Altair Flux™

2D Example: Contactor optimization with Flux and HyperStudy

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1 Description

Introduction

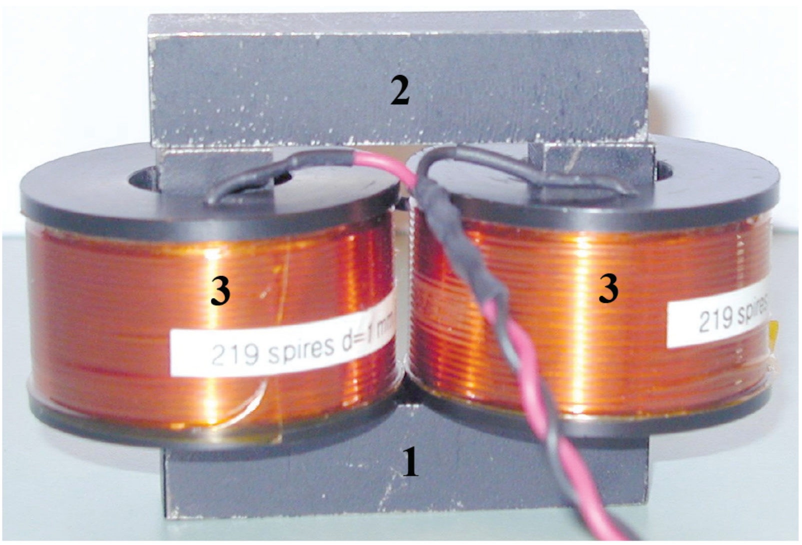
The goal of this document is to describe how to use HyperStudy, HyperWorks’s multi-disciplinary design exploration tool to study a device described under Flux 2D. The study in HyperStudy covers DOE, Optimization and Stochastic approaches. The optimization will consist to obtain a force of 200 N on the mobile part.

Data computed	Magnetic force
Application	Magneto Static
Feature used	Flux HyperStudy coupling

Studied device

The studied device is an electromagnetic contactor composed by:

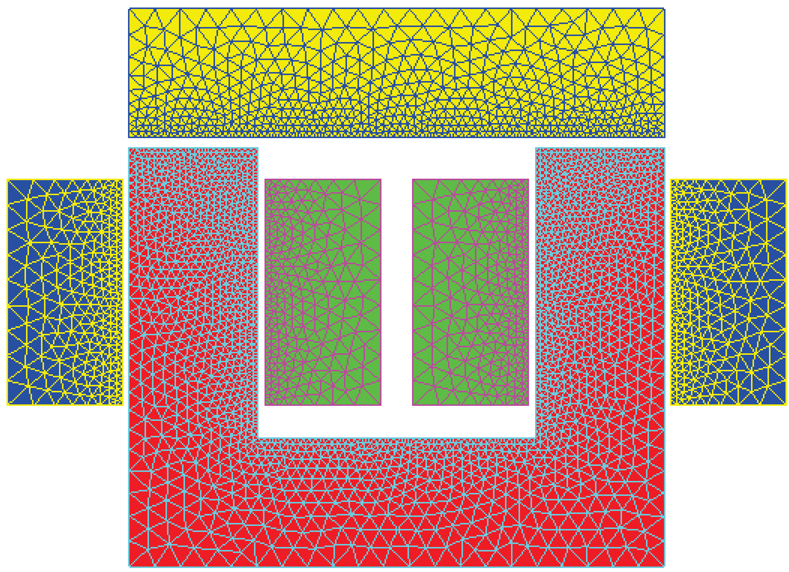
1. U magnetic core
2. Magnetic mobile part
3. Coils supplied by an amp-turn number (AT)



2 Flux Project

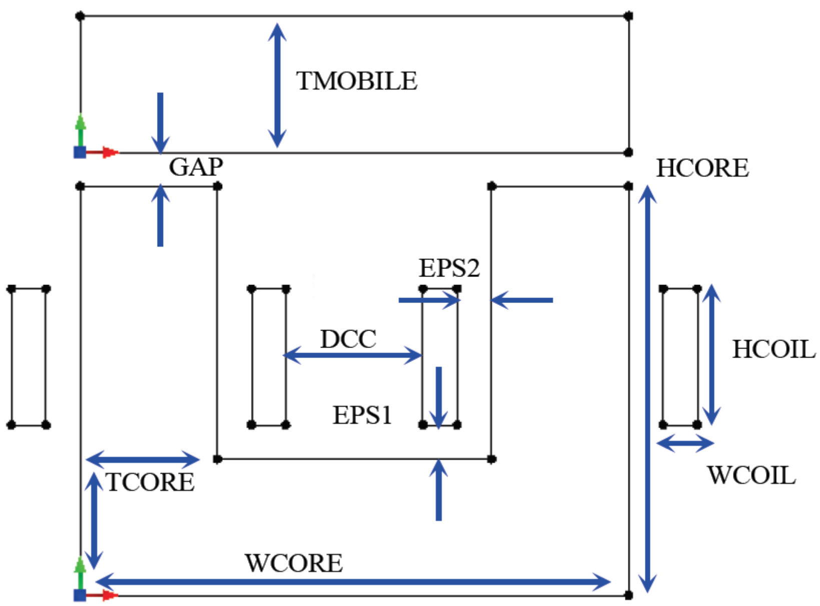
Flux 2D geometry and mesh

The following picture shows the device designed in Flux 2D:



Flux 2D geometry parameters

The following picture shows the geometric parameters used in the geometry definition:



There is also one physical parameter **AT** for the amp-turn number.

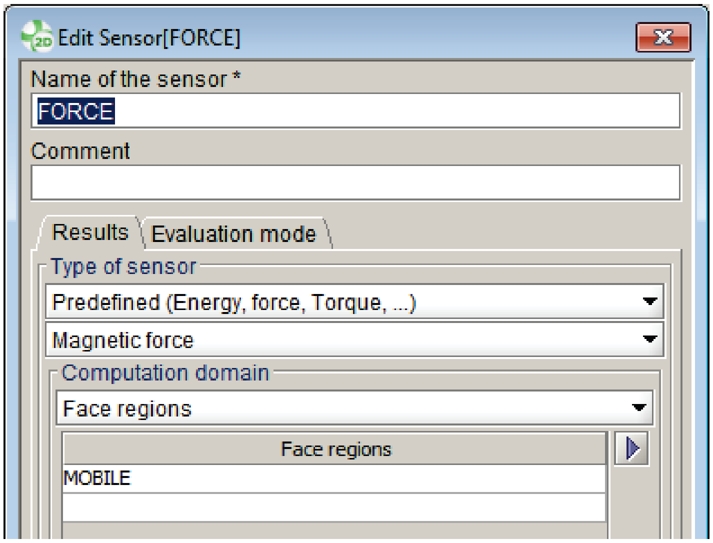
Starting Flux project

The starting Flux project is the `2D_Contactor.FLU`.

