TAYLOR'S UNIVERSITY

Wisdom • Integrity • Excellence

School of Engineering

PRJ60303
Multidisciplinary Engineering Design

Final Report
A Study of Attributes of an Air Intake Affecting its Efficiency and Performance

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Evidences

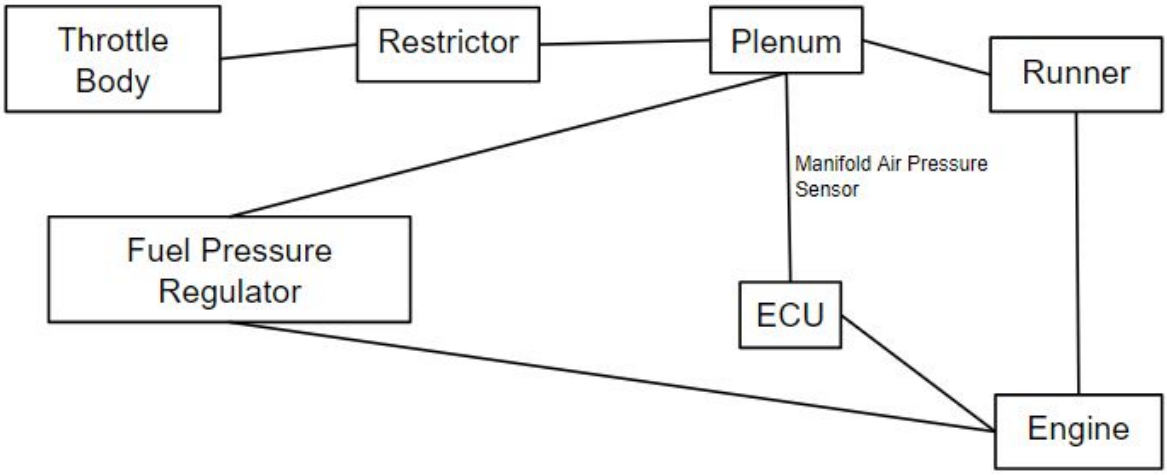
(LO1) Produce useful ideas and concepts using Brainstorming (C).

Technological feasibility	The air intake will be designed and simulated in Solidworks and ANSYS. Both are famous industrial grade software that are available to use in the computers in Taylor's University Campus
Economic viability	Most of the materials required for the manufacturing of the prototype can be obtained from the campus labs or from the Taylors Racing Team. Therefore, since the prototypes are all 3D printed using Polylactic Acid (PLA), the cost of manufacturing is reduced.
Impact on Environment	The material PLA is a biodegradable thermoplastic made from renewable resources. The carbon footprint from using this material is small and also environmentally friendly.
Sustainability	The proposed design changes will allow any damaged or faulty parts to be replaced or switched out without the need to build a new intake from scratch. This will save up on cost long-term wise and reduce material wasted on manufacturing.
Legal and Ethical	Safety precautions are taken when constructing the prototype. The designs used in this project are designed and fully modelled by the team members, with care taken that no single part is plagiarized from external sources.

(LO2) Design a system that solves a complex engineering challenge using the Design Process (D).

We are using ACID to solve the engineering challenge on FSAE Air Intake. Where A is system architecture, C is configuration design, I is integrated design and D is detailed design.

System Architecture



Configuration Design

An FSAE intake consists these parts which are required following the rules:

- Throttle Body
- Restrictor
- Plenum
- Runner
- Fuel Injector
- Fuel Rail

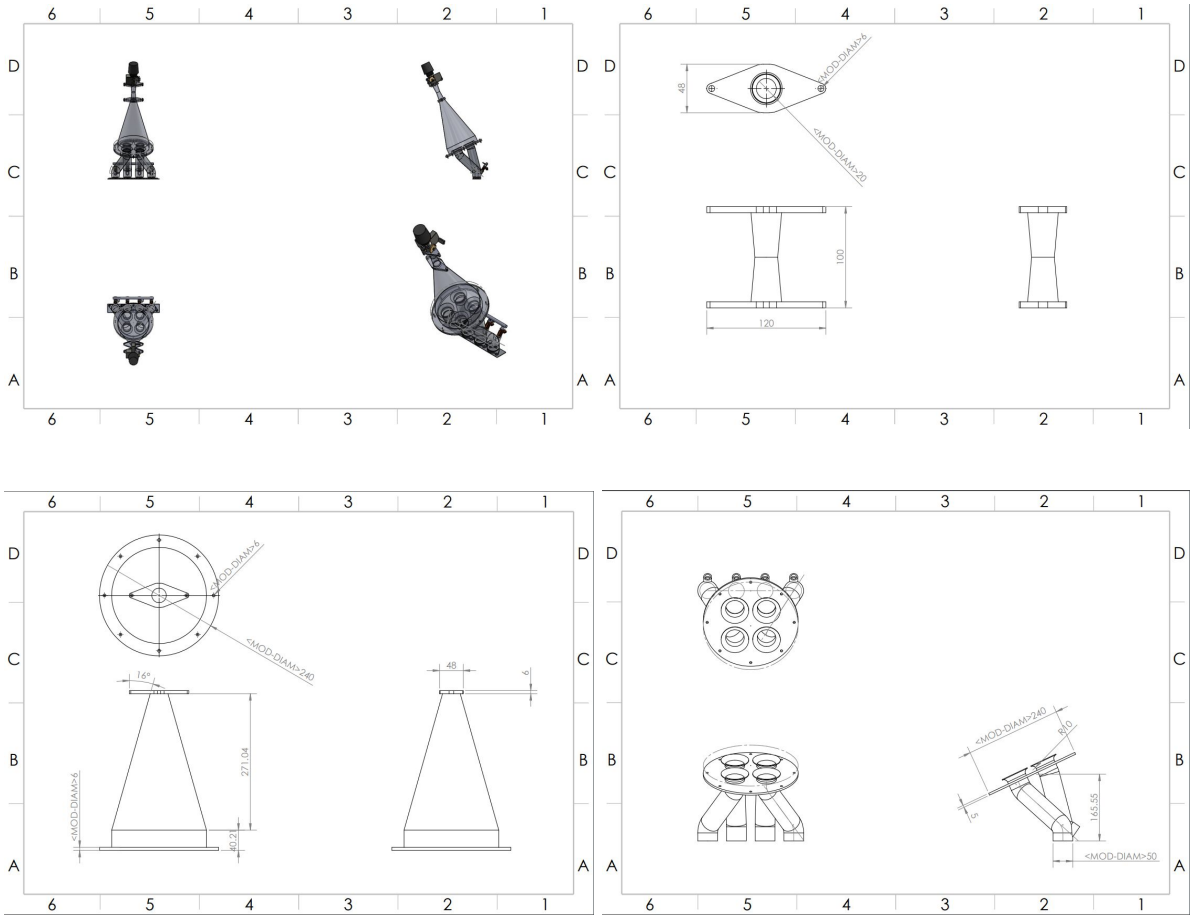
These parts above are 3D printed for rapid prototyping and plans are made to produce parts in aluminium.

Integrated design

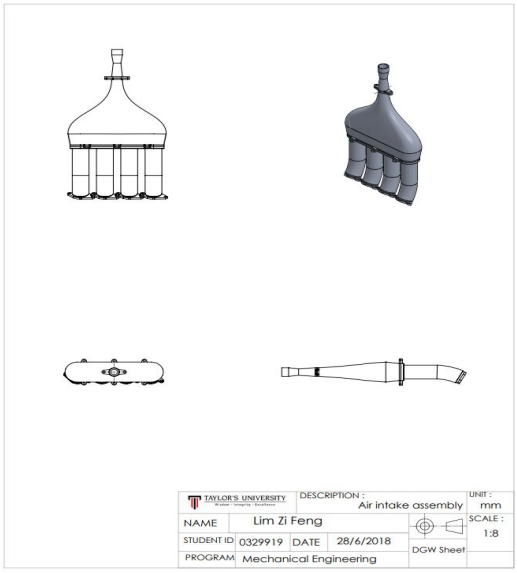


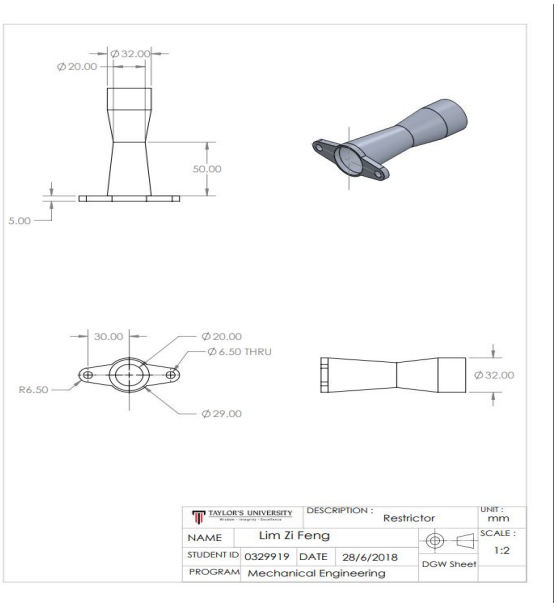
- These are the designs proposed for FSAE Air Intake.
- Air Intake above were designed in Solidworks.

