Implementing Simulation Governance & Democratization of CAE

Automation Process of Clutch Assembly
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  - Component Meshing
  - Contact Generation
  - Material Property Assignment
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Introduction

- Process automation in Engineering Analysis implies the use of scripting technology to perform a process or a series of processes to accomplish a workflow

- Total automation as well as partial automation with minimal human intervention at strategic points

- Replace repetitive human interactions with flawless virtual machines
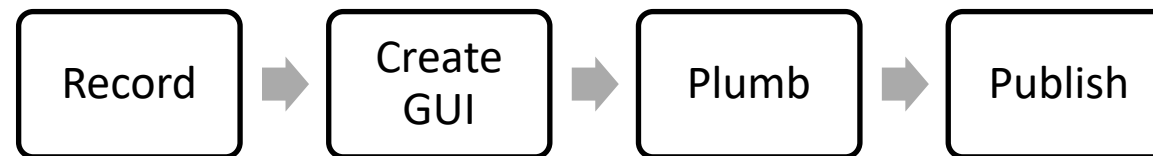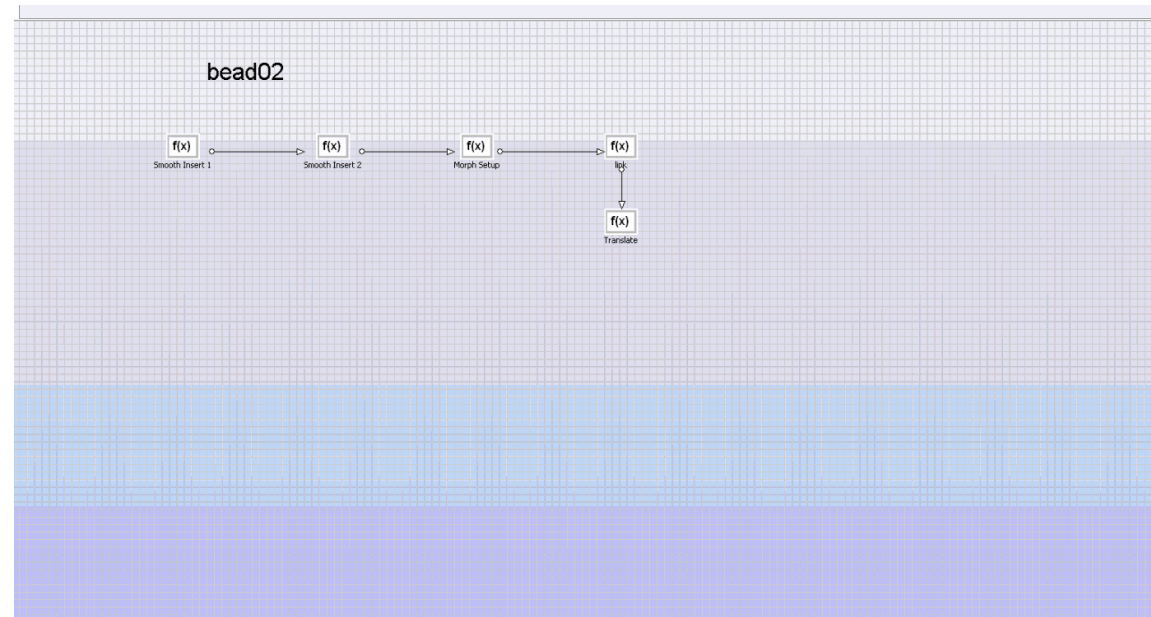
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Automation of Clutch Assembly

- Wet clutches are widely used in an automatic transmission for torque transfer.

- The typical loadings on a clutch include torque load, oil pressure, thermal loads, and centrifugal force.
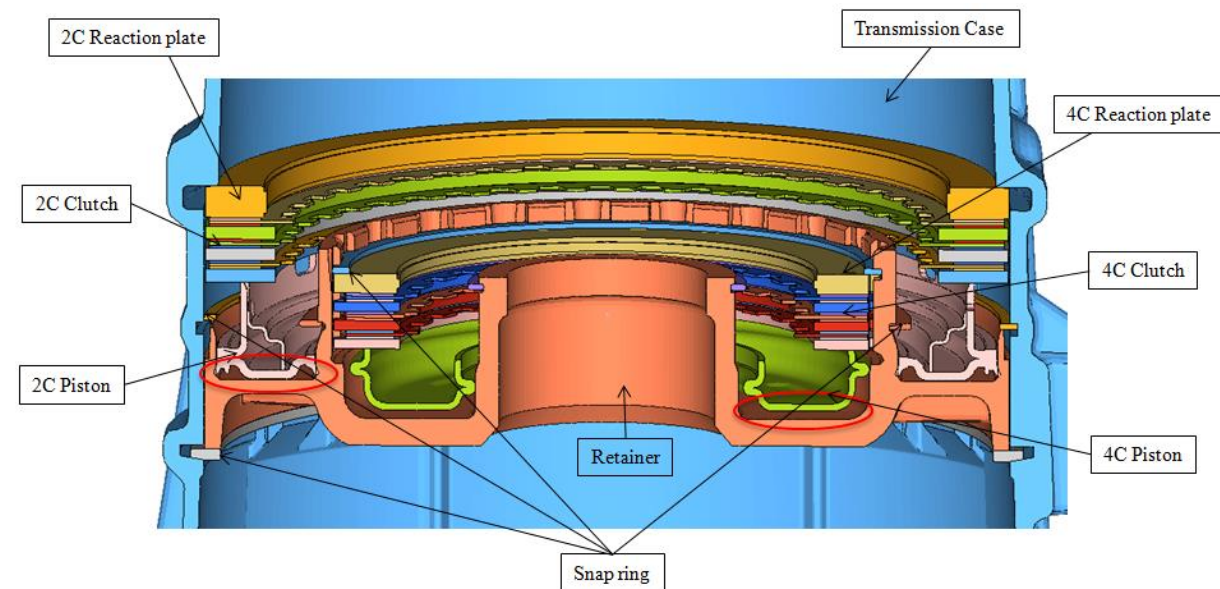
Why automate

Interactive operations with scripts minimize errors and work time.

