## Second Solution

The internal layout of the cooling system of the die-cast is based on generating individual channels and connecting them one at a time.

The concept uses datasets present in a spreadsheet. The datasets parameters are forming the inner layout of the cooling system (channels). An individual dataset is just a single row inside the sheet and contains 4 parameters – x, y, z and radius. The x, y and z are used for reference start and endpoint of a single channel and the radius as its z dimensional property.

Creating the channels based on the given sets can be complicated if the initial approach doesn’t break the tasks properly. Because of that, a simple starting method of using a for loop that extracts 2 consecutive datasets and performs single-channel generation on them was identified. The single channels are created with a connection at both ends ensures that the layout will always be fully connected.

A schematic that represents the approach can be seen in Figure 17.

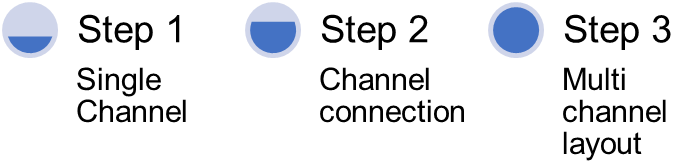


Figure 22: Basic structure approach

This method focuses on creating a single channel as the initial step and then creating a connection at both ends of the newly created channel. When the second, third, etc. channels are generated, they will automatically form the inner layout of the cooling system. Preventing any additional work to be done for improving the cooling structure. Making the overall system highly accurate regardless of how far down the sheet the method has been executed. A slight problem based on this approach is related to the connection. The connection represents a spherical cut inside the solid geometry placed where one channel starts and other ends. The spherical link was selected because a round connection will have lower stress concentration at a single point. In contrast, a sharp connection will have higher stress at a single point, usually the sharp edges. This can lead to unwanted and excessive stress creating crack inside the cooling system.

## Method

The pseudocode of the technique can be seen in Appendix C and the explanation of the below.

This solution focuses on generating a channel that is entirely inside a solid geometry, unlike the first solution that is based on making a pocket starting from a chosen surface. Because the fully embedded channel needs to be designed in such a way that it doesn’t require any contact with a surface as a reference but make its own reference. Leading to the development of the approach described below.

### Step 1 - Single channel generation

The sub-method works with the following input:

* X1, Y1, Z1 – as a start point of the channel
* Radius 1 – the radius at the start of the channel
* X2, Y2, Z2 – as an endpoint of the channel
* Radius 2 – the radius at the end of the channel

The way the approach works is by making a plane in 3D space that will be used as a reference of a channel end regardless of its distance from any surface leading to creating a plane with origin point at the given x, y, z components for both the start and end of the single channel.

Using the x, y and z values of the datasets a plane will be created that is offset to the other end of the channel.

It is making the positioning of the plane exactly at the x, y, z values and having its origin point (0, 0, 0) to be referenced those values.

On the generated plane, a circle with the specified radius will be created.

The plane and circle generations are done at both the start and the end of the channel.

It is then followed by creating a pocket-like structure that will remove the solid material between the two circles at the start and end of the channel.

This summarizes the generation of a single channel.

A possible addition to the solution can be the difference in diameter of the channel from the start to the end, such as narrowing or enlarging one of the ends. Such addition will require additional research.

At the end of the single-channel generation, connection sections will be manufactured, as stated in step 2.

### Step 2 – Connection

The connection of the individual channels is based on using the point where two channels meet. This is usually (always) where one channel ends and the next one starts. This is done to improve the structural integrity of the die and reducing the stress concentration present at sharp edges. The spherical solid removal is created using the radius value of the adjacent ends of the channels and performing a solid cut. This leads to removing the round section from the solid and making the final channel connection.

Like in the previous step this is completed for both ends of the channel.

### Step 3 – Multi-channel layout

Uses a for loop to go through the sheet and calls the single-channel generator with rows(ii-1) as a start point and line (ii) as end row where ii is an array of integers from 2 to the length of the sheet.

