Coventry University

Faculty of Engineering, Environment & Computing

Department of Mechanical, Aerospace & Automotive Engineering

325MAE Logbook

Developing CAD of cooling channels inside a 3-D printed mould for a quality Aluminium die cast

Submitted in partial fulfilment of the requirements for the degree of Bachelor of Engineering

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BEng Mechanical Engineering
Supervisor: Erdal Turkbeyler
April, 2020

Declaration: The work described in this report is the result of my own investigations. All sections of the text and results that have been obtained from other work are fully referenced. I understand that cheating and plagiarism constitute a breach of University Regulations and will be dealt with accordingly.	
Signed: Tsvetomir Pashov	Date: 01/05/2020

Logbook Guidance

The Logbook should follow the template below. The table describes how the marks are allocated. Please note that the logbook must be submitted electronically.

Logbook	Marks
Standard Cover Page. To include: Title, Logbook, Student Name, ID, Supervisor, Declaration	MANDATORY
Log of Activities A professional record of the project to include: meeting minutes (both with supervisor and group), record of key developments and project management, details of individual technical work performed. This is not an exhaustive list and you need to evidence the progress made. This could include your methodology, method or materials; data collected, case studies identified, analysis and design tools identified; development of your model, design or process, technical or concept decided etc. Also note that you will need to refer to your project plan, aims and objectives. The log should be in sufficient detail to allow another engineer to reconstruct your contribution to the group project just by reading your entries. It does not need to be written as a formal document but should be sufficiently clear to understand your logic. It will also be used to judge your own engagement and contribution to the group project.	50
Reflective Report (guide 1000 words) An extended piece of writing that highlights key project milestones and challenges and your individual contribution to them. You should include critical reflection on how you demonstrate the Engineering Council's (IMechE) competencies both technical and professional and how you have improved and developed these during the course of the project. Clear actions should be identified and mapped against the competences in the table below. The writing needs to be clear, concise and organised with your thoughts expressed in a logical manner.	50
	TOTAL: 100 Marks

Project Title

Developing CAD of cooling channels inside a 3-D printed mould for a quality Aluminium die cast

Client details

Essam Abdelfatah - Assistant Professor
Yuancheng Liang - Research Assistant
Rein show – additive machine manufacturing producer
Cast Alum – lead company for casing automotive parts

Group members and contact details

Group 24:
Anshdeep Batta (battaa2@uni.coventry.ac.uk)
Dimosthenis Stratis (stratisd@uni.coventry.ac.uk)
Tsvetomir Pashov (pashovt@uni.coventry.ac.uk)
Yash Mehta (mehtay@uni.coventry.ac.uk)

Supervisor and staff contacts

Erdal Turkbeyler (ab0936@coventry.ac.uk)

Aim

Develop a GUI on top of CATIA that will automatically make changes to CAD geometries. The changes represent material extrusion to shape die cast cooling channels. The automatic process involves the use of an algorithm for making conformal cooling channels using specific data point locations.

Objectives

- Initial task/role allocation
- Development of a sample geometry - 3D solid block
- Review the literature review resource available
- Develop a couple of approaches to solving the problem
    1. Use macro recordings option inside CATIA
    2. Create multiple circles inside the geometry – initially using VBA & Excel
    3. Use VB to develop the code from scratch
- Get a sample of complex geometry
- Test if the currently developed approaches are functioning as expected
- Work on developing shape alteration (change in direction) of channel

- Identify minimum distance from the surface in order to decrease the chance the high pressure inside the channel to cause crack formations
- Develop a GUI using example model from Group meeting 1
- Add export section inside the GUI to accommodate for different types of file extensions that will include extension compatible with 3D printer
- Presentation (final) for client summarising the finding
- Report
- Wizzard Showcase

Deliverables

An automation tool build inside CAT using the inbuild VBA. The tool is to assist the cooling channel extrusion. Hence it will be a conformal cooling channel generation tool. (1st May 2020)

Plan

The initial Gantt chart is available on Table 1.

Log of Activities

Contents

Meeting on 22/Oct/2019

All group members have been selected – Group 24:

- Anshdeep Batta – has previous experience with macros
- Yash Mehta – highly skilled
- Dimosthenis Stratis – previous group member and skilled CAD engineer

Meeting on 1/Nov/2019

The whole group attended the Project Fair organised by the module team. On the Fair the list of possible projects that the group has interest in was reduced to 10. From that list a final screening was completed and the final selection of 5 project topics was made. The projects topics selected were as following:

1. Sparrowhawk - Development of final design of the sparrowhawk racing car
2. Fluids and Complex systems research centre - Developing CAD of cooling channels inside a 3D printed mould for a quality Aluminium cast
3. Microcab - analysis of multi radio transmission
4. Royal Enfield - Improve heat rejection from air cooled engine
5. Lotus - Optimisation of SMC tailgate

Final selection of project

Final selection was released on **22/Nov/2019** and the group was assigned the **Developing CAD of cooling channels inside a 3D printed mould for a quality Aluminium cast** project. In this project I will be able to further develop my coding skills because the project requires the development of a Graphical User Interface and based on the title possible making changes to CAD geometries without using CAD software.

Meeting minutes with “client” - 22/01/2020 15:00

Attendance: the whole group were present, supervisor and “client”

First presentation showcasing the project aims and objectives – 3-4 week

Project – outlining the cooling system of a die cast for aluminium. The die cast is made from steel and in order to increase the production rate of casting the cooling system needs to be improved.

Project budget 1.2 million £.

The project is sponsored by the 2 companies:

- Rein show – additive machine manufacturing producer
- Cast Alum – lead company for casing automotive parts

Conformal cooling channel (the channel needs to follow the shape of the geometry)

Cooling channel (pipes) filled with water are added inside the mould.
The focus is on identifying good cooling channels. By good it means that:

- There is an effective cooling – quick and uniform cooling
- Temperature at the surface is uniform
- The temperature needs to be reduced to the point the cast is cooled enough for it to be taken out of the die and remain solid

The task is to create a code that will be working on top of CATIA and will be making changes to the geometry as tasked. This will be done to create the cooling channels of the die that are desired. The input will be location of the points and the code work is to create extrusion cuts inside the geometry. An example of a given input is (x, y, z, diameter, Shape). The software needed for the task is

- CATIA for high complexity geometry editing
- Visual Basics for developing the code that is manipulating the CATIA editing and functionality.

The project is focused on circular pipes infrastructure inside the mould to increase the cooling rate and improve the traditional method used.
The code is to be applicable to different types of geometry, hence being able to work on any given CAD model regardless of complexity and properties.
The output file needs to be able to be send to 3D printer, hence it needs to be compatible with the different file extensions.

Tasks to be completed

- Get familiar with CATIA or CAD software and how it operates with complex geometry
- Additional tasks in table below with time bounds

Status	**325MAE**	**Start**	Duration	From	By
Yes	325MAE - Initial Briefing	1/22/2020	1	1/22/2020	1/22/2020
No	325MAE - Acquire geometry from lab assistant	1/22/2020	9	1/22/2020	1/31/2020
No	325MAE - Get weekly meeting invite	1/22/2020	9	1/22/2020	1/31/2020
No	325MAE - Learn Visual Basics	1/29/2020	16	1/29/2020	2/14/2020
No	325MAE - Distribute role and work within group	1/22/2020	9	1/22/2020	1/31/2020
No	325MAE - See how to implement code inside CATIA	2/7/2020	22	2/7/2020	2/29/2020

No	325MAE - Try implementation of complex geometry	2/21/2020	52	2/21/2020	4/13/2020
No	325MAE - Wizard Showcase	3/25/2020	1	3/25/2020	3/25/2020
No	325MAE - Presentation 1		1		
No	325MAE - Presentation 2		1		
No	325MAE – Report	2/7/2020	68	2/7/2020	4/15/2020

Table 1: Initial tasks from the Gantt chart

Code specifications:

- Needs to be applicable to any geometry
- Various output file extensions need to be available inside the final GUI – add different saving extensions

Group meeting 1 – 28/2/2020 12:45

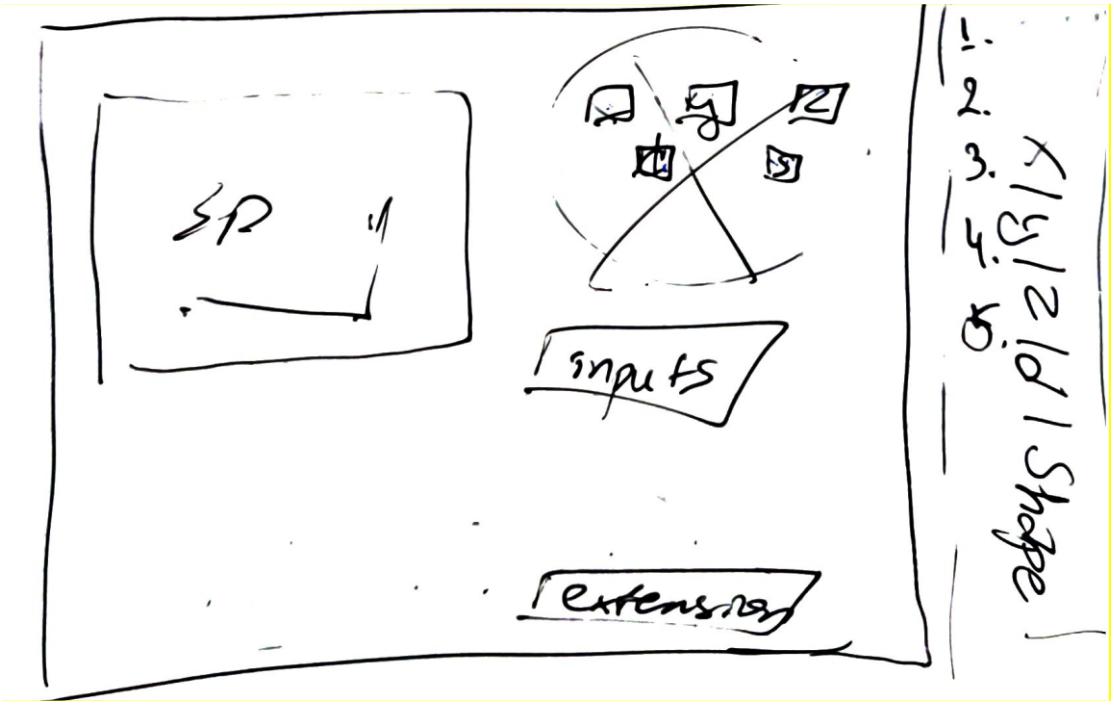

Figure 1: An example of the GUI

Have an import button for excel file with input data => expand the GUI side section so input data can be added

TODO:

- Split into 2 men teams

Team 1	Team 2
VBA	Marco

Table 2: Project work split

- Find resources about VBA and VB and linking them to CATIA
- Dimos to ask what needs to be showcased in the first presentation
- Completed the online quiz to access the project brief
- Make a solid block in CATIA
- Experiment on the block
- Input data & importing it into CATIA (making circles) using VBA
- Extruding them (from one circle to another)

Presentation needs to consist of:
- Aims and objectives
- Example of possible solutions

Aims and Objectives – 31/01/2020

Aim – develop a GUI on top of CATIA that will automatically make changes to CAD geometries. The changes represent material extrusion to shape die cast cooling channels. The automatic process involves the use of an algorithm for making conformal cooling channels using specific data point locations.

Objectives –
- Initial task/role allocation
- Development of a sample geometry - 3D solid block
- Review the literature review resource available
- Develop a couple of approaches to solving the problem
    4. Use macro recordings option inside CATIA
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Group meeting 2 – 31/01/2020 12:00

Members: All members were present

To ask on the next meeting with Erdal:

- What shape will be the 5th input – an example of shapes that can be given as an input

TODO:

- Circulate aims and objectives to the rest of the group

Group Meeting – 13/02/2020

Meeting for distributing work on the Presentation

All members present

Common - Cover page
Problem and description – 2 slides
- Dimos - {Fast diagram}

Personal - Aims and objectives – 1 slide
Common - Current trends - Brief introduction with small literature review on cast – 2/3 slides
Solutions (2 different methods) – pros and cons of the solutions (2/4 point) – 2 per topic
- Yash - Catia with VBA/marco using record macro
- Tes - Catia with VB

Ansh - (risk assessment of the project [making it like a tree]) – 1/2 slides
Design specification – 1 slide
Tes - Draft GUI – 1 slide
What will be improved from outpoint of view – 1/2 slide
Tes - Gantt chart – 1 slide
Personal - Meet the team – 1 slide
Personal - Q&A from us
Personal - Q&A for us

Tes – research on GUI with VB

Risks for the risk assessment
- Lack of expertise
- User trying to make changes to the software, leading to malfunctions
- Software not available
- Losing data

Update

Due to health issues that resulted in a surgery on 14/02/2020 I was unable to attend any of the team meetings and project supervisor (Erdal) meetings. The time gap is from 03/02/2020 to 07/03/2020.

In this period, I have only been unable to provide any assistance on the work on the project and just a small assistant on the client presentation. From the presentation I have provided the initial Gantt chart (Table 1) that has been update, extensive description of the **aims and objectives**, the draft layout of the GUI and the break down and methodological/logical structure of the code/tool.

Group Meeting 10 – 13/03/2020

All members are present

Discussed the current progress – almost nothing has been done. No working prototype, no visible solution is possible to be created from the current state.
Still learning about CATIA VBA functionality, it's capabilities, etc.