Scripts can
- create contact models,
- assign material properties, and
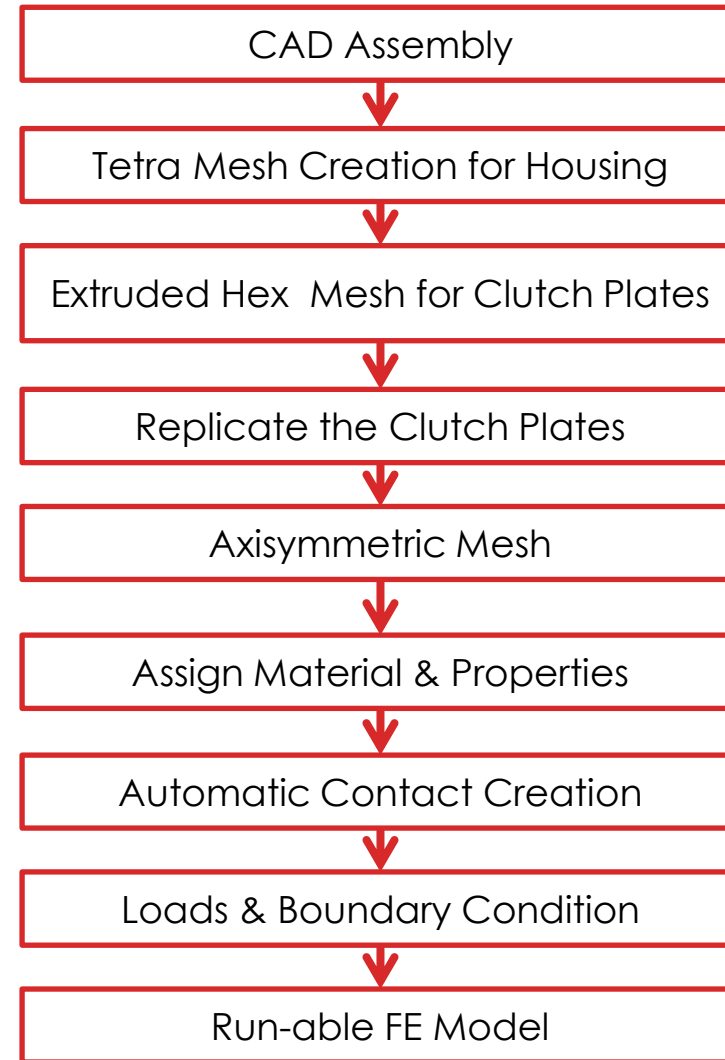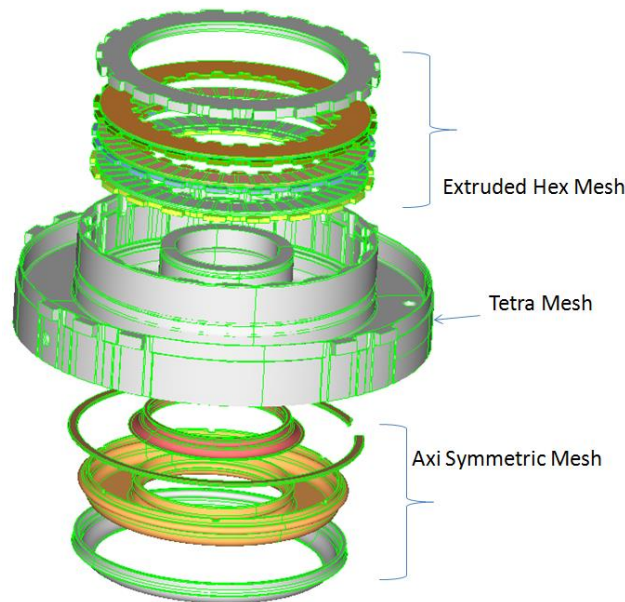- apply load and boundary conditions.

Automated scripts reduce the effort of replacing components with revised designs.