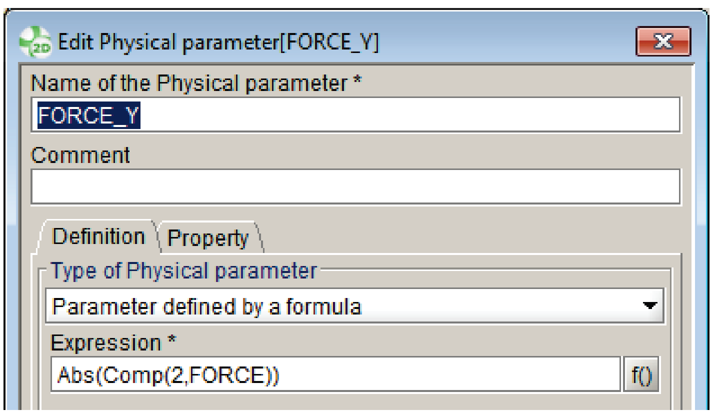
It contains:

- the parameterized geometry of the device
- the mesh
- the physics definition (application, materials, regions, coils)

The sensor **FORCE** has been created to compute the force on the mobile part.

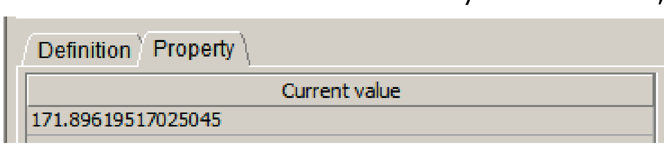


Next, the I/O parameter **FORCE_Y** has been created to store only the Y component of the sensor response.



The project has been solved with **REFERENCEVALUES** solving scenario.

The sensor and the I/O parameter are evaluated automatically. For instance, for **FORCE_Y**:

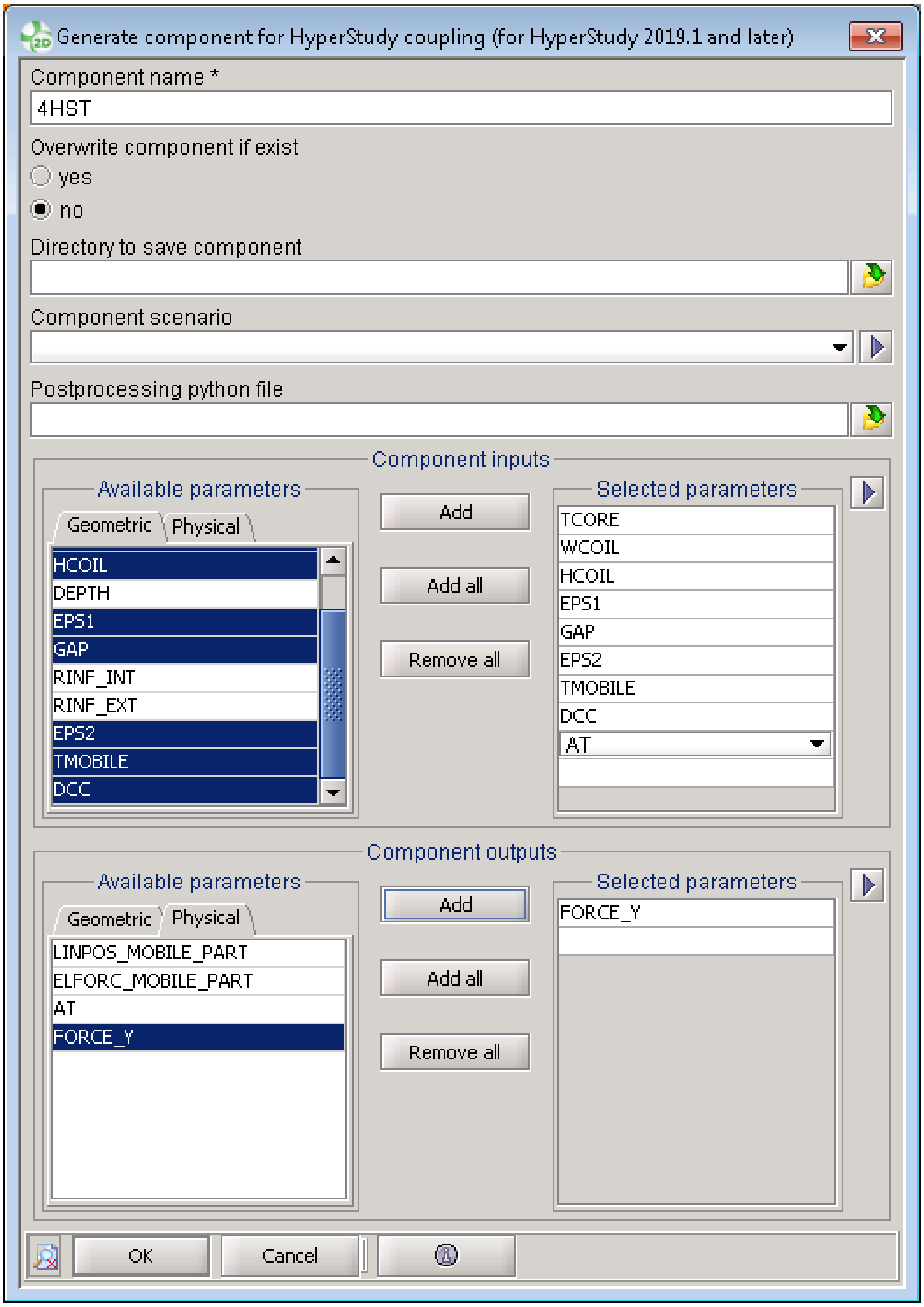


Generating the link file from Flux

Here are the steps to generate the link file `F2HST` from Flux. After having done this you can close the Flux project and Flux.

