Lecture 2.4
Illustration
• Three examples related to turbomachines are considered in the Lecture 2.1. Among them, the third example is a single stage impulse wheel, which illustrates an assembly of several parts, refer Fig.2.1.3, which is repeated here as 2.4.1.

Fig 2.4.1 Assembly of aerofoils to form a turbine wheel for CFD study

• The generation of plane and space curves and surfaces are covered in the previous lectures. These techniques are useful in developing various parts of a turbomachine. Further, these parts can be assembled with simple algorithms, finally to obtain a model suitable for computational fluid dynamic study.
Boundary Representation Algorithms

- In solid modelling and computer-aided design, boundary representation - often abbreviated as B-rep or BREP—is a method for representing shapes using the limits.

- A solid is represented as a collection of connected surface elements, the boundary between solid and non-solid.

- Boundary representation models are composed of two parts: topology and geometry (surfaces, curves and points).

- The main topological items are: faces, edges and vertices.

- A face is a bounded portion of a surface; an edge is a bounded piece of a curve and a vertex lies at a point.
• Other elements are the *shell* (a set of connected faces), the *loop* (a circuit of edges bounding a face) and *loop-edge links* (also known as *winged edge links* or *half-edges*) which are used to create the edge circuits.

• Algorithms are individually written for computing these B-reps of solids that are combined by the Boolean operations.

• It is relatively simple to convert a B-rep model into a wireframe model because its boundary definition is similar to the wireframe definitions.

• An alternative to the B-rep algorithms are CSG based algorithms.
Constructive Solid Geometry Algorithms

- Constructive solid geometry (CSG) is a technique used in solid modelling. Constructive solid geometry allows a modeller to create a complex surface or object by using Boolean operators to combine objects with high complexity.

- The simplest solid objects used for the representation are called primitives. Typically they are the objects of simple shape: cuboids, cylinders, prisms, pyramids, spheres, cones.

- One of the advantages of CSG is that it can easily assure that objects are "solid" or water-tight if all of the primitive shapes are water-tight.

- By comparison, when creating geometry, based upon boundary representations, additional topological data is required, or consistency checks must be performed to assure that the given boundary description specifies a valid solid object.
There are several software packages which make use of the B-rep or CSG based algorithms or similar other geometric modeling algorithms.

The purpose here is to brief the methodology of usage such algorithms rather than making the student develop them.

In the following, the referred example in Fig. 2.4.1 will be revisited. Making use of software package, *SolidWorks*, the steps of making the solid model, which encompasses the fluid domain for further fluid dynamic analysis, are brought out.

The students are urged to understand the simple basics as given in this demonstration and develop the solid models of the computational domains.
Physical Modeling of Rotor
In order to create the “shaft”, choose the circle as the basic curve

New - > Part
Tools - > Options - > Document Properties - > Units - > MMGS (Changing default dimensions to mm)
Select Front Plane - > Insert - > Sketch
Circle - > Select Origin as centre - > Click anywhere on screen - > Input Radius as 10mm
Exit Sketch
The shaft of chosen length is created by “Extrude” command equivalent to sweeping

Select the sketch -> Insert -> Boss/Base -> Extrude
Under Direction 1 ->Select Mid Plane
Input 50mm as D1
Click OK
In order to create the “disc”, choose the circle as the basic curve

Select Front Plane -> Insert -> Sketch
Circle -> Select Origin as centre -> Click anywhere on screen -> Input Radius as 15mm
Exit Sketch
Select the sketch -> Insert -> Boss/Base -> Extrude
Under Direction 1 -> Select Mid Plane
Input 10mm as D1
Click OK
Select Top Plane
Insert -> Reference Geometry -> Plane
Input 12.5mm as Distance
Sample Coordinates for Rotor Blades are specified, as in Table.

Copy the following coordinates (without Headings) to an MS Excel File.