2C Reaction plate
Transmission Case
4C Reaction plate
2C Clutch
4C Clutch
2C Piston
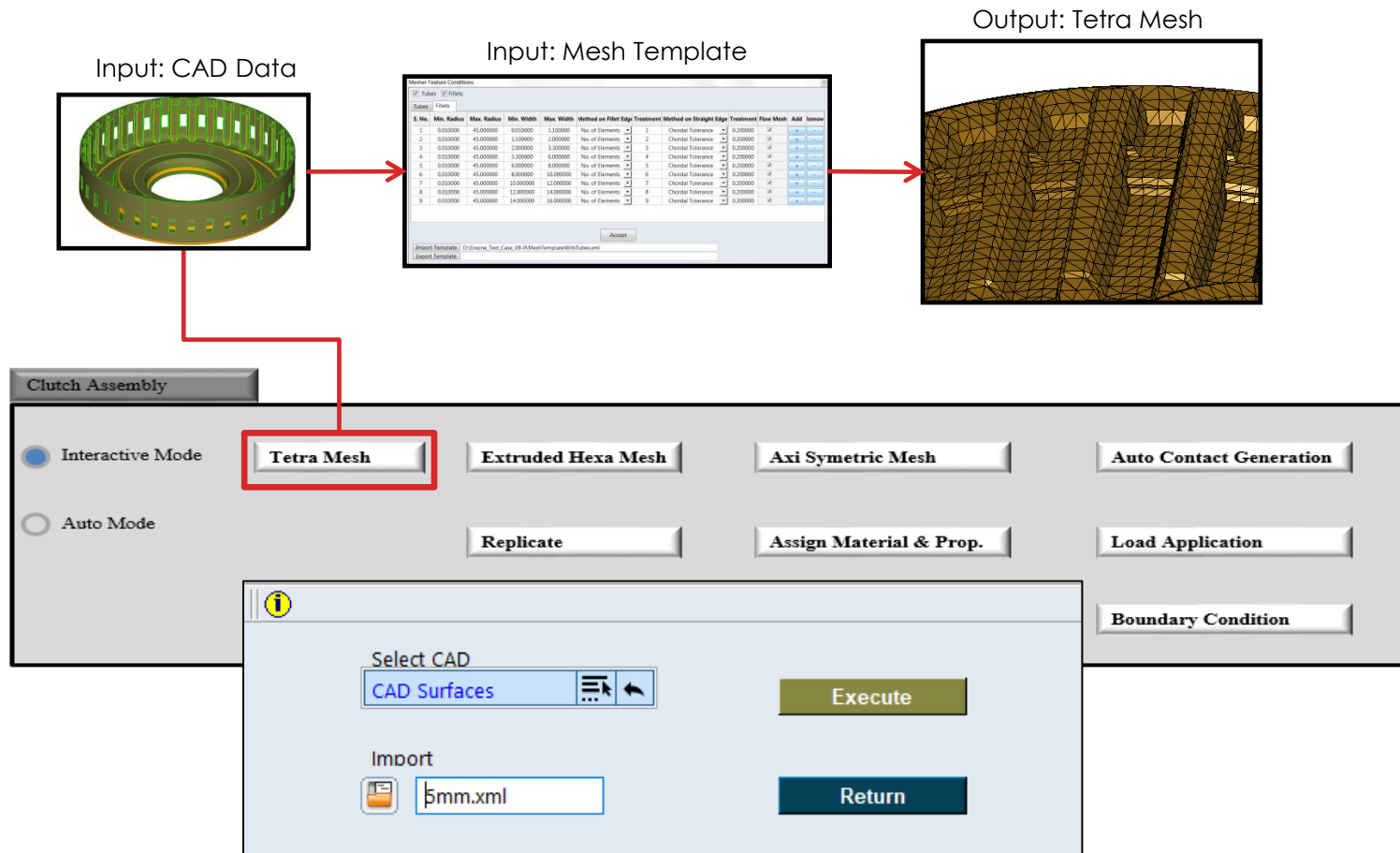4C Piston
Retainer
Snap ring

Process Chart

The Parts in the clutch assembly are grouped into three categories based on mesh type

- Extruded Hex Mesh
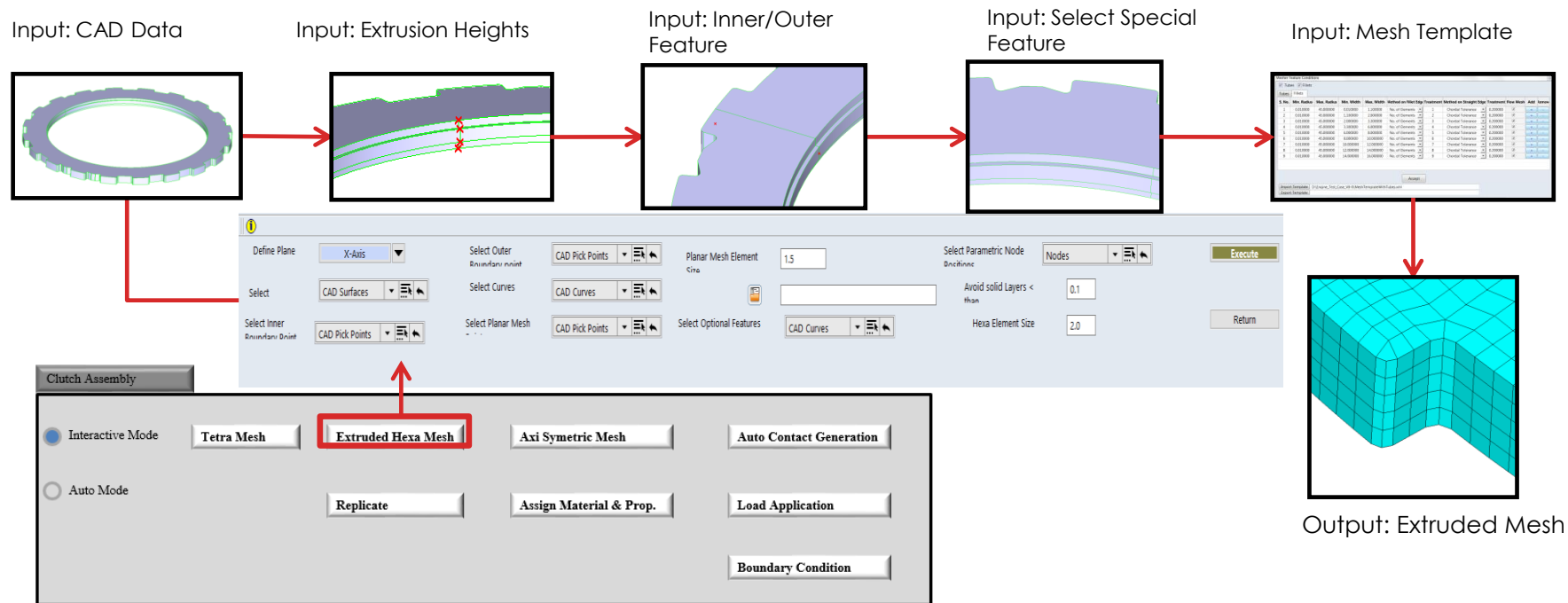- Tetra Mesh
- Axi-symmetric Mesh

