and suspension from the University. Students will refrain from any academic dishonesty or misconduct including, but not limited to:

- Upon suspicion and doubt of the authenticity of the work submitted, the Instructor has the right to ask the student to verify her/his work. This can be done through, but not limited to, oral examination or discussion, or any other action deemed necessary. If the student fails to prove the authenticity of the work, then the Instructor will apply the academic misconduct rules as mentioned in the AUM Student Handbook
- A zero grade will be given to all students that share exactly the same results: You will also be held responsible if someone else copies your work - unless you can demonstrate that you have taken reasonable precautions against copying.

- Any violation of the AUM standards will be taken as a violation to AUM policy and can lead to penalties. If you wonder whether a course of action violates this policy, simply ask in advance and please refer to the undergraduate AUM Student Handbook.

For a detailed description of academic misconduct, please refer to the AUM Student Handbook.

VIII. Copyrights

Students are expected to adhere to copyright practices, refer to the undergraduate AUM Student Handbook.

IX. Project and team-based work

The Project component of the course, if exist, is essential to passing this course. The project shows competency in understanding and applying the course objectives and achieving the learning outcomes. The project should allow the student to investigate, apply, research, and practice real-life business situations. It is expected that each student to fully and actively participate in the project as an effective team member. A project document will be distributed later in the semester with details about the project.

For all group related work, the entire team is responsible for the team outcome and the deliverables, except for the specific parts of the project that may be graded individually depending on the project's requirement and as communicated in the project document.

X. Marking Scheme

The project is worth 30% of the total grade of your course. The grade will be based on every group's work, code, prototype, etc. The student will be evaluated based on the below grading scheme:

Final Report:

Introduction (20%)	Available Solutions (10%)	Proposed Solution (30%)	Conclusion (10%)	References (5%)	Formatting and language used (25%)

• Problem Definition (5%) • Criteria and Constraints (5%) • Objectives (5%) • Structure of the Report (5%)	• Brainstorming (5%) • Advantages and Inconvenient of each solution (5%)	• Background and Theory (5%) • Block Diagram/ flow chart (Using MS-Visio). (5%) • List of Components if applicable (5%) • Steps of building the circuit/Design/simulations with pictures of final prototype (10%) • Discussion/ Simulation/ Code correctly follows the flowchart/ block diagram (5%)	• Summary of the work done. (5%) • Future work. (5%)	• Use IEEE or APA references	• Grammatical and sentence structural mistakes (15%) • Formatting: Cover page, group members' names, consistent fonts and size throughout the document (i.e. no copy-pasting from the net) (10%)

Final results (prototype, simulations, or research products, etc.):

- Design [70%]
  a. Does the prototype/simulation, etc. work or Not? **(10%)**
  b. How does the prototype/simulation look? [nice/catchy/basic design] **(5%)**
  c. Results meet initial expectation? Are the outputs satisfactory? **(5%)**
  d. Are the material/components used to build the prototype adequate for such problems? **(5%)**
  e. Is the proposed solution/idea the most optimized? **(5%)**
  f. What is the impact of the material/components on the environment? **(5%)**
  g. Explaining the engineering design process clearly based on the proposed design. **(5%)**
  h. A detailed flowchart/block diagram describing the functionality of the system and the process to go from inputs to outputs (Using MS-Visio). **(5%)**
  i. Connection diagram showing all wiring connections between the components and your inputs and outputs (if applicable). (Using fritzing software www.fritzing.org or any other software) **(5%)**
  j. Steps of building the circuit/code/schematic (with its code if applicable) **(5%)**
  k. Using real illustrations extracted from prototype/ simulation (graphs, tables, trends, Pictures) and proper organization using IEEE style or APA style **(5%)**
  l. Explaining exactly the same components and elements used in the design/circuit **(5%)**
  m. Clear and convincing explanation on implementation of the design **(5%)**

