HEEDS® Technical Tip – Controlling Minimum Variable Change Using Variable Resolution

Level: Beginner

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Introduction

During optimization, the values of variables are automatically changed to create new designs. In many studies, it is important to control the minimum amount by which a variable can change during optimization. For example, with design variables that cannot be fractional (e.g., the number of teeth on a gear), can only be controlled to a coarse precision level, or are only available in certain sizes, you need to be able to control step size during optimization.

In HEEDS Professional, there are two methods you can use to control the minimum amount by which a variable value can change to produce a new design:

1. **You can define a set of values and assign them to a discrete variable.**

   In this case, you will need to define all possible choices for the variable by creating a discrete set in HEEDS. When this set is assigned to a discrete variable, only the choices defined in the set can be used for that variable during optimization. While this is a reasonable method, it may require a lot of work to define all of the possible values in the set.

2. **You can define a continuous variable with an appropriate resolution**.

   A second method is to define a continuous variable and set a resolution to control the minimum allowed change in the variable. This is applicable in cases where the step size is constant over the entire range of the variable's values. (If the step size is not uniform, or the variable choices are not numeric, the first method must be used.)

This tip will describe how to use the second method.

What is Variable Resolution?

The smallest allowed change in a variable value is determined by the *resolution* you have defined for that variable. The resolution of a variable in HEEDS is the total number of equally spaced choices allowed for that variable within a specified range; that set of choices includes the minimum and the maximum values.

Consider, for example, the set of values provided below. The minimum value is 0.1 and the maximum value is 1.0. The step size is 0.1.

0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0

In this case, the resolution of the variable is 10 (the number of values in this set including the minimum (0.1) and the maximum (1.0) values).

Now consider the general definition of a continuous variable, called *variable1*.

A ≤ *variable1* ≤ **B**

In this case, the minimum value allowed for the variable is **A**, and the maximum value allowed for it is **B**. Without a resolution specified for *variable1*, it can be assigned any real value between **A** and **B**. However, as mentioned before, you can assign a resolution to this variable to control the step size. The step size of the variable is calculated using the equation provided below after a resolution has been specified.

$$\text{stepSize} = (B - A) / (\text{resolution} - 1) \qquad (1)$$

Using the same equation, we can calculate the resolution to use for a desired step size.

$$resolution = ((B - A) / stepSize) + 1 \qquad (2)$$

Examples:

$1.0 \le variable1 \le 2.0$	resolution = 101	stepSize = 0.01
$1.0 \le variable1 \le 2.0$	resolution = 1001	stepSize = 0.001

Defining Variable Resolution in HEEDS

In HEEDS, you define the resolution of variables on the **Assembly** tab. On this tab, click on the **Variables** button in the **Agent Graph**, select the desired variable from the **Agent Variables** list, and enter the desired value in the **Resolution** field.

For example, consider the variable *Thickness*, shown below. The red circled area shows the field where the resolution of the variable can be changed. This value should be changed based on the results from equation (2).