1. Open the dialogue box:

   Click on **Generate component for HyperStudy coupling** in the **Solving** menu



2. Define the **Component name**, for example: `4HST`
3. Go to **Component inputs** section and choose input parameters:

   Add TCORE, WCOIL, HCOIL, EPS1, GAP, EPS2, TMOBILE, DCC, AT
4. Go to **Component outputs** section and choose the outputs:

Add FORCE_Y

5. Validate by clicking on **OK**

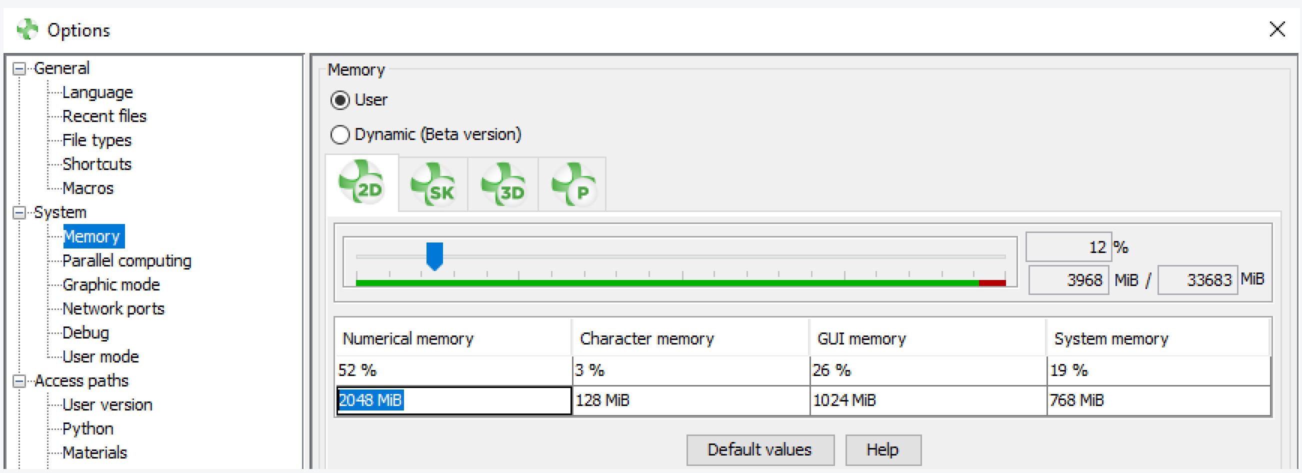
`4HST.F2HST` file has been created.

The Flux project has been duplicated and registered under the name: `4HST.F2HST.FLU`

Warning:

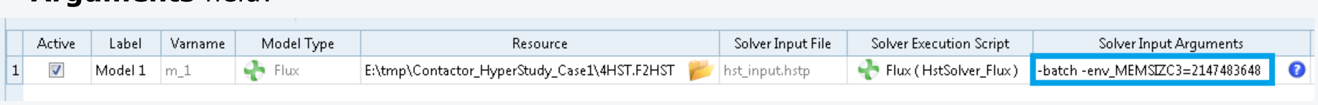
The memory values specified manually or by default in the Flux Supervisor options are written in the `F2HST` file when generating the component for HyperStudy from Flux. By default, HyperStudy will launch Flux with these values.

If these values are unnecessary high, it can limit the multiple Flux launching from HyperStudy. So, before generating the component, a suggestion is to tune the memory values to the minimum required to solve your model, in the **Flux Supervisor options**:



Note that if you change the memory values in the Flux Supervisor options, after generating the component, the new values will not be communicated to HyperStudy.

If you would like to change the memory values after generating the component, you can do it directly in HyperStudy using the solver arguments for Flux in the **Solver Input Arguments** field:



3 HyperStudy Project

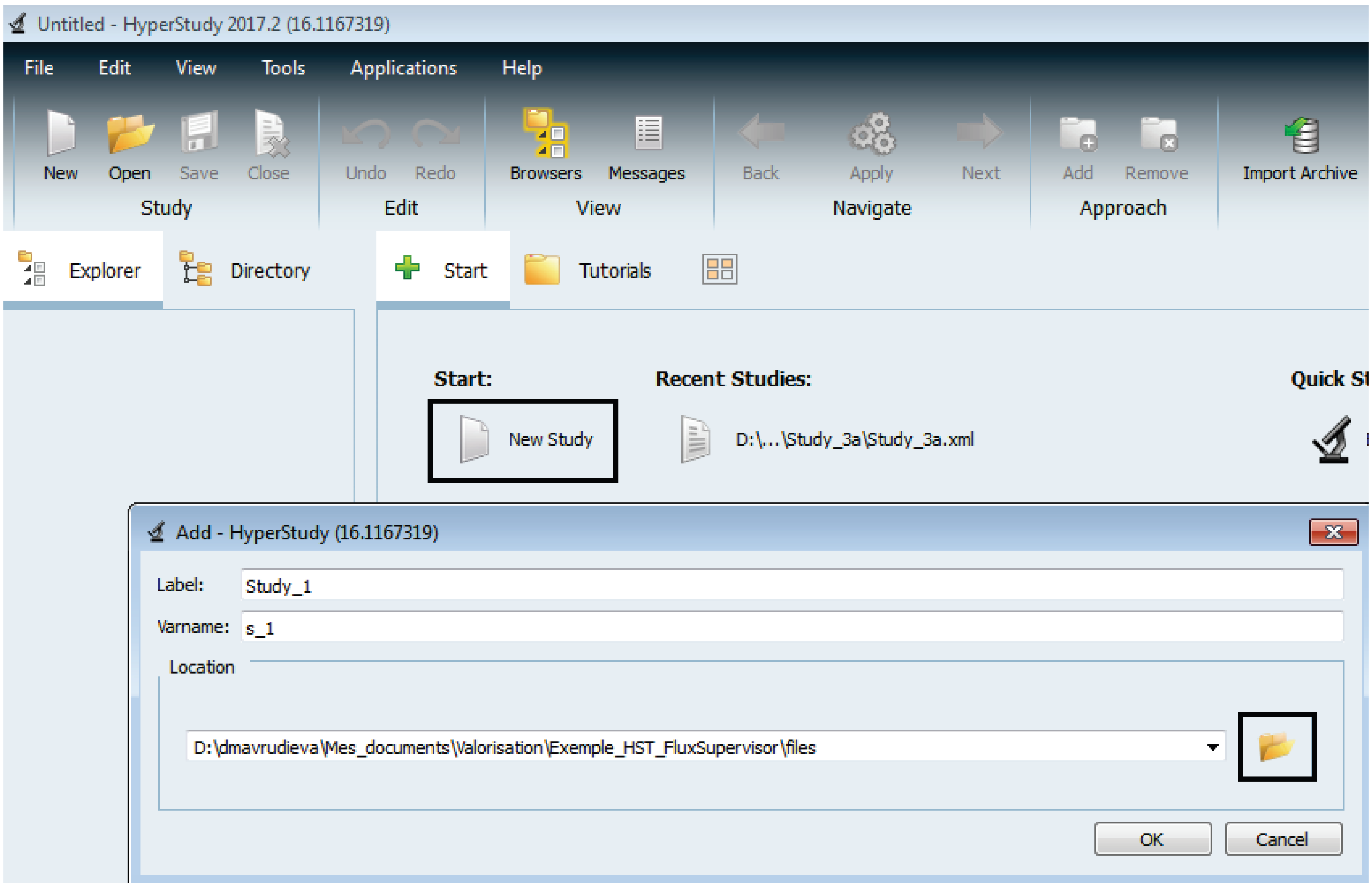
This chapter covers the following:

- 3.1 Setup (p. 9)
- 3.2 DOE (p. 11)
- 3.3 Optimization (p. 14)
- 3.4 Stochastic (Reliability of the optimum solution) (p. 16)
- 3.5 Export study archive (p. 18)

