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VISTA

Design Automation of Helical Spring using CREO Excel Analysis, Excel VBA and CREO Parametric Pro-Programming

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A B S T R A C T

Designing a component in a CAD software has been beneficial over the years due to its capability to virtual look at the possibilities a design can have. However, today the expectation is to have number of possibilities in a quick succession to reduce the time to design and eventually time to market. To increase the productivity, reduce iterative tasks and reduce errors automation in CAD proves beneficial and has become essential. Automation can be done with the CAD inbuilt features. In this paper, we have developed a tool for design and model automation of helical compression spring. The tool comprises of a GUI which shows various selection parameters and calculations. We have used CREO inbuilt capabilities such as CREO Excel automation, CREO Pro-programming, relations and excel VBA to develop the tool. In addition to the creation of spring, the tool also gives user the liberty to choose circular or elliptical coil cross-section.

Keywords : *Helical compression spring, CREO Excel automation, CREO Pro-programming, relations, elliptical cross-section. Excel VBA.*

1. Introduction

The CAD software's have seen great evolution in the past decade. Designer has the ability to model and verify concepts at early design stage and come up with feasible and optimal solutions. However, every design goes through iterations and takes time to arrive at a final solution. Design automation perfectly fits as an appropriate solution for this problem. Today's CAD software's have inbuilt features that enables a designer to automate design, model, assembly and drawing. Automation reduces the iterative tasks, reduced errors, reduced time to design and has resulted in more accurate designs. CREO parametric is one such software with such capabilities. Due the parametric nature of the model, CREO gives the user flexibility to customize and automate designs. The parametric modeling approach uses parameters, dimensions, features and relationships for understanding the product design characteristics and behavior. Moreover, one can even optimize and analyze the designs using CREO in built utilities.A parametric model is defined by its attributes which could be input parameters; an input parameter is a variable or relationship that defines a key dimension. A parametric model is re-usable model because modification can be implemented on model. Mostly two approaches used for parameterization- Interfacing and Programming.

In this paper, we have presented an approach of automating a helical spring modeling it in CREO and then linking the feature ID's of the spring with excel input parameters. The automation is carried out using CREO Excel Analysis tool. The Excel used is further programmed using VBA for a better user interface for the user. CREO Relations are used to connect the excel parameters with the model parameters. Finally, CREO Pro-Programming is used in addition to CREO the above tools to reduce the complexity of design, increase design capability and incorporate the flexibility for the variants of spring. This will also relieve the user from finding the feature in model tree and edit it. In short, the user will not click anything other than Excel Analysis in the model tree.

There are some related studies in relation the automation which describe the customization of coupling in solid modelling with Pro/Engineer can be approached, by means of Excel macros (piece of code), working under the windows operating system and with the visual basic as event driven programming [1]. Similar automation strategy using excel, VB and CAD are shown in [4, 8]. Integration of C-language and Pro-Engineer to improve product design capability for automation of a pully arrangement [2] and using C# for cam lobe model automation [3]. The use of excel and CAD for automation is explained by the researchers [5, 6, 7].

2. Approach used for automating spring design

Automating any design or modeling process optimizes the time required to arrive at optimal and feasible design. It also reduces errors and improves quality of the model. Any spring design too has input parameters such as wire diameter, mean diameter, number of active coils, type of ends, etc. These parameters derive the shear stress and deflection calculations.Calculating all these for individual springs and then modeling them using features in any modeling software is time consuming and iterative. Thus, automation tools provide a lot of benefits for a designer to design and validate his/her design. as shown in Fig.1

The automated modeling approach and its significance is as follows:

- The spring design and modeling is automated with the use of spring design tool created using CREO excel analysis feature along with VBA, CREO relations and CREO Pro-programming.
- User gets a GUI where-in he/she enters desired helical spring input parameters and generated output. With this, the CREO model is generated automatically. (Fig.2)
- Now, if you want an update in the design just update the parameters using the GUI and the model is regenerated with the updated specifications.
- This enables a user to update the design very quickly. Moreover, a user with a non-modeling background such as analyst can also update the design as he wants very quickly.
- This is how the automation tools becomes very powerful in making quality designs with a very less modeling time.

