GRANTA MI™ version 11.0

GRANTA MI:Optimize Guide



GRANTA MI[™] is the leading system for materials information management in engineering organizations. It enables you to control, analyze, and securely share critical corporate data on materials and processes, managing the materials information lifecycle.

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1 About GRANTA MI:Optimize

GRANTA MI:Optimize enables you to optimize materials and manufacturing choices by considering the functional requirements of a material in conjunction with the 'cost' of specifying and using that material. 'Cost' may mean, for example, the \$ cost of procuring and processing the material, the environmental implications of its use, or a packaging cost such as volume.

The optimization process begins with specifying the design objective—for example, to select the best material to minimize the cost of a panel loaded in bending. Additional constraints can then be specified, including 'must-have' functional requirements such as thermal or electrical properties, benchmark materials, and 'preferred' materials and/or suppliers. MI:Optimize will then rank candidate materials with respect to the specified optimization criteria.

A ready-configured materials database is provided with MI:Optimize. The database provides materials reference data from the MaterialUniverse data module and the ability for you to add your in-house data and business rules to implement an MI:Optimize 'materials selection wizard' that supports your company's materials selection strategy.

1.1 How MI:Optimize works

MI:Optimize is designed to support your business processes. Both the Optimize tool in MI:Viewer, in which the user specifies their design objectives, and the calculations and preferred material classifications underlying it, can be readily configured, enabling your company to follow the process shown in Figure 1, in which:

- The functions of the various products are analyzed and categorized by the company's materials, process and manufacturing experts.
- The preferred materials classification is established by considering 'cost per unit function' and other related techniques (specific details are typically proprietary, representing company knowledge of how to best exploit materials in their products) and aggregating across the various applications.
- The resulting categorization is exposed to designers and engineers via the Optimize page in MI:Viewer. A wizard-like user interface prompts the engineer in the specification of requirements, ensuring all pertinent factors are considered.
- In response to these user inputs, the software applies the business rules to identify preferred materials that best fit the company's strategy for that particular class of application, and ranks them according to relative combinations of performance and cost.
- If no materials match the user's requirements, the system can go to a higher 'tier' to switch from preferred materials to all available materials.



Figure 1. GRANTA MI:Optimize materials selection

1.2 Implementing MI:Optimize

The 'business rules' – the calculations and preferred material classifications - that define your materials selection strategy are captured systematically in a Microsoft Excel template file. When imported into an MI database, worksheets in the template specify the steps, options and controls available in the Optimize wizard.

Summary of implementation steps

- 1. Capture the 'business rules' that define your company's materials selection strategy in an MI:Optimize template (Microsoft Excel) file. See Section 2, Defining MI:Optimize worksheets.
- 2. Import the MI:Optimize template file into your database using the MI:Optimize Importer plugin in MI:Admin. See Section 3, *Importing MI:Optimize worksheets*.
- 3. Designers and engineers using MI:Viewer can then go to the Optimize page and begin compiling and ranking material candidates, asking questions such as "What material is the lowest cost for a panel loaded in bending?" and receive an answer based on the business rules. See Section 4, *Using MI:Optimize*.

2 Defining MI:Optimize worksheets

The MI:Optimize features and functionality available to MI:Viewer users are defined using a number of named worksheets in a Microsoft Excel file.

- 'FOCs' worksheet defines the function, objective and cost constraints that will be presented to MI:Optimize users.
- 'Optimization Templates' worksheet (or 'Optimization Templates') specifies the available subsets, tiers of preference and additional filters.
- 'User Parameters' worksheet imports any new parameters needed for equations which are not already in the system.
- 'EELs Charts' worksheet defines any equation-based reports to include at the end of the analysis.
- 'XY Charts' worksheet defines reports that compare one property against another.

2.1 'FOCs' worksheet

This worksheet defines the available functions, objectives and constraints that will be presented to MI:Optimize users.