Extruded Hex Mesh

Tetra Mesh

Axi Symmetric Mesh

```
CAD Assembly
      ↓
Tetra Mesh Creation for Housing
      ↓
Extruded Hex  Mesh for Clutch Plates
      ↓
Replicate the Clutch Plates
      ↓
Axisymmetric Mesh
      ↓
Assign Material & Properties
      ↓
Automatic Contact Creation
      ↓
Loads & Boundary Condition
      ↓
Run-able FE Model
```

Step-1: Tetra Mesh

Input: CAD Data

Input: Mesh Template

Output: Tetra Mesh

Tetra Mesh:

- CAD Geometry and the Mesh Template are inputs
- Mesh criteria and quality parameters will be taken from template file to mesh the part
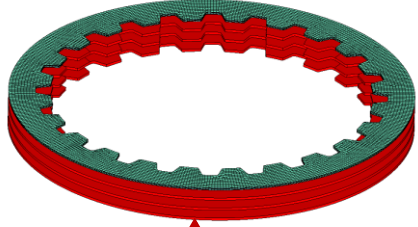
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Step-2: Extruded Mesh

Input: CAD Data

Input: Extrusion Heights

Input: Inner/Outer Feature

Input: Select Special Feature

Input: Mesh Template

Output: Extruded Mesh

- CAD Geometry, Mesh Template & user defined parameter are inputs
- Mesh criteria and quality parameters will be taken from template file to mesh the part
- Extrusion height, Inner/Outer Features & Special Features are additional inputs from user for Extruded Mesh
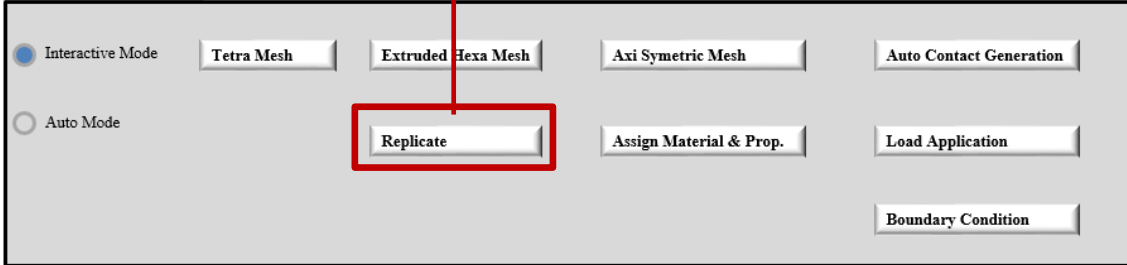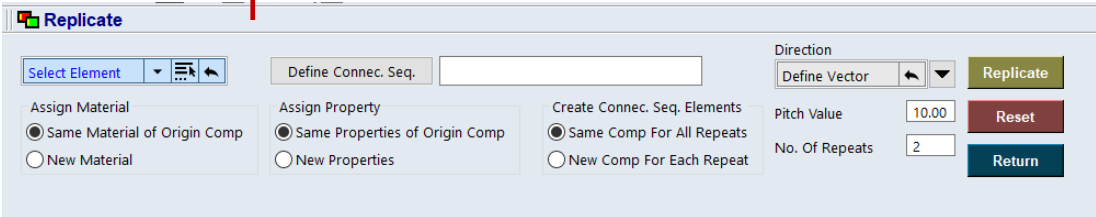
Step-3: Replicate the Clutch Plates