- Answering question correctly [30%].
  a. Able to answer the questions related to the prototype and provide data to support their answers. (Accurate & detailed explanation of answer) **(15%)**
  b. Show deep understanding on the prototype/simulations etc., its main functionality, the implementation, etc. **(15%**

Presentation:

Knowledge and Content (15%)	Technical methods (10%)	Results (figures, graphs, etc.) (10%)	Contribution of work (15%)	Knowledge of subject (30%)	Presentation Skills (20%)
• Material sufficient for clear understanding and exceptionally presented	• Sufficient for understanding and exceptionally presented	• All figures clear with the same format and exceptionally explained	• Significance exceptionally well explained	• Demonstrated full knowledge; answered all questions with elaboration	• Excellent language skills, gestures, etc.

XI. Student Assessment Rubric

Deliverables	Bare pass mark (60%-69%)	C classification (70%-79%)	B classification (80%-87%)	A classification (>87%)
Final report	• The report is succinct and to the point. The maximum size of the report is met. • The report includes only brief analysis. • Brief conclusion and discussion. • The writing of the report includes some mistakes.	• The report gives clear details on all of the components of application. • The report includes some analysis. • The conclusion/discussion on the application partially relevant. • The writing of the report does not include mistakes.	• The report gives clear details on all of the components of application. • The report includes detailed analysis. • The conclusion/discussions on the application are relevant. • The writing of the report does not include mistakes.	• The report gives clear details on all of the components of application. • The report includes detailed analysis. • The conclusion/discussions on the application are relevant. • The report is well structured and it does not include mistakes.
Hardware demonstration + manual	• The prototype/simulation is built on a breadboard and is functioning.	• The prototype/simulation is built on a breadboard and is functioning.	• The prototype/simulation is built on a breadboard and is functioning.	• The prototype/simulation is built on a breadboard and is functioning. • The team demonstrated excellent understanding of

	• The team is answering only basic questions on the prototype/simulation.	• The team demonstrated basic understanding of the prototype/simulation operation.	• The team demonstrated good understanding of the prototype/simulation operation.	the prototype/simulation operation by reflecting on the reasons of operations of the application.
Oral presentation	• The presentation covered *most* of the topics in the final report. • The team Spoke clearly and made only few mistakes. • Only few questions are answered.	• The presentation covered *all* of the topics in the final report. • Information is presented in logical order. • Some questioned are answered.	• The presentation covered *all* of the topics in the final report. • Information is presented in logical order. • All of the questions are answered.	• The presentation covered *all* of the topics in the final report. • Information is presented in logical order. • The analysis are clearly discussed and the implemented method is • All of the questions are answered.

XII. Appendix: Required Figures

Study 1: **Mesh sensitivity study**

NOTE: All graphs except contours must be drawn along the Convergent-Divergent Centre line

Fig1: Pressure curve for P-receiver = 80000 Pa, for Mesh 1 Mesh 2 and Mash 3

Fig2: Temperature curve for P-receiver = 80000 Pa, for Mesh 1 Mesh 2 and Mash 3

Fig3: Mach number curve for P-receiver = 80000 Pa, for Mesh 1 Mesh 2 and Mash 3

Study 2: **Effect of receiver pressure on the C-D nozzle performance**

NOTE: All pressure Cases except contours must be drawn in one graph

Fig4: Temperature curve for all pressures at selected Mesh

Fig5: Pressure curve for all pressures at selected Mesh

Fig6: Mach number curve for all pressures at selected Mesh

Fig7: Pressure contour (80000)

Fig8: Temperature contour (80000)

Fig9: Mach number contour (80000)

Fig10: Pressure contour (60000)

Fig11: Temperature contour (60000)

Fig12: Mach number contour (60000)

Fig13: Pressure contour (3000)

Fig14: Temperature contour (3000)

Fig15: Mach number contour (3000)

Fig16: Pressure contour (500)

Fig17: Temperature contour (500)

Fig18: Mach number contour (500)