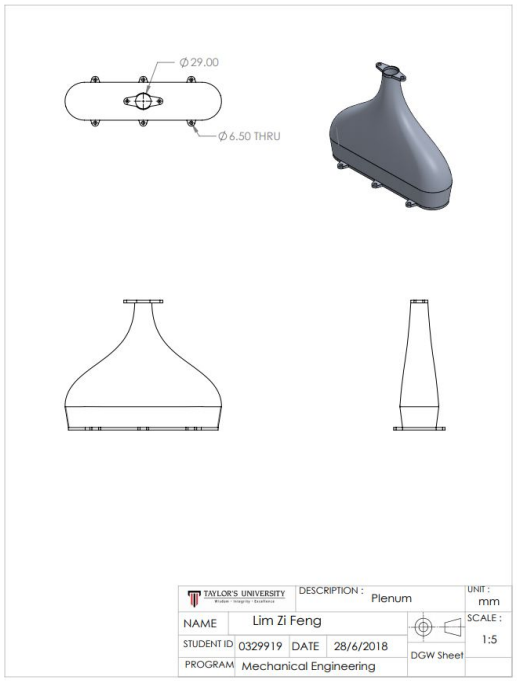
Detailed design
First design:

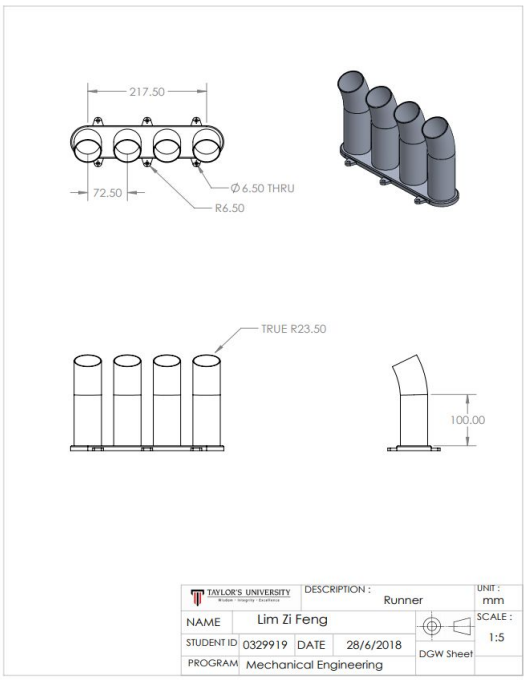


Second design:

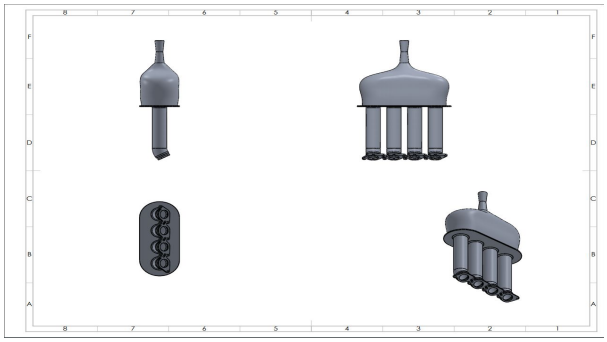


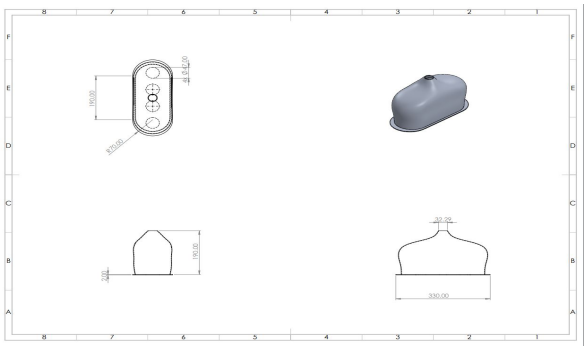


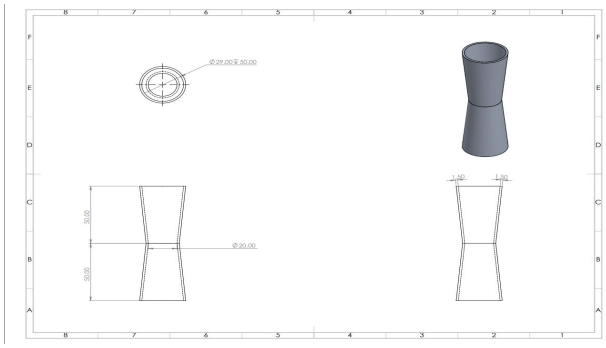


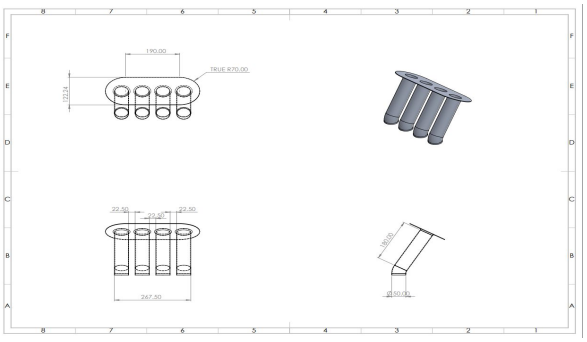


Third design:









(LO3) Conclude findings from working in a team through technical documentation (I&O)

Material testing of FSAE air intake

The objective of this experiment is to determine the effect of the temperature on different types of materials such as steel, aluminium and 3-D printed plastic. This is to make sure that the selection of the material to build the air intake of the FSAE car is the most suitable and is heat resistant. Thermal stress test has also taken into account to test the durability of the materials under multiple intervals.

PROCEDURE

Experiment 1: Test the Effect of Temperature on Certain Materials

1. A small piece of aluminium with the dimension of 5 cm by 7 cm and the thickness of 1.5 mm was cut using a band saw.
2. The oven was switched on and it was preheated to 40°C using a temperature controller.
3. The aluminium was placed on a tray that is then put into the oven and was left in the oven for 5 minutes.
4. The effect of the aluminium on the temperature was observed and recorded.
5. Step 1 to 4 was repeated with the temperatures of 50°C, 60°C, 70°C, 80°C, 90°C, 100°C and 110°C.
6. Step 1 to 5 was also repeated with a different material which is steel that is cut using a grinder and 3-D printed plastic.

Experiment 2: Test the Thermal stress on Certain Materials

1. The oven was switched on and the temperature was set to 90°C.
2. A small piece of aluminium was placed into the oven for 5 minutes using a stopwatch.
3. After 5 minutes, the aluminium plate was left to cool for 3 minutes.
4. Step 1 to 3 was repeated for 5 times using the same aluminium plate.
5. The aluminium plate was then placed on a retort stand and a 10N weight load is then placed on it for 3 minutes.
6. The bending of the aluminium plate is observed and recorded.
7. Step 1 to 6 is then repeated using steel plate.

Experimental design

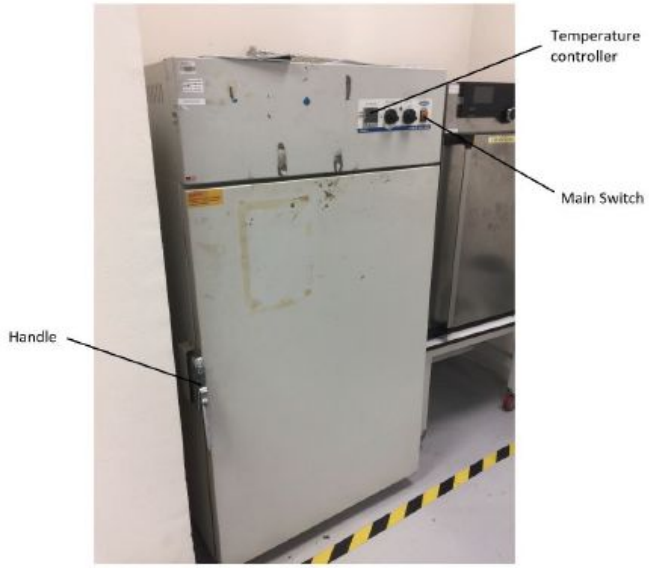


Diagram 1 : Laboratory oven

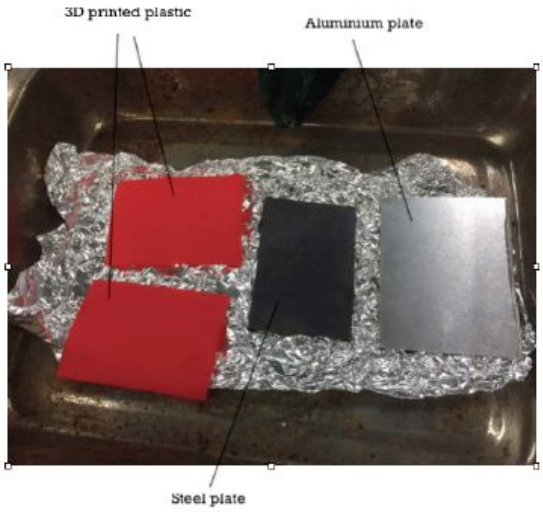


Diagram 2 : Materials being tested under various temperature

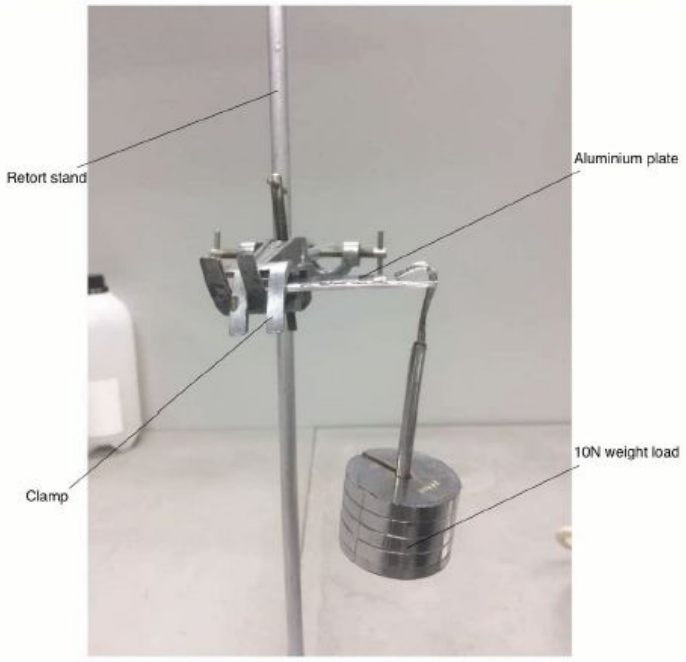


Diagram 3 : Material being tested for bending under a 10N weight load

Materials and Apparatus

1. Aluminium
2. Steel
3. 3-D printed plastic
4. Metal tray
5. Laboratory oven
6. Retort stand
7. 10 N weigh load
8. Stopwatch

Experimental variables

Experiment 1: Test the Effect of Temperature on Certain Materials

Manipulated variable : The materials used in the experiment, the temperature of the oven.