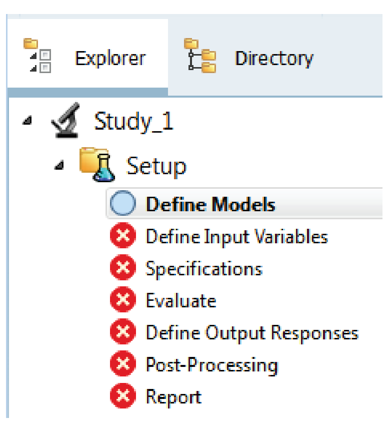
3.1 Setup

Procedure

1. Open HyperStudy and **Start** a **New Study** in the same directory where `.F2HST` and `.F2HST.FLU` files are located:

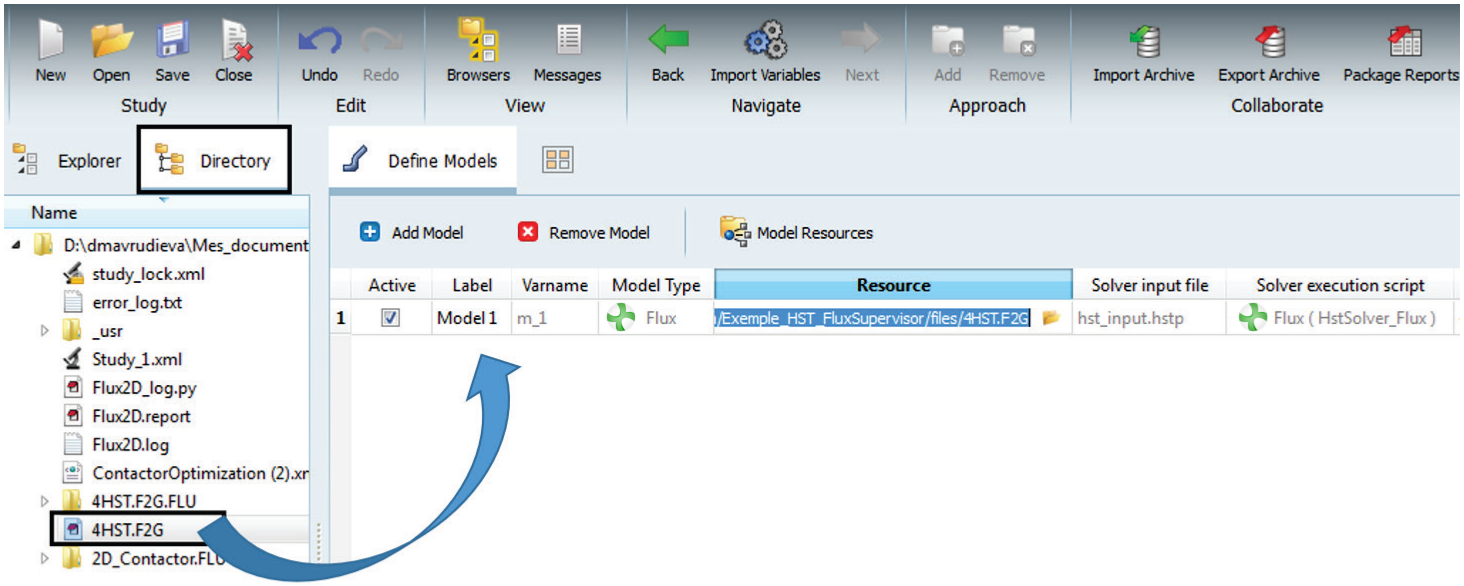


2. Select **Define Models** in **Setup** and define a Flux model:



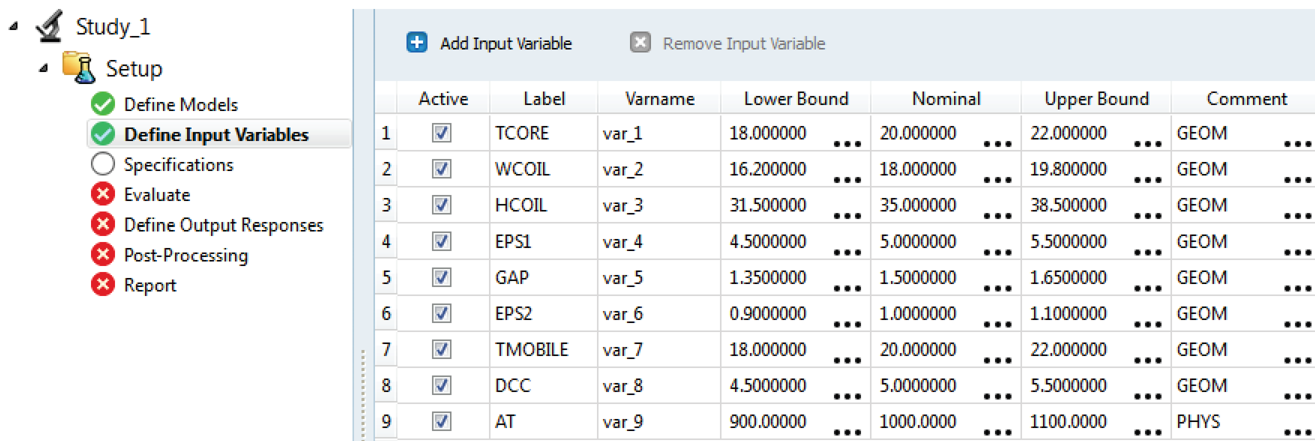
Click on **Directory** and **drag & drop** the `4HST.F2HST` into the graphical interface.

The Flux model is automatically created and the tabs are populated.



3. Click on **Import Variables**.

Input variables appear in **Define Input Variables**.



	Active	Label	Varname	Lower Bound	Nominal	Upper Bound	Comment
1	☑	TCORE	var_1	18.000000	20.000000	22.000000	GEOM
2	☑	WCOIL	var_2	16.200000	18.000000	19.800000	GEOM
3	☑	HCOIL	var_3	31.500000	35.000000	38.500000	GEOM
4	☑	EPS1	var_4	4.5000000	5.0000000	5.5000000	GEOM
5	☑	GAP	var_5	1.3500000	1.5000000	1.6500000	GEOM
6	☑	EPS2	var_6	0.9000000	1.0000000	1.1000000	GEOM
7	☑	TMOBILE	var_7	18.000000	20.000000	22.000000	GEOM
8	☑	DCC	var_8	4.5000000	5.0000000	5.5000000	GEOM
9	☑	AT	var_9	900.00000	1000.0000	1100.0000	PHYS

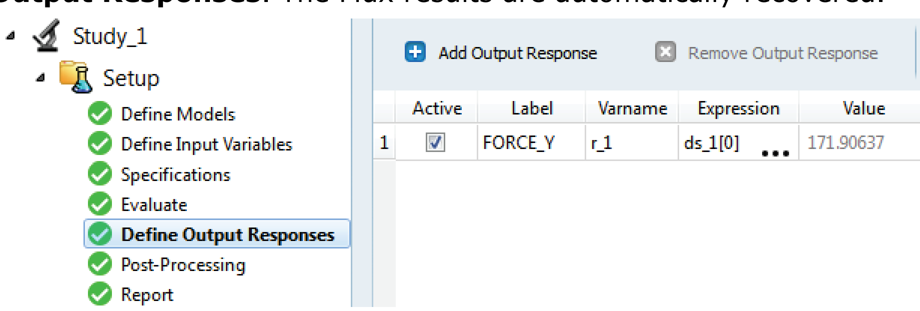
4. Go to **Specifications**.