Fig. 1. Overview of the integrated process

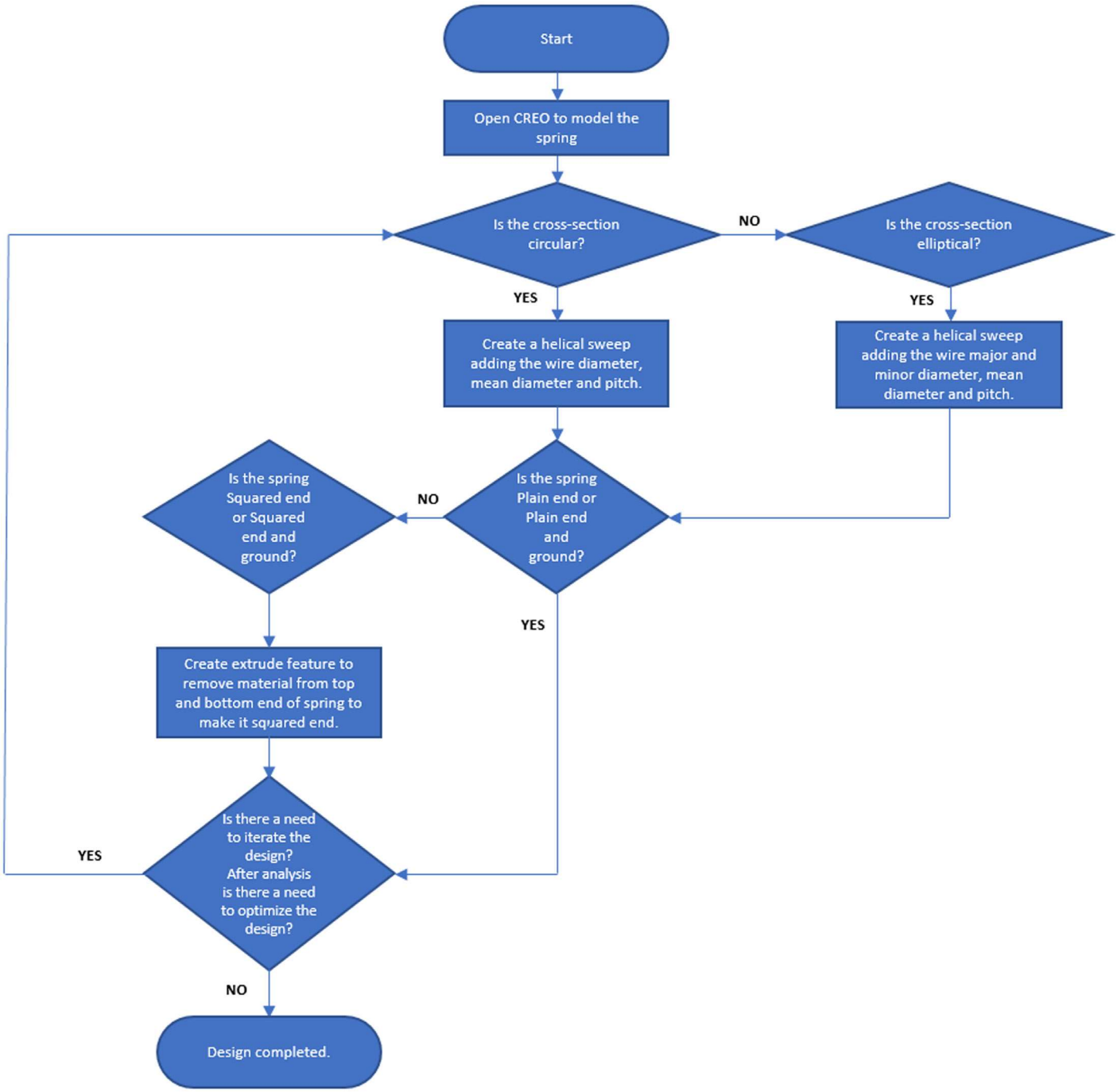

Fig. 2. Traditional approach of designing a helical compression spring.

2.1 Preparing macro-enabled excel for helical spring input and output parameters.

Firstly, excel for spring design was prepared using Excel Macro. Here all the spring input and output parameters were taken into consideration while programming the excel. All the input and output parameters were programmed. As we know that there are four types of compression springs namely;

- Plain end
- Squared end
- Plain end and Ground
- Squared end and ground

Excel based VB programming was done so that the user will be able to select the type of spring and fill the input parameters. These parameters will then

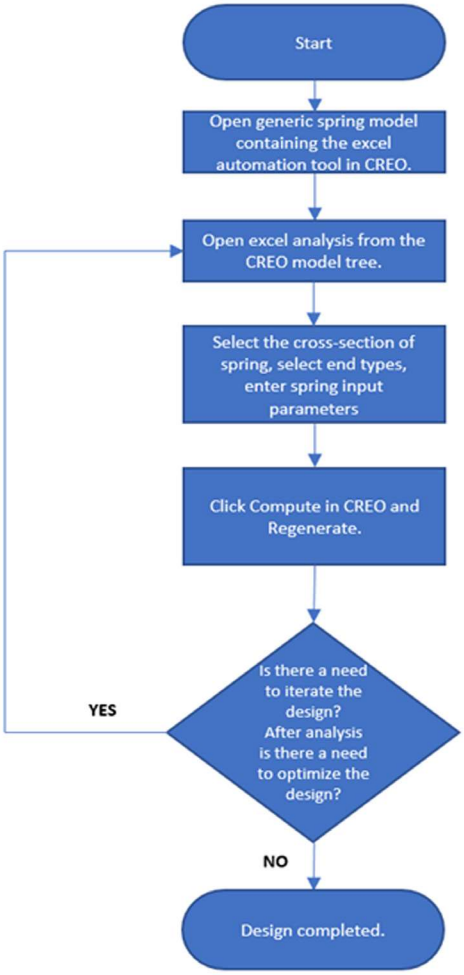

Fig. 3. Developed tool for helical compression spring design and modeling approach.