Input: Extruded Mesh
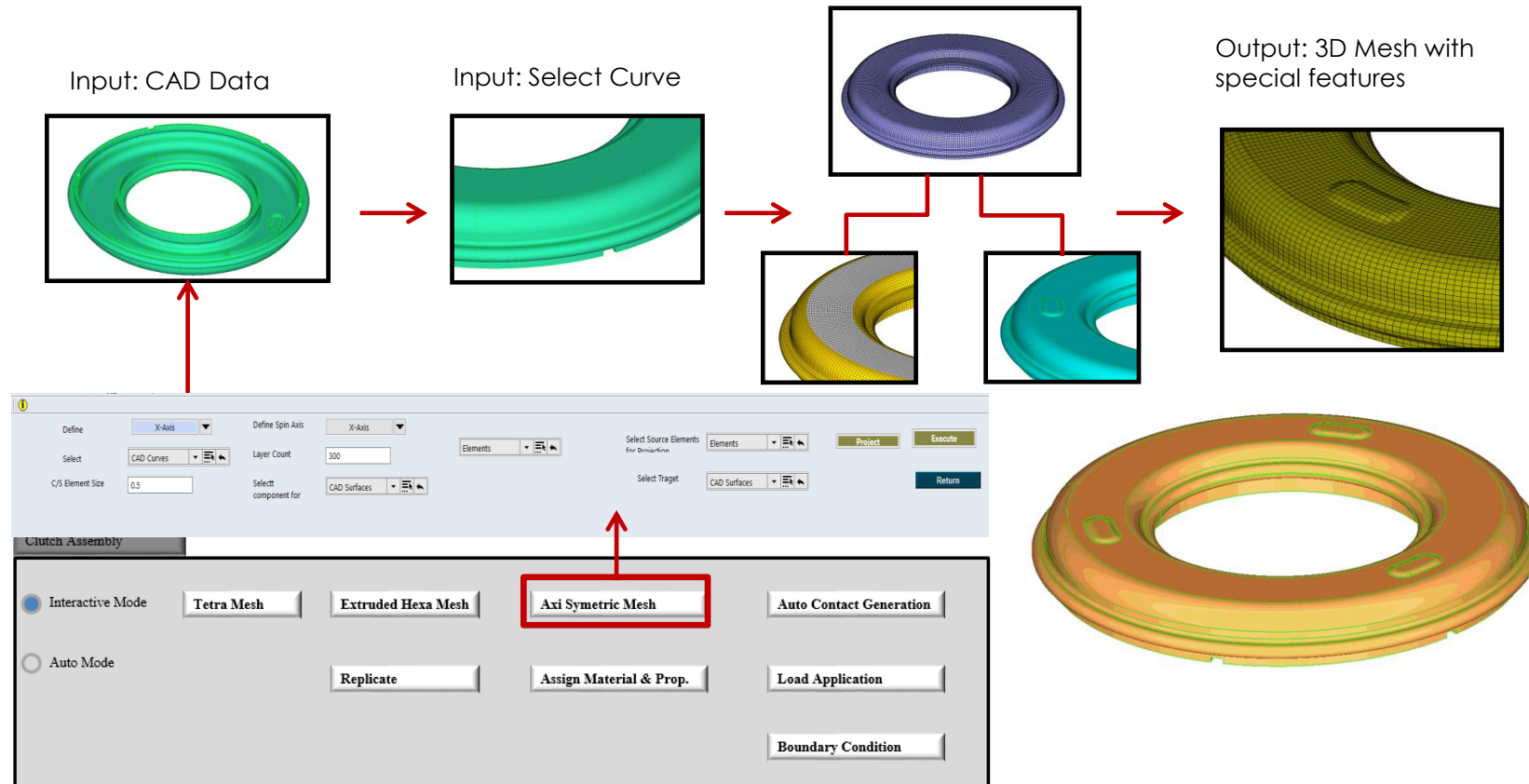
Input: User Defined
- Direction
- Gap
- No of repeats

Output: Replicate Mesh

- ▪ If we have similar parts, we can use Replicate function
- ▪ Extruded mesh is the core input
- ▪ Direction, Pitch & No of repeats are additional input from user in Replicate Mesh

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Step-4: Axisymmetric Mesh

Input: CAD Data

Input: Select Curve

Output: 3D Mesh with special features

- CAD Geometry, Mesh Template, Axis of Rotation and Selecting the Cross Section are inputs
- Specifying the Special Features is an additional input from user for Axisymmetric Mesh

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Step-5: Auto Contact Generation

Input: Complete Meshed Model

Template: CSV File
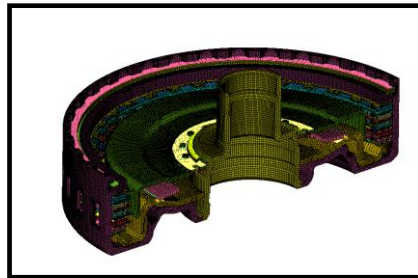
Output: Contact Pair Creation

FE Model, CSV file are inputs.

- The CSV file will contain the part names and tolerances
- Tool will take the inputs from CSV file and creates contact surfaces and contact pairs

Step-6: Assign Material and Properties
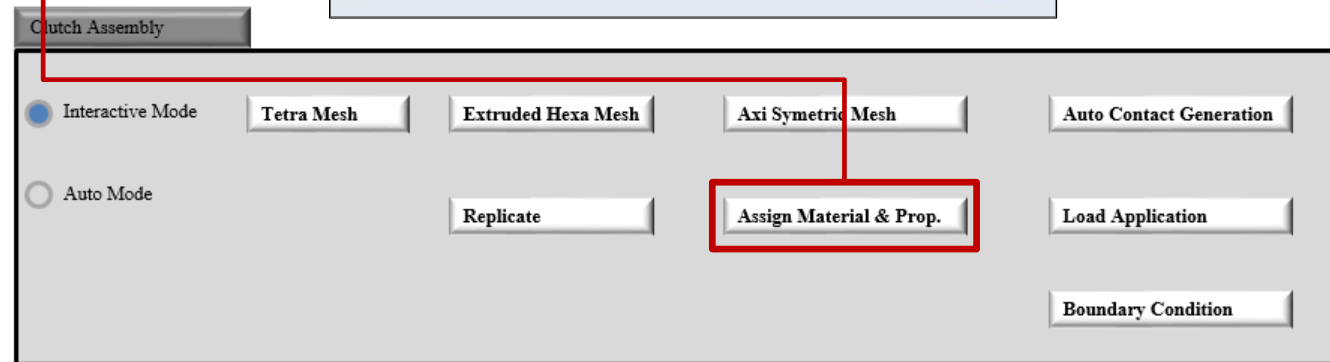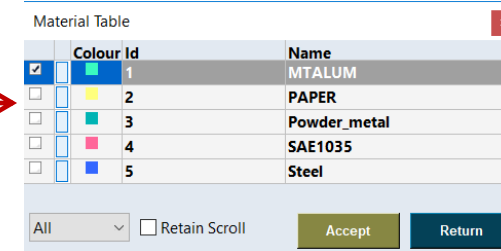
Input: Complete Meshed Model