Working on how to parse a point created in 3D with all of its properties to a function. Or return it as an output of a customised point generator function.

Working in CATIA

Initial Method for solution 2

Initial method that will be used for the project:

- Import geometry
- Set points – based on x,y,z
- Draw line
- Generate plane reference
- Set circles – x,y,z,d/2
- Extrude with same diameter
- Extrude with different diameter
- Keep distance from surface at end points
- Keep distance from surface at all points
- Follow the shape of the surface
    - Find the points for the shape – end points where the shape changes
    - Do extrusion with the same diameter
    - Find the ratio and alter the diameter and do extrusion with the new diameter

Approaches that didn't work from the initial method:

- Draw line – the line doesn't support the plane generation or the channel extrusion
- Generate plane of reference (xy, yz, zx) – not an applicable approach because the plane that needs to be created is at a specific offset from the Normal Origin Point and it is at a specific angle in all 3 planes. **A new method is to be developed.**
- The is not difference in the extrusion with the same or a different diameter because the used tool is **Removed Multi-section solid**. The tool has not problem removing

the solid material between the 2 generated circle regardless of the difference in their diameter.

- The distance from the surface at all points is N/A. If the end points of the channel are kept at a minimum distance from the surface and the channel is designed as conformal channel there won't be any need to check that all points of the channel are at a minimum distance from the surface. The idea behind this was that if the distance from the channel to the surface is too small it will impact the integrity of the die cast. This is based on the fact that when water is heated up by the cooling of the cast inside the die it will create high levels of pressure that can lead to cracks if the wall is thin.

Tasks and approaches to try for creating a plane:

- Approach 1
  - Find how to parse a point (generated point) to the next function
  - Add the shifted plane – try creating a plane that at the given offset using the generated point above and shifting it in the 3 directions
- Approach 2
  - Generate 2 extra points – calculate their position so that their will lie in the plane that needs to be generated. This is based on creating a plane using 3 reference points
    - Find distance between 2 points in 3D
    - End point will lie on a circle – resulting in a cone type like sketch
- Approach 3
  - Calculate where the centre point of the circle is
  - Draw circle on the newly created plane

Completed tasks:

- The centre point of the circle was found to be with (0,0) on the generated plane

The approaches above has all been tested and none of them were applicable. Even more approaches 1 & 2 are tedious and time consuming. Hence a new approach has been found which is to create a plane based on an equation. This approach will be tested.

Final approach for solution 2

Final approach to generating a plane – to generate the needed plane 2 points are used (start and end point of the channel (x,y,z, coordinates)). End to start distance represent the perpendicular distance to the plane. Then the plane equation is formulated using the start point and the perpendicular vector properties: $a(x-x_0) + b(y-y_0) + c(z-z_0) = 0$

Progress on 15/03/2020

GitHub repository created. Link to the private repository: https://github.com/pashovt/Group-dissertation.git

Problem: how to assign a given value to the needed variable

The syntax of the language has created a lot of complications. The assignment of a input value has been completed but it has taken a significant amount of time. The problem is partially solved because the way that the language works and handles variables as containers. The integer input has been assigned by a main input when running the function. A problem has occurred when trying to parse a whole container to a next method/function. This issue could not be resolved because VBA is not designed to receive such input, or my current understanding is not sufficient enough. The solution to this problem was to use one method and not create multiple methods like normal coding languages (e.g. Python, C++). That is because it was concluded that using multiple methods and function is not applicable for such a project.

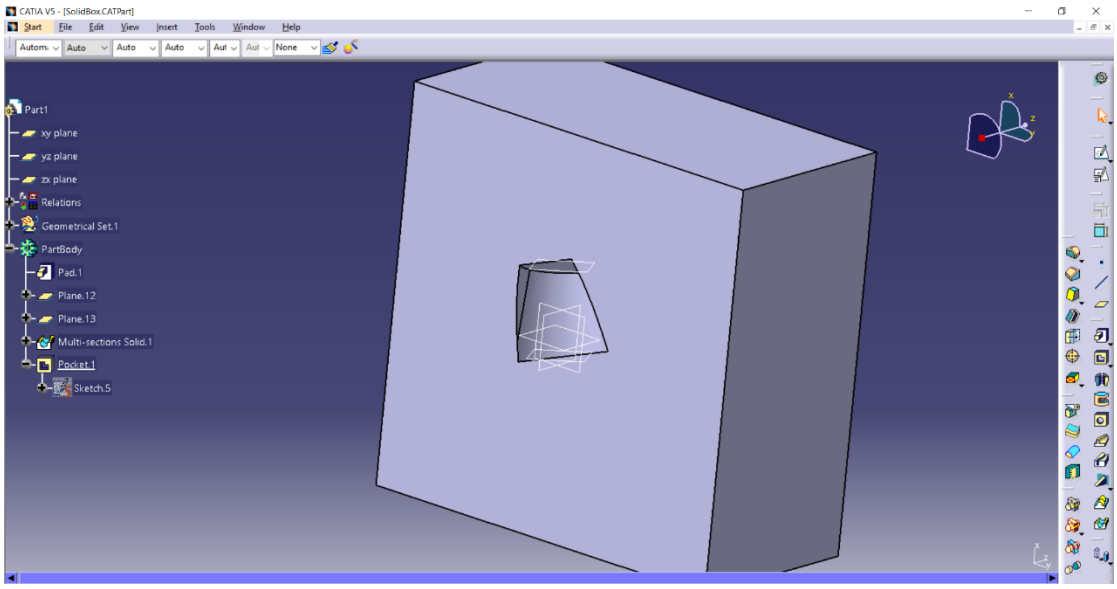

Figure 2: Example extrusion of a channel

Progress on 16/03/2020

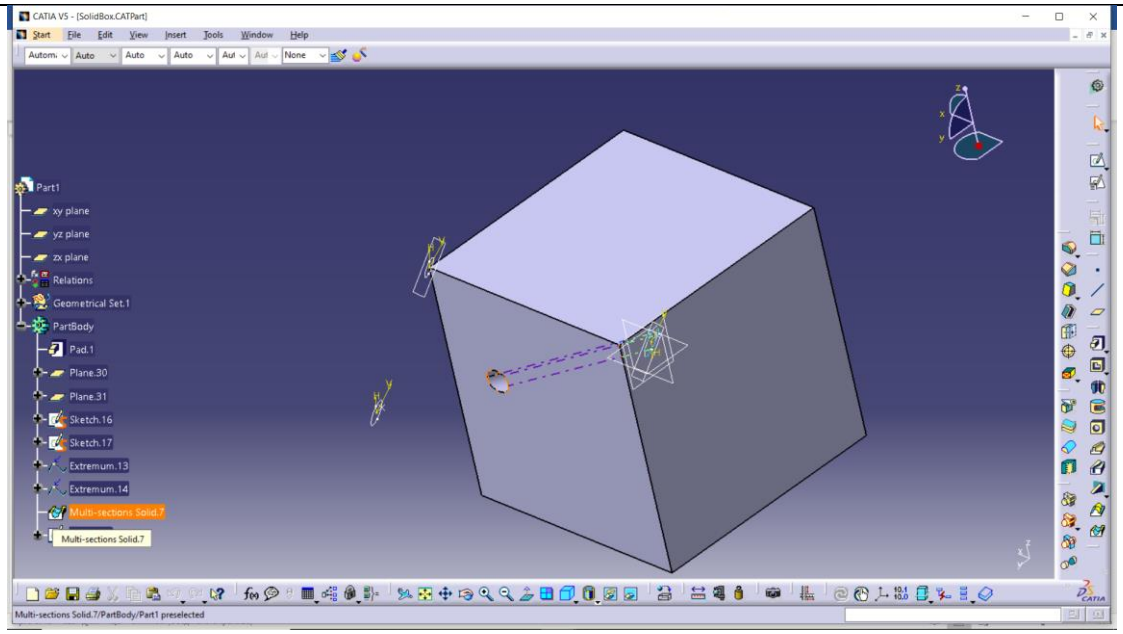

Figure 3: Extrusion of the automated tool – returns the wrong channel

Code pushed to GitHub
Updated version of the channel generation

The main VBA module is "Module2". It takes 2 circle properties (x,y,z,d) and creates an appropriate plane, circle on it and extrudes a hollow channel between the two given inputs.

TODO: make the tool work with multiple input points with the use of EXCEL spread sheet

Errors to Fix:

The generated circle on the second plane is not positioned correctly. The reason is currently unknown, and it is to be found and fixed.

```
'get root product
Dim rootProd as Product
Set rootProd = CATIA.ActiveDocument.Product

'extract the part number part to match
Dim sPN as string
sPN = Left(rootProd.PartNumber,15)

'wrap the hyphens with single quotes
sPN = Replace(sPN,"-","'-'")

'build query string
Dim sQuery as string
sQuery = "'AssemblyDesign'.Product.'Part Number'=" & sPN & "*,in"
```

CATIA.ActiveDocument.Selection.Search sQuery

Code for changing string name of available objects. After testing the code, it was found that it doesn't run properly. It is also not applicable for automating the tool. The doesn't assist in checking what is the name of the new plane.

Progress from 18/03/2020

Solution to finding the name of the newly generated 2 planes:

```
Dim selection1 As Selection
Set selection1 = partDocument1.Selection

Dim FirstPlane As Integer
Dim SecondPlane As Integer

selection1.Search ("Name=plane*,all")
selectionCount = selection1.Count2
'MsgBox selectionCount
FirstPlane = selectionCount - 1
SecondPlane = selectionCount
FirstPlaneName = selection1.Item(FirstPlane).Value.Name
'MsgBox FirstPlaneName
SecondPlaneName = selection1.Item(SecondPlane).Value.Name
'MsgBox SecondPlaneName
```

The found name of the plane is used by a **HybridShapes** container that uses the plane as a reference and produces a sketch on it. The sketch is a circle based on the starting diameter of a single channel.

Various approaches were used in order to find the name of the Plane. Those approaches consisted of creating a variable as a specific type of container and trying to extract information from the output. Example of used types and methods can be seen in table 3

Var as HybridShapeFactory	Var.ChangeFeatureName Var.GetItem Var.GetObjectFromReference Var.Name
Var as HybridShapePlaneEquation	Var.GetOrigin Var.Name
Var as HybridShape	Var.Item Var.Name Var.Parent
Used types	Used methods

Table 3: Tested approaches

But all of them were not applicable at all and returned errors, empty variables or unwanted information.

Next step:

- Hide the generated objects excluding the **Multi-Section solid remover**
- Fix the problem with the circle location/position on the second plane (it is not centred correctly)

Hiding the generated objects (**planes, sketches and extremums**) task has been completed using the above method for finding their names. After finding their names a custom method was developed that picks what type the object is and its name and hides it from the main user view. After this operation the objects will still remain part of the part or assembly tree.

The problem with the circle location on the second plane has been fixed. The method that was used was to change the following code

Dim arrayOfVariantOfDouble1(8) arrayOfVariantOfDouble1(0) = 2.509091 arrayOfVariantOfDouble1(1) = 10.663636 arrayOfVariantOfDouble1(2) = -3.136364 arrayOfVariantOfDouble1(3) = 0.973417 arrayOfVariantOfDouble1(4) = -0.229039 arrayOfVariantOfDouble1(5) = -0# arrayOfVariantOfDouble1(6) = 0.063041 arrayOfVariantOfDouble1(7) = 0.267924 arrayOfVariantOfDouble1(8) = 0.961375	Dim arrayOfVariantOfDouble1(8) arrayOfVariantOfDouble1(0) = 0# arrayOfVariantOfDouble1(1) = 0# arrayOfVariantOfDouble1(2) = 0# arrayOfVariantOfDouble1(3) = 0# arrayOfVariantOfDouble1(4) = 0# arrayOfVariantOfDouble1(5) = 0# arrayOfVariantOfDouble1(6) = 0# arrayOfVariantOfDouble1(7) = 0# arrayOfVariantOfDouble1(8) = 0#
Old code	New code

Table 4: Reference points used for the plane generation

The variable above is used in the below lines

Set sketch1Variant = sketch1
sketch1Variant.SetAbsoluteAxisData arrayOfVariantOfDouble1

And it is an essential variable that is responsible for setting the absolute origin point of the specified plane. That is extremely important because the plane is at a specific angle and is in a specific offset from the Normal Origin Point (0,0,0).

With this the Single Channel Extrusion/Solid Material Removal is Complete.

Next steps:

- Complete 2 channel extrusions
- Create a Connection between them are extrude that connection as well
- Make a multiple input selection – current approach that will be used is by using Excel spreadsheet.

Error of the circle position and plane origin point position that interferes with the desired channel position. After running a small analysis and a few tests to identify the problem it was discovered that the problem is the equation that generates the plane. The plane is generated correctly but the origin point of the plane is not the desired one that needs to correspond to the given x, y and z coordinates.

The solution of this problem will be further investigated.
The below figures show the mispostioning of the channel. The specified coordinates of the channel are (40, 40, 40) and (40, -40, 40). Due to the way the reference vector of the plane is generated the channel itself is created at x = 0 and z = 0. This can be seen on figure 4.