be pulled by CREO to automate the spring design. (Fig.3)

2.2 Creating spring model using CREO and importing the excel values.

A CAD model of spring was created using CREO and nomenclatures were given as shown in Fig.5.for understanding purpose when we relate them to excel parameters. Now, the excel must be linked to CREO model. For this, we need to load the created Macro-Enabled Excel in CREO. Excel Analysis tool is used for this purpose. We used Relations to relate the Excel parameters. Following are the some of the relations used to relate the MacroEnabled Excel spring values to CREO spring parameters. (Fig.4-5)

2.3 Relations used to relate excel values of spring with the CREO parameters.

Following is just a partial code shown in this paper:

FREE_LENGTH=XL_8_3:FID_ANALYSIS1SPRING_DIAMETER=XL_9_3:FID_ANALYSIS1

ACTIVE_COIL_START_SIDE=XL_18_3:FID_ANALYSIS1ACTIVE_COIL_END_SIDE=XL_18_3:FID_ANALYSIS1

/*FOR PLAIN ENDS

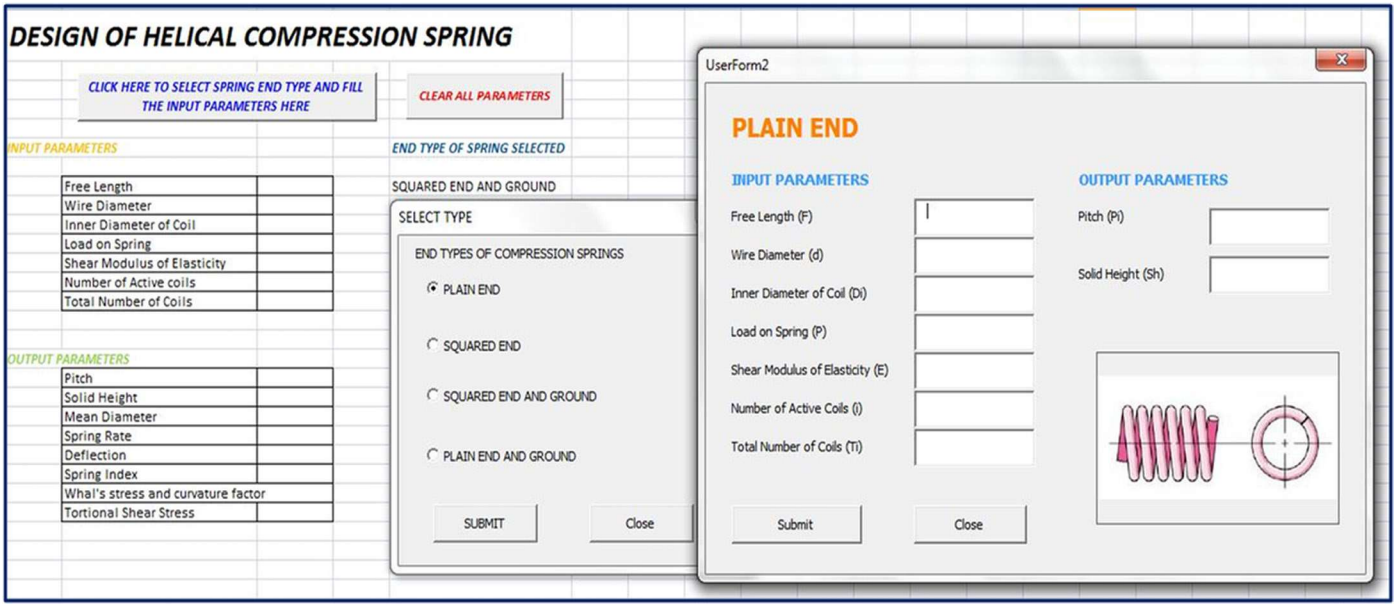

Fig. 4. Macro-Enabled excel for spring input and output parameters.