From the MS Excel File, copy to a text file and Save As “Rotor_Coordinates.txt”

<table>
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<tr>
<th>X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
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<tr>
<td>4.33</td>
<td>12.5</td>
<td>3.56</td>
</tr>
</tbody>
</table>
Insert -> Curve -> Through XYZ Points
Browse for the Rotor Coordinates .txt file
Click OK
Insert -> Sketch-> Spline Tool
Click on the trailing edge -> Click at different points on the curve -> Follow the curve -> End it at the trailing edge
Click OK
When Done, Sketch appears as in the following picture.
Insert -> Boss/Base -> Extrude
Input 11mm as D1
Click OK
Right Click Right Plane -> Show
Right Click Top Plane -> Show
Insert -> Reference Geometry -> Axis -> Two Planes -> Select Right Plane & Top Plane
Click OK
Insert -> Pattern/Mirror -> Circular Pattern
Select the Axis
Input 12 as “Number of Instances”
Select the blade as “Feature to Rotate”
Click OK
When Done, the part appears as in the following picture.

Save As Rotor.SLPRT
Physical Modeling of Stator
New -> Part
Tools -> Options -> Document Properties -> Units -> MMGS (Changing default dimensions to mm)
Select Front Plane -> Insert -> Sketch
Circle -> Select Origin as centre -> Click anywhere on screen -> Input Radius as 12mm -> OK
Circle -> Select Origin as centre -> Click anywhere on screen -> Input Radius as 15mm -> OK
Exit Sketch
Select the sketch -> Insert -> Boss/Base -> Extrude
Under Direction 1 -> Select Mid Plane
Input 10mm as D1
Click OK
Select Top Plane
Insert -> Reference Geometry -> Plane
Input 12.5mm as Distance
Sample Coordinates for Stator Blades

Copy the following coordinates (without Headings) to an MS Excel File.

From the MS Excel File, copy to a text file and Save As “Stator_Coordinates.txt”
Insert -> Curve -> Through XYZ Points
Browse for the Stator Coordinates .txt file
Click OK
Insert -> Sketch -> Spline Tool
Click on the trailing edge -> Click at different points on the curve -> Follow the curve -> End it at the trailing edge
Click OK
When Done, Sketch appears as in the following picture.
Insert -> Boss/Base-> Extrude
Input 11mm as D1
Click OK
Right Click Right Plane -> Show
Right Click Top Plane -> Show
Insert -> Reference Geometry -> Axis -> Two Planes -> Select Right Plane & Top Plane
Click OK
Insert -> Pattern/Mirror -> Circular Pattern
Select the Axis
Input 12 as “Number of Instances”
Select the blade as “Feature to Rotate”
Click OK
When Done, the part appears as in the following picture.
Save as Stator.SLDPRT
Physical Modeling Assembly
New -> Assembly
Browse for Rotor.SLDPRT -> Click on screen.
Insert -> Component -> Existing Part -> Browse for Stator.SLDPRT -> Click on screen
Insert -> Component -> Existing Part -> Browse for Stator.SLDPRRT -> Click on screen
To Constraint the position of Stator with respect to Rotor:

Insert -> Mate
Select the face of Rotor as shown
Select the face of Stator as shown
Input 1mm as Distance
Click OK
Insert -> Mate
Select “Concentric”
Select the cylindrical face of Rotor as shown
Select the inner cylindrical face of the Stator
To give a circular contour to the blades:

Select Front Plane -&gt; Insert -&gt; Sketch -&gt; Circle (radius – 23mm)
Click Ok
Insert -> Assembly Feature -> Cut -> Extrude
Input 20mm as D1
Select Flip side to cut
Click Ok
When Done, the Assembly appears as in the following picture
Save As Rotor_Stator_Assembly.SLDASM
An illustration of generating a turbine wheel with stator-rotor combination is presented with the help of a known software, while describing the steps given in Lectures 2.1 to 2.3.

END OF LECTURE 2.4