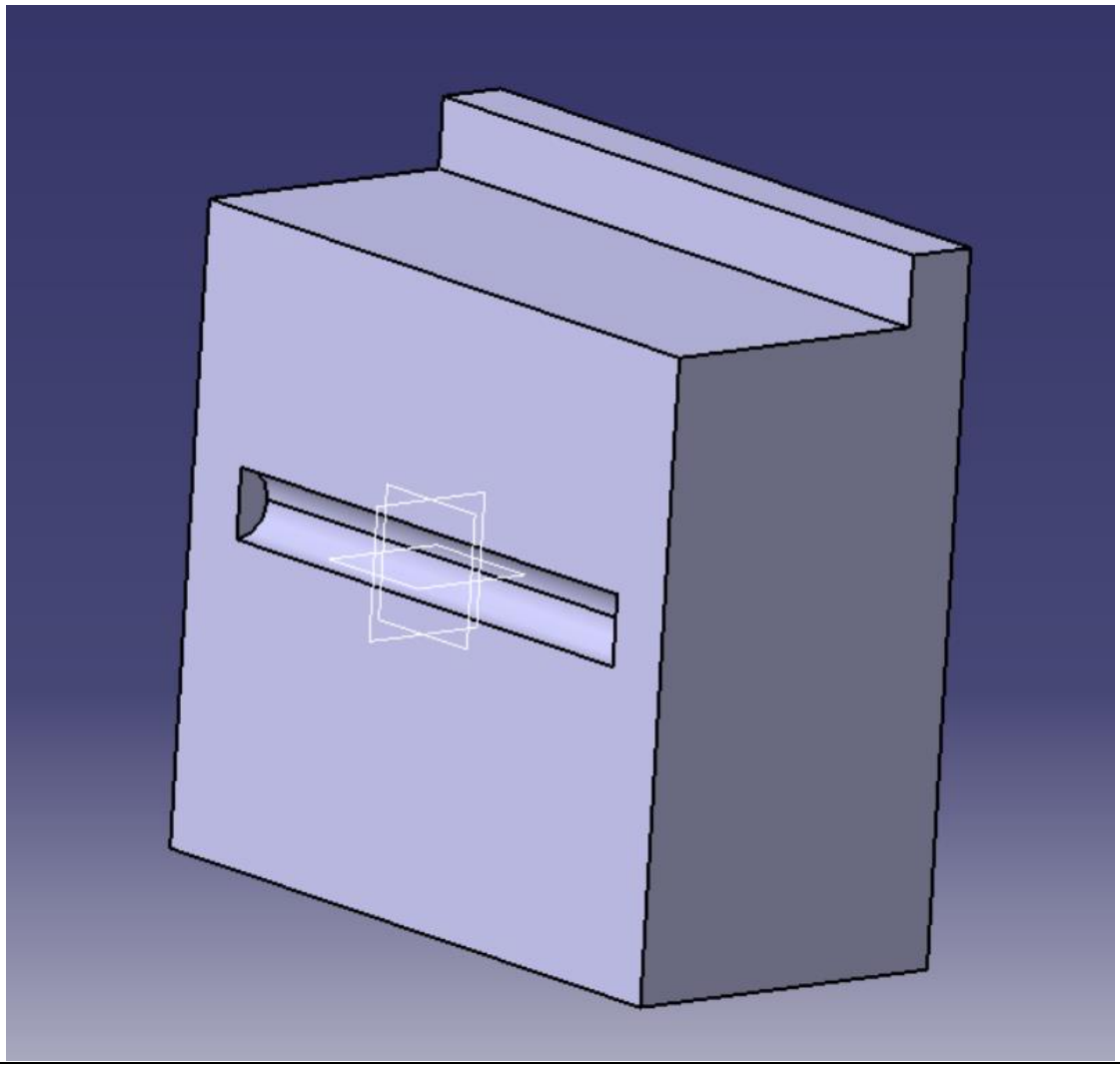

Figure 4: Channel extrusion misposition

On figure 5 the correct channel position can be seen in the top left corner not in the middle of the solid geometry. This problem is clearly major and if not fixed it will impact the delivery of the product and corrupt the future work that it will be used for.

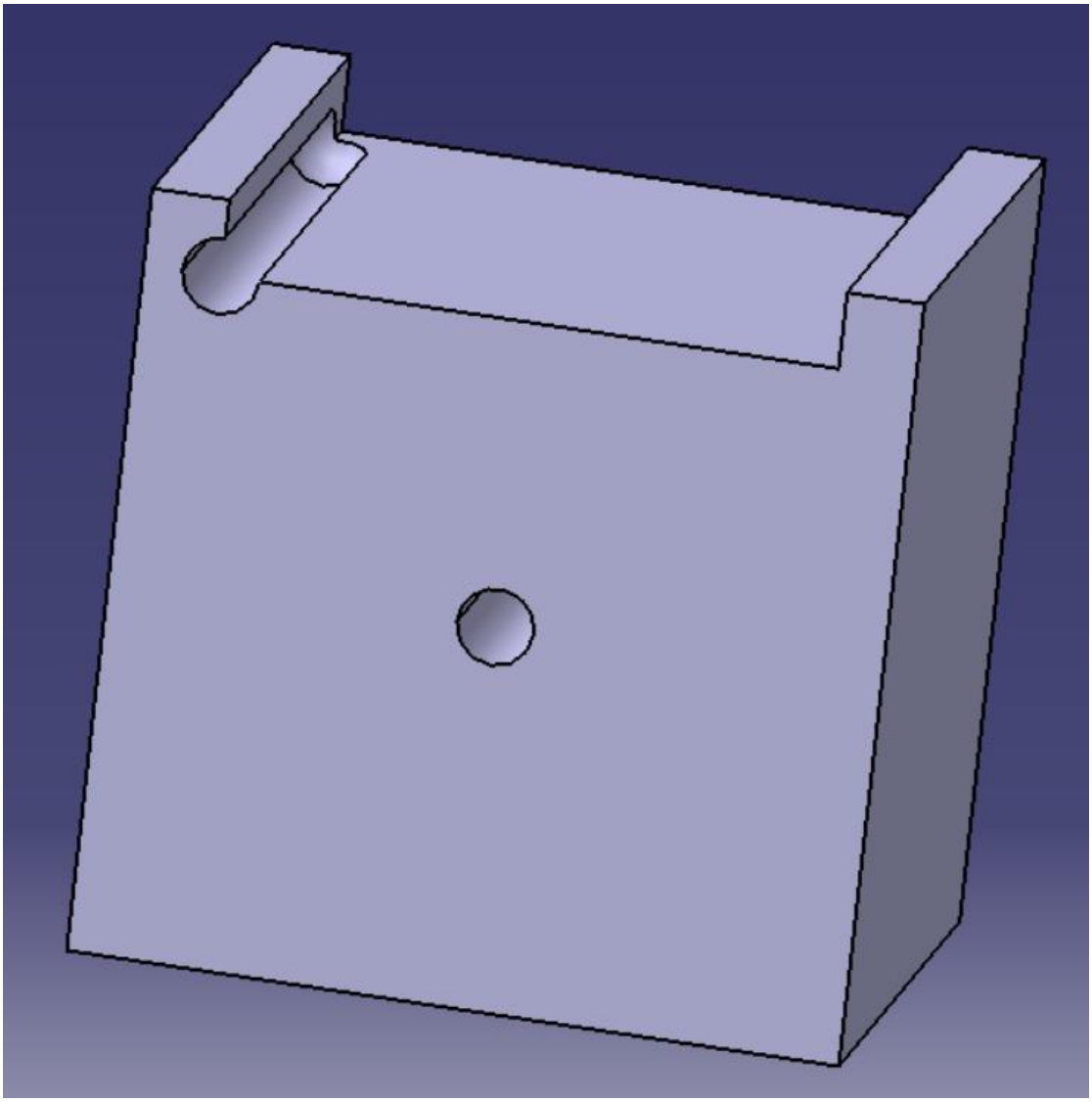

Figure 5: Channel misposition and comparison

Channel connection

Using remove solid tool is not applicable it this case as it can be seen on figures 6 to 8. The removed solid in this example won't be completed because the software recognises it as too complicated.

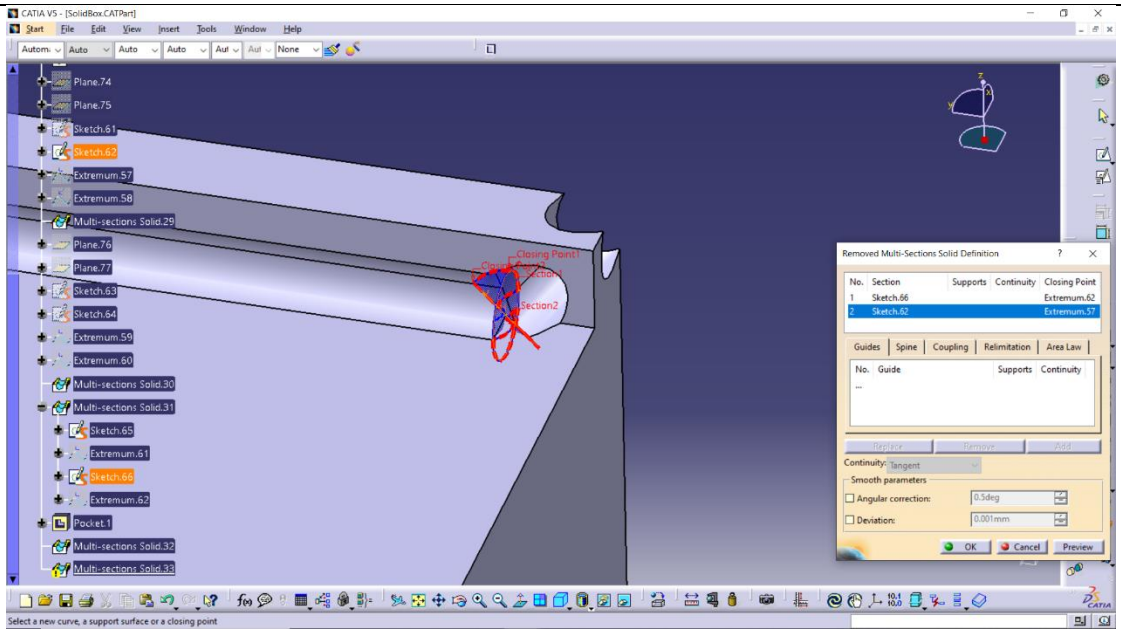

Figure 6: Connection of channels using solid material remover tool

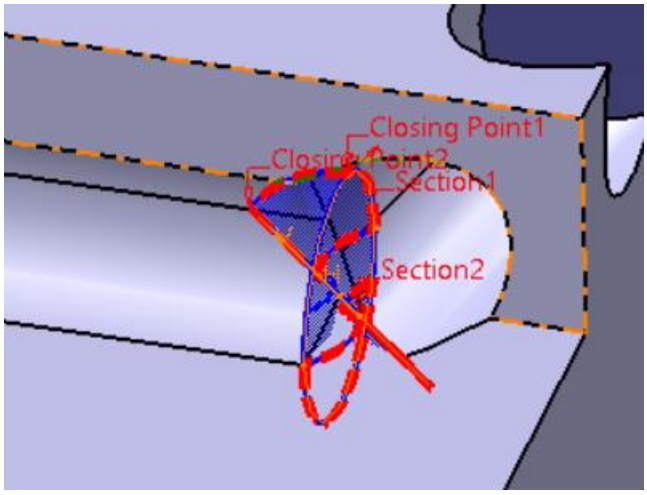

Figure 7: Close plan of the issue of solid removal

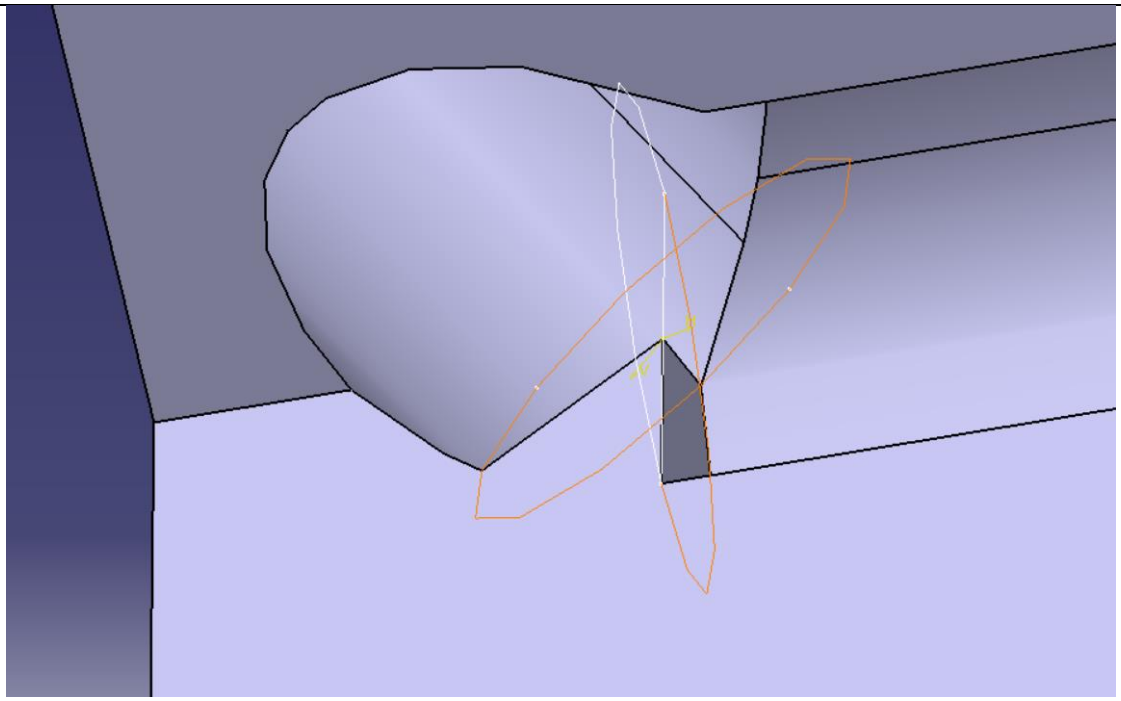

Figure 8: Look of the 2-circle representing the channels end points

Ideas to try:

- Try creating a sphere and removing the solid material
  - Test if it can be done by **Removing Solid material** tool

A spherical solid removal of the section where 2 channels are meeting/connecting is a must. That is because a non-uniform object extrusion/material removal will affect the working properties of the die cast creating weak points. Those point can lead to cracks affecting the thermal cooling properties of the cast itself resulting in changes to the time required for the solidification process.