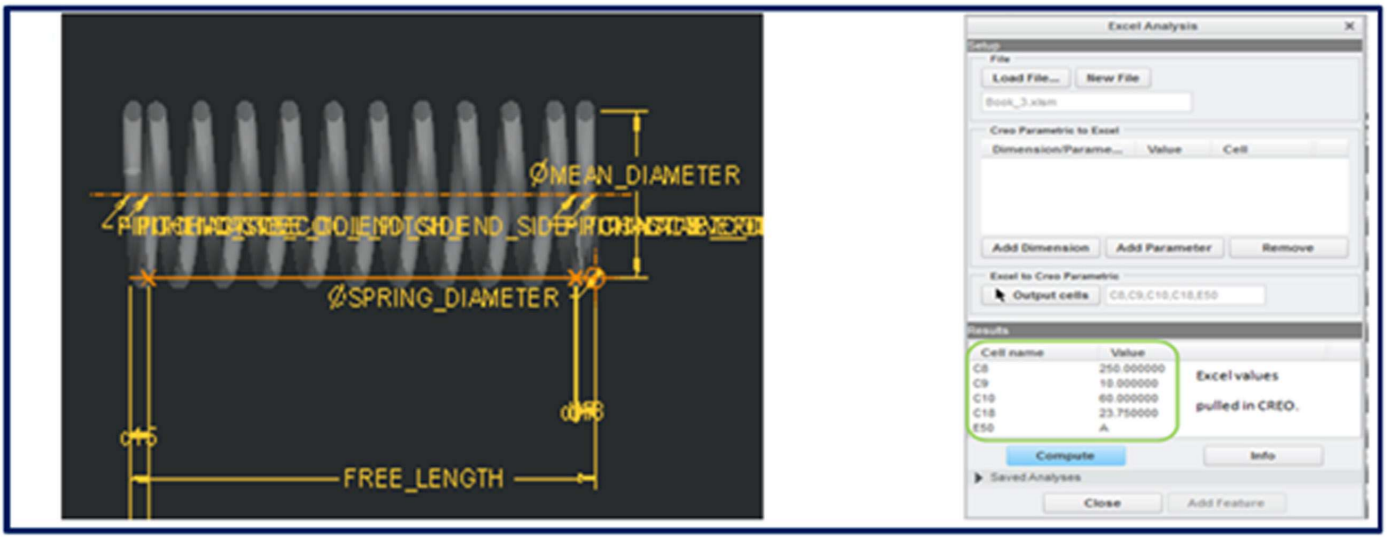

Fig. 5. Nomenclatures for features and dimensions linked toexcel values pulled in CREO. parameters

IF XL_50_5:FID_ANALYSIS1==”A”
START_PITCH=XL_18_3:FID_ANALYSIS1
END_SIDE=XL_18_3:FID_ANALYSIS1
INACTIVE_COIL_PITCH_START_SIDE=XL_18_3:FID_ANALYSIS1
INACTIVE_COIL_PITCH_END_SIDE=XL_18_3:FID_ANALYSIS1
/*FOR SQUARED ENDS
ELSE
IF XL_50_5:FID_ANALYSIS1==”C”
D17=SPRING_DIAMETER
D18=SPRING_DIAMETER+0.5
D15=SPRING_DIAMETER
D16=SPRING_DIAMETER+0.5
START_PITCH=SPRING_DIAMETER
ENDIF

2.4 Procedure to automate spring design

From the CREO model tree, “Edit Definition” the “Excel analysis”. The excel which we linked earlier will pop-up. As shown in Fig. 6. , click on “CLICK HERE TO…HERE”. A pop will emerge where one has to select the type of spring end. Once this is selected, another pop up will emerge which will have input text boxes for the type of spring end one has selected. When the user is done filling the input parameters, click “SUBMIT”. Now you will see all the input parameters that user has filled and the calculated output parameters. Now, SAVE the Excel and in CREO press COMPUTE and CLOSE in the Excel Analysis menu. Finally, “REGENERATE” the model to see the design changes in the model.