Select **Nominal run**. It allows performing one run at nominal values.

5. Go to **Evaluate** and click on **Evaluate Tasks**.

It runs Flux in batch, solves the project and recovers the results.

6. Go to **Define Output Responses**. The Flux results are automatically recovered.

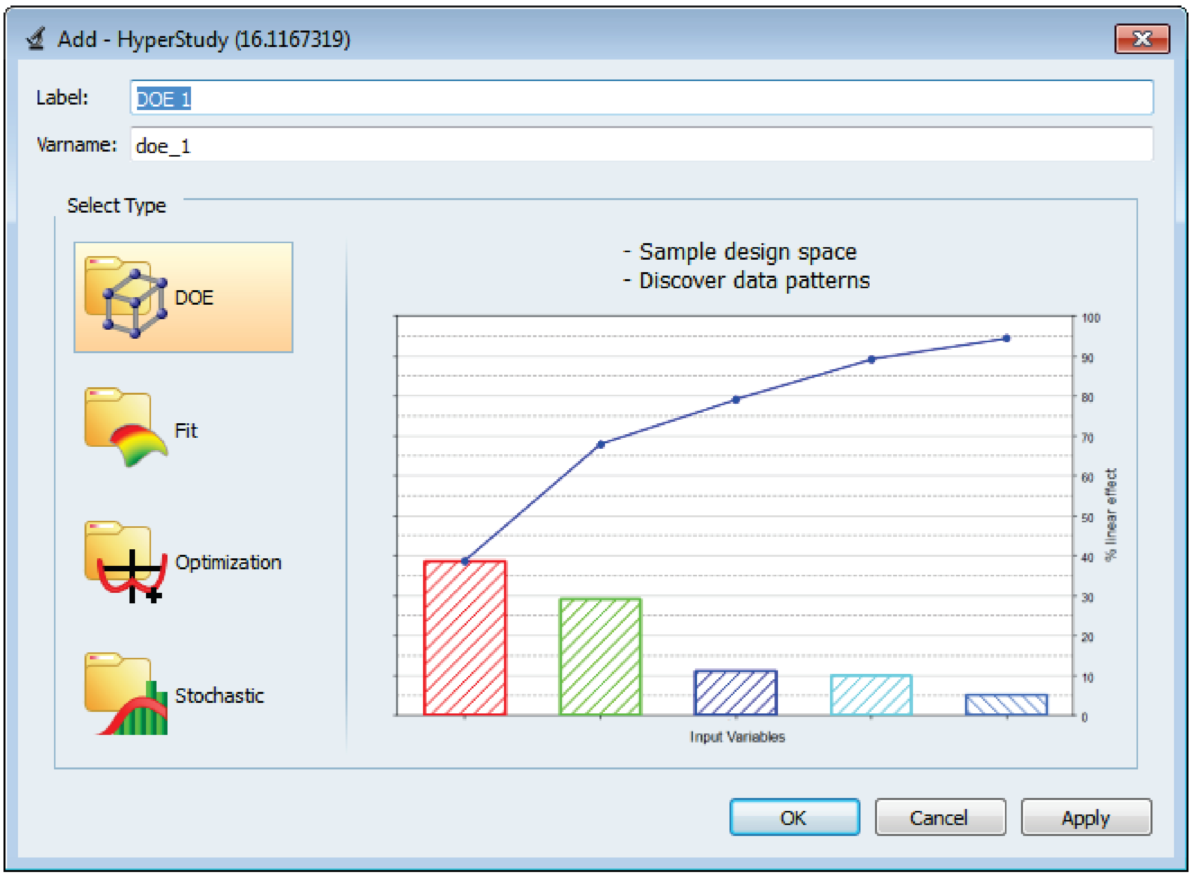


3.2 DOE

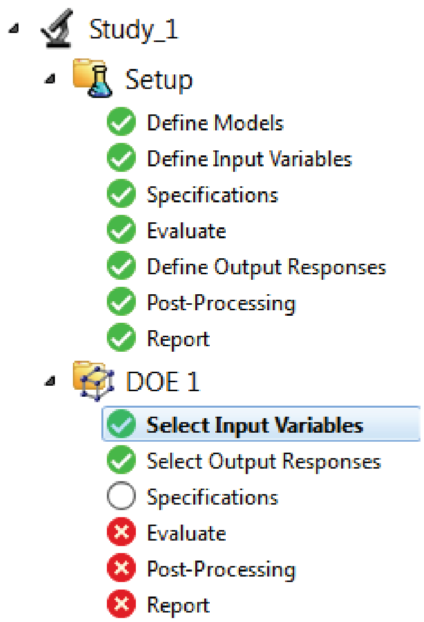
Procedure

1. Add **DOE** approach.

   Right-click in the data tree and select **Add**.

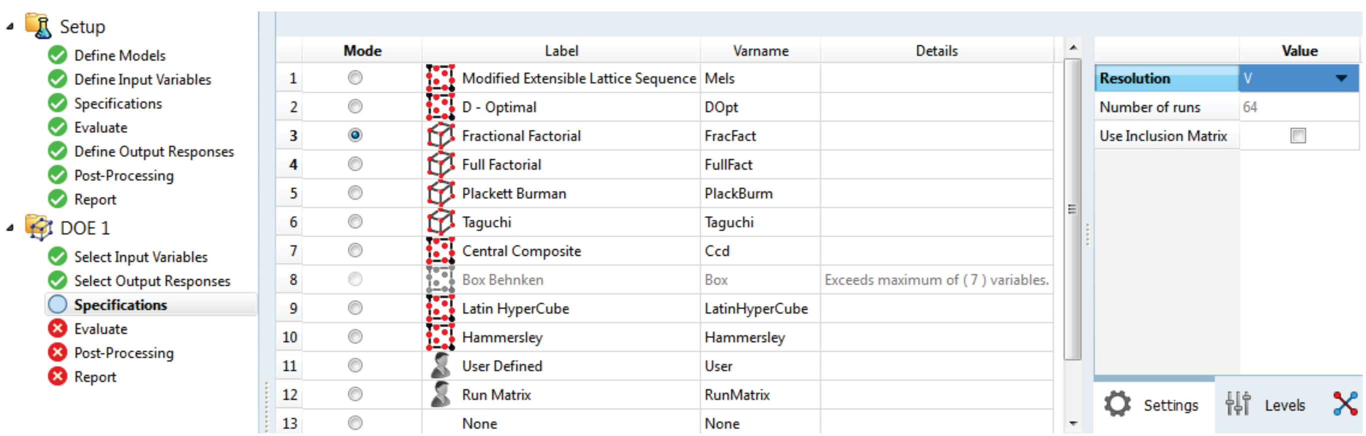
   

   DOE 1 approach appears in the data tree. **Select Input Variables** and **Select Output Responses** are automatically copied from the **Setup**.