Useful source

Useful source of information about the syntax and the way VBA works has be identified. (Google Books 2020) Useful sections from it are:

- Chapter 9 – Creating an extrusion table
- Chapter 18 – Creating a tool icon for the macro

Question of interest:

- What the GUI is suppose to look like based on the user interest? Will the user want to work inside CATIA or want the whole process to be automated outside of the CAD software? If inside CATIA will an icon from a toolbar be useful rather than going to the macro settings?
- Extension due to health problems

- Example of a shape input (different shapes that can be seen)

Spherical solid removal

The spherical solid removal used for the connection of 2 channels has been completed using on online tutorial (Youtube 2016). The cut was completed using Groove tool to a half circle placed at the intersection of 2 channels meetings.

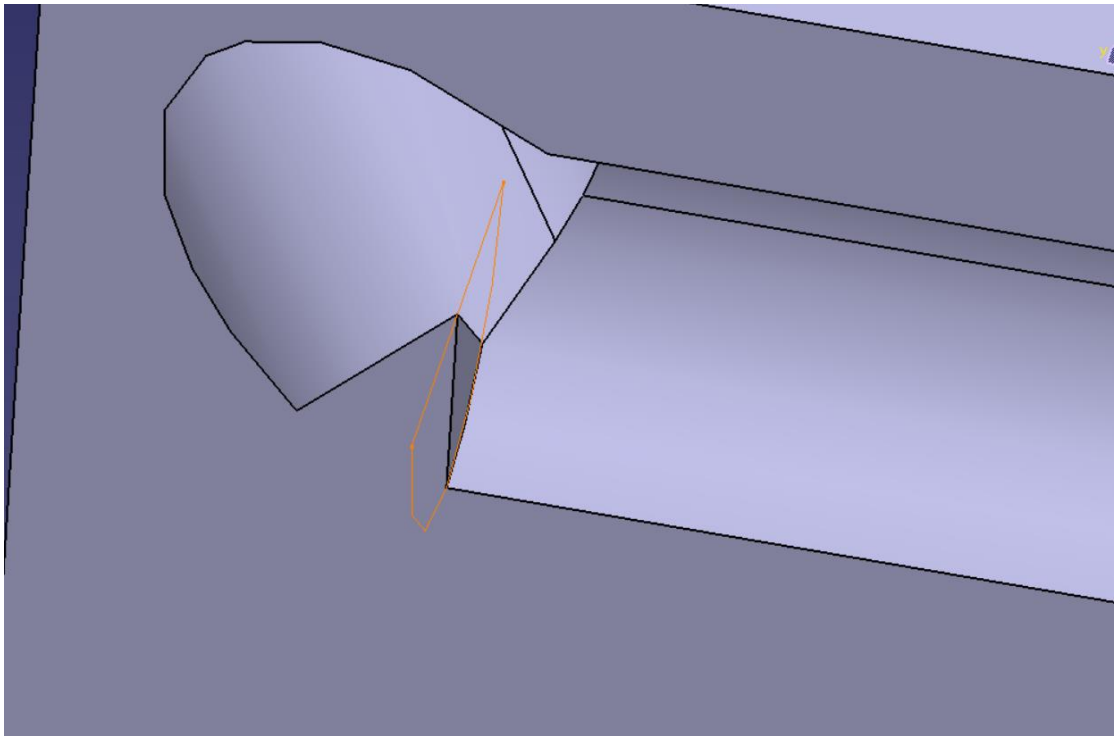

Figure 9: Half circle sketch for spherical cut

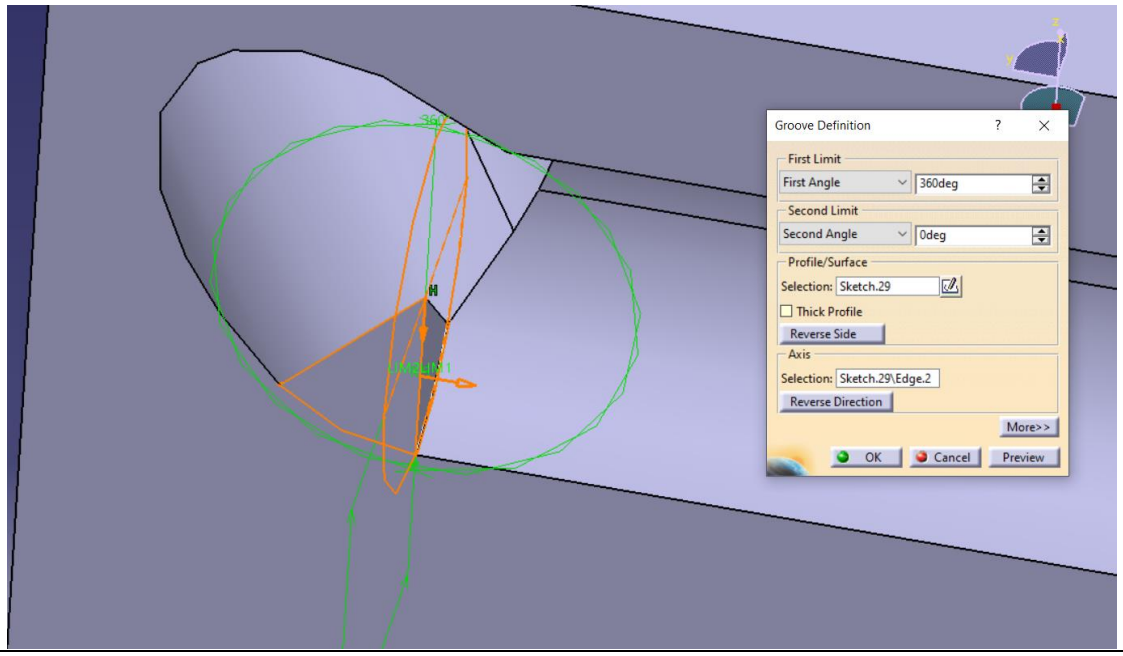

Figure 10: Spherical cut preview from Groove tool

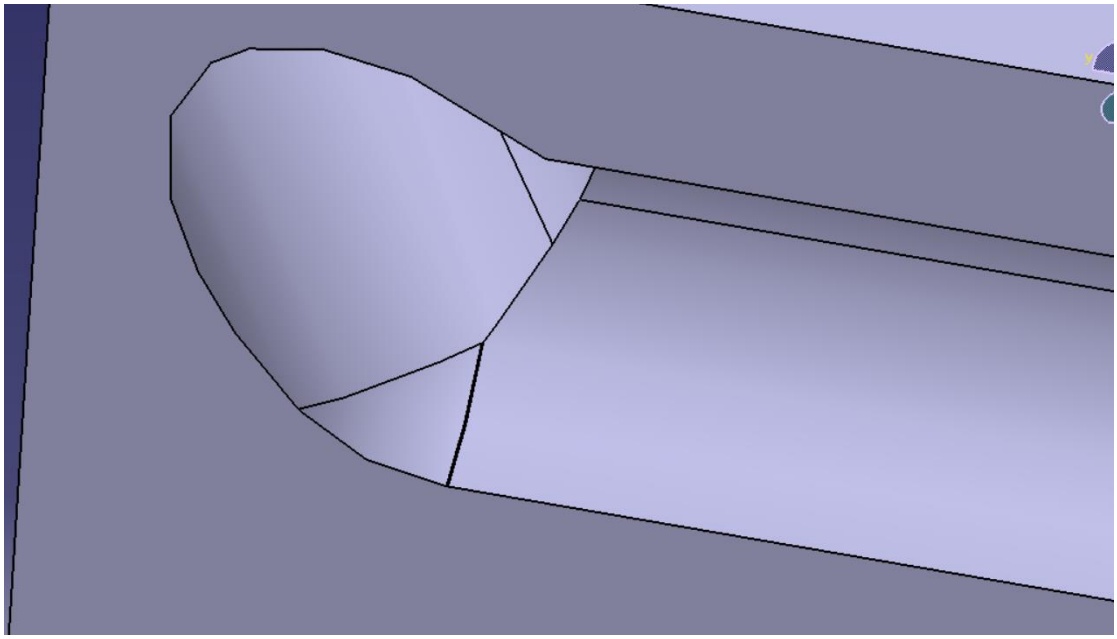

Figure 11: Spherical cut

In the automation application this spherical cut will have a radius of the smaller channel diameter.

Issue when making the Groove code has been found. The Groove doesn't select the reference object (the reference line) in order to create the spherical cut.

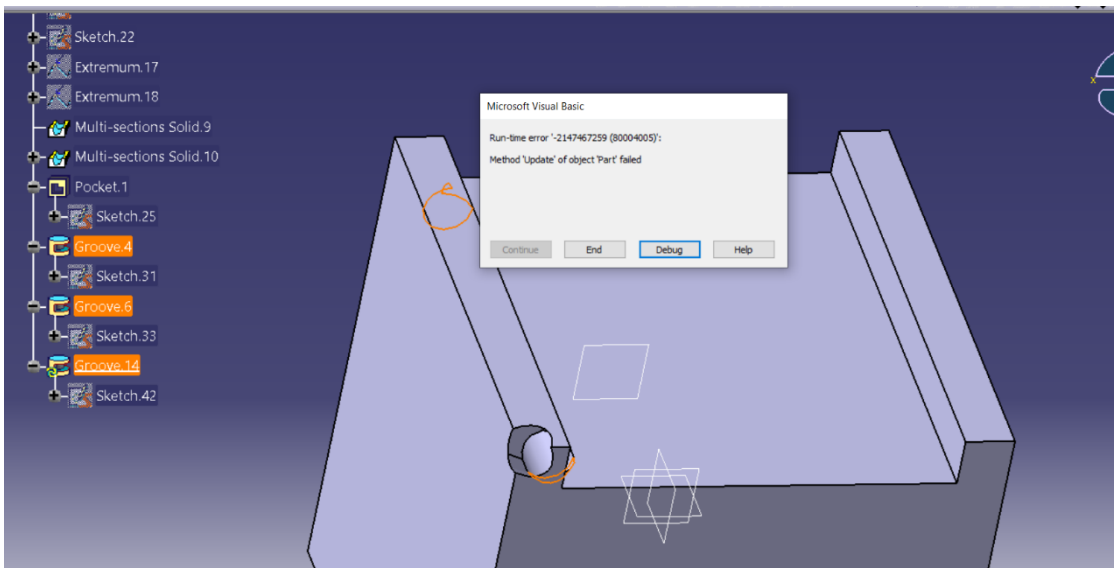

Figure 12: Error from Groove generation 1

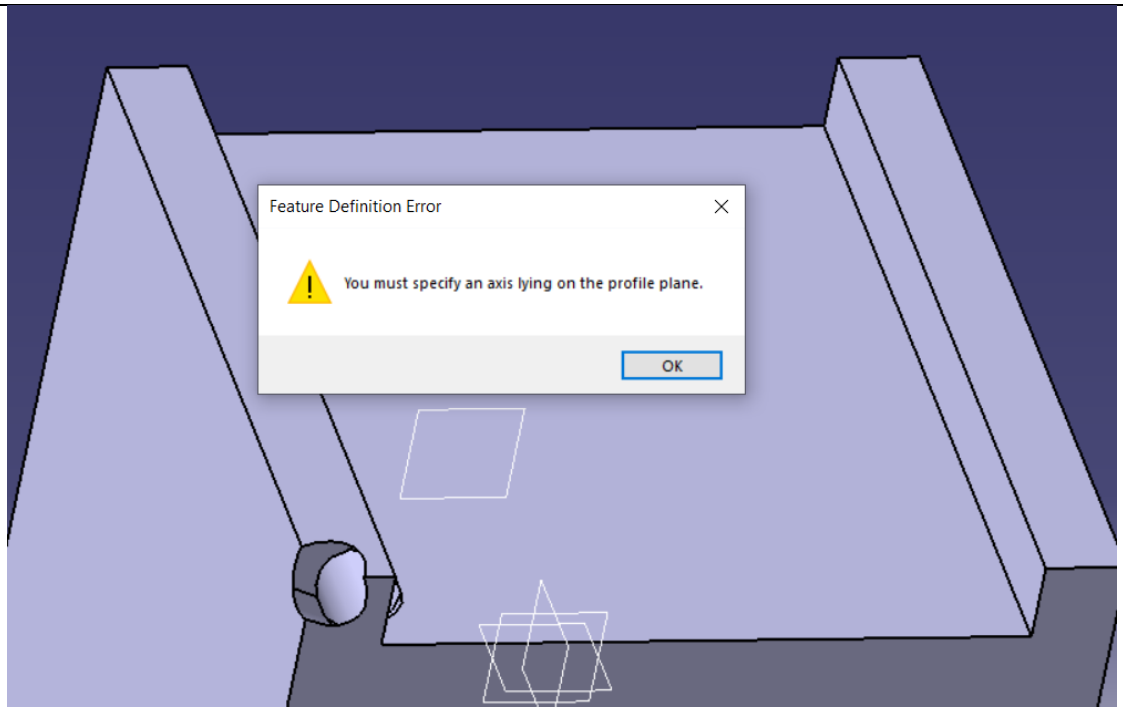

Figure 13: Error from Groove generation 2

The needed action is to select the reference line.