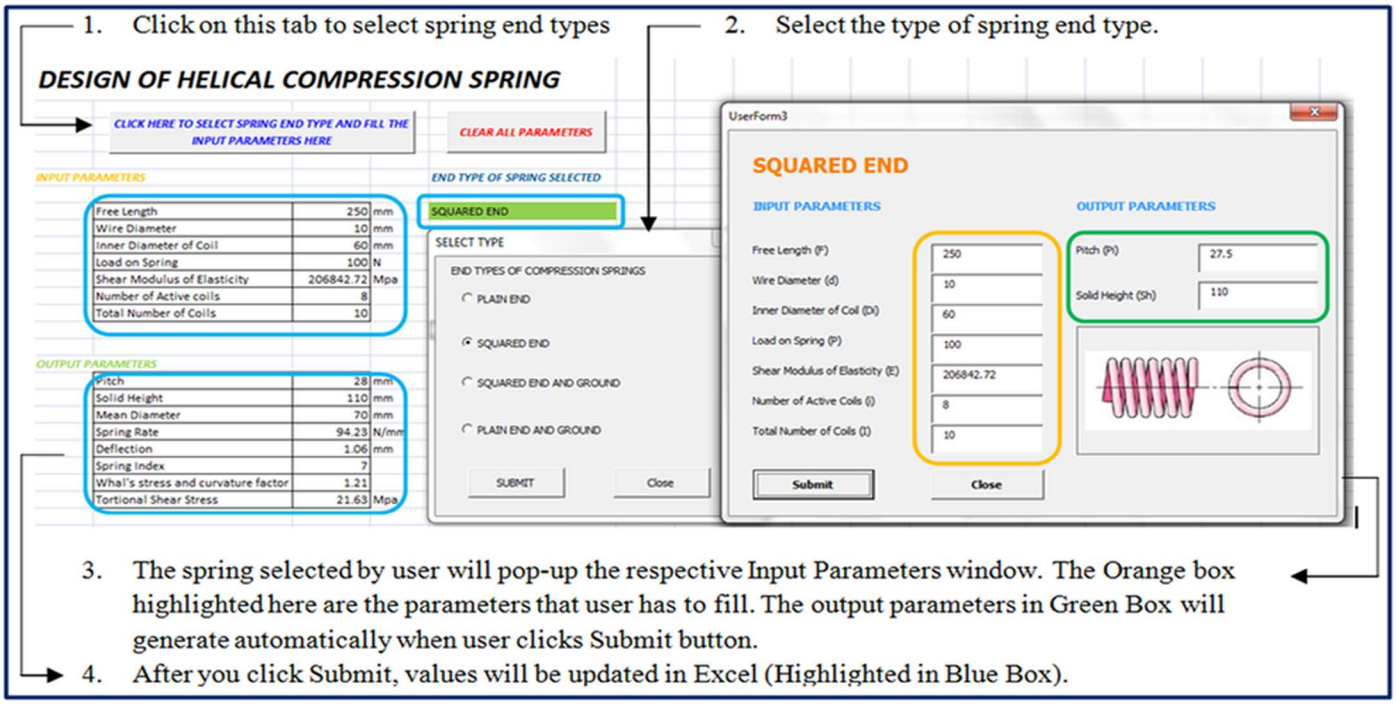

Fig. 6. Steps to use Macro-Enabled excel.

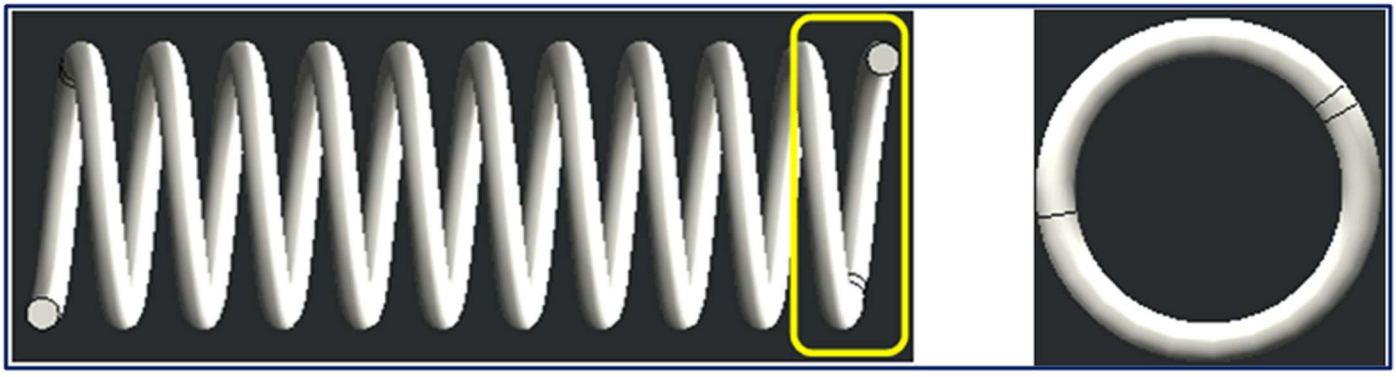

Fig. 7. Compression spring with Plain ends.

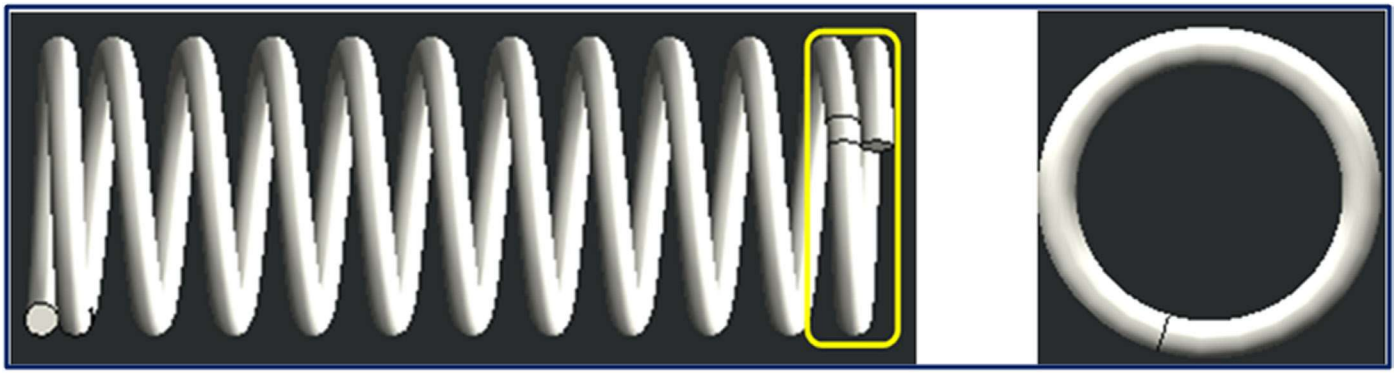

Fig. 8. Compression spring with Squared ends.