Next section provides a detailed description of the developed solutions, how they work and what are their dependencies. It also points out the difference between them and based on what a final solution has been chosen along with challenges along the way of the development curve.

## Solution 2:

The pseudocode of the method can be seen in Appendix C and the explanation of the below.

As shown in Appendix C and the description of the initial approach in methodology, many of the sections and subsections are the same. The differences are those that support the execution of the significant components of the macro. Like stated before the solution is based on generating channels that are entirely inside a solid geometry removing the need for any contact with the surface as a reference. Below is the detailed explanation of the method.

### Step 1 - Single channel generation

The inputs remain the same:

* X1, Y1, Z1 – as a start point of the channel
* Radius 1 – the radius at the start of the channel
* X2, Y2, Z2 – as an endpoint of the channel
* Radius 2 – the radius at the end of the channel

The method works by creating a plane is in 3D space at the specified coordinates by using them as a reference. This plane is made for both ends of the channel and is created regardless of its distance from any surface.

The plane is created using the following sub-method

Using the x, y and z values of the datasets, a reference point in 3D place is created. Additionally, the values for a plane equation are calculated based on A\*x + B\*y + C\*z = D where A, B and C represent the 3D values of the vector between the generated start and endpoint in 3D space of the single channel. (DataSet2 – Dataset1 for x, y and z).

The plane is then created using the equation value to support the tilt of the plane in all 3 axes. Because there were some issues with the positioning of the plane when using only the equation, the reference point on 3D was required to be used as a Reference. This has led to setting the plane origin point (0, 0, 0) to be referenced exactly at the x, y, z values to be.

The constructed plane is used as a reference on which a circle with the specified radius in the dataset is created.

The procedure of produced planes and reference circles is completed at both the start and the end of the channel. Followed by the “Remove multi solid section” operator using the two circles as references and removes the solid between with unselecting the twisting option from the menu. This concludes the extrusion of solid cut inside a 3D geometry essentially mimicking a channel.

Using the “Multi solid section” the difference in the diameter at the ends of the channel can be neglected because it is incorporated and will not trigger any errors or miscalibration when creating the channel.

This step is followed by making the channel connection in step 2.

### Step 2 – Connection

Connecting two adjacent channels is vital because the cooling fluid needs to pass through them and cool the die as intended. For that purpose and as previously described a spherical connection is used. The location of that connection is at the meeting point of 2 or more channels, meaning it is the point where one channel ends and another starts. For a link of more than two channels, the connection is the same with the exception that multiple channels pass through it.

The link essentially represents a spherical solid cut or material removal with the radius value of the adjacent end of the channel executed using a Groove cut. The Groove cut uses a sketch of a half a circle and a diameter line of the circle as an axis of rotation. This leads to removing the spherical section from the solid and creating the final channel connection. The cut method is carried out at both ends.

And as mentioned in the technique overall description if more than two channels use the same link the connection itself will have a radius equal to the highest z dimensional property of all the channel passing through it. This will only have an implication of the channel diameters are not consistent through the layout.

### Step 3 – Multi-channel layout

The same concept as the one described in the methodology section has been kept. Hence no changes to it have been made.

### Assembly of methods

The assembly of the methods used in solution 2 can be divided into three sections.

* Identify the part in which channels will be generated
* Identify sheet containing the locations of the channels
* Perform the channel generation using the three steps

Identification of part that will be edited is the first component of the assembly. It focuses on identifying if there is a part that is currently active in the workplace, and if not, it prompts the user to select one from the pop-up file selection window. This is created in such a way because the user could be editing or designing a geometry that hasn’t yet be saved or is currently in progress.

The second component is again another file selection. This file selection is the datasheet file and is compatible with .csv or .xl\* file extensions. If no file has been selected, the component will create a new datasheet and inform the user to populate it. The spreadsheet was selected as the ideal method for inputting dataset on a large scale.

Finally, the last component of the assembly is a for loop that executes the channel generation and channel connection described above with two datasets as a starting point.