(🖾 GRANTAMI_Optimize.xlsx 🗗 🗉 🔀								
	А	В	С	D	E	F	G	Η 🔺	
1	Table 💌	Function	Function	Function 💌	Function 🔄	Cycl 🔻	Objecti 🔻	Objecti	
2	name	name	description	heading	picture		name	descrip	
17	MaterialUniverse	Tie in tension	Hangers, tie rods,	Mechanical	\images\9.png		foot	print (CC	
18	MaterialUniverse	Tie in tension	Hangers, tie rods,	Mechanical	\images\9.png		res	onant free	
19	MaterialUniverse	Tie in tension	Hangers, tie rods,	Mechanical	\images\9.png		vibr	ation am	
20	MaterialUniverse	Column in compre	Columns, pillars,	Mechanical	\images\6.png		vol	ume	
21	MaterialUniverse	Column in compre	Columns, pillars,	Mechanical	\images\6.png		ma	SS	
22	MaterialUniverse	Column in compre	Columns, pillars,	Mechanical	\images\6.png		CO	st	
23	MaterialUniverse	Column in compre	Columns, pillars,	Mechanical	\images\6.png		em	bodied er	
24	MaterialUniverse	Column in compre	Columns, pillars,	Mechanical	\images\6.png		foot	print (CC	
25	MaterialUniverse	Column in compre	Columns, pillars,	Mechanical	\images\6.png		vol	ume	
26	MaterialUniverse	Column in compre	Columns, pillars,	Mechanical	\images\6.png		ma	ss 💌	
H.	FOCs 0	ptimization Templa	tes 🏑 user paramet	ers 🧹 EELs Ch	harts 🖉 XY Charts	/ 🔁 /		▶ 1.1	

The first two rows of the worksheet are used to specify the content of the column, and each subsequent row represents a single 'FOC item'. For example, a column with Row 1 = 'Function', Row 2 = 'Name' is used to specify the Function Names.

Not every column is required, for example the worksheet does not need to have an 'Optimization Template' column or any 'Function' columns.

The MI:Optimize Importer will start importing 'FOC items' at row 3 and continue until a row with an empty Table Name cell is encountered at which point it will stop.

The order of the columns does not matter but they have to start at column 1 and be continuous i.e. the importer will stop parsing the file at the first empty cell in row 1.

Column		Value required?			
Header in Row 1	Header in Row 2				
Table	Name	Yes			
Function	Name	Yes if a Function is required			
Function	Description	Yes if a Function Name is specified, otherwise optional;			
Function	Heading	Yes if a Function Name is specified, otherwise optional			
Function	Picture	No			
Cyclic		No; if entered, value must be True or False. Default is False.			
Objective	Name	Yes			
Objective	Description	No			
Objective	Minimize or maximize	No; if entered, value must be Minimize or Maximize			
Constraint	Name	Yes if a Constraint is required			
Constraint	Description	No			
Objective Expression	Expression	Yes Note there is no 'Name' column for the 'Objective Expression' as it is given the same name as the Objective.			
Objective Expression	Unit	No			
Data Expression	Name	Yes if a Data Expression is required, otherwise optional (Empty column is required)			
Data Expression	Expression	Yes if a Data Expression is required (Empty column is required)			
Data Expression	Description	No			
Data Expression	Unit	No; if a unit is entered, it is also used for the Design Expression unit.			
Design Expression	Name	Yes if a Design Expression is required, otherwise optional (Empty column is required)			
Design Expression	Expression	Yes if a Design Expression is required (Empty column is required)			
Design Expression	Description	No			
Free Variable	Name	Yes if a Free Variable is required			
Free Variable	Description	No			
Fixed Variables	Name	Yes if Fixed Variables are required			
Fixed Variables	Description	No			
Optimization Template	Name	No ; specifies the optimization template name			
XY Charts	Name	No; value is a comma-separated list of charts found in the 'XY Charts' tab.			

Table 1. 'FOCs' worksheet column format

Column		Value required?		
EELs Charts	Name	No, value is a comma-separated list of charts found in the 'EELs Charts' tab		
Allow DWV Filtering		Optional; if entered, the value must be True or False.		