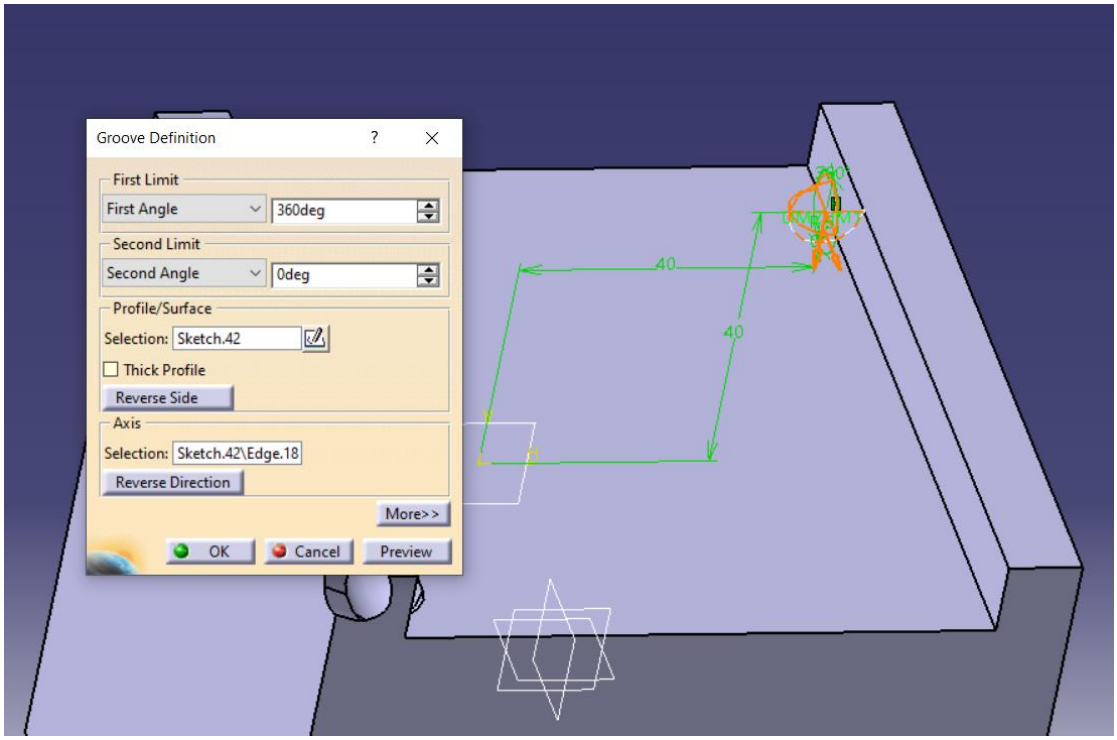

Figure 14: Solution

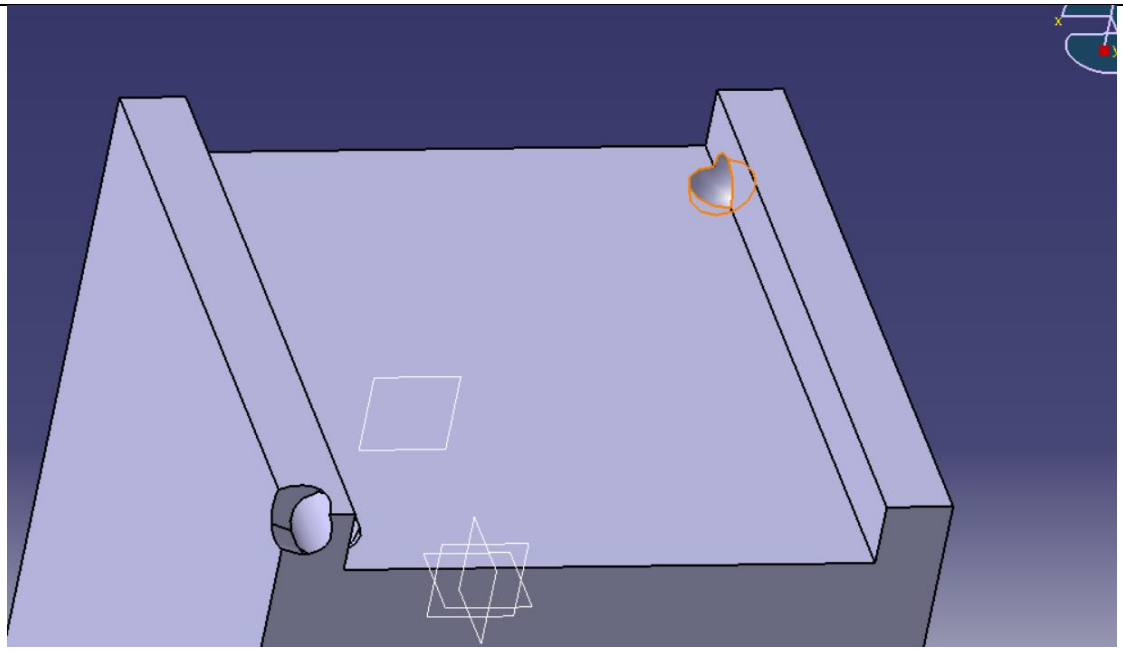

Figure 15: Spherical Cut

A way to automatically select the reference line must be identified in order to complete the cut without any interaction.

Meeting minutes from Erdal – 26/03/2020

Logbook + reflection, written report to be submitted on 24/04
Presentation + individual viva to be submitted on 04/04 or 10/04

Guidance on video is on Moodle

- 2-4 min video
- Viva – 3 question available on Moodle
  - 1st question is the same for the whole group
  - The remaining 2 questions are personal choose from the 5 possible option on Moodle

What is supposed to be on the presentation?

- What has been achieved so far
- Next steps

Solution submission on Moodle along with the report

Meeting minutes 28/03/2020

Current state of the project and a small showcase to the rest of the group has been made. Along with a discussion of the errors and time frame to fix them.

U or L example shapes – Dimos

Work on current approach
2/3 more days will be needed to fix the errors in the tool

Next meeting will be on Monday or Tuesday where the final selection of tool will be made, and the presentation will be started
Discussed the structure of the report, Dimos showed examples

To do:

- Speak with Ansh for providing support on the tool development

Progress on 29/03/2020

Problem with completing the spherical cut has been resolved. This was solved by creating 2 separate sketches that contain half a circle representing the sphere radius and a line representing the axis that will be used by Groove for the spherical cut. This method has resolved the issue with the user interaction and has supported the automation of the tool.

A possible flow in the automation has been identified. The flow is based on the generated macro, example of which can be seen on figure 16 line 2.

```
Dim length8 As Length
Set length8 = parameters1.Item("Part1\PartBody\Groove.12\ThickThin1")

Dim length8 As Length
Set length8 = parameters1.Item("Part1\PartBody\" & GrooveName & "\ThickThin1")

Dim length8 As Length
Set length8 = parameters1.Item(fullPath & "\ThickThin1") '"Part1\PartBody\" & GrooveName & "\ThickThin1")
```

Figure 16: Automation of part selection

The first 2 line represent the direct call to a specified Groove and its methods which will return an error when ran in a different environment. The second set of lines has the Groove element name found using Selection Search but as it can be seen it will run fine for part one and it will not be applicable to an assembly. While the last 2 lines are based on the generated tree path of the required Groove component.

I new problem has been identified that is connected to the plane position. The problem is the positioning of the Groove cut in the specified plane at the end or start of a channel. The problem will be fixed along with the Plane positioning completing the Multiple Channel Generation Task. And it can be be seen on figure 16.

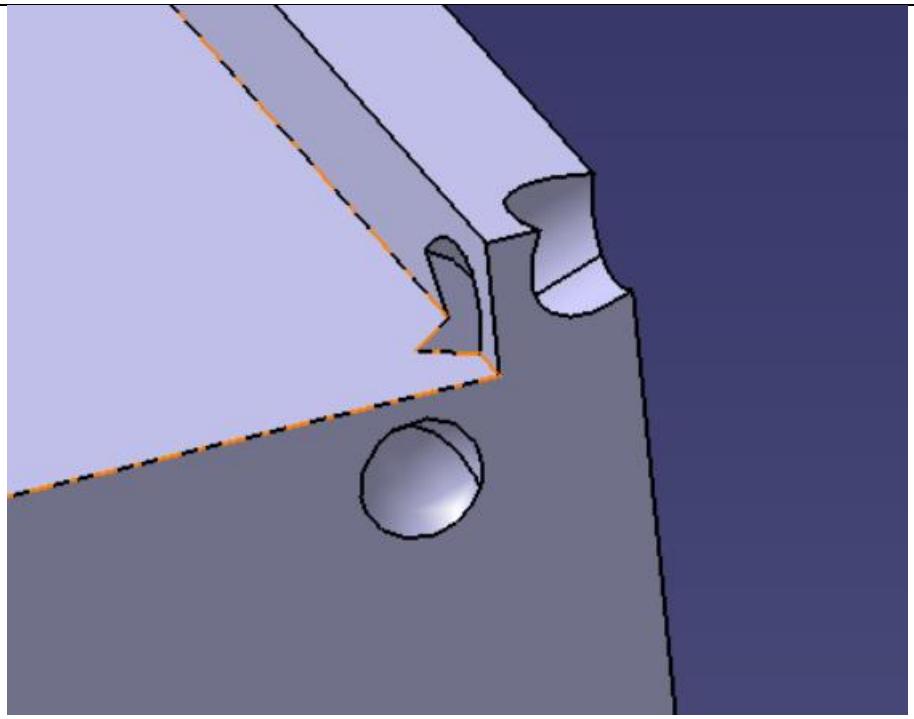

Figure 17: Spherical cut misposition

Next steps:

- Fix the plane positioning
- Start the GUI or find a way how to use multiple points data outside of hardcoding it

Ideals about the GUI

Questions for Erdal:

- What the GUI is suppose to look like based on the user interest? Will the user want to work inside CATIA or want the whole process to be automated outside of the CAD software? If inside CATIA will an icon from a toolbar be useful rather than going to the macro settings?
- Example of a shape input (different shapes that can be seen)

Ideals:

- File selection box (box input)
- Geometry look
- Update button
- Export option dropdown menu
- Export button

- Excel or other type of sheet for data inputting or importing an excel sheet with a specific structure

Group Meeting on 02/04/20

The meeting agenda was to support the issue with the plane origin point.
The method of creating a channel and more specifically the way the start and end plane are generated was explained in detail to the team.
The solution and the problem were visualized to the rest of the team. A small discussion on what could be the problem was conducted and that the equation might be on the power of 2 for the A, B and C values based on Dimos opinion.

Ansh presented his solution which was based entirely on starting from the surface in order to generate any channel.
My solution is based on starting at any desired point regardless of it being the surface or inside the 3D geometry. Making the final product more robust and have better application.

There was a further discussion and critique section of both solutions.

It was decided that a meeting with the supervisor is needed for provide guidance on how to progress with the work and how to choose the appropriate solution.

Meeting on 03/04/20 with Erdal

Ansh – not present

Submission dates confirmed with supervisor – 01/05/20 for all the components of the Group project

2 solutions are currently available – Ansh and mine (Tes)

Problem 1 – Selecting the final solution

- Both solutions were explained to the supervisor and my personal solution was visualized
- The decision should be made on the better and more appropriate outcome of the individual solutions
- It should be based on a number of criteria
  - More manageable
  - More logical

- An excess point of the surface is needed because the water needs to enter the channel somehow

- The solution needs to be able to create the internal layout and channels

- Internal layout and channels are a main objective

Problem 2 – The positing of the plane

- The problem was explained to the supervisor
- The solution was identified by describing the solution in detail
- The problem can be fixed by using the current method based on the plane equation and using a reference point (with the coordinates of the channel start or end point) as an origin point

Ansh to be updated on the meeting

Further meeting with Essam will be arranged by the supervisor in order to develop an understanding and gain information about the layout of the GUI.

Progress on 03/04/20

The problem with the positing of the start and end plane and especially their origin point was fixed. Below 3 examples can be seen (Figure 18 to 20) with different datasets. They represent the start and the end of the generated channel.