Responding variable : The condition of the material after its heated.

Constant variable : The time taken for the material to be in the oven for each temperature, the thickness of the material used.

The aim of this experiment is to observe the condition of different types of materials with the change of temperature. The time taken for each materials to be in the oven for each temperature was 5 minutes and was measured by using a stopwatch. The materials used in the experiment was aluminium, steel and 3-D printed plastic and all of the materials being used has the thickness of 1.5 mm with the dimension of 5 cm by 7 cm. The temperature of the oven was controlled by using a temperature controller and had a range of 40°C, 50°C, 60°C, 70°C, 80°C, 90°C, 100°C and 110°C. The condition of each materials could be recorded by observing whether the materials crack and have an extension.

Experiment 2: Test the Thermal stress on Certain Materials

Manipulated variable: The materials used in the experiment.

Responding variable: The bending of the materials on a weight load.

Constant variable: The temperature of the oven, the thickness of the materials used, the weight load on the materials, the time taken for the material to be in the oven.

The objective of this experiment is to test the thermal stress on different types of materials. The temperature of the oven was set to 90°C using the temperature controller that is on the oven and a stopwatch was used to time the material being heated in the oven. Furthermore, the weight load on the materials was added till it reaches 10 N and the thickness of the materials is set to be 1.5 mm. The bending of the materials on the weight load is then observed and recorded.

Experimental results

Experiment 1 : Test the Effect of Temperature on certain Materials

Temperature (°C)	Cracking	Extension
40	NO	NO
50	NO	NO
60	NO	NO
70	NO	NO
80	NO	NO
90	NO	NO
100	NO	YES
110	NO	YES

Table 1 : Result for Aluminium plate under various temperature(°C)

Temperature (°C)	Cracking	Extension
40	NO	NO
50	NO	NO
60	NO	NO
70	NO	NO
80	NO	NO
90	NO	NO
100	NO	NO
110	NO	YES

Table 2 : Result for Steel plate under various temperature(°C)

Temperature (°C)	Cracking	Extension
40	NO	NO
50	NO	NO
60	NO	NO
70	NO	YES
80	NO	YES
90	YES	YES
100	YES	YES
110	YES	YES

Table 3 : Result for 3D printed plastic plate under various temperature(°C)

Density of Aluminium = 2700 kg/m^3
Density of Steel = 7850 kg/m^3
Density of 3D printed plastic = 1250 kg/m^3

Experiment 2: Test the Thermal stress on Certain Materials

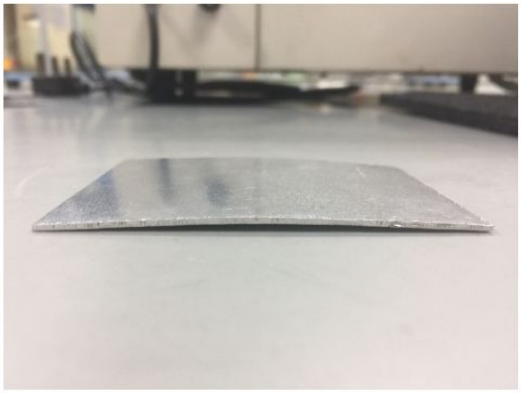


Diagram 4 : Aluminium plate after applying 10N on it

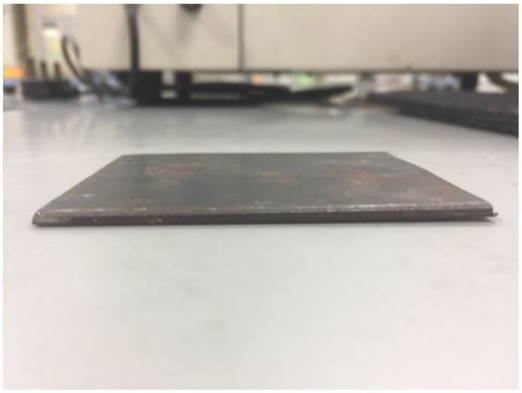
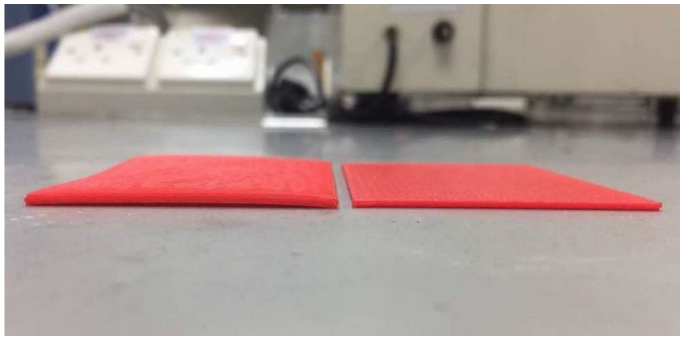


Diagram 5 : Steel plate after applying 10N on it

Discussion

After carrying out the experiment, we can concluded that the 3D printed plastic is not a suitable material to use to build the FSAE air intake. This is due to some obvious reasons as the 3D printed plastic start to show defects such as body extension and bending at temperature of 70°C. It is very easy to bend and has a "jelly-like" characteristic when the 3D printed plastic is above 70°C. The normal engine operating temperature is between 80-95°C. The 3D printed plastic extend exponentially when the temperature is at 100°C. If failure occurs in the system, the temperature of an overheating engine will exceed 120°C. This extreme temperature will completely deformed and melt down the 3D printed plastic.



From left to right : A deformed printed plastic under 80°C, A printed plastic without any deformation

Steel is the strongest material in the three materials that we have tested. It shows a little bit of extension when it heated up to 110°C. The surface temperature of the steel is hotter than

aluminium and 3D printed plastic when it took out from the oven but it cools rapidly over time. This is because the heat capacity of the steel is lower than aluminium and 3D printed plastic which means that less energy is required to increase the temperature by 1°C. Besides the minor extension on the after its heated, there are no any other defect on the steel plate such as bubbling, cracking or bending.

Aluminium plate shows a little body extension when its heated to 100°C. The aluminium plate retracts back to its normal length when it left to be cooled in room temperature. The aluminium plate also appear to have a slight bending above 90°C. This is because the bottom of the aluminium plate is covered and does not receive the same amount of heat as the top of the plate while heating in the oven. Expansion occurs greater on the top surface than the bottom surface, thus, bending occurs. Steel performs better than aluminium under thermal stress. Steel does not show any surface bending after a 10N is applied to it while aluminium shows a visible bending.

Error analysis

Zero error may happen as the reading of Vernier calliper is not 100% accurate. Therefore, it will affect the reading of the thickness of the material used when absorbing the heat inside the oven. This is due to different thickness of material have different heat capacity. Secondly, random error may happen as some heat loss when opening and closing the door of the oven. According to 2nd law of thermodynamics, heat transfer from high quality to low quality, so, this may affect the heat absorbed by the material and the result after taking out for observation purposes. Thirdly, systematic error may happen because the heat transfer such as conduction will be occurred from the molecules of the material to the molecules of the metal tray. Besides, random error like the temperature of the oven is not very consistent when experiment was conducted. This may cause the results vary to the theoretical results as the temperature is different from time to time. Finally, one of the potential random error in this experiment is human reaction rate. This is because different individuals have different reaction rate. If the person who is conducting this experiment records a longer time, the heat transferred from the oven to the material tested will be higher. So, the results may be varied to the theoretical result.

Conclusion and recommendations

After conducting the experiment, it was concluded that steel has the least defect when exposed to heat from 40-110 °C. Aluminium comes in next to be the second strongest material in our three materials being tested. It shows a little extension when taking out from the oven at 100°C and retracts back to its original length rapidly after it's being cooled in room temperature. The 3D printed plastic materials has to be the weakest material in our material testing because it start to show some bending at 70°C. It starts to crack at 90°C which means the intermolecular bond within fibrous polymer strand has broken. The condition of the 3D printed plastic at 90°C or above is very soft and can be easily reshape into another form with an external force.

After considering all the factors, we concluded that aluminium is the best materials to use to build the FSAE air intake. The reason is because it can withstand high temperature and it is lighter than steel. Although steel can hold its shape better than aluminium at high temperature but its heavier than aluminium by 2.9 times which is not desirable to use to build the FSAE air intake because the aim is to use a lighter material to build the car so it can have a quicker acceleration on the track. The 3D printed plastic will not be considered to use as a material to build the FSAE air intake is because it cannot withstand heat well enough.