2.2 'Optimization Templates' worksheet

This worksheet specifies the available subsets, tiers of preference and additional filters available to MI:Optimize users.

	📳 GRANTAMI_Optimize.xlsx 👝 🗉 🖏								
	А	В	С	D	E	F	=		
1	Table	Name	Description	Subset	Associated Ter	Order	Addi		
2	MaterialUniverse	All Bulk Materials	Consider mechanical, ther	All Bulk Materials	i		Yield		
3	MaterialUniverse	Polymers	Consider mechanical, ther	Polymers - All			Yield		
4	MaterialUniverse	Ceramic	When considering applicat	Ceramics	All Bulk Materials	5	Yield		
5	MaterialUniverse	Metal	Consider mechanical, ther	Metals	All Bulk		Yield		
6	MaterialUniverse	Thermal	Consider thermal propertie	All Bulk Materials	i		Yield		
7	MaterialUniverse	Electrical	Consider electrical propert	All Bulk Materials			Yield		
8							•		
	H • • • FOCs Optimization Templates user parameters / EELs Charts / XY Charts / 🔁 / 🛛 • 🛄 🕨 🕨 🕅								

The worksheet must contain all seven columns listed, but values are not required in all columns, as indicated in the table.

Column	Value required?
Table	Yes
Name	Yes
Description	No; can include basic HTML The value of this cell ends up as heading for Step 3
Subset	No
Associated Template	No
Order	No
Report Attributes	No; value is a comma separated list of report attributes A column name of 'Additional report attributes' is also accepted.

Table 2. 'Optimization Templates' worksheet format

2.3 'User Parameters' worksheet

This worksheet defines the name, units and default value of any user parameters used in optimization equations. Note that the parameters already defined in the MI database can also be used.

(🔊 GRANTAMI_Optimize.xlsx 👝 📼 🔀							
	A	В	С	D	E	F	G	H 🚍
1	Name	unit 💌	default value 💌	-	-	-	-	
2	Height	m	0.5					
3	a	m	0.2					
4	b	m	0.2					
5	Force per unit height	N/m	15					
6	Torque	N	15					
7	Extension	μm	10					
8	Width	m	0.2					
9	Length	m	0.2					
10	Force	N	100			1.4. /		
14 4	FOCs / Optimization T	emplates 📜 us	er parameters 🖉 🛙	EELs Charts	XY Char	ts <u>/ 🔁 /</u>) ▶ [].∄

All three columns on this worksheet are required. However, values are required only in the first column

Table 3. 'User Parameters' worksheet format

Column	Value required?
Name	Yes
Unit	No
Default value	No

2.4 'EELs Charts' worksheet

This worksheet defines any equation-based reports ('Optimization Expression Charts') to include at the end of the analysis.

📳 GRANTAMI_Optimize.xlsx 👝 🗉 🕅								
	A	В	С	D	E	F	G 🚍	
1	Table	Name	Description	Chart Title	X axis	X axis	X axis	
2					parameter	title	logarithm _	
3	Aluminum Alloys, Ca	Cost vs. Design Strength	Cost of mater	Cost vs. Design S	DWV	Increasing	TRUE	
4	Aluminum Alloys, Ca	Cost vs. Design Strength (Cost of mater	Cost vs. Design S	DWV	Increasing	TRUE	
5	Aluminum Alloys, Ca	Cost vs. Total Production	Cost of mater	Cost vs. Total Pro	Total Produc	Total Produ	TRUE	
6	Aluminum Alloys, Ca	Cost vs. Mass	Cost of mater	Cost vs. Mass	Mass	Mass	TRUE	
7	Aluminum Alloys, Ca	Cost vs. Complexity	Cost of mater	Cost vs. Complex	Complexity	Complexity	FALSE	
8	Aluminum Alloys, Ca	Cost vs. Tolerance	Cost of mater	Cost vs. Toleranc	Tolerance	Tolerance	TRUE	
9	Aluminum Alloys, Ca	Cost vs. Finish	Cost of mater	Cost vs. Finish	Finish	Finish	TRUE	
10	Aluminum Alloys, Ca	Cost vs. Number of Cavitie	Cost of mater	Cost vs. Number	Number of C	Number of	FALSE 🔻	
	🕩 🕨 🛛 FOCs 🦯 Opti	imization Templates 🏑 user	r parameters 🔍	EELs Charts X	Y Charts 🖯 😤]/]	▶ I .::	

The table below shows the format of the worksheet.

