VIRTUAL INSTRUMENT FOR CALCULATING THE MAXIMUM LOAD SUPPORTED BY A FLAT STEEL BAR CONSISTING OF TWO PORTIONS

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ABSTRACT: This paper describes the results obtained by designing and creating a virtual tool made in the LabVIEW graphic programming enviroinment with the help of which material resistance calculations are performed. The virtual tools allows the calculation of the largest axial load that can be safely supported by a flat steel bar consisting of two portions connected by fillets under a normal stress.

KEYWORDS: LabVIEW, axial load, stress concentration factor, allowable stress, normal stress.

1. Introduction

Solving problems in the strenghts of materials domain requires complex and laborious mathematical calculations. Mistakes can be made, most of the times, in means of solving the calculations, which lead to wrong results. Besides, the time required to solve these calculus and making the diagrams is pretty long.

This vitual tool allows us to precisely, and under a very short time, make the calculus of the reactions for a flat bar consisting of two portions connected by fillets, based on the formulas given by the speciality literature. These calculation formulas are made up according to the diameters of the bars, the fillet's radius and the stress concentration factor.

2. Current status

The flat steel bar consisting of two portions, connected by fillets is represented in figure 1.

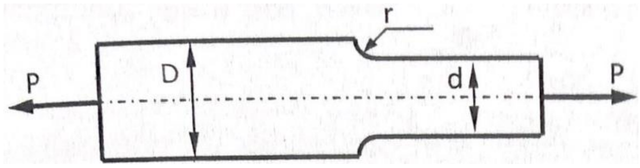

Fig. 1. Flat steel bar consisting of two portions

For the steel bar made up by the two portions we assume an allowable normal stress. The two portions that make up the entire bar consist of two different dimensions $\boldsymbol{D}$ and $\boldsymbol{d}$, of a thickness $\boldsymbol{t}$, and the fillets of radius $\boldsymbol{r}$ that connects them together.

To determine the stress concentration factor $\boldsymbol{K_\sigma}$ the following formulas were used:

$$\frac{D}{d} \quad (1)$$

$$\frac{r}{d} \quad (2)$$

where:

$\boldsymbol{D}$ – the big dimmension of the steel bar
$\boldsymbol{d}$ – the small dimmension of the steel bar
$\boldsymbol{r}$ – fillet radius

After determining the two geometrical ratios , the stress concentration factor can be found in the chart given for a filleted shaft in tension, figure 2.

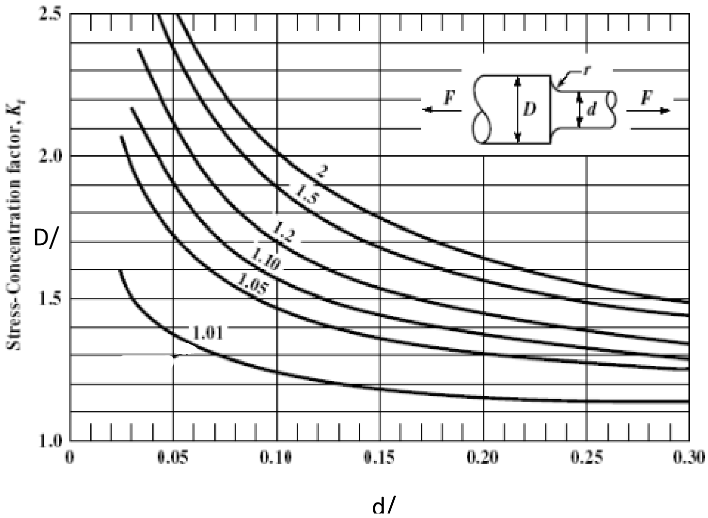

Fig. 2. Stress concentation factor sheet for a filleted shaft in tension

The next step is to determine the allowable average normal stress using the material allowable normal stress and the stress concentration factor:

$$\sigma_m = \frac{\sigma_{max}}{K_\sigma} \quad (3)$$

where:

$\boldsymbol{\sigma_m}$ – allowable average normal stress

$\boldsymbol{\sigma_{max}}$ – allowable normal stress

$\boldsymbol{K_\sigma}$ – stress concentation

The last step is to apply the definition of normal stress the find the allowable load, for which the following formulas were used :

$$\boldsymbol{A = d \times t} \quad (4)$$

$$\boldsymbol{P = A \times \sigma_m} \quad (5)$$

where:

$\boldsymbol{A}$ – area of the smaller section

$\boldsymbol{P}$ – axial allowable load

3. Description of the virtual tool's functions

The following controls are available on the front panel, necessary for specifying input data: a table element where specific values should be written, every column getting its name corresponding to its measurement : **D**, **d**, **t**, **r**, **Smax** ($\boldsymbol{\sigma_{max}}$), **Ks** ($\boldsymbol{K_\sigma}$), and three elements of horizontal pointer slide type available to convert the output values depending on the user's needs.

In order to display the resulting data, another table was added to the program . The variables **D/d**, **r/d**, **A**, **P**, **Sm** ($\boldsymbol{\sigma_m}$), are displayed in the first column, followed by their numerical values on the second column, and the units corresponding to them.

Figure 3 represents the front panel of the virtual tool, with the control elemnts and the tables used to input and display the values in order to solve the problem.