Template: material properties in CSV File

Output: Assign Material

Material Name	Material Type	E (MPa)	Density(ton/mm3)	Nu
Material_1	Genaral Material	71000		0.325
Material_2	Genaral Material	158000		0.25
Material_3	Genaral Material	159	2.00E-09	0.25
Material_4	Genaral Material	200000	7.85E-09	0.29
Material_5	Genaral Material	210000	7.85E-09	0.3

Component   Clutch_Assm_Component_Table.csv

Material   Clutch_Assm_Material_Table.csv

Material Table

	Colour	Id	Name
☑		1	MTALUM
☐		2	PAPER
☐		3	Powder_metal
☐		4	SAE1035
☐		5	Steel

All   ☐ Retain Scroll   Accept   Return

Clutch Assembly

● Interactive Mode   Tetra Mesh   Extruded Hexa Mesh   Axi Symetric Mesh   Auto Contact Generation

○ Auto Mode   Replicate   **Assign Material & Prop.**   Load Application
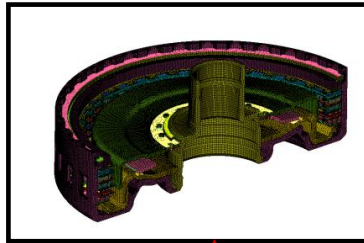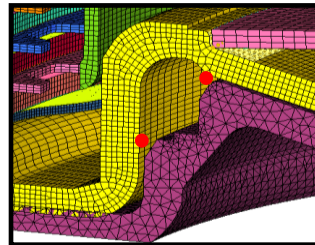
Boundary Condition

Assign Material and Properties:

▪ FE Model, CSV file are inputs

▪ The CSV file will contain all the material details

▪ Tool will take the values from CSV file and assign to PID's
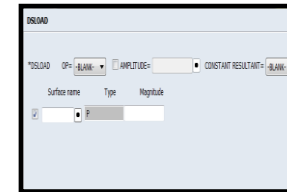
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Step-7: Loads & Boundary Condition

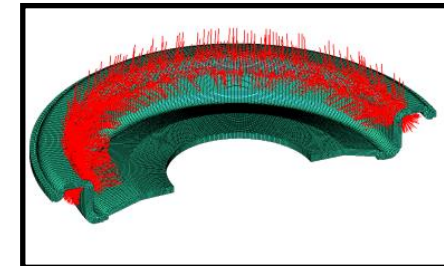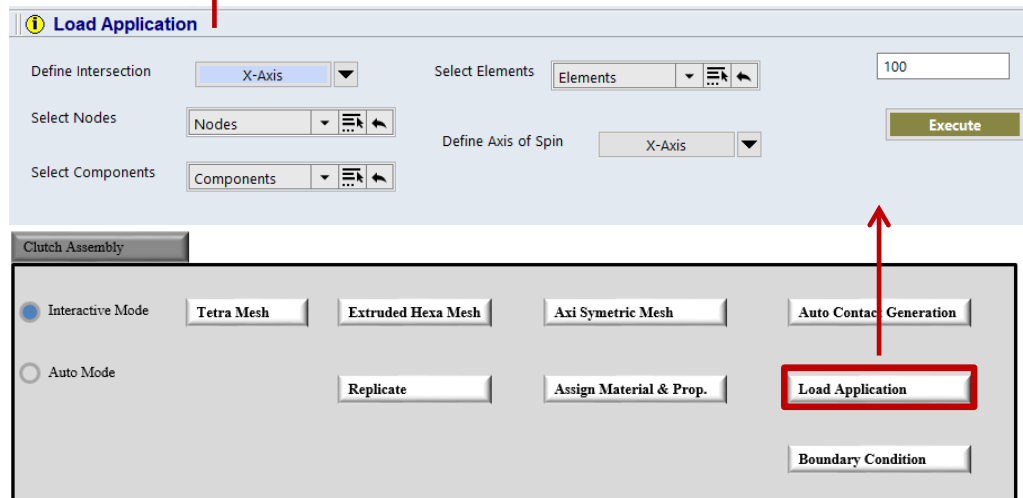Input: Complete Meshed Model with Contacts

Membrane Extraction By selecting start and endpoint

Input: Pressure Value

Output: Pressure applied

Load Application

Define Intersection — X-Axis
Select Nodes — Nodes
Select Components — Components
Select Elements — Elements
Define Axis of Spin — X-Axis
100
Execute

Clutch Assembly

- Interactive Mode
- Auto Mode

Tetra Mesh | Extruded Hexa Mesh | Axi Symetric Mesh | Auto Contact Generation
Replicate | Assign Material & Prop. | **Load Application**
Boundary Condition
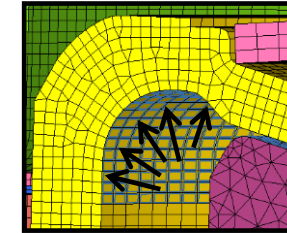
- FE Model, user defined parameter are inputs
- Define Region, Components, Axis of Rotation, Angle are additional inputs from the user for Load application