But by the above procedure we can only automate CREO to model "PLAIN END" and "SQUARED END" springs. The "PLAIN END & GROUND" and "SQUARED END & GROUND" where the upper and lower part of spring is grounded is not reflected in CREO. This is when CREO Pro-Program comes in picture. (Fig.7-8)

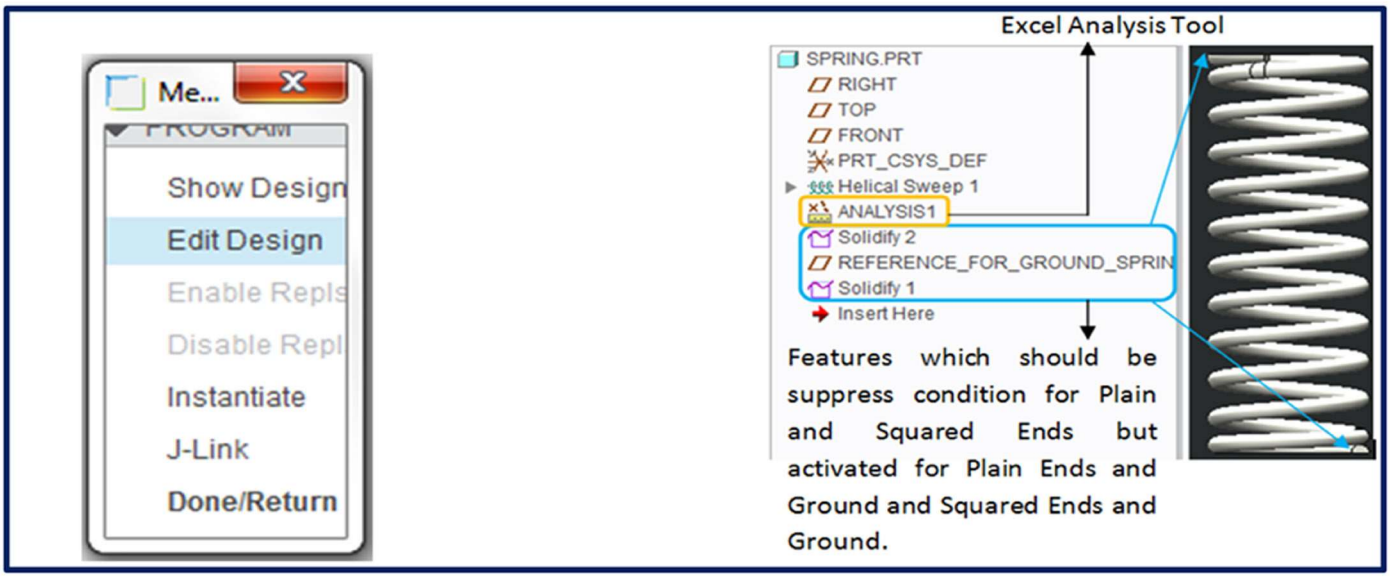

Fig. 9. Pro-program menu and features to be programmed in Pro-program

2.5 Using CREOPro-program to automate ground ends.

In addition to selecting the Ground end types in the Macro Enabled Excel, we need to edit the CREO Pro-Program to do the following:

For Plain End Spring: Suppress the features highlighted in Fig.9.

For Squared End Springs: Suppress the features highlighted in Fig.9.

For Plain End and Ground: Activate the features highlighted in Fig.9.

For Squared End and Ground: Activate the features highlighted in Fig.9.

To incorporate the above conditions, we have to edit the code in Pro-Program which is in subsection 2.6. For that Click "Edit design" Fig.9 in Program Menu and edit the Feature ID with "IF…ELSE" condition. (Fig. 10-11)

2.6. Code written in CREOPro-program to execute the highlighted features in fig. 9.

```
IF
XL_50_5:FID_ANALYSIS1=="B"|XL_50_5:FID_ANALYSIS1=="D"
ADD FEATURE
INTERNAL FEATURE ID 225
PARENTS = 3(#2)
END ADD
ADD FEATURE
INTERNAL FEATURE ID 212
PARENTS = 3(#2)
NAME = REFERENCE_FOR_GROUND_SPRINGS
END ADD
ADD FEATURE
```