There are few recommendations that can be done to improve this experiment. First and foremost, the materials that being heated should only supported at its corners. This is to prevent the bottom plate from being covered so that the equal amount of heat is being exposed to the top and bottom surface while being heated in the oven. Secondly, the materials should being observed as quickly as it took out from the oven. This is to prevent the materials from being cool under room temperature and causes it to divert back to its original length if there is any changes occur to the material.

Calculation on the design of FSAE Air Intake

Helmholtz Resonance Theory

$$Fp = \frac{162}{K}\ c\sqrt{\frac{A}{LV}}\sqrt{\frac{R-1}{R+1}}$$

Where,
RPM = Engine RPM
162 = constant incorporating unit
C = Speed of sound (ft/s)
V = Displacement of engine per cylinder (in^3)
L = Runner Length, in
A = Cross sectional area of runner
R = Compression ratio of the engine

	A	B	C	D	E	F	G	H	I	J	K	L
1		Helmholtz Resonator Calculation method										
2	Length (Inch)	RPM	Length/2	length/4		Speed of Sound (ft/s)	Runner Area (inch^2)	Displacement per Cylinder (inch^3)	Compression Ratio		First part of the Equation	Third part of the equation
3	26	8533.528076	13	6.5		1144	2.69	9.15	12.8		86785.71429	0.9247012835
4	25	8702.525236	12.5	6.25								
5	24	8881.977626	12	6		https://www.sportrider.com/tech/sportbike-weights-and-measurements						
6	23	9073.009752	11.5	5.75		Peak Torque	Peak Power					
7	22	9276.923072	11	5.5		43.8Nm @ 11500	112.1hp @ 14000	AUFSAE Target goal				
8	21	9495.233484	10.5	5.25				82.7 hp @ 10500				
9	20	9729.719002	10	5		Yamaha Claimed (Wiki)		58.3Nm @ 8000				
10	19	9982.481068	9.5	4.75			125.3hp @ 14500					
11	18	10256.02435	9	4.5								
12	17	10553.36199	8.5	4.25								
13	16	10878.15654	8	4								
14	15	11234.91177	7.5	3.75								
15	14	11629.23851	7	3.5								
16	13	12068.23114	6.5	3.25								
17	12	12561.01322	6	3								
18												
19	Zi Feng											
20	Length (Inch)	RPM	Length/2	length/4		Speed of Sound (ft/s)	Runner Area (inch^2)	Displacement per Cylinder (inch^3)	Compression Ratio		First part of the Equation	Third part of the equation
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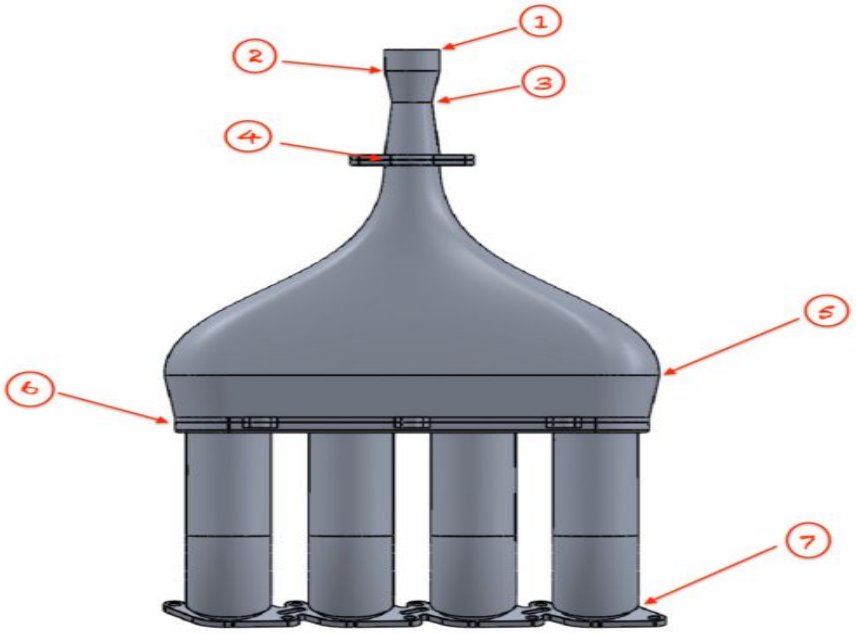
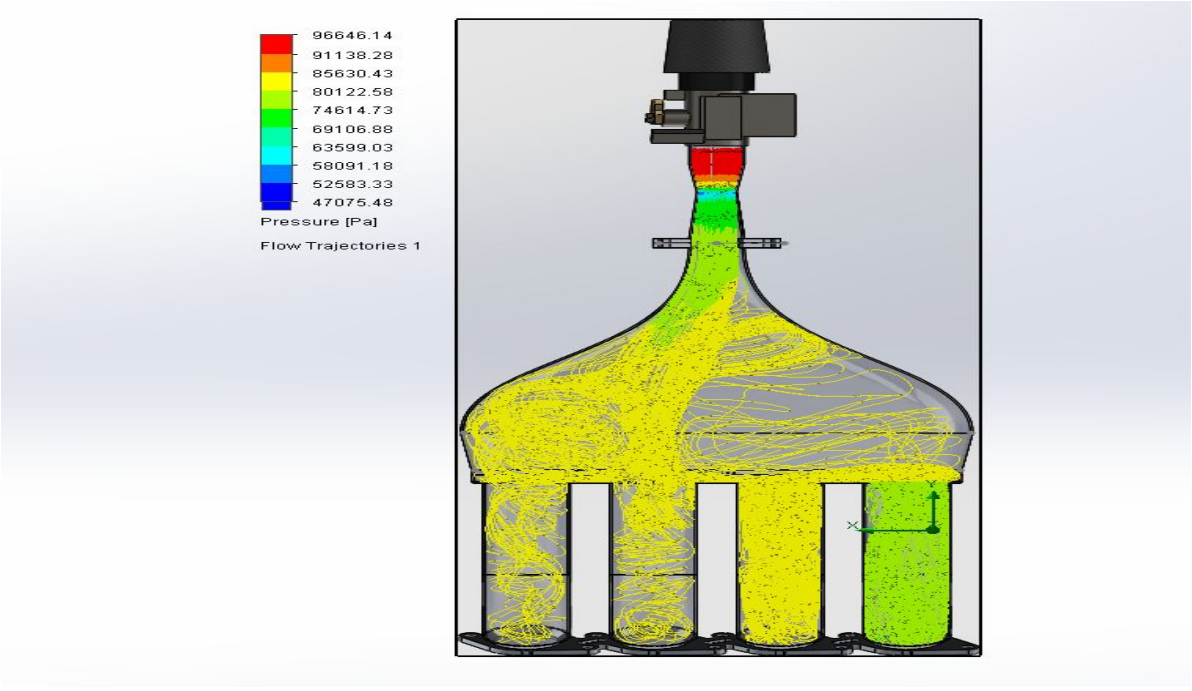
33	14	11629.23851	7	3.5								
34	13	12068.23114	6.5	3.25								
35	12	12561.01322	6	3								
36	11	13119.55043	5.5	2.75								
37	10	13759.90057	5	2.5								
38	9	14504.20873	4.5	2.25								
39												

- Figure: These are the data that calculated by using Microsoft Excel.

Calculations for Pressure Drop





- Figure: The numbering for calculation on FSAE Air Intake.

$g = 9.81\ m/s^2$

$\dot{m} = 0.075\ kg/s$

$\rho = 1.225\ kg/m^3$

$\dot{m} = \rho A v$

$v = \frac{\dot{m}}{\rho A}$

$= \frac{0.06122}{A}$

$V_1 = 0\ m/s$ $\quad A_2 = \pi (0.0145)^2 = 0.00066\ m^2$ $\quad V_2 = 92.68\ m/s$ $\quad A_3 = \pi (0.01)^2 = 0.000314\ m^2$ $\quad V_3 = 194.87\ m/s$

$A_4 = \pi (0.0145)^2 = 0.00066\ m^2$ $\quad V_4 = 92.68\ m/s$ $\quad A_5 = \pi (0.035)^2 + 0.22(0.07) = 0.01925\ m^2$ $\quad V_5 = 3.186\ m/s$

$A_6 = \pi (0.03)^2 + 0.2175(0.06) = 0.01588\ m^2$ $\quad V_6 = 3.856\ m/s$ $\quad A_7 = \pi (0.0235)^2 = 0.001735\ m^2$ $\quad V_7 = 35.286\ m/s$

$P_1 = 101325\ Pa$

$P_2 = P_1 + \frac{1}{2}(V_1^2 - V_2^2) + \rho g \Delta h = 101325 + \frac{1}{2}(0^2 - 92.68^2) + 1.225(9.81)(0.02)$
$= 97030\ Pa$

$P_3 = P_2 + \frac{1}{2}(V_2^2 - V_3^2) + \rho g \Delta h = 97030 + \frac{1}{2}(92.68^2 - 194.87^2) + 1.225(9.81)(0.03)$
$= 82338\ Pa$

$P_4 = P_3 + \frac{1}{2}(V_3^2 - V_4^2) + \rho g \Delta h = 82338 + \frac{1}{2}(194.87^2 - 92.68^2) + 1.225(9.81)(0.05)$
$= 97031\ Pa$

$P_5 = P_4 + \frac{1}{2}(V_4^2 - V_5^2) + \rho g \Delta h = 97031 + \frac{1}{2}(92.68^2 - 3.186^2) + 1.225(9.81)(0.2)$
$= 101323\ Pa$