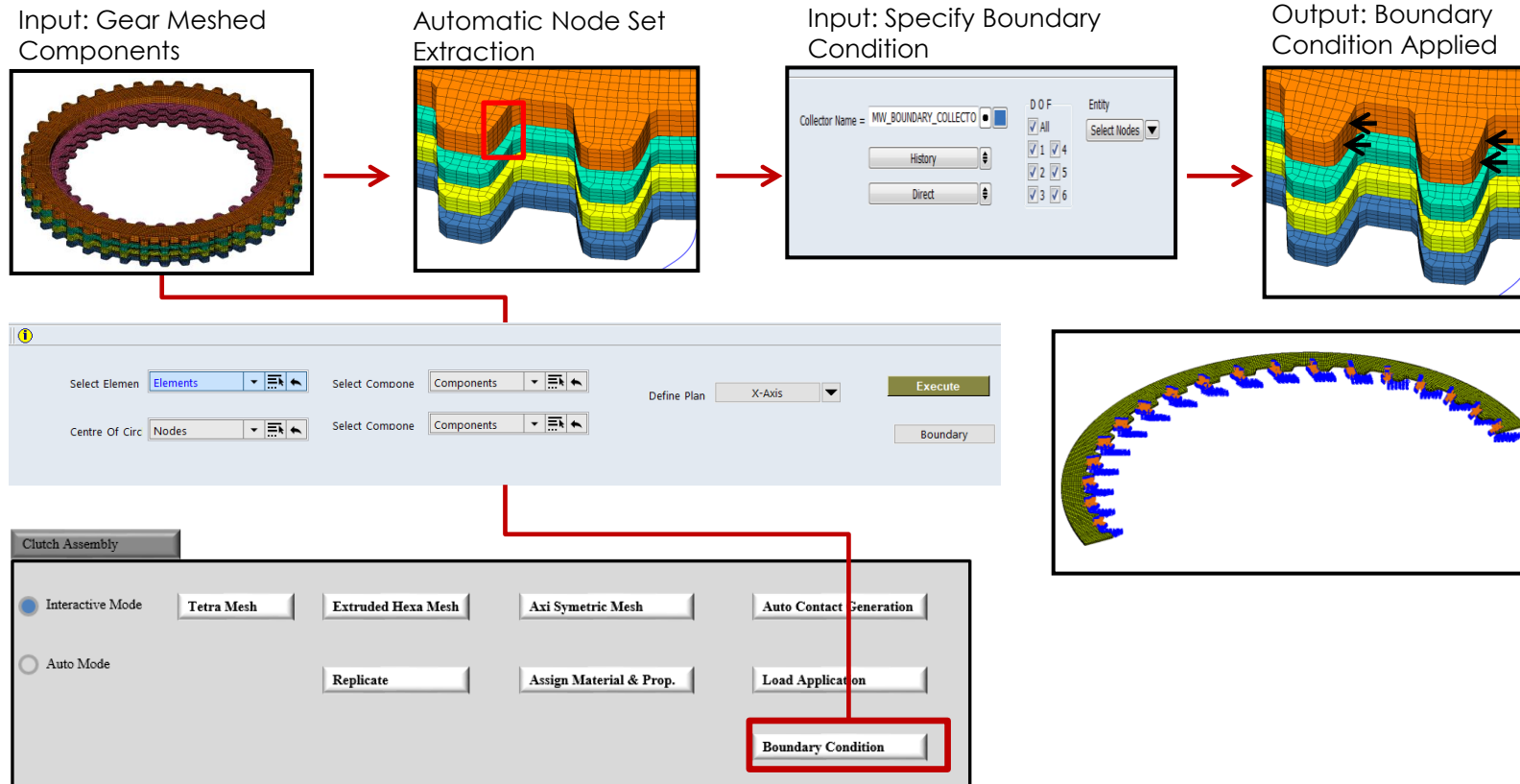# Step-7: Loads & Boundary Condition

Input: Gear Meshed Components

Automatic Node Set Extraction

Input: Specify Boundary Condition

Output: Boundary Condition Applied

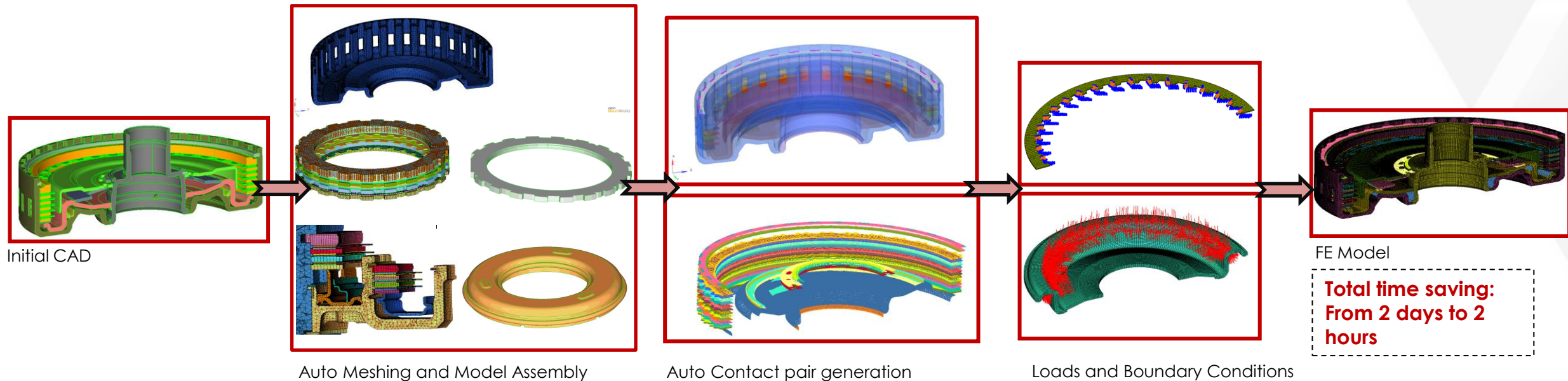- FE Model, user defined parameters are inputs
- Select Element / Components, Origin, axis of rotation are additional inputs from user for Boundary Condition