Table 4. 'EELs Charts' worksheet format

Col	Value required?	
Header in Row 1	Header in Row 2	
Table		Yes
Name		Yes
Description		No
Chart Title		No
X axis	parameter	No
X axis	Title	No
X axis	Logarithmic	Yes; True or False
X axis	Scale from	No
X axis	Scale to	No
Y axis	is objective expression	No
Y axis other expression	name	No
Y axis other expression	expression	No
Y axis other expression	unit	No
Y axis	Attribute	No
Y axis	Is objective expression	Yes; True or False
Y axis	Title	No
Y axis	Logarithmic	Yes; True or False
Y axis	Scale from	No
Y axis	Scale to	No
Y axis expression	Name	No

Colu	Value required?	
Header in Row 1	Header in Row 2	
Y axis expression	Unit	No
Y axis expression	Expression	No

Expressions Format

The format of the expressions in this worksheet are as follows, where:

- A: Attribute
- C: Constant
- P: Parameter
- U: User parameter

Example

1000*[A:Density]*[A:Price]/([A:Young's modulus]^(1/3))

Further information about equations and logic in GRANTA MI is included in the MI: Viewer help.

Example

Figure 2 shows an optimization expression (EELs) chart where the material and processing cost model is plotted relative to the total production run size for the list of candidate materials. Other parameters in the equation are held constant.



Figure 2. Example of an Optimization Expression Chart

2.5 'XY Charts' worksheet

The XY Charts worksheet defines reports that compare one property against another.

GRANTAMI_Optimize.xlsx							
	A	В	С	D	E	—	
1	Table	Name	Description	Chart Title	X axis	X axi	
2					attribute	is dat	
3	MaterialUniver	Performance vs. Yield St	For comparing the	Performance vs. Yield Strength	Yield strength (e	FA≡	
4	MaterialUniver	Performance vs. Young's	For comparing the	Performance vs. Young's Modul	us Young's modulu	FA	
5	MaterialUniver	Performance vs. Flexural	For comparing the	Performance vs. Flexural Modul	us Flexural modulu	FA_	
6	MaterialUniver	Performance vs. Flexural	For comparing the	Performance vs. Flexural Streng	th Flexural strengtl	FA	
7	MaterialUniver	Performance vs. Fatigue	For comparing the	Performance vs. Fatigue Streng	h Fatigue strength	FA	
8	MaterialUniver	Performance vs. Electric	For comparing the	Performance vs. Electrical Resist	sti Electrical resisti	FA	
9	MaterialUnive	Performance vs. Thermal	For comparing the	Performance vs. Thermal Condu	ct Thermal conduc	I FA	
10	MaterialUniver	Performance vs. Specific	For comparing the	Performance vs. Specific Heat C	a Specific heat ca	FA_	
- 4 4 4 - 4	FOCs	Optimization Templates	user parameter	s / EELs Charts / XY Charts /	*⊒ ∕ 🛛 ◀ 📖 👘	▶ []	

For a valid Optimization XY chart, one of the following must be true for each axis:

- The value of 'is data expression' (X axis) or 'is objective expression' (Y axis) must be set to True OR
- An 'Attribute' value must be specified for the axis OR
- Values must be specified in the 'Expression' columns for the axis

The following table shows the format of the columns on this worksheet:

Table 5. 'XY Charts' worksheet form

Col	Value required?		
Header in Row 1	Header in Row 2	value required r	
Name		Yes	
Table		Yes	
Description		No	
Chart Title		No	
X axis	Attribute	No	
X axis	Is data expression	Yes, value must be True or False	
X axis	Title	No	
X axis	Logarithmic	Yes, value must be True or False	
X axis	Scale from	No	
X axis	Scale to	No	
X axis expression	Name	No	
X axis expression	Unit	No	
X axis expression	Expression	No	
Y axis	Attribute	No	
Y axis	Is objective expression	Yes, value must be True or False	
Y axis	Title	No	

Col	Value reguired?		
Header in Row 1	Header in Row 2	value required?	
Y axis	Logarithmic	Yes, value must be True or False	
Y axis	Scale from	No	
Y axis	Scale to	No	
Y axis expression	Name	No	
Y axis expression	Unit	No	
Y axis expression	Expression	No	

Example

The example below shows an Optimization XY chart where optimization results have been plotted to compare the calculated cost of the part (which is the objective of the optimization) to the yield strength of candidate materials.



Figure 3. Example of an Optimization XY Chart

3 Importing MI:Optimize worksheets

You import MI:Optimize worksheets into your MI database using the MI:Optimize Importer, a plugin available in MI:Admin.

MI:Optimize Imp	oorter				
Select Database	Software Test v16 (Soft	twareTestv16)			
File to import:	\\files\mi\optimize.xl	s		Browse	Load
Worksheets:	FOCs	V Optimization Te	mplates		
	User Parameters	VY Charts	V EELs Charts		
	FOC Orderings				Import
Messages:	File loaded successfully.	•			*
					-
Frrors	· · · · · · · · · · · · · · · · · · ·				
2					<u> </u>
					~
					łł.

Figure 4. The MI:Optimize Importer

3.1 To import worksheets

Follow these steps to import MI:Optimize configuration worksheets from a Microsoft Excel file into your MI database:

- 1. Open the MI:Optimize Importer: in MI:Admin, on the Tools menu, click MI:Optimize Importer.
- 2. Select a database.
- 3. Load the Excel file into the Importer: locate the file using the **Browse** button, and then click **Load**.
- 4. For each named worksheet found in the source Excel file, the relevant Worksheets check box will automatically be selected.

Clear the worksheet's checkbox if you do not want to import it

5. Click Import to begin importing the selected worksheets.

4 Using MI:Optimize

Once a database has been configured as described in the previous sections, users can access MI:Optimize functionality from the Optimize page in MI:Viewer.

A wizard-like interface enables users to work step-by-step through the process of selecting design objectives and additional functional requirements, identifying benchmark materials and preferred materials and/or suppliers, and finally generating a list of candidate materials ranked with respect to the overall design objective. Graphical reporting tools can then be used to analyze results—for example, highlighting on a graph cheaper materials that can offer the same performance as a reference material.



4.1 To use MI:Optimize

In MI:Viewer, select a database that has been configured for MI:Optimize, and then click **Optimize** on the toolbar:



The sequence of steps and the options available at each step are all defined in the MI:Optimize Excel worksheets, and will vary from company to company, and from template to template.

GRENTE MA Tools Contents Optimize	Optimize	Home Optimize Substitute Subs	A EPORTS	Quick Search Q Help Advanced Search Settings View Tools Units
MI:Starter	Objectives Reference data Crit	ical requirements		
 m → MaterialUniverse m → ProcessUniverse 	I want to:	Minimize Mass	-	
⊕ ● Design Data ⊕ ● Metals Pedigree ⊕ ● Tensile Statistical Data ⊕ ● Tensile Test Data ⊕ ● Restricted Substances ⊕ ● Legislations and Lists	For:	Oxygen barrier		Membranes, packaging, barrier films that are not subjected to significant loads t - thickness a - surface area
		Click image to change function		
	I am free to change:	thickness	•	
	My design case is:	area fixed	•	
	My design is limited by:	permeability resistance (O2)	•	
		Clear All		Clear user entries from all optimization steps
	Next Step What do you know abo	ut the current design?		Get Results

Figure 5. Example of MI:Optimize options in MI:Viewer