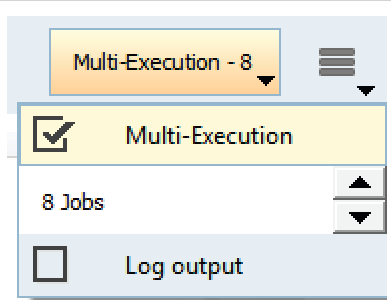
2. Go to **Select Input Variables** and disable **GAP** parameter.
3. Go to **Specifications**.

   Select **Fractional Factorial**, **Resolution V**. Click on **Apply**.



4. Go to **Evaluate**. Activate the option **Multi-execution** in the right top corner.

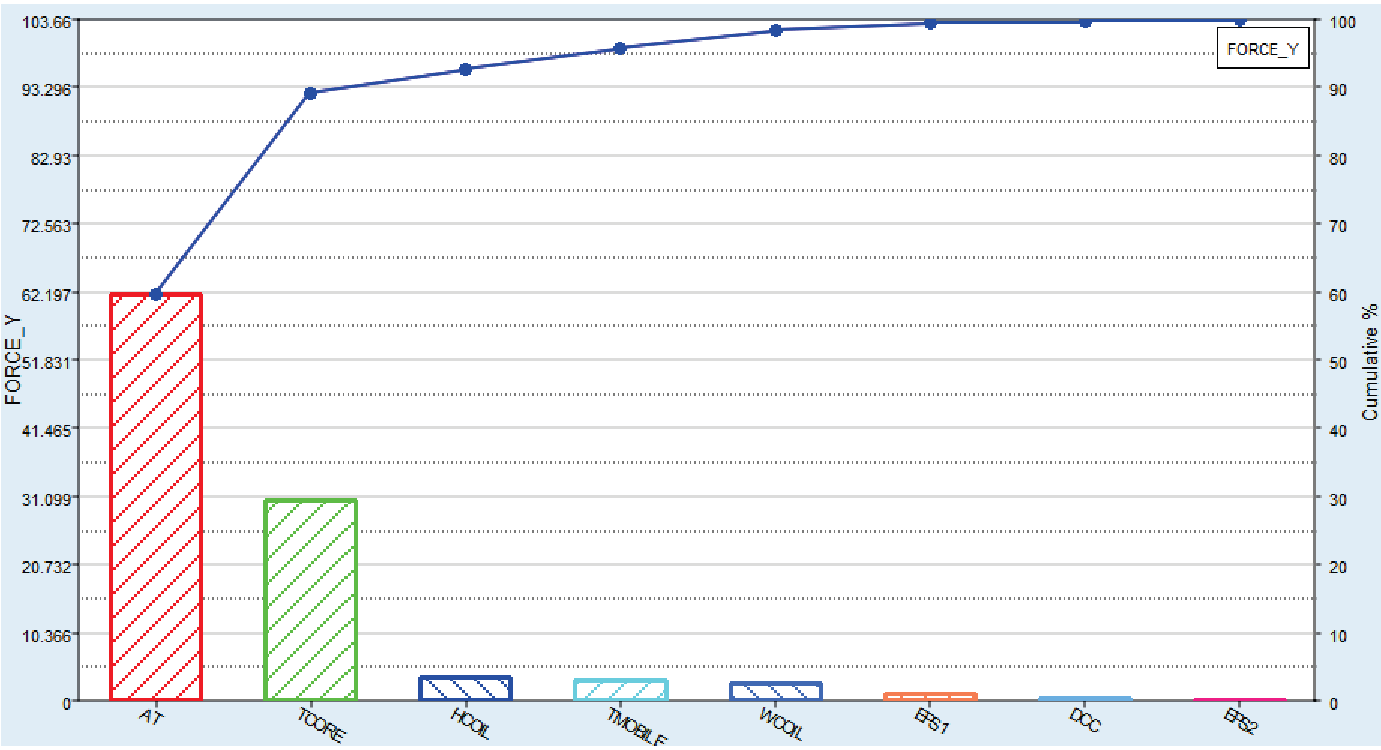
> **Note:** The number of concurrent Flux jobs should be chosen depending on the cores available on the machine and the RAM required to run all the jobs.



Click on **Evaluate Tasks**.

5. Go to **Post Processing**.

Click on **Pareto Plot** tab.



The effects of variables on output responses are plotted in hierarchical order (highest to lowest). Hashed lines with a positive slope indicates a positive effect. If a variable increases, the output response will also increase. Hashed lines with a negative slope indicates a negative effect. Increasing the variables lowers the output response.

The less influential parameters are **EPS1**, **DCC** and **EPS2**. We will exclude them for the optimization.

3.3 Optimization

Procedure

1. Add **Optimization** approach.
2. Go to **Select Input Variables**. Disable **EPS1**, **DCC**, **EPS2** and **GAP**.
3. Go to **Define Output Responses**. Define an **Objective** of **System Identification** type applied on **FORCE_Y** to reach a target value of 200 N. **Apply**.

Add Objective   Remove Objective

	Active	Label	Varname	Type	Apply On	Evaluate From	Target Value
1	☑	Objective 1	obj_1	System Identification	FORCE_Y (r_1)	Solver	200.00000

4. Go to **Specifications**.

   An optimization algorithm is automatically proposed by HyperStudy. Click on **Apply**, then **Next**.

	Mode	Label	Varname	Details
1	◉	Adaptive Response Surface Method	ARSM	
2	○	Global Response Search Method	GRSM	
7	○	Sequential Optimization and Reliability Assessment	SORA	Random design/parameter variables necessary
		Show more ...		