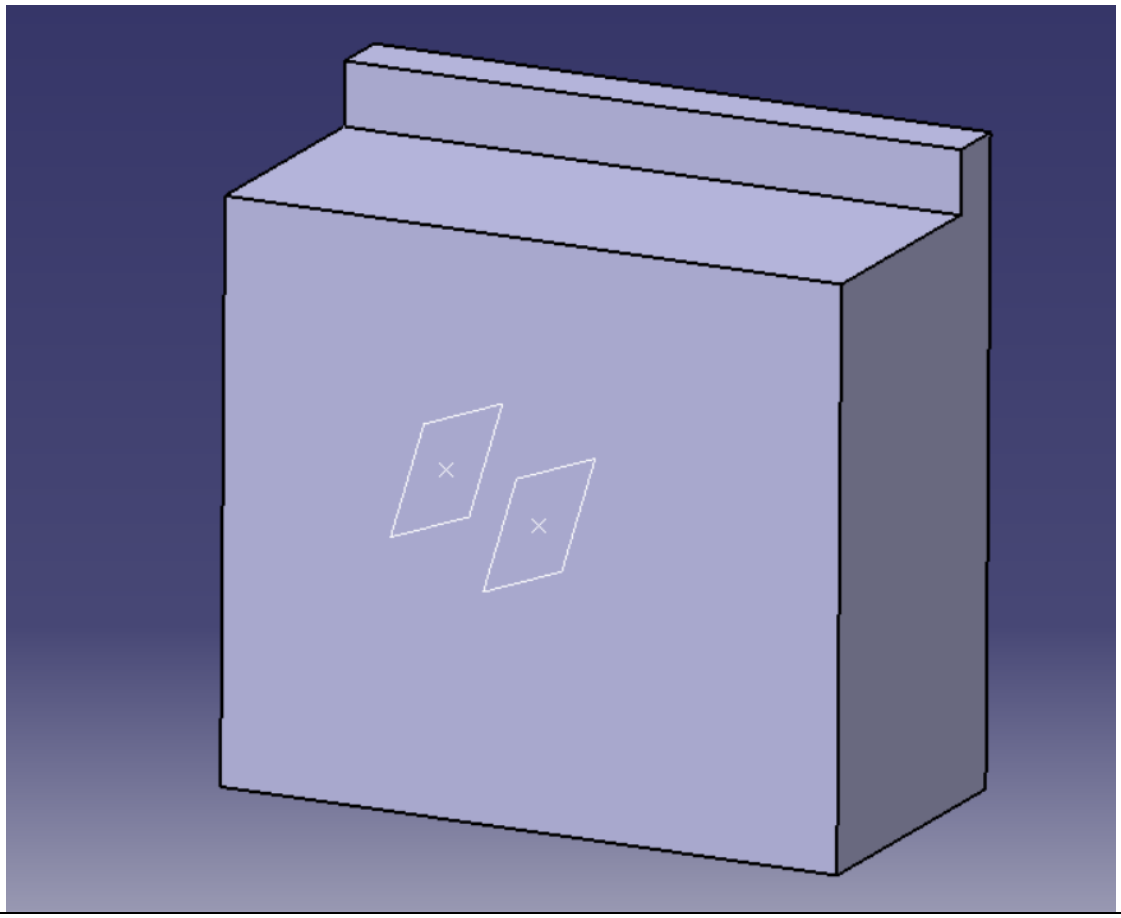

Figure 18: Plane orientation 1

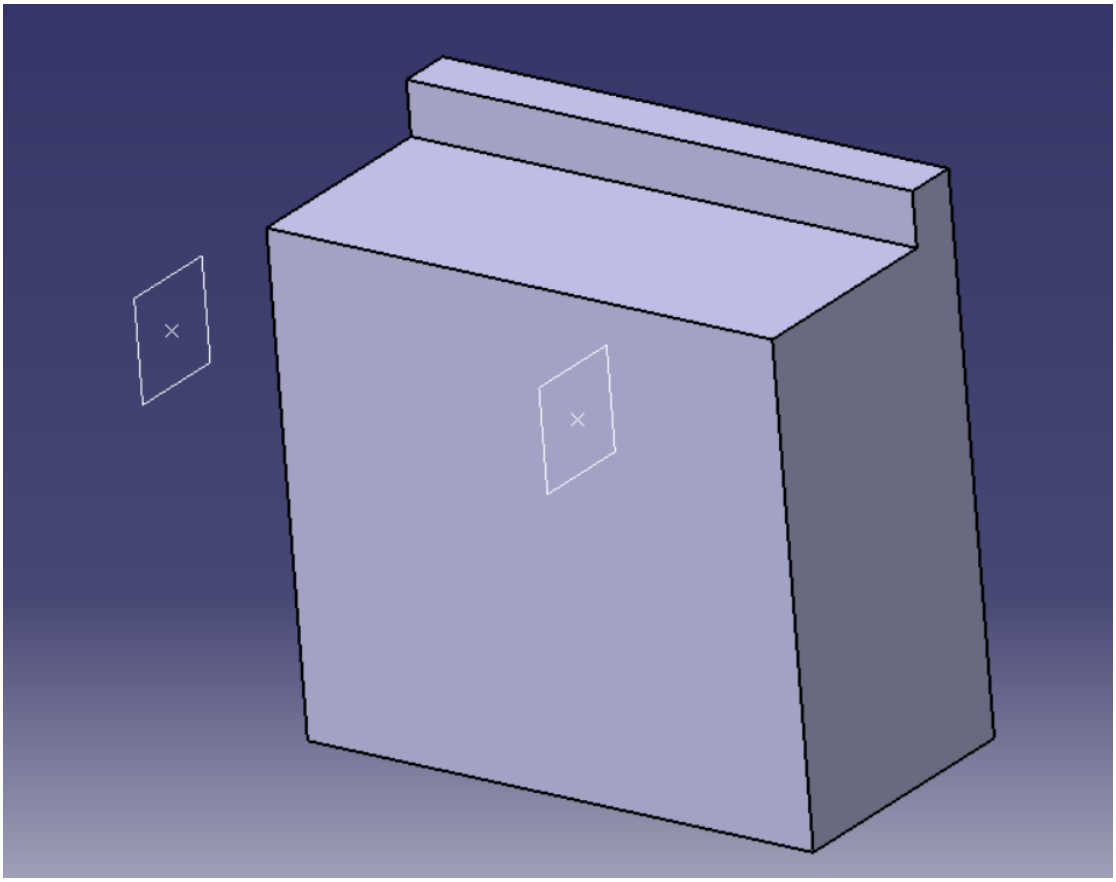

Figure 19: Plane orientation 2

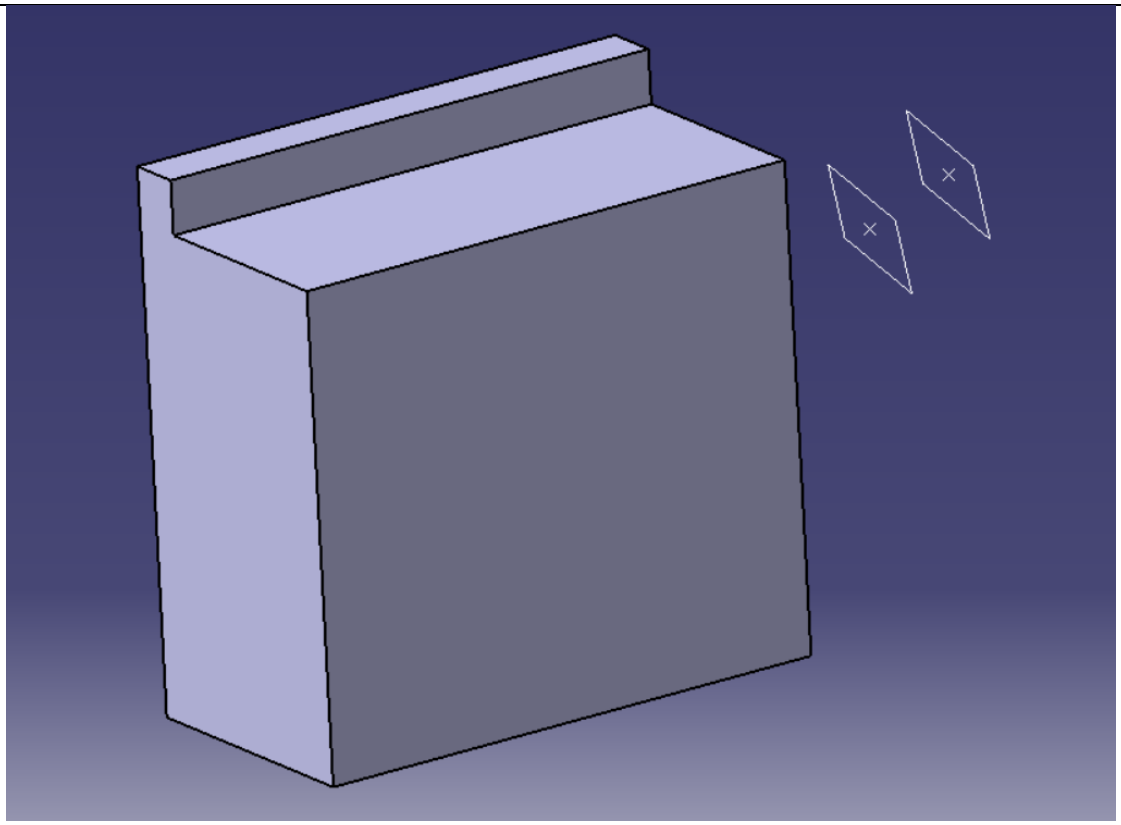

Figure 20: Plane orientation 3

The solution has been embedded to the macro solution. During the testing period of the solution it was observed that the new method does generate the channel where it is supposed to, but a new problem has been identified. The problem can be seen on figure 21 and as it can be seen the Groove solid removal is not located in the desired position which is at the end of the newly generated channel.

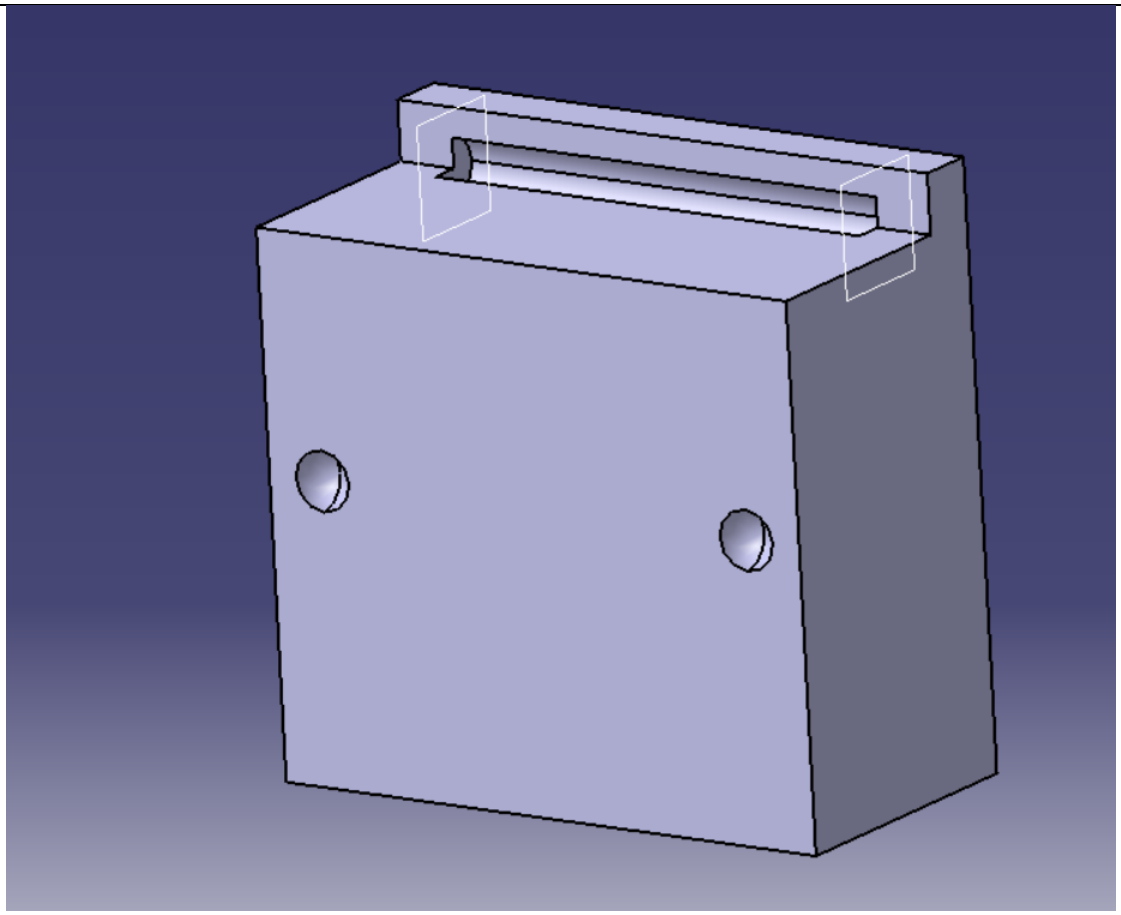

Figure 21: Wrongly positioned Groove solid remover

The issue was solved by moving the Groove code from the Groove function to the main function. This made the Groove code use the origin point of the plane related to the end point of the channel. Along with fixing the error the tool was automated and the multiple channel extrusion section was completed (figure 22).