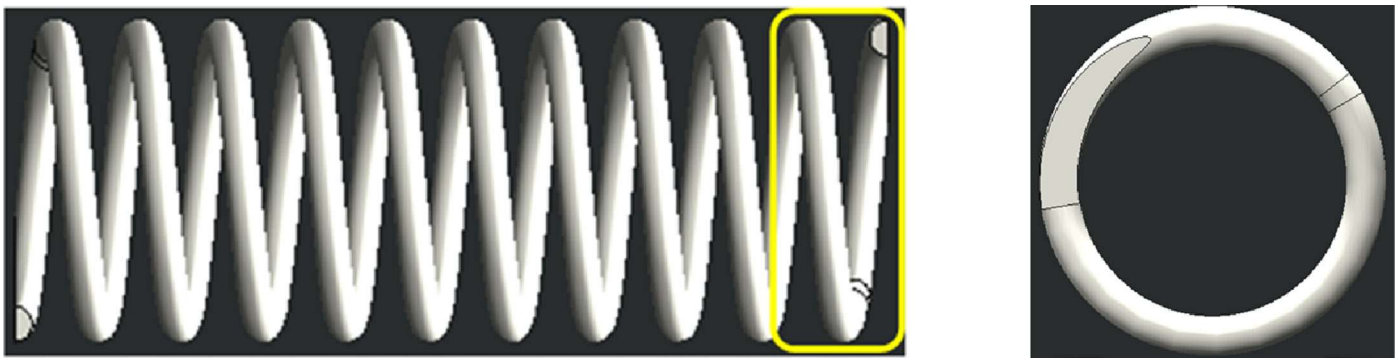

Fig. 10. Compression spring with Plain and Ground ends.

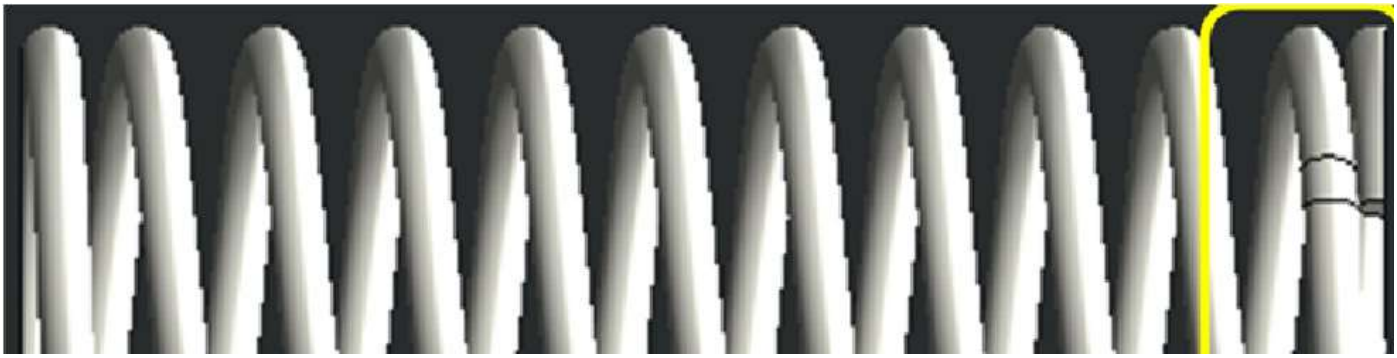

Fig. 11. Compression spring with Squared and Ground ends.

INTERNAL FEATURE ID 214
PARENTS = 212(*)
END ADD
END IF
MASSPROP
END MASSPROP

Now the Excel and CREO is compatible for use of all 4 types of springs.

2.7 Shape automation of helical spring

The spring is further automated for its change in cross-sectional area which will be used in further analysis. The helical spring as shown in below snap can me automated to model into circular or elliptical cross-sections. After the selection of the cross-section the excel will pop-up for input parameters as stated in this paper earlier. The user needs to fill those input parameters to produce the required spring which can be analyzed further for its structural behavior. If the user selects the Elliptical cross-section, he needs to input the Major and Minor diameters first and then the others input parameters windows will pop up to finally get out desired model in CREO. (Fig. 12)