$P_6 = P_5 + \frac{1}{2}(V_5^2 - V_6^2) + \rho g \Delta h = 101323 + \frac{1}{2}(3.186^2 - 3.856^2) + 1.225(9.81)(0.04)$
$= 101321\ Pa$

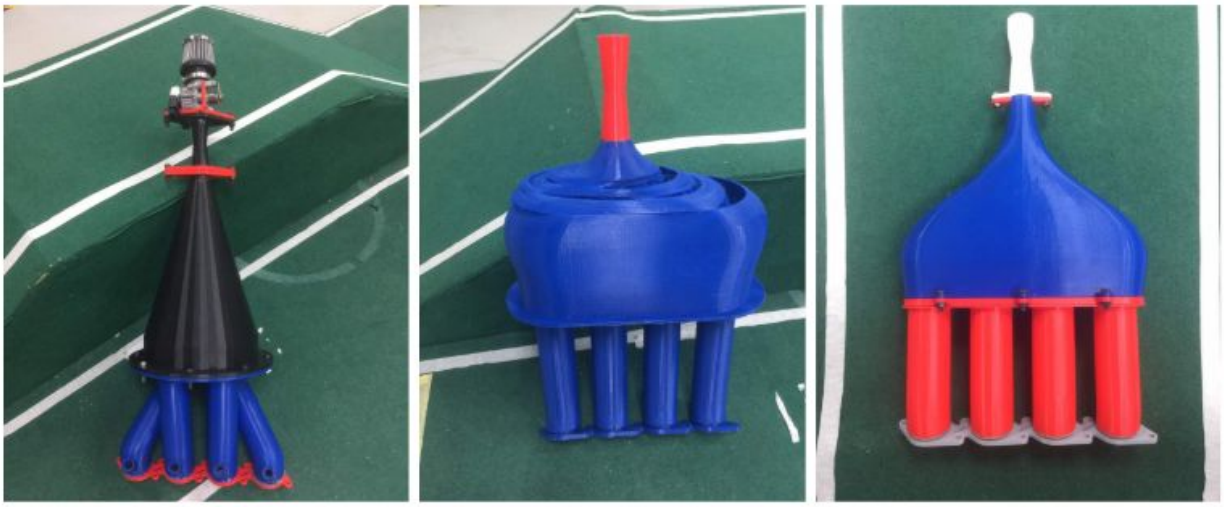
$P_7 = P_6 + \frac{1}{2}(V_6^2 - V_7^2) + \rho g \Delta h = 101321 + \frac{1}{2}(3.856^2 - 35.286^2) + 1.225(9.81)(0.1)$
$= 100707\ Pa$

(V3) Air intake assembly.SLDASM [Project(1) [Default]]

Goal Name	Unit	Value	Averaged Value	Minimum Value	Maximum Valu	Progress [%]	Use In Convergence	Delta	Criteria
PG Total Pressure Runner Start	[Pa]	80627.55206	80274.42989	78138.40735	82434.58569	100	Yes	421.0820181	1292.437917
PG Total Pressure Runner End	[Pa]	79911.08265	79771.8165	77795.60887	82002.48099	100	Yes	459.6278305	1382.410245

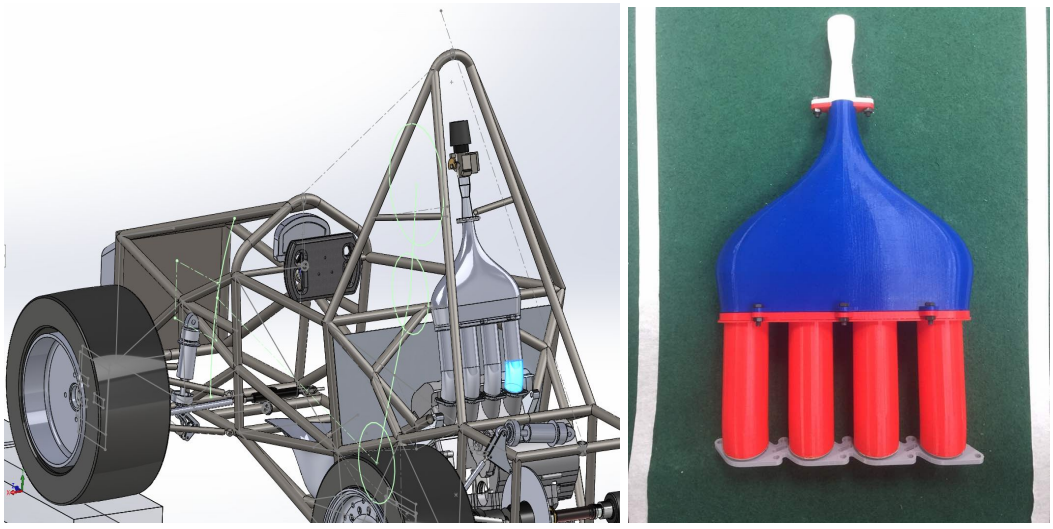
Percentage Difference between the inlet and outlet of FSAE Air Intake is 1.38%.

Final design



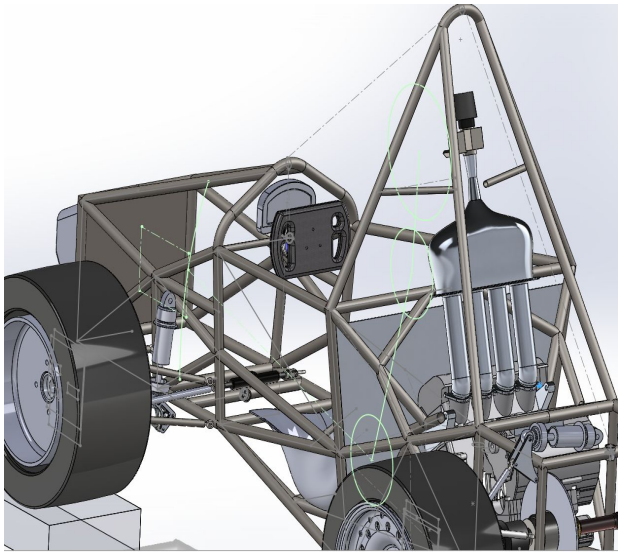
- Figure: These three model are the final design to present on Engineering fair.

Model 1:



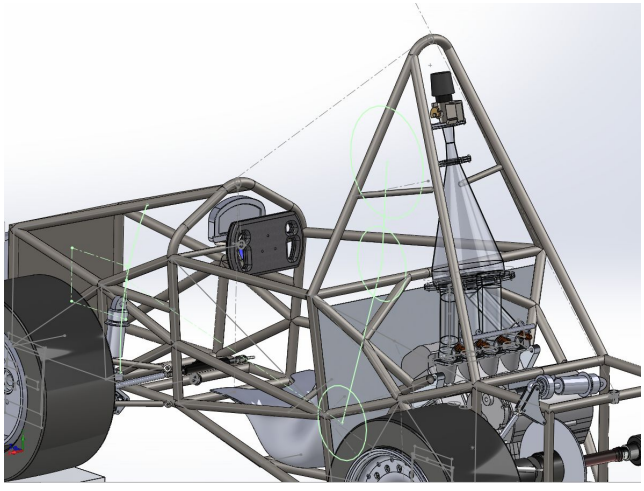
- Weight of 2.58kg
- Has a runner length of 168.87mm (6.648inch)
- 1.106kg excluding the throttle body
- Peak Volumetric Efficiency of 12k to 12.5k RPM
- A very high C.G when throttle body is added

Model 2:




- Similar to previous design
- Runner Length 217.92mm (8.58inch)
- 1.61kg excluding throttle body
- Peak Volumetric Efficiency @ 10,500 to 10,800 RPM

Model 3:




- Circular Centric Design
- Runner Length:66.53mm (2.691 inch) & 186.98mm (7.36inch)
- 2.58kg theoretical weight
- Uneven Runner length

Meeting of Minutes (MoM)

Week 2

TAYLOR'S UNIVERSITY
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SCHOOL OF ENGINEERING

Multidisciplinary Engineering Design (PRJ 60303)

Meeting Minutes 1

Date: Friday, 6th April 2018 Time: 2.00pm Venue: CDIO Room

Members Present: Yap Jin Teck (JT), Tang Ming Zhao (MZ), Lim Zi Feng (ZF), Wong Jiun Liang (JL), Nur Adriana binti Nor Azman (NA), See Siew Lee (SL)

ITEM	DESCRIPTION/MATTERS DISCUSSED	ACTION
1.0	**INTRODUCTION** The team leader which is JT would like to thank each group member that attended the meeting.	
2.0	**CONFIRMATION OF PREVIOUS MEETING MINUTES** -	
3.0	**MATTERS ARISING FROM THE PREVIOUS MEETING MINUTES** -	
4.0	**MATTERS FOR DISCUSSION**	
4.1	Brainstorming session was held The group members came up with 3 ideas regarding the hydrogen fuel cell project.	ALL
4.2	Idea Suggestion An idea was suggested to the group members to change the project title to FSAE Air Intake.	JT
5.0	**ADJOURNMENT** The meeting ended at 3.00 pm and the next meeting will be held next Wednesday (11th April 2018) at Faculty office with Dr. Satesh at 12.00pm.	