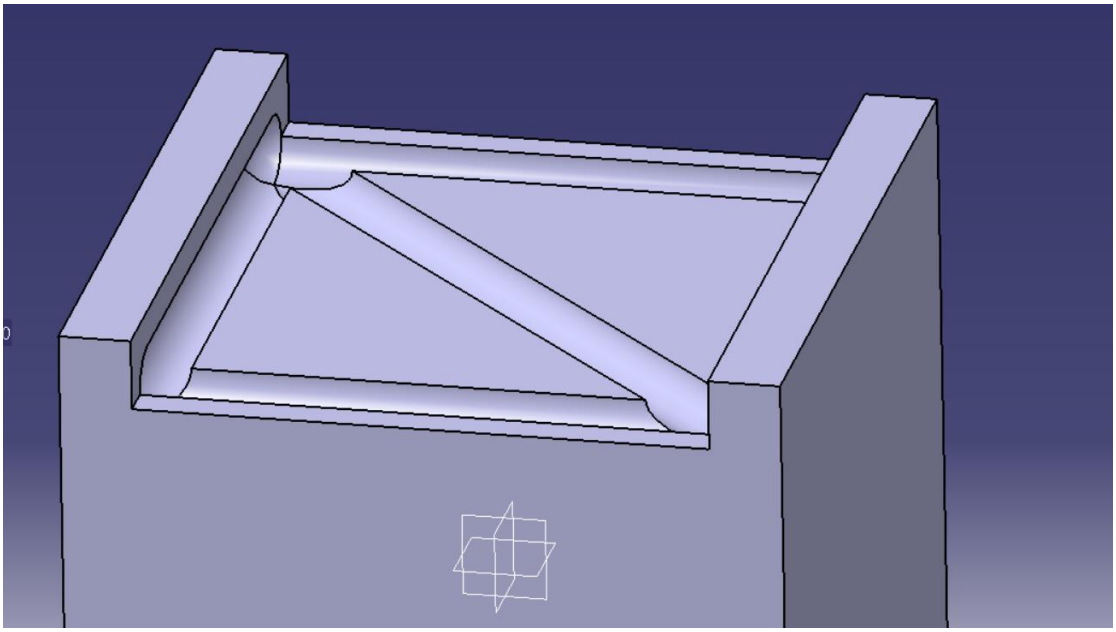

Figure 22: Multiple channel extrusion

To do – To ask Client or Supervisor during the client meeting:
The diameter of the spherical cut (the channels connect) needs to be confirmed.

- If it is the smaller radius of the 2 connected channels?
- Or the larger radius?
- Answer is more based on material science

Questions:

- What the GUI is suppose to look like based on the user interest? Will the user want to work inside CATIA or want the whole process to be automated outside of the CAD software? If inside CATIA will an icon from a toolbar be useful rather than going to the macro settings?
- Example of a shape input (different shapes that can be seen)
- Where to add the peer assessment

selection of 0,0,0 point or automatically set

Client meeting on 8/4/20

The 2 models were showed to the Client. There were some technical difficulties with the first model.
The client agreed with the second model and its methodology.

It was discussed that the CATIA python library doesn't have sufficient capabilities to work with the CATIA macro script.

The project is behind and there are multiple tasks to be completed:

- Import an excel file extension to the CATIA script and use the data from it to generate the channels
- Offset the channels to be 2*diameter of the channel from the surface – base it on the conformal inner layout
- Apply the macro to the provided complex geometry

Shape parameter will not be needed as an input since the channel will be straight.

Report:

- Have chapter titles/table of content ready by Friday
- Literature review
- Aims and objectives

TODO:

- Develop new methodology that will be applicable to the conformal channel generation

Progress on 16/04/20

Tasks to do:
Get origin point of geometry
Get dimensions of geometry

Set the radius as constant – 4mm
Set the z value to be set – 2*diameter

From client meeting:

- Import an excel file extension to the CATIA script and use the data from it to generate the channels
- Offset the channels to be 2*diameter of the channel from the surface – base it on the conformal inner layout
- Apply the macro to the provided complex geometry

Possible add an extension weather the channels needs to be conformal.
Extract all the points of the top surface

Progress on the above tasks:

Extraction of the specification tree. The purpose of this task is to add the automation of the tool that is required by the unknown names and connections present in the tree. The geometry was saved as a text file with .txt extension that supposable should just save the tree content. (Rand 2017) In the version of that that is used V5 provided by the university such saving extension does not exist. This was approaches by creating a macro that save the geometry in whatever extension is needed. The problem was this approach is that the newly saved .txt file is humanly unreadable. Additional approaches undertaken were to save the tree in an excel sheet (Stack overflow 2017) which didn't have any success.
The main problem with the identification method was that the "selection" container could not recognize inbuild function related to it. Such functions were parent.name, children.name, value.name or any other type of function and method that could be applied to it. Hence the previously developed method of constructing a path for the Groove (Appendix A) could not be applied.

The reconstruction of the specification tree has been completed and the related code for it can be seen on figure 23. Only 2 parameters are required to be extracted from the tree which is addressed by the active Part and Geometrical body set.

```
' Main part of CATIA documentation
Dim partDocument1 As PartDocument
' Retrieve your active document
Set partDocument1 = CATIA.ActiveDocument
Dim part1 As Part
Set part1 = partDocument1.Part

Dim partName, bodyName
Dim Bodies

' Extracts the active part name
partName = partDocument1.Product.Name
' Scans the collection of Bodies in a part
Set Bodies = partDocument1.Part.Bodies
'counter = Bodies.Count
bodyName = Bodies.Item(1).Name
path = partName & "\" & bodyName
```

Figure 23: Code for reconstruction of specification tree

This feature is crucial for the application in order to be automated and accommodatable to any imported CAT geometry.

Next steps:

- Extract top surface points and generate channel that is 2*diameter below the surface.

Explanation of step and stp file formats
https://www.google.com/search?q=stp+file+extension&oq=stp+file+ex&aqs=chrome.0.0j69i57j0l6.4113j0j7&sourceid=8

https://www.google.com/search?q=ascii+format&oq=ASCII+format&aqs=chrome.0.0l8.475j0j7&sourceid=chrome&ie=

https://3d-printing-expert.com/what-is-a-stp-or-step-file-format-standard-for-the-exchange-of-product-model-data/

the STP file was tried to be tested and opened using python. For this occ library was used, more about it can be found in the below link.
https://github.com/tpaviot/pythonocc-core

a potential source for analysisng stp files and extracting data from them has been identified (). But the software is private and license for it will be required.
https://www.nist.gov/services-resources/software/step-file-analyzer-and-viewer

Due to time constrains the conformal cooling task of the project needs to be pushed aside and be left for future work.

Meeting on 22/04/2020

Splitting the work on the report

To write:

- Discussion
- Explanation of solution
- Comparison table of the solutions
- Methodology
- Next steps

Add update on the written report

Pseudocode of the project has been developed and can be seen in Appendix B.
The methodology including background information and explanation of individual solution.

Group meeting on 24/04/2020

The progress on the individual sections of the report was discussed and showed to the group. Each member has written over 1000 words and most from the first 3 sections have been completed. Based on that it can be concluded half of the report has been written.
The next meeting was arranged where the report will be built up and the final 3 sections will be split. Additionally, the presentation will be started by me with a breakdown of the section on some of the work on the methodology and results sections.

Group meeting on 25/04/20

To do:

- Problem specification as part of section 3
- Share presentation slide
- Challenges from the discussion section

Tasks completed - The challenges of using macro have been described and the presentation has been shared with the group.

Progress update on 29/04/20

Part selection and csv data sheet selections have been completed.
The future recommendations have been written and added in the final report.

Tasks to do:

- Read csv
- Create csv
- Make a for loop

Additional:

- Go through the report – Done
- Fix the methodology section so there is logic that is followed – Done
- Add explanation of the second solution in the ppt – Done
- Add the future recommendations to ppt – will be done by Yash
- Add handbook/guidelines to using the solution to the final report - Done

All the tasks that needs to be completed will conclude the report, ppt and final solution

Create a complex channel layout, make a screenshot and give it to Dimos. – Done

Check where should the name and SID be put in the presentation.
Check if the presentation needs to be submitted by everyone.

Final error that have been identified is that if two channels have either the starting or ending point the spherical link will return an error. The method that needs to be used to fix this problem is to use a if statement with a specific string input at the ChannelGeneration method. This will be based on a checker that will find if a point is used for the start or for the end of a channel more than ones and if that is true than it will not create a link where such already exists.

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Rand (2017) How to export specification tree
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COE (2011) CATIA: folder selection with VBA
[Online] available from < http://www.coe.org/p/fo/et/thread=24519 > (09/06/2011)

Catiadoc (2020) Infrastructure
[Online] available from < http://catiadoc.free.fr/online/CAAScdInfUseCases/CAAInfOpenDocument.htm> (2

Stackoverflow (2017) CATIA VBA check parameter existence
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Catiadoc (2020a) CAAKniDesignTable.
[Online] available from < http://catiadoc.free.fr/online/CAAScdKniUseCases/macros/CAAKniDesignTable.CAT

Appendix A – Generating Groove path

```
Dim reference36 As Reference
Set reference36 = part1.CreateReferenceFromName("")
Dim groove1 As Groove
Set groove1 = shapeFactory1.AddNewGrooveFromRef(reference36)
Dim parameters1 As Parameters
Set parameters1 = part1.Parameters

' Finding the name of the last groove
Dim FinalGroove As Integer
selection1.Search ("Name=Groove*,all")
FinalGroove = selection1.Count2
GrooveName = selection1.Item(FinalGroove).Value.Name

While Not reachroot
   'fullPath = objPrd.Name & "\" & fullPath
   objP0 = selection1.Item(FinalGroove).Value.Parent.Name
   objP1 = selection1.Item(FinalGroove).Value.Parent.Parent.Name
   objP2 = selection1.Item(FinalGroove).Value.Parent.Parent.Parent.Name
   objP3 = selection1.Item(FinalGroove).Value.Parent.Parent.Parent.Parent.Name
   objP4 = selection1.Item(FinalGroove).Value.Parent.Parent.Parent.Parent.Parent.Name
   objP5 = selection1.Item(FinalGroove).Value.Parent.Parent.Parent.Parent.Parent.FullName
   'On Error Resume Next
   'checkParent = objPrd.Parent.FullName
   'On Error GoTo 0
   If objP4 = CATIA.ActiveDocument.Name Then reachroot = True
Wend

originalFullPath = objP3 & "\" & objP1
```

```
fullPath = objP3 & "\" & objP1 & "\" & GrooveName
```

Appendix B

Check if there is an open part
Check if there is an existing excel spread sheet with data points
For every 2 consecutive datasets
    Plane equations parameters
    Generate reference point for 1st dataset
    Generate reference point for 2nd dataset
    Generate plane for 1st dataset
    Generate plane for 2nd dataset
    Create a circle on 1st plane
    Create a circle on 2nd plane
    Remove solid between the circles on 1st and 2nd plane - channel generated
    Remove spherical solid section at both ends of the channel - channel connection
Next

Reflective Report

The section of the solution development that I have completed are the creation of a full solution that is described above and follows my personal logical thinking of creating a channel inside a solid geometry that can be fully or partially embedded inside the solid. This depends entirely on the user and the position where he wants to place the cooling channel.

Because the solution incorporates the design of a multi-channel layout for the cooling system it was chosen as the final solution that will be provided to the client.

Additionally, I was unable to complete any work on the first client presentation and I have only focused on describing my solution in the report and presentation that was later select as the final solution.

Use a combination of general and specialist engineering knowledge and understanding to apply existing and emerging technology.

Since the project is based on application development e.g. writing code the engineering knowledge needed to perform the work dramatically reduces. The engineering understanding needed during the project was mainly to do with breaking down tasks and creating graphs such as FAST diagram and Gantt chart that will support the development process. The remaining work was based on using coding knowledge for researching, documentation explanation writing code. All of those skills I have previously acquired during work on automation of analytical method for engineering components. Even though I had experience in writing code and automating solution I experience a lot of difficulties when developing the code. The reason for that is that I had experience in different computing languages (python, MATLAB, etc.) that have entirely different syntax and method of explanation of functionalities. Although all languages have the same logic behind them and my expectation of creating a solution faster, I collided with the insufficient documentation that is extremely hard to be found and the entirely different method of storing and using variable inside VBA. This has tough me not to underestimate the work that needs to be done on a project just because I have previous experience.

Apply appropriate theoretical and practical methods to design, develop, manufacture, construct, commission, operate, maintain, decommission and re-cycle engineering processes, systems, services and products. & Provide technical and commercial management.

The development of the solution has been based on using logical division of the components. The logical division is based on developing a solution starting from the final product breaking it down into tasks that satisfy the identified sub sections. An example of that is following the logic of multiple channels → single channel and connection between channels → positioning of channels → etc. This method was identified to help with the development of a logical solution. By using this method, I was able to learn how to approach work on such projects, how to identify tasks and sub-tasks, find problems within methods. This has provided support during the development stages of the application helping me create a better solution and will

meet the client needs. I will be applying this approach on every future project that I will be working on because it will provide the base for designing a product of a high standard from the first time removing the trial and error method that is used by many engineers. Additionally, working with computer language documentation has tough me a lot about code writing and application development. That is critical because all the documentation of such languages is concise and to the point with minimum explanation and minimum number of examples. As an engineer this is important because it tough me about automation and enhancement of work that can be done.

Demonstrate effective interpersonal skills.