Step-8: Export the FE Model

Summary

Initial CAD

Auto Meshing and Model Assembly

Auto Contact pair generation

Loads and Boundary Conditions

FE Model

Total time saving: From 2 days to 2 hours
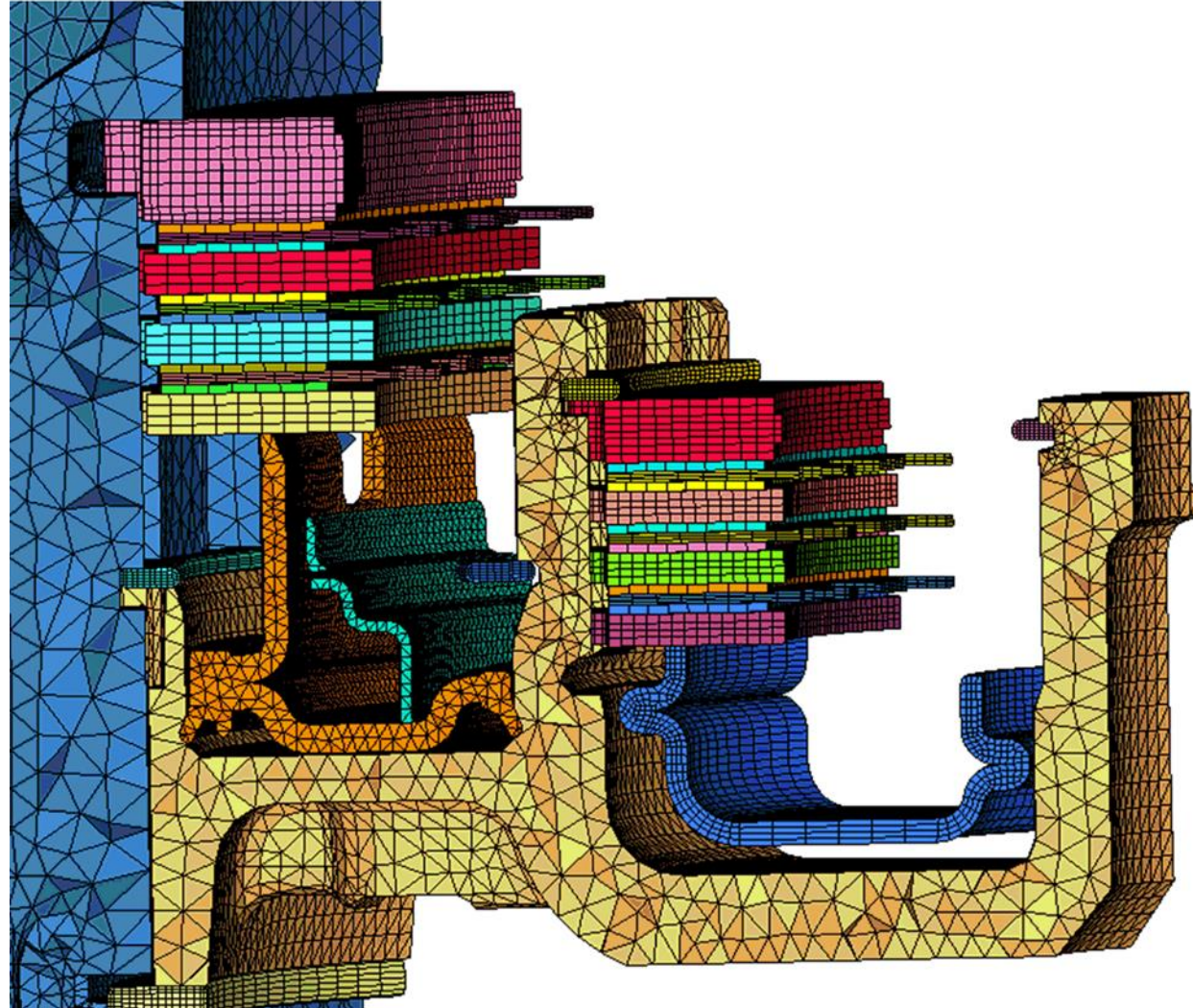
Conclusion:

- Automated process is used to build run-able FE Model from CAD with improved accuracy
- Nearly 25x time saving
- CAE Process automation described in this paper democratizes CAE in a way that engineer who uses the tool develops the automation and does not need to be an expert programmer to create automation
- The 4 steps process presented for process automation is very elegant for any type of component across industry verticals.
- The 4 steps are pillars that not only automate but also intends to democratize CAE

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Future Implementation

Phase-2:

- The idea is to build the entire process for Clutch Assembly in Auto – Mode : Completed.

- Automatic Part Replacement for Clutch Assembly : Completed

- Expand the Process Automation ideology across other subsystems : In progess

Thank You!

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