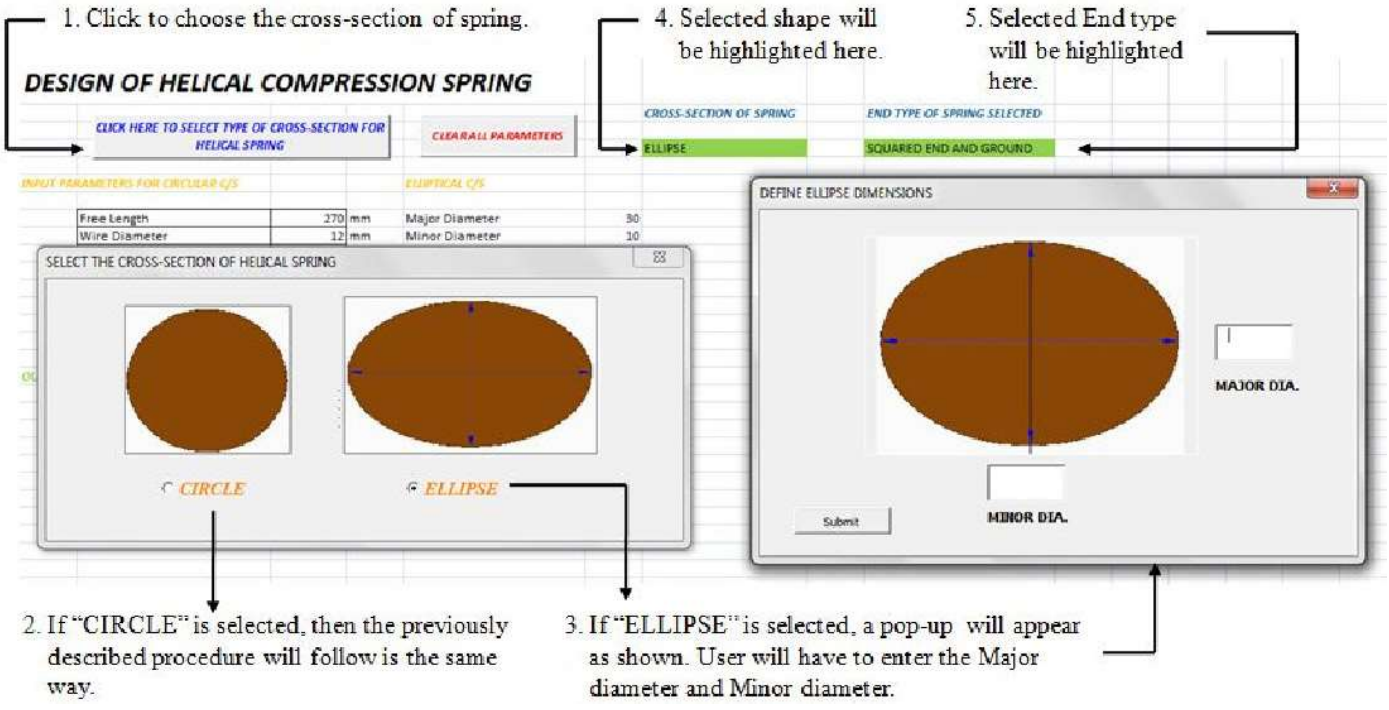

Fig. 12. Console to select cross-section of spring.

3. Comparative study of design, modeling and analysis of a helical spring with traditional vs automated approach.

Following table gives the average time required for manual modeling done by any proficient designer in CREO. It shows that the required time for automated modeling using spring design tool is very less than the manual modeling with similar accuracy in both approaches. Also, the design calculation and selection of appropriate type of springs is automatically done within few seconds in automated design approach. Moreover, with required input parameters, it calculates and models the desired spring design.

The traditional modeling approach is as follows:

- Perform design calculations for the required spring. We need to consider the type of spring, pitch, shear stress, deflection, etc. for the same.
- Model the spring with the required dimensions using feature-based functions. This includes creating wire diameter, creating helical sweep, modeling the spring according to plain, squared and grounded configuration.
- If design needs to be updated, we need to again redefine the feature in modeling software to generate the required updated design.
- This cycle continues till we get a feasible and optimal design.

The automated modeling approach is as follows:

- The spring design and modeling is automated with the use of spring design tool created using CREO excel analysis feature along with VBA, CREO relations and CREO Pro-programming.
- User gets a GUI where-in he/she enters desired helical spring input parameters and generated output. With this, the CREO model is generated automatically.
- Now, if you want an update in the design just update the parameters using the GUI and the model is regenerated with the updated specifications.
- This enables a user to update the design very quickly. Moreover, a user with a non-modeling background such as analyst can also update the design as he wants very quickly.

4. Conclusion

Using the automation in any process reduces time, cost and errors. The approach used in this paper is specifically for helical spring. CREO Parametric inbuilt utilities are used to automate the spring model as seen from Table 1. CREO Excel analysis which is used with Excel VB Macro and Pro-Programming are the utilities used for this purpose.

Now the user just needs to input the variables in the Excel and regenerate the model; no need to click

Table 1. Manual and automated approach comparison.

Modeling and designing type of spring	Manual modeling and design calculations	Automated modeling	Automated design calculations
Helical spring with plain end (Linear Rate)	30 min	10 sec.	30 sec.
Helical spring with squared end (Linear Rate)	30 min	10 sec.	30 sec.
Helical spring with plain end and grounded (Linear Rate)	40 min	10 sec.	30 sec.
Helical spring with squared end and grounded (Linear Rate)	40 min	10 sec.	30 sec.

any of the features in the model tree and edit them. This will reduce the time, errors and eventually cost.

Acknowledgement

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