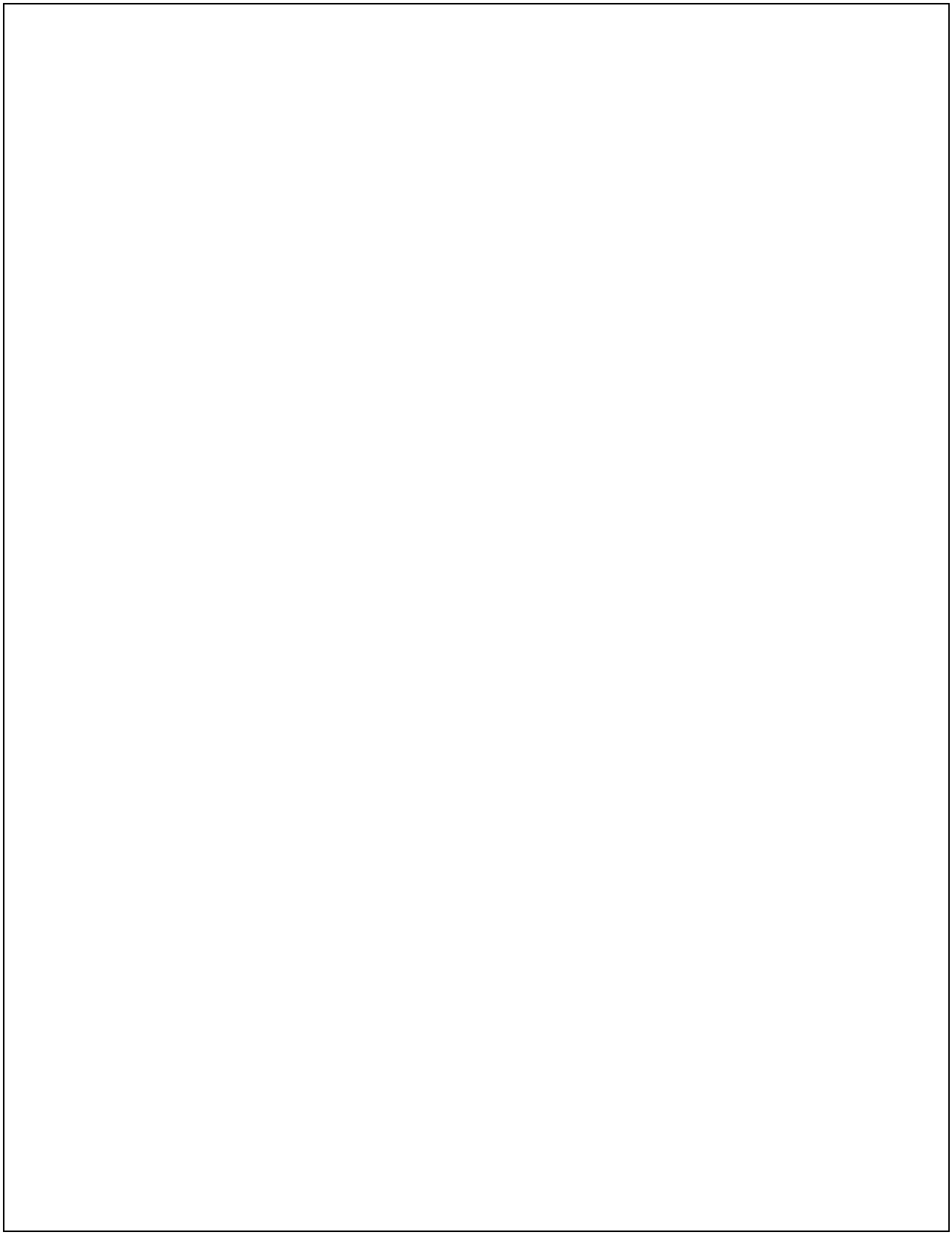
During the project a lot of communication and collaboration between the group was conducted. From the very start when the group was formed, and the project titles were selected the communication and interaction of the whole team was at a high level. Everyone could freely express their opinion and be supported or judged by the rest of the group. Providing constructive feedback on personal level in terms of understanding of the engineering fields, skillset possessed be members logical structuring of project tasks etc. All the decisions made on the project including individual elements of the solution during the development stage have been communicated with the team where the team has reviewed them providing personal opinion on changes, questioning methods used. This has led to creating a solution that expresses the opinion of more than one engineer further enhancing the capacities of the final solution. I was able to learn a lot from the team and receive support during the work especially when I have health problems.

Demonstrate a personal commitment to professional standards, recognising obligations to society, the profession and the environment.

Since the start of the project I have been fully committed to the solution development because I saw the possible learning outcome for me. I have spent time learning about VBA and different method of using it because developing an application for CATIA using the enhanced version VBA is not easy. Using it can create a lot of confusion because there are some small differences between the original VBA used by Microsoft Office and the one present in CATIA.

Because the product is an application that does not access any additional information besides the loaded part name, its location of the device and the loaded spreadsheet there are no … that needs to be met. It was designed as professional as possible to the best of the capabilities and understanding of the team.

In conclusion the team has been amazing, the work that we have done as a group is unique and interaction between the member has been more than professional. It has tough me how I am supposed to behave in a professional environment, work with a team and depend on them to deliver a final product that support the client needs. I have also learned a lot about my personal development in the engineering fields and improved my interpersonal skills. I am happy with the work that I have done and the progress I have made on the solution development. I am not happy with the fact that the conformal cooling method couldn’t be designed but there were a lot of problem that interfered.



Engineering Council Competency Table

Ref.	Competency	Example
A	Use a combination of general and specialist engineering knowledge and understanding to apply existing and emerging technology.	
A1	Maintain and extend a sound theoretical approach to the application of technology in engineering practice. This could include an ability to: • Identify the limits of own personal knowledge and skills • Strive to extend own technological capability • Broaden and deepen own knowledge base through new applications and techniques.	Engage in formal learning. Learn new engineering theories and techniques in the workplace, at seminars, etc. Broaden your knowledge of engineering codes, standards and specifications.
A2	Use a sound evidence-based approach to problem-solving and contribute to continuous improvement. This could include an ability to: • Use market intelligence and knowledge of technological developments to promote and improve the effectiveness of engineering products, systems and services • Contribute to the evaluation and development of continuous improvement systems • Apply knowledge and experience to investigate and solve problems arising during engineering tasks and implement corrective action.	Manage/contribute to market research, and product and process research and development. Involvement with crossdisciplinary working. Conduct statistically sound appraisal of data. Use evidence from best practice to improve effectiveness. Apply root cause analysis.
B	Apply appropriate theoretical and practical methods to design, develop, manufacture, construct, commission, operate, maintain, decommission and re-cycle engineering processes, systems, services and products.	
B1	Identify, review and select techniques, procedures and methods to undertake engineering tasks. This could include an ability to: • Establish users' requirements for improvement • Select a review methodology • Fully exploit and implement current technology • Review the potential for enhancing engineering practices, products, processes, systems and services, using evidence from best practice • Establish an action plan to implement the results of the review.	Contribute to the marketing of and tendering for new engineering products, processes and systems. Contribute to the specification and procurement of new engineering products, processes and systems. Develop decommissioning processes. Set targets, and draft programmes and action plans. Schedule activities.
B2	Contribute to the design and development of engineering solutions. This could include an ability to: • Contribute to the identification and specification of design and development requirements for engineering products, processes, systems and services • Identify operational risks and evaluate possible engineering solutions, taking account of cost, quality, safety, reliability, appearance, fitness for purpose, security, intellectual property (IP) constraints and opportunities, and environmental impact • Collect and analyse results • Carry out necessary tests.	Contribute to theoretical and applied research. Manage/contribute to value engineering and whole life costing. Work in design teams. Draft specifications. Find and evaluate information from a variety of sources, including online. Develop and test options. Identify resources and costs of options. Produce detailed designs. Be aware of IP constraints and opportunities.
B3	Implement design solutions and contribute to their evaluation. This could include an ability to: • Secure the resources required for implementation	Follow the design process through into product manufacture. Operate and maintain processes, systems etc. Contribute to reports on the evaluation of the effectiveness of the designs, including risk, safety and life cycle considerations.

	• Implement design solutions, taking account of critical constraints, including due concern for safety and sustainability • Identify problems during implementation and take corrective action • Contribute to recommendations for improvement and actively learn from feedback on results.	Contribute to product improvement. Interpret and analyse performance. Contribute to determining critical success factors.
C	Provide technical and commercial management.	
C1	Plan for effective project implementation. This could include an ability to: • Identify factors affecting the project implementation • Carry out holistic and systematic risk identification, assessment and management • Prepare and agree implementation plans and method statements • Secure the necessary resources and confirm roles in project team • Apply the necessary contractual arrangements with other stakeholders (client, subcontractors, suppliers, etc).	Manage/contribute to project planning activities. Produce and implement procurement plans. Contribute to project risk assessments. Collaborate with key stakeholders. Plan programmes and delivery of tasks. Identify resources and costs. Prepare and agree contracts/work orders.
C2	Manage tasks, people and resources to plan and budget. This could include an ability to: • Operate appropriate management systems • Work to the agreed quality standards, programme and budget, within legal and statutory requirements • Manage work teams, coordinating project activities • Identify variations from quality standards, programme and budgets, and take corrective action • Evaluate performance and recommend improvements.	Manage/contribute to project operations. Manage the balance between quality, cost and time. Manage contingency processes. Contribute to the management of project funding, payments and recovery. Satisfy legal and statutory obligations. Manage tasks within identified financial, commercial and regulatory constraints.
C3	Manage teams and develop staff to meet changing technical and managerial needs. This could include an ability to: • Agree objectives and work plans with teams and individuals • Identify team and individual needs, and plan for their development • Reinforce team commitment to professional standards • Manage and support team and individual development • Assess team and individual performance, and provide feedback.	Carry out/contribute to staff appraisals. Plan/contribute to the training and development of staff. Gather evidence from colleagues of the management, assessment and feedback that you have provided. Carry out/contribute to disciplinary procedures.
C4	Manage continuous quality improvement. This could include an ability to: • Ensure the application of quality management principles by team members and colleagues • Manage operations to maintain quality standards • Evaluate projects and make recommendations for improvement.	Promote quality. Manage/contribute to best practice methods of continuous improvement, eg ISO 9000, EFQM, balanced scorecard. Carry out/contribute to quality audits. Monitor, maintain and improve delivery. Identify, implement and evaluate changes to meet quality objectives.
D	Demonstrate effective interpersonal skills.	
D1	Communicate in English with others at all levels. This could include an ability to: • Contribute to, chair and record meetings and discussions	Reports, letters, emails, drawings, specifications and working papers (eg meeting minutes, planning documents, correspondence) in a variety of formats. Engaging or interacting with professional networks.

	• Prepare communications, documents and reports on technical matters • Exchange information and provide advice to technical and non-technical colleagues.	
D2	Present and discuss proposals. This could include an ability to: • Prepare and deliver appropriate presentations • Manage debates with audiences • Feed the results back to improve the proposals • Contribute to the awareness of risk.	Presentations, records of discussions and their outcomes.
D3	Demonstrate personal and social skills. This could include an ability to: • Know and manage own emotions, strengths and weaknesses • Be aware of the needs and concerns of others, especially where related to diversity and equality • Be confident and flexible in dealing with new and changing interpersonal situations • Identify, agree and work towards collective goals • Create, maintain and enhance productive working relationships, and resolve conflicts.	Records of meetings. Evidence from colleagues of your personal and social skills. Contribute to productive working relationships. Apply diversity and anti-discrimination legislation.
E	Demonstrate a personal commitment to professional standards, recognising obligations to society, the profession and the environment.	
E1	Comply with relevant codes of conduct. This includes an ability to: • Comply with the rules of professional conduct of own institution • Manage work within all relevant legislation and regulatory frameworks, including social and employment legislation.	Contribute to the affairs of your institution. Work with a variety of conditions of contract.
E2	Manage and apply safe systems of work. This could include an ability to: • Identify and take responsibility for own obligations for health, safety and welfare issues • Manage systems that satisfy health, safety and welfare requirements • Develop and implement appropriate hazard identification and risk management systems and culture • Manage, evaluate and improve these systems • Apply a sound knowledge of health and safety legislation.	Undertake formal health and safety training. Work with health and safety legislation and best practice. In the UK, examples include HASAW 1974, CDM regulations, OHSAS 18001:2007 and company safety policies. Carry out safety audits. Identify and minimise hazards. Assess and control risks. Deliver health and safety briefings and inductions.
E3	Undertake engineering activities in a way that contributes to sustainable development. This could include an ability to: • Operate and act responsibly, taking account of the need to progress environmental, social and economic outcomes simultaneously • Provide products and services which maintain and enhance the quality of the environment and community, and meet financial objectives • Understand and encourage stakeholder involvement in sustainable development • Use resources efficiently and effectively.	Carry out/contribute to environmental impact assessments. Carry out/contribute to environmental risk assessments. Manage best practice environmental management systems, eg ISO 14000. Manage best practice risk management systems eg ISO 31000. Work within environmental legislation. Adopt sustainable practices. Contribute to social, economic and environmental outcomes.
E4	Carry out and record CPD necessary to maintain and enhance competence in own area of practice including: • Undertake reviews of own development needs • Plan how to meet personal and organisational objectives • Carry out planned (and unplanned) CPD activities	Keep up to date with national and international engineering issues. Maintain CPD plans and records. Involvement with the affairs of your institution. Evidence of your development through on-the-job learning, private study, in-house courses, external courses and conferences.

	• Maintain evidence of competence development • Evaluate CPD outcomes against any plans made • Assist others with their own CPD.	
E5	Exercise responsibilities in an ethical manner.	Give an example of where you have applied/upheld ethical principles as defined by your organisation or company, which may be in its company or brand values.