Stage: Forming

Prepared by:

(NUR ADRIANA BINTI NOR AZMAN)

Checked by:

(YAP JIN TECK)

Week 3

TAYLOR'S UNIVERSITY
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SCHOOL OF ENGINEERING

Multidisciplinary Engineering Design (PRJ 60303)

Meeting Minutes 2

Date: Wednesday, 11th April 2018 Time: 12.00pm Venue: Faculty Office

Members Present: Yap Jin Teck (JT), Tang Ming Zhao (MZ), Lim Zi Feng (ZF), Wong Jiun Liang (JL), Nur Adriana binti Nor Azman (NA), See Siew Lee (SL)

ITEM	DESCRIPTION/MATTERS DISCUSSED	ACTION
1.0	**INTRODUCTION** The team leader which is JT would like to thank each group member that attended the meeting.	
2.0	**CONFIRMATION OF PREVIOUS MEETING MINUTES** The MoM was presented, checked and improved by JT and seconded by NA.	
3.0 3.1	**MATTERS ARISING FROM THE PREVIOUS MEETING MINUTES** The FSAE Air Intake project was accepted by the dean of engineering which is Dr Satesh.	
4.0 4.1 4.2	**MATTERS FOR DISCUSSION** Research on FSAE Air Intake The group members were given tasks to research on the parts of the FSAE Air Intake • Plenum • Cylinder Runner • Restrictor • Materials used for the parts The task for project proposal was distributed. • Abstract, SWOT, Proposed Budget Conclusion • Objective, Methodology, Concept, Design • Gantt Chart, Linear Responsibility chart, Work breakdown chart	ALL ZF, JL JT,MZ SL, NA
5.0	**ADJOURNMENT** The meeting ended at 2.00 pm and the next meeting will be held next Monday (16th April 2018) at Lab.	

Stage: Forming

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Prepared by:

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(NUR ADRIANA BINTI NOR AZMAN)

Checked by:

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(YAP JIN TECK)

Week 4

TAYLOR'S UNIVERSITY
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SCHOOL OF ENGINEERING

Multidisciplinary Engineering Design (PRJ 60303)

Meeting Minutes 3

Date: Monday, 16th April 2018 Time: 12.00 pm Venue: Lab

Members Present: Yap Jin Teck (JT), Tang Ming Zhao (MZ), Lim Zi Feng (ZF), Wong Jiun Liang (JL), Nur Adriana binti Nor Azman (NA), See Siew Lee (SL)

ITEM	DESCRIPTION/MATTERS DISCUSSED	ACTION
1.0	**INTRODUCTION** The team leader which is JT would like to thank each group member that attended the meeting.	
2.0	**CONFIRMATION OF PREVIOUS MEETING MINUTES** The MoM was presented, checked and improved by JT and seconded by NA.	
3.0 3.1	**MATTERS ARISING FROM THE PREVIOUS MEETING MINUTES** For a better understanding of the FSAE Air Intake, the group members were needed to do research on the mechanism, function and the parts of the FSAE Air Intake.	
4.0 4.1	**MATTERS FOR DISCUSSION** FSAE Air Intake An example of the FSAE Air Intake was shown to the group members to show the importance of the design and a brief explanation of the mechanism was also discussed.	ALL
5.0	**ADJOURNMENT** The meeting ended at 2.00 pm and the next meeting will be held on Friday (20th April 2018) at Lecture Theatre (LT) 14.	

Stage: Storming

Prepared by:
.....
(NUR ADRIANA BINTI NOR AZMAN)

Checked by:
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(YAP JIN TECK)

Week 5

TAYLOR'S UNIVERSITY
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SCHOOL OF ENGINEERING

Multidisciplinary Engineering Design (PRJ 60303)

Meeting Minutes 4

Date: Friday, 20th April 2018 Time: 1.00 pm Venue: LT 14

Members Present: Yap Jin Teck (JT), Tang Ming Zhao (MZ), Lim Zi Feng (ZF), Wong Jiun Liang (JL), Nur Adriana binti Nor Azman (NA), See Siew Lee (SL)

ITEM	DESCRIPTION/MATTERS DISCUSSED	ACTION
1.0	**INTRODUCTION** The team leader which is JT would like to thank each group member that attended the meeting.	
2.0	**CONFIRMATION OF PREVIOUS MEETING MINUTES** The MoM was presented, checked and improved by JT and seconded by NA	
3.0 3.1	**MATTERS ARISING FROM THE PREVIOUS MEETING MINUTES** For a better understanding on the air intake, the previous FSAE Air Intake that was done by the Taylor's Racing Team (TRT) was shown to the group members.	
4.0 4.1 4.2	**MATTERS FOR DISCUSSION** Material Testing Research was done on materials that would be suitable for the FSAE Air Intake under certain conditions such as temperature. Design of the FSAE Air Intake Research was done on the design for each part of the FSAE Air Intake. • Plenum • Restrictor • Cylinder Runner	 SL,NA JT, MZ, ZF, JL
5.0	**ADJOURNMENT** The meeting ended at 2.00 pm and the next meeting will be held next Wednesday (25th April 2018) at Student Life Centre (SLC).	

Stage: Storming

Prepared by:
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(NUR ADRIANA BINTI NOR AZMAN)

Checked by:
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(YAP JIN TECK)

Week 6

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Multidisciplinary Engineering Design (PRJ 60303)

Meeting Minutes 5

Date: Wednesday, 25th April 2018 Time: 12.00pm Venue: SLC

Members Present: Yap Jin Teck (JT), Tang Ming Zhao (MZ), Lim Zi Feng (ZF), Wong Jiun Liang (JL), Nur Adriana binti Nor Azman (NA), See Siew Lee (SL)

ITEM	DESCRIPTION/MATTERS DISCUSSED	ACTION
1.0	**INTRODUCTION** The team leader which is JT would like to thank each group member that attended the meeting.	
2.0	**CONFIRMATION OF PREVIOUS MEETING MINUTES** The MoM was presented, checked and improved by JT and seconded by NA.	
3.0	**MATTERS ARISING FROM THE PREVIOUS MEETING MINUTES**	
3.1	A list of materials was proposed based on the research done for the material testing. The list consists of aluminium, carbon fibre, 3-D plastic, steel, brass and copper.	
3.2	The design of the parts on the FSAE Air Intake was sketched on a draft.	
4.0	**MATTERS FOR DISCUSSION**	
4.1	Material Testing A procedure has been discussed and prepared for the material testing based on the factor of temperature	SL, NA, ZF
4.2	Design The design of the FSAE Air Intake was started with each individual design from each group member using solid work.	JT, MZ, JL, ZF
5.0	**ADJOURNMENT** The meeting ended at 2.00 pm and the next meeting will be held next Wednesday (2nd May 2018) at Student Life Centre (SLC).	

Stage: Storming

Prepared by:
.....
(NUR ADRIANA BINTI NOR AZMAN)

Checked by:
.....
(YAP JIN TECK)

Week 7

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Multidisciplinary Engineering Design (PRJ 60303)

Meeting Minutes 6

Date: Wednesday, 2nd May 2018 Time: 2.00pm Venue: SLC

Members Present: Yap Jin Teck (JT), Tang Ming Zhao (MZ), Lim Zi Feng (ZF), Wong Jiun Liang (JL), Nur Adriana binti Nor Azman (NA), See Siew Lee (SL)

ITEM	DESCRIPTION/MATTERS DISCUSSED	ACTION
1.0	**INTRODUCTION** The team leader which is JT would like to thank each group member that attended the meeting.	
2.0	**CONFIRMATION OF PREVIOUS MEETING MINUTES** The MoM was presented, checked and improved by JT and seconded by NA.	
3.0	**MATTERS ARISING FROM THE PREVIOUS MEETING MINUTES**	
3.1	The procedure was shown to the group leader and other factors were needed to be added into the experiment which was stress and pressure.	
3.2	The first design of the FSAE Air Intake was done using the Solidworks software.	
4.0	**MATTERS FOR DISCUSSION**	
4.1	Material Testing • A new procedure was proposed based on the factors of temperature, stress and pressure. • Samples for the material testing which are aluminium, 3-D plastic and steel with the same dimensions were collected.	ZF, NA, SL
4.2	Design • Design of FSAE Air Intake is drawn by each group member and has been checked by group leader. • Second design of FSAE Air Intake will be proposed during the next meeting to be finalised.	JT, MZ, JL, ZF
5.0	**ADJOURNMENT** The meeting ended at 2.00 pm and the next meeting will be held next Friday (11th May 2018) at Student Life Centre (SLC).	

Stage: Storming

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Prepared by:

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(NUR ADRIANA BINTI NOR AZMAN)

Checked by:

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(YAP JIN TECK)

Week 8

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Multidisciplinary Engineering Design (PRJ 60303)

Meeting Minutes 7

Date: Friday, 11th May 2018 Time: 1.00 pm Venue: SLC

Members Present: Yap Jin Teck (JT), Tang Ming Zhao (MZ), Lim Zi Feng (ZF), Wong Jiun Liang (JL), Nur Adriana binti Nor Azman (NA), See Siew Lee (SL)

ITEM	DESCRIPTION/MATTERS DISCUSSED	ACTION
1.0	**INTRODUCTION** The team leader which is JT would like to thank each group member that attended the meeting.	
2.0	**CONFIRMATION OF PREVIOUS MEETING MINUTES** The MoM was presented, checked and improved by JT and seconded by NA.	
3.0	**MATTERS ARISING FROM THE PREVIOUS MEETING MINUTES**	
3.1	The procedure was checked and accepted by the group leader and will be conducted when the lab has been booked.	
3.2	The procedure was done based on the situation when the FSAE Air Intake function in the car.	
3.3	The samples were collected by cutting the aluminium sheet and steel sheet into 4 pieces with the dimension of 5 cm by 7 cm with the thickness of 1.5 mm. The 3-D plastic was printed using a 3-D printer with the same dimension and thickness as the aluminium and steel pieces.	
3.4	Second design of FSAE Air Intake has been proposed.	
4.0	**MATTERS FOR DISCUSSION**	
4.1	Material Testing An experiment was conducted with the samples collected with the factors of stress and temperature in the lab.	ZF, NA, SL
4.2	Design • The second design has been proposed and finalised. • The designs will be sent for 3-D printing before Engineering Fair.	JT, MZ, ZF, JL

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5.0	**ADJOURNMENT** The meeting ended at 1.00 pm and the next meeting will be held next Wednesday (16th May 2018) at Student Life Centre (SLC).	