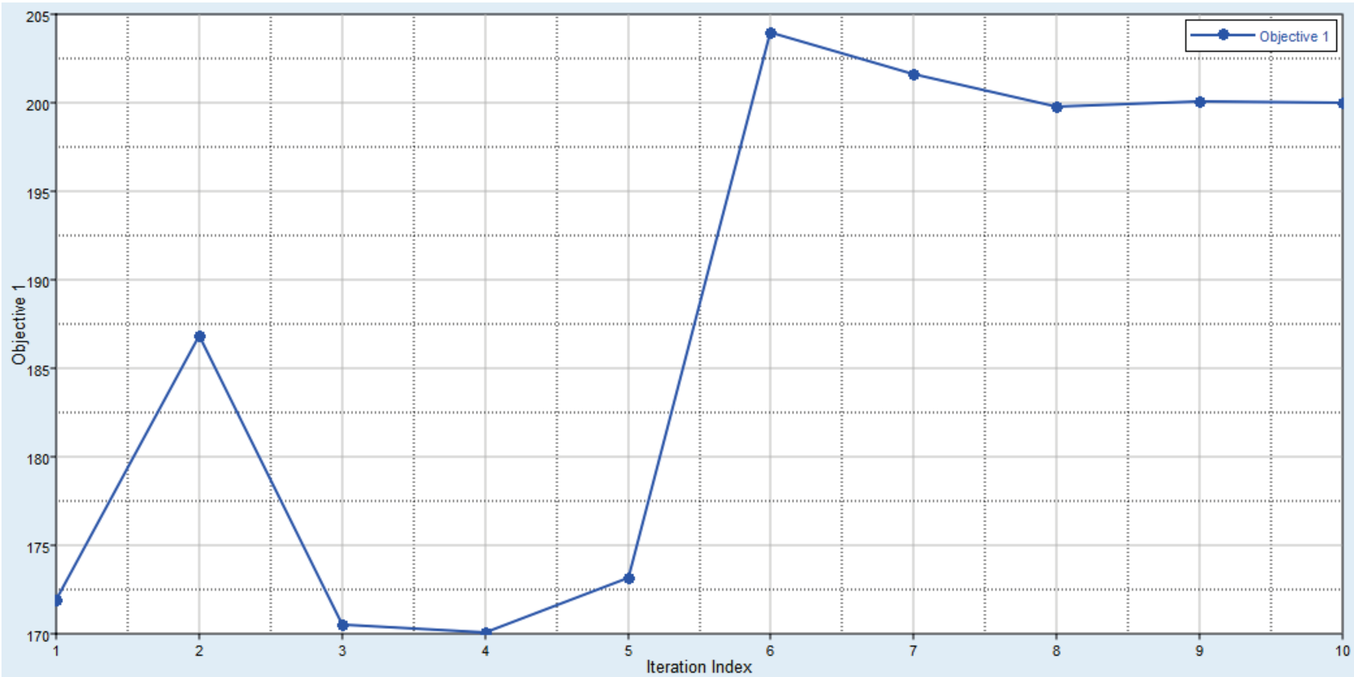
5. Click on **Evaluate Tasks**.
6. Stay in **Evaluate** to analyze the results.

   The optimum solution is available in the **Iteration History** tab (green line in the chart). The objective (199,998 N) has been reached in only 10 iterations (10 evaluations in this case) starting from the initial value (171,906 N).

Go to Directory   Browse files

	TCORE	WCOIL	HCOIL	TMOBILE	AT	FORCE_Y	Objective 1	Iteration Index
1	20.000000	18.000000	35.000000	20.000000	1000.0000	171.90637	171.90637	1
2	22.000000	18.000000	35.000000	20.000000	1000.0000	186.80921	186.80921	2
3	20.000000	19.800000	35.000000	20.000000	1000.0000	170.54405	170.54405	3
4	20.000000	18.000000	38.500000	20.000000	1000.0000	170.09980	170.09980	4
5	20.000000	18.000000	35.000000	22.000000	1000.0000	173.13390	173.13390	5
6	20.000000	18.000000	35.000000	20.000000	1100.0000	203.98381	203.98381	6
7	22.000000	16.200000	31.500000	22.000000	1027.4161	201.64353	201.64353	7
8	21.791509	16.312135	31.571400	21.950073	1027.3852	199.76414	199.76414	8
9	21.810931	16.308238	31.564990	21.954658	1027.6215	200.04434	200.04434	9
10	21.808892	16.309763	31.567942	21.952604	1027.6109	199.99820	199.99820	10

Iteration Plot shows the optimization progress through the iterations until the objective is reached.



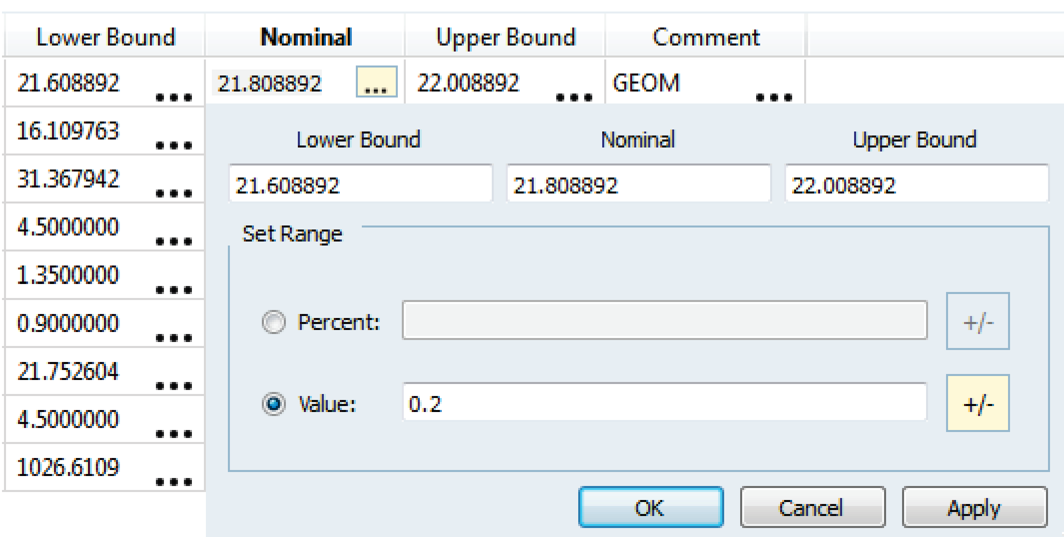
3.4 Stochastic (Reliability of the optimum solution)

Procedure

1. Add **Stochastic** approach.
2. Go to **Select Input Variables**.
   a. Disable **EPS1**, **DCC**, **EPS2** and **GAP**.
   b. Copy the optimum values for **TCORE**, **WCOIL**, **HCOIL**, **TMOBILE** and **AT** from **Iteration History** tab in **Optimization** approach and paste them in the **Nominal** column in the **Stochastics** approach.