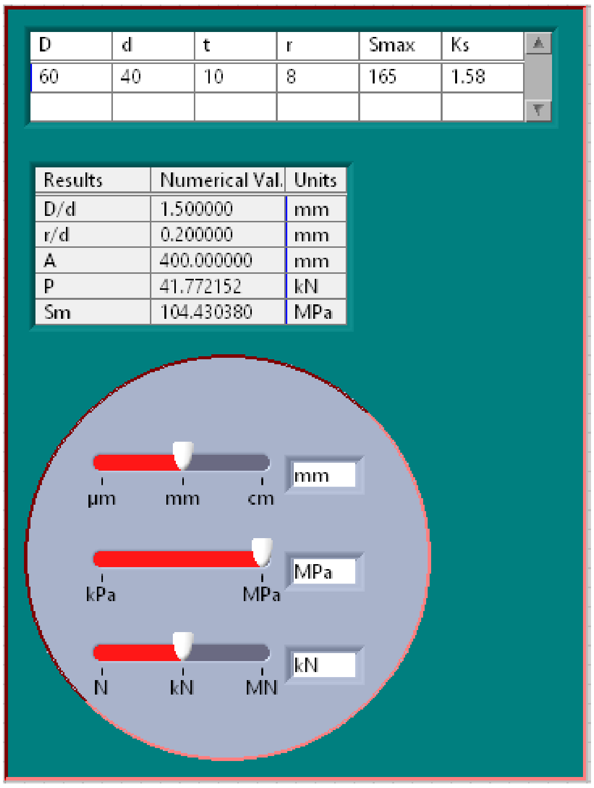

Fig. 3. Front panel of the program

4. Description of the virtual tool's algorithm

In the virtual's tool diagram, the **Formula Node** structure was used to calculate the results of the problem. Inside the **Formula Node** structure, formulas 1 – 5 were inserted. Each expression was ended with a semicolon.

The input table was connected to the **Fract/Exp String To Number** string element in order to interpret the string input into a number, specified the row to be taken in consideration with an **Index Array**, and then, parted the column with another **Index Array** in order to output the measurements values.

Figure 4 represents the diagram with the programming algorithm of the calculus.

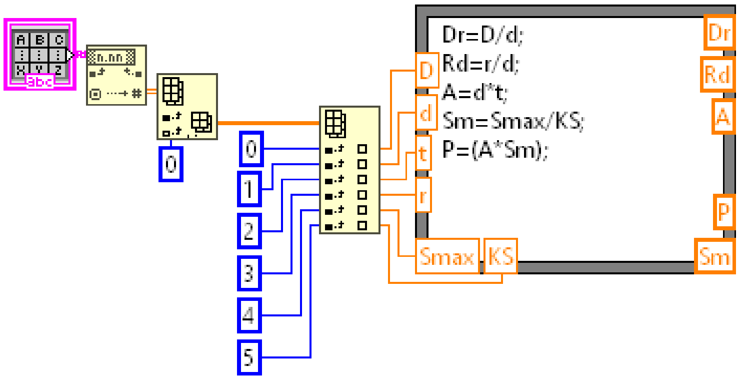

Fig. 4. Algorithm used for the calculus

In order to convert each of the values to different sizes of the value, **Case Structures** were used to make the conversion possible . Every value is taken and inspected inside the case structure, depending on the horizontal pointer slides, and it outputs the values into a **Build Array** function, connected to a **Number To Fractional String** in order to convert the numbers back into a string data type.

For each of the result, a specific unit is given, and for this to be possible **Array Constants** were used, filled with **String Constants** followed by **Index Array** functions bounded to the Horizonal Pointer Slides in order to determine the required sizes, and then, connected to **Initialise Array** functions to specify the number of rows where the units should be displayed.

After using a **Array Constant** with **String Constants** to name the results, everything was conneccted to a **Build Array** function and the output data went into a **Transpose 2D Array** function in order to place every value, name and unit into its place.

The whole algorithm used for conversion and displaying the values into the table is represented in figure 5.

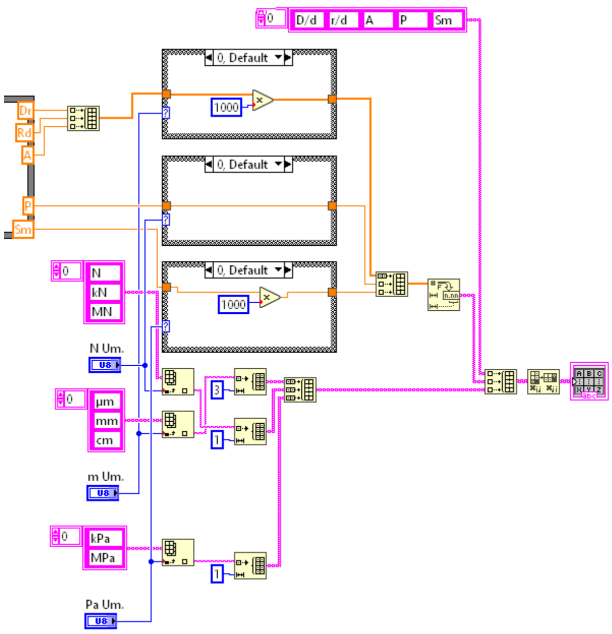

Fig. 5. Algorithm built for conversion and displaying values.

5. Conclusions

The virtual tool created is able to accurately solve this kind of calculus required in strenght of materials, under a matter of seconds, and it is very efficient in need. It has a simple and interactive interface, and it can be used by everybody, even by users that do not have any knowledge about programming.

As future upgrades, the interface will get to gain more functions such as graphical representations, Picture type functions, and even more functions in the algorithm to allow one time click solving.

Additionally, saving the pictures and findings in a report or files means that everyone can acces them without having to use the LabVIEW software.

6. References

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