Stage: Norming

Prepared by:

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(NUR ADRIANA BINTI NOR AZMAN)

Checked by:

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(YAP JIN TECK)

Week 9

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Multidisciplinary Engineering Design (PRJ 60303)

Meeting Minutes 8

Date:Wednesday, 16th May 2018 Time: 12.00 pm Venue: SLC

Members Present: Yap Jin Teck (JT), Tang Ming Zhao (MZ), Lim Zi Feng (ZF), Wong Jiun Liang (JL), Nur Adriana binti Nor Azman (NA), See Siew Lee (SL)

ITEM	DESCRIPTION/MATTERS DISCUSSED	ACTION
1.0	**INTRODUCTION** The team leader which is JT would like to thank each group member that attended the meeting.	
2.0	**CONFIRMATION OF PREVIOUS MEETING MINUTES** The MoM was presented, checked and improved by JT and seconded by NA.	
3.0 3.1	**MATTERS ARISING FROM THE PREVIOUS MEETING MINUTES** A short report was done based on the results that were observed and recorded.	
4.0 4.1 4.2	**MATTERS FOR DISCUSSION** Material Testing The short report that was done has been finalised and checked by the group leader. Design The designs that were done by the group members were sent out to 3-D print.	 ZF, NA, SL JT, MZ, ZF, JL
5.0	**ADJOURNMENT** The meeting ended at pm and the next meeting will be held next Wednesday (9th June 2018) at Library Collaboration Room (LCR).	

Stage: Norming

Prepared by:
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(NUR ADRIANA BINTI NOR AZMAN)

Checked by:
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(YAP JIN TECK)

Week 11

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Multidisciplinary Engineering Design (PRJ 60303)

Meeting Minutes 9

Date: Wednesday, 9th June 2018 Time: 12pm Venue: LCR

Members Present: Yap Jin Teck (JT), Tang Ming Zhao (MZ), Lim Zi Feng (ZF), Wong Jiun Liang (JL), Nur Adriana binti Nor Azman (NA), See Siew Lee (SL)

ITEM	DESCRIPTION/MATTERS DISCUSSED	ACTION
1.0	**INTRODUCTION** The team leader which is JT would like to thank each group member that attended the meeting.	
2.0	**CONFIRMATION OF PREVIOUS MEETING MINUTES** The MoM was presented, checked and improved by JT and seconded by NA.	
3.0 3.1	**MATTERS ARISING FROM THE PREVIOUS MEETING MINUTES** All the design that were printed out were tested using a flow simulation to observe the air flow in the system and this would determine the most efficient design.	
4.0 4.1	**MATTERS FOR DISCUSSION** Design The parts of the FSAE Air Intake which are the plenum, cylinder runner and the restrictor are done printing and could already be assembled.	ZF, MZ, JT
5.0	**ADJOURNMENT** The meeting ended at 2.00 pm and the next meeting will be held next Thursday (21st June 2017).	

Stage: Norming

Prepared by:
.....
(NUR ADRIANA BINTI NOR AZMAN)

Checked by:
.....
(YAP JIN TECK)

Week 13

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SCHOOL OF ENGINEERING

Multidisciplinary Engineering Design (PRJ 60303)

Meeting Minutes 10

Date: Friday, 21st June 2018 Time: 12.00 pm Venue: Lab

Members Present: Yap Jin Teck (JT), Tang Ming Zhao (MZ), Lim Zi Feng (ZF), Wong Jiun Liang (JL), Nur Adriana binti Nor Azman (NA), See Siew Lee (SL)

ITEM	DESCRIPTION/MATTERS DISCUSSED	ACTION
1.0	**INTRODUCTION** The team leader which is JT would like to thank each group member that attended the meeting.	
2.0	**CONFIRMATION OF PREVIOUS MEETING MINUTES** The MoM was presented, checked and improved by JT and seconded by NA.	
3.0 3.1	**MATTERS ARISING FROM THE PREVIOUS MEETING MINUTES** The parts were printed out into 5 different parts as the plenum and cylinder runner were split into 2 as they require a lot of support.	
4.0 4.1	**MATTERS FOR DISCUSSION** Design • Three designs were printed out and the parts which were the plenum, cylinder runner and the restrictor were assembled together. • Calculations were done on the FSAE Air Intake to compare the efficiency of the old design with the new design. • Flow simulation were tested on the design of the FSAE Air Intake to ensure there was no turbulence in the air intake.	ZF, MZ, JT
5.0	**ADJOURNMENT** The meeting ended at 2.00 pm and the next meeting will be held next Thursday (28th June 2017).	

Stage: Norming

Prepared by:

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(NUR ADRIANA BINTI NOR AZMAN)

Checked by:

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(YAP JIN TECK)

Week 14

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Multidisciplinary Engineering Design (PRJ 60303)

Meeting Minutes 11

Date: Thursday, 28th June 2018 Time: 1.30 pm Venue: Lab

Members Present: Yap Jin Teck (JT), Tang Ming Zhao (MZ), Lim Zi Feng (ZF), Wong Jiun Liang (JL), Nur Adriana binti Nor Azman (NA), See Siew Lee (SL)

ITEM	DESCRIPTION/MATTERS DISCUSSED	ACTION
1.0	**INTRODUCTION** The team leader which is JT would like to thank each group member that attended the meeting.	
2.0	**CONFIRMATION OF PREVIOUS MEETING MINUTES** The MoM was presented, checked and improved by JT and seconded by NA.	
3.0	**MATTERS ARISING FROM THE PREVIOUS MEETING MINUTES**	
3.1	Three designs of the FSAE Air Intake that were done by the group members were printed out and were assembled using hot glue gun, bolts and nuts.	
3.2	The pressure at multiple points, efficiency and the energy loss of the air intake were calculated to determine the efficiency of the design that was done by the group members.	
4.0	**MATTERS FOR DISCUSSION**	
4.1	Engineering Fair The slides and the poster for the Engineering Fair were prepared to present our FSAE Air Intake project.	ALL
5.0	**ADJOURNMENT** The meeting ended at 5.00 pm and the next meeting will be held on Friday (29th June 2017) for Engineering Fair.	

Stage: Performing

Prepared by:

(NUR ADRIANA BINTI NOR AZMAN)

Checked by:

(YAP JIN TECK)

Team Analysis

Week 2

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School of Engineering
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Multidisciplinary Engineering Design
Team Analysis Form

Name: Yap Jin Teck (Leader), Tang Ming Zhao, Lim Zi Feng, Wong Jiun Liang, Nur Adriana binti Nor Azman, See Siew Lee

Week	Feedback	Team Stage	Team Activity	Lecture/ Learning	Project Status	Supervisor signature and date
2	The team leader suggested to change the project to build a FSAE air intake instead of building a Hydrogen Fuel Cell. Team members agree the change and start researching about FSAE air intake.	Forming	1. The team members brainstormed 3 ideas regarding the hydrogen fuel cell project 2. Idea selection was done during the meeting with the lecturer. 3. Research was done for a better understanding on the FSAE Air Intake	The lecturer thought and explain to us the importance of Hydrogen Fuel Cell and some tips on how to build one to power a mini motor.	Conceive-Project Investigation and Challenges Research.	

Week 3

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Multidisciplinary Engineering Design
Team Analysis Form

Name: Yap Jin Teck (Leader), Tang Ming Zhao, Lim Zi Feng, Wong Jiun Liang, Nur Adriana binti Nor Azman, See Siew Lee

Week	Feedback	Team Stage	Team Activity	Lecture/ Learning	Project Status	Supervisor signature and date
3	For the group members to have a better understanding on the project, research was needed to be done on the mechanism, function and the parts of the FSAE Air Intake.	Forming	1. Research was done on the parts and the material suitable for the FSAE Air Intake. 2. The task for project proposal was distributed among the group members.	CDIO was implemented into the designing of this project.	Conceive-Project Investigation, Challenges Research, Parts on FSAE Air Intake, Material Source Research.	

Week 4

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Multidisciplinary Engineering Design
Team Analysis Form

Name: Yap Jin Teck (Leader), Tang Ming Zhao, Lim Zi Feng, Wong Jiun Liang, Nur Adriana binti Nor Azman, See Siew Lee

Week	Feedback	Team Stage	Team Activity	Lecture/ Learning	Project Status	Supervisor signature and date
4	The group members were having a difficult time understanding the use of the FSAE Air Intake and a model of the air intake with the explanation of the uses of each part was sufficient enough to help the group members understand.	Storming	1. The team leader showed the previous design of the FSAE Air Intake that was being used.	Engineering ethics and the importance of teamwork were being taught by the lecturer.	Conceive- Challenges Research, Parts on FSAE Intake System. Design - Materials Source Research.	