	Active	Label	Varname	Lower Bound	Nominal	Upper Bound	Comment
1	☑	TCORE	var_1	21.608892	21.808892	22.008892	GEOM
2	☑	WCOIL	var_2	16.109763	16.309763	16.509763	GEOM
3	☑	HCOIL	var_3	31.367942	31.567942	31.767942	GEOM
4	☐	EPS1	var_4	4.5000000	5.0000000	5.5000000	GEOM
5	☐	GAP	var_5	1.3500000	1.5000000	1.6500000	GEOM
6	☐	EPS2	var_6	0.9000000	1.0000000	1.1000000	GEOM
7	☑	TMOBILE	var_7	21.752604	21.952604	22.152604	GEOM
8	☐	DCC	var_8	4.5000000	5.0000000	5.5000000	GEOM
9	☑	AT	var_9	1026.6109	1027.6109	1028.6109	PHYS

   c. Edit **Lower** and **Upper Bounds**:
   TCORE, **WCOIL**, **HCOIL**, **TMOBILE**: ±0.2 ; **AT**: ±1

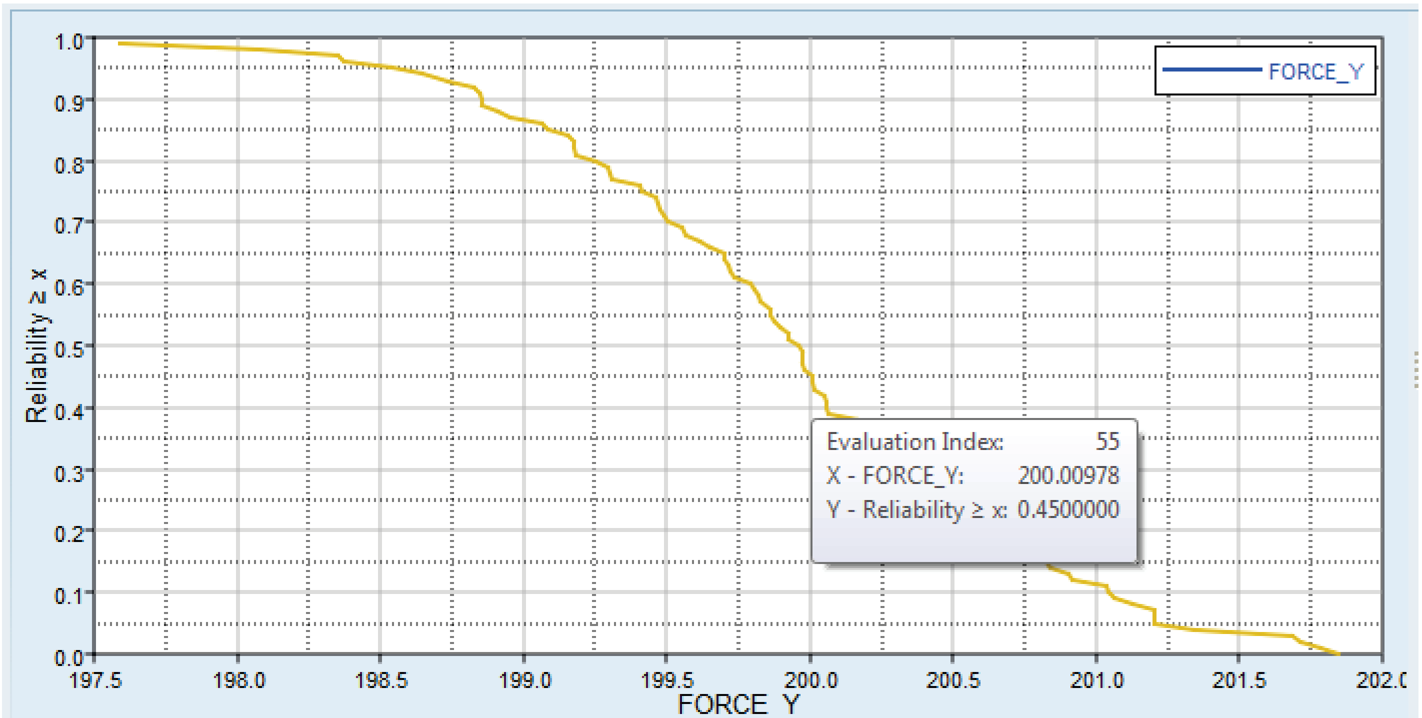


3. Go to **Specifications**.

Select **Hammersley** with **100** runs. **Apply**, then **Next**.

4. **Evaluate Tasks**.
5. Go to **Post Processing**.

In the **Reliability Plot** tab you can check what is the reliability (in %) to have **FORCE_Y**=200 N.



3.5 Export study archive

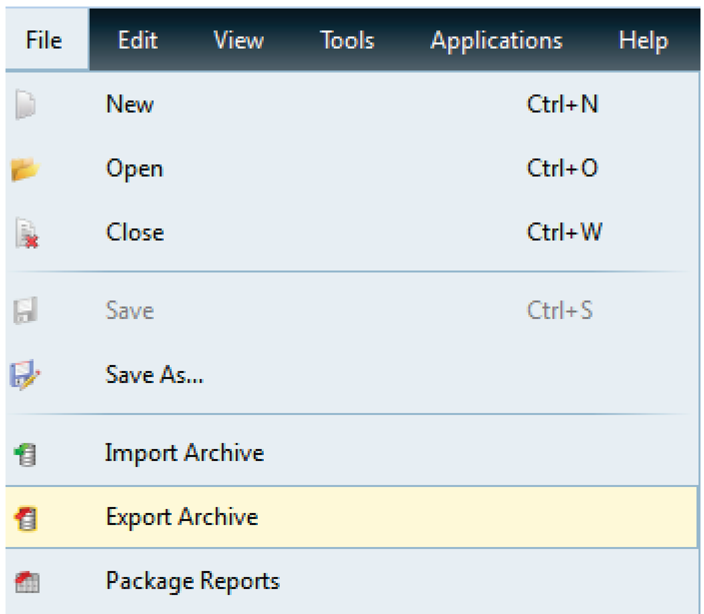
Introduction

In order to store your study in reduced file size, or to be able to share it easily with a colleague, you can use the **Export Archive** functionality available in HyperStudy. It allows creating archives by packaging all the files used in the study. Once imported in HyperStudy such an archive allows restoring the complete study as it has been done initially.

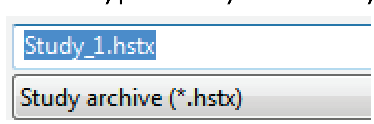
Procedure

In order to export an archive you need to do the following steps:

1. Go to menu **File** and click on **Export Archive**.



2. Give a name (by default the name of the HyperStudy `xml` study is taken).



3. Click on **Save**.

   It creates an `hstx` file in the working directory.

> **Note:** In the files provided with this tutorial, you will find the archive `2D_Contactor_study.hstx` including all the studies completed in the tutorial. If you need to look at it, you need to import it in HyperStudy using the command **Import Archive**, or just **drag & drop** the `hstx` into the graphical interface.