Week 5

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Multidisciplinary Engineering Design
Team Analysis Form

Name: Yap Jin Teck (Leader), Tang Ming Zhao, Lim Zi Feng, Wong Jiun Liang, Nur Adriana binti Nor Azman, See Siew Lee

Week	Feedback	Team Stage	Team Activity	Lecture/ Learning	Project Status	Supervisor signature and date
5	The design of the FSAE Air Intake is a crucial part as it determines the amount of air that could enter the cylinder runner. The materials that are suitable for the FSAE Air Intake were listed down to be tested and experimented on afterwards.	Storming	1. Conditions such as temperature were needed to be considered when doing research for material testing. 2. The design on the parts of the FSAE Air Intake was done.	The FSAE Air Intake has 3 parts which are the plenum, restrictor and the cylinder runner.	Conceive- Parts on the FSAE Intake System. Design- Materials Source Research, Sketch and Design of the FSAE Intake System.	

Week 6

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Multidisciplinary Engineering Design
Team Analysis Form

Name: Yap Jin Teck (Leader), Tang Ming Zhao, Lim Zi Feng, Wong Jiun Liang, Nur Adriana binti Nor Azman, See Siew Lee

Week	Feedback	Team Stage	Team Activity	Lecture/ Learning	Project Status	Supervisor signature and date
6	The group members design the FSAE Air Intake using Solidworks software. Conditions such as pressure and stress were needed to be added to the factors to choose the most suitable materials for material testing.	Storming	1. A procedure was done to test the material to be used for the FSAE Air Intake. 2. Each group members that are involved with the design of the FSAE Air Intake were needed to design it individually.		Conceive – Parts on FSAE Intake System. Design – Material Source Research, Sketch Design of the FSAE Intake System	

Week 7

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Multidisciplinary Engineering Design
Team Analysis Form

Name: Yap Jin Teck (Leader), Tang Ming Zhao, Lim Zi Feng, Wong Jiun Liang, Nur Adriana binti Nor Azman, See Siew Lee

Week	Feedback	Team Stage	Team Activity	Lecture/ Learning	Project Status	Supervisor signature and date
7	The procedure of the material testing is based on the condition when the FSAE Air Intake is functioning in the car. The group leader would check the procedure that was proposed for the material testing and will finalize it.	Storming	1. A new procedure was done based on the factors of temperature, stress and pressure. 2. Samples for material testing were collected. 3. Each group member is needed to propose their design to the group to choose the best design.	The samples for the material testing could be taken by cutting the aluminium using electric hand saw and steel using a grinder and the 3-D plastic could be obtained by printing it with 3-D printer.	Design- Materials Source Research, Sketch Design of the FSAE Intake System. Implement- Testing of the FSAE Air Intake	

Week 8

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Multidisciplinary Engineering Design
Team Analysis Form

Name: Yap Jin Teck (Leader), Tang Ming Zhao, Lim Zi Feng, Wong Jiun Liang, Nur Adriana binti Nor Azman, See Siew Lee

Week	Feedback	Team Stage	Team Activity	Lecture/ Learning	Project Status	Supervisor signature and date
8	A short report was needed to be done for the material testing to ensure that the right and most suitable material is chosen for the FSAE Air Intake.	Norming	1. The experiment for material testing was done and the results obtained were recorded. 2. The designs that were done by the group members were done and was proposed to the group leader to be finalised.	An oven and load were being used for the material testing to analyze how the materials reacted to temperature and stress.	Design - Sketch Design of the FSAE Intake System. Implement - Testing of FSAE Intake System	

Week 9

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Multidisciplinary Engineering Design
Team Analysis Form

Name: Yap Jin Teck (Leader), Tang Ming Zhao, Lim Zi Feng, Wong Jiun Liang, Nur Adriana binti Nor Azman, See Siew Lee

Week	Feedback	Team Stage	Team Activity	Lecture/ Learning	Project Status	Supervisor signature and date
9	With the experiment that was done for material testing, it could be seen that aluminium was the most suitable material to be used for the FSAE Air Intake as it is light and could withstand high temperature and stress.	Norming	1. The short report was checked and finalise by the group leader. 2. The designs of the FSAE Air Intake were sent to be 3-D printed.	A flow simulation was used to observe the air flow in the system for each design to determine the most efficient design which would be used in the Engineering Fair.	Implement - Constructing Prototype, Testing of FSAE Air Intake system	

Week 11

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Multidisciplinary Engineering Design
Team Analysis Form

Name: Yap Jin Teck (Leader), Tang Ming Zhao, Lim Zi Feng, Wong Jiun Liang, Nur Adriana binti Nor Azman, See Siew Lee

Week	Feedback	Team Stage	Team Activity	Lecture/ Learning	Project Status	Supervisor signature and date
11	During the printing of the parts, the plenum and cylinder runner were needed to be printed separately as a lot of support are needed for both of them.	Norming	1. The parts of the FSAE Air Intake are done printing and it could be assembled.		Implement - Constructing Prototype, Testing of FSAE Air Intake system	

Week 13

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PRJ60303
Multidisciplinary Engineering Design
Team Analysis Form

Name: Yap Jin Teck (Leader), Tang Ming Zhao, Lim Zi Feng, Wong Jiun Liang, Nur Adriana binti Nor Azman, See Siew Lee

Week	Feedback	Team Stage	Team Activity	Lecture/ Learning	Project Status	Supervisor signature and date
13	The old design and new design of the FSAE Air Intake are needed to be compared to ensure that the new design is efficient enough to be put into the race car for the Taylor's Racing Team (TRT).	Norming	1. The parts of the FSAE Air Intake are being assembled by using hot glue gun, bolts and nuts.	Calculations such as pressure at multiple points, efficiency and energy loss are needed to be done on the FSAE Air Intake to compare the efficiency of the old design and new design.	Implement - Constructing Prototype, Testing of FSAE Intake System	

Week 14

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Multidisciplinary Engineering Design
Team Analysis Form

Name: Yap Jin Teck (Leader), Tang Ming Zhao, Lim Zi Feng, Wong Jiun Liang, Nur Adriana binti Nor Azman, See Siew Lee

Week	Feedback	Team Stage	Team Activity	Lecture/ Learning	Project Status	Supervisor signature and date
14	Final touchups and testing were needed to be done to the FSAE Air Intake to be presented in the Engineering Fair.	Performing	1. The group members are getting ready for the Engineering Fair by creating slides and poster to present our project,		Implement - Constructing Prototype, Testing of FSAE Intake System	

Return on failure

Making mistakes and failing is an integral part of learning. Failures and mistakes can be the result of accidents, ignoring instructions or regulations or ignoring basic laws of nature. Failures can also be a result of trial and error when the correct answer or the right solution does not exist or has not been discovered yet.

Failures are often a source of very valuable learning. For us to reap the full benefit of the failures we encounter and mistakes we make, it is necessary for us to see failure as an investment that we can seek return over. This form is named Return on Failure and is designed to help you analyse your failure and grow. Let us start!

Complete the sections below. You may expand the space and use diagrams and pictures as necessary

Describe the failure or mistake that you are analysing
(Describe whether the mistake or failure is physical, technical or otherwise. If the failure was done during a trial and error process, describe the cutting edge that you are exploring as well. The failure may happen while you are testing a new process or device or while you are trying a new skill. Use pictures, sketches and diagrams if necessary)

1. Technical failure - During the printing of the prototype, a layer shift occurred during the 3D printing process of the prototype which resulted in part of the model being displaced.

The top part of the plenum is displaced from the rest of the intake

2. Technical failure - Wrong equation used while calculating the pressure difference. Measurement is less accurate using calculations and prediction.

3. Experimental failure - While conducting the thermal stress experiment, the experimental data that we obtained has a huge difference to theoretical data.

Examine what was the Root Cause of the failure

(Ask 5 Why questions starting with "Why this failure happened?" if the answer is the failure occurred because of "X", as "Why X happened?" and repeat this 5 times. This will yield the Root Cause of the failure)

1. One of the possible root causes for this error is that vibration of the printing machine whether from external sources or due to the movement of the machine itself has caused the layer of the intake to shift while printing.

2. While doing the hand calculations for the air intake. Reynolds number was not taken into account when determining the use of the bernoulli's equation. With the lack of Reynolds number, consideration of flow type in not included into the calculations. This caused the hand calculations to be inaccurate compared to the simulations data.

3. While conducting the thermal stress experiment for different materials, the temperature of the materials dropped very quickly as when we took it out from the laboratory oven. This has affected the results as the materials are not conducted at the specific range of temperatures.

Are there any other ways that you could have failed to achieve your objectives?
(Here try to predict other ways that failure could have also happened)

1. Another possible failure could have occured due to the different designs of each intake. While there may not be errors with each design by itself, problems may occur if the dimensions of the intake designs exceed the printing capabilities of the 3D printing machines. This will result in numerous design changes that may have been unnecessary if this error had been known prior to the printing process.

2.

Describe how you will use the insight above so that you eliminate or minimise the possibility of failure in the future.

1. Proper supports and the printing process should be taken into consideration even during the design phase. To prevent errors like these to happen again, proper research and precautions should be carried out, like investigations into the possible errors or problems that might occur for 3D printing. Thought has to be given to the entire manufacturing process so that all potential causes of failure can be minimised or throughly eliminated.

2. Proper time management could have helped in this project. With proper time management, prototype of the failed print would have been able to be reprinted in time for presentation. With proper time management the team could also have discussed further the calculations required for the research.

3. For the thermal stress experiment, the materials that has been heated up in the laboratory oven should have put in a near vacuum chamber to prevent or minimise heat loss.

What are the other key learnings from this failure?

1. Complete and thorough research and precautions has to be undertaken so that no unexpected failures will occur. As a result of some oversight and unexpected failures at the end of the manufacturing phase, there was no time to reprint the design. This could have been avoided if the failure was discovered sooner or if there was a backup solution prepared beforehand.

2.

References

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