Parametric Design of Batch Flender's Gear Units Based on Pro/Engineer

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Abstract

On the basis of studying the structure and design specification of Flender's gear units, a method of parametric design and modeling for batch gear units based on Pro/Engineer has been adopted. According to given dimensions, we has initially defined variables in Pro/Engineer and established a family table which comprises all the required dimensions, then assigned variables or equations to corresponding feature dimensions during modeling. The model of a gear unit consists of two sections: one is the fundamental shape, the dimensions of which are all given; the other is the external embellish, including the bosses around the axes, the oil gallery for lubrication, the inspecting hole and so on, the dimensions of which are to be designed and determined by designers so as to create an ideal figure of the case. Thus, each series of gear units merely requires a single model, so that all parts in the entire series of gear units shall be generated through the family table and saved as an individual product respectively. The experimental results demonstrate that the development period is shortened, the cost is reduced and the productivity is increased.

Keywords: Pro/Engineer, Gear Unit, Parametric Design, Family Table

1. Introduction

Flender Co.Ltd is an enterprise named by a German engineer called Flender, which has been purchased by SIEMENS automation group and become its new member. (Liang & Yu, 2006, p.21). The major products of Flender Co.Ltd include gear units, gear motors, couplings, etc. Gear unit is one of the most remarkable products in this enterprise. Flender's gear units have all sorts of structures such as vertical and horizontal. The transmission shafts are usually parallel or vertical. The revolving speed is transmitted into the case by motor connected with flange and axis, then exported by solid or hollow shaft with key. Owing to its artistic appearance, convenient installation, low noise, large capacity and longevity, the Flender's gear unit has been widely applied to the industry of heavy assembly.

This subject is to present a method of parametric design and modeling on large quantities of Flender's gear units using Pro/Engineer. Figure 1 shows a 3-dimensional model of one set's gear units (completed). The gear unit

should be flatly fixed, and there are two axes on both the front and the back of the case, the smaller of which is input axis and the larger one is output axis. The revolving speed is transmitted into the case by motor connected with flange and input axis, then lowered to the target rotating velocity through gear drive inside the case and exported by output axis. On both the top and the bottom of the case there are several screw holes for installation, through which the case is fixed by screws or bolts in operation. In order to facilitate the assembling and removing of shafts and gears, a tank cover is required as well as an inspecting hole, which is convenient for operators to check whether the transmission is proceeding smoothly. In addition, there should be an oil gallery at the bottom of the case so as to facilitate the lubrication of transmission parts inside.

There are more than 150 gear cases, which involve several sets and more than 10 sizes in each set. Besides, the amount of dimensions in each case is extremely large as well. Obviously, owing to its arduous task, long-lasting developing period and low efficiency, it's not wise to model them or modify their dimensions respectively. On the contrary, if we are capable to create one parametric model for each set so as to generate products of all sizes, then the period of developing shall be reduced to a great extent. The 3-D modeling software Pro/Engineer has its own function of parametric design, which meets our demand completely.

2. Parametric design function of Pro/Engineer

Parametric design (namely dimension-driven) is a subject which has been put forward in the application of CAD technology. At present it's also an important subject and to be further developed in CAD application field. On the basis of parametric designing method, the special products designing system is capable to improve the manufacturing velocity, precision, quality, performance and reliability, lower the developing cost and accelerate the products' update, so as to adapt to the fierce market competition and the demand of construction. (Wu, 2010, p.137). The major advantage with parametric design is that CAD model is not only a static geometry result but also with the designer's intent and design history included. (Wang, Li, Wu & Zhang, 2010, p.861).

Pro/Engineer, developed by PTC Co.Ltd, is a 3-dimensional software based on Windows' platform, which is famous for parametric design and based on feature designing, dimension constraint and dimension -driven. (Wang, 2010, p.103).

There are several commands relevant to parametric design, which are included in the menu "tools" of Pro/Engineer's interface.

The command "Parameters" is used for defining the required parameters and providing them to equations or family tables.

The command "Relation" is used for creating relationships among dimensions (variables) or between dimensions and the defined parameters, written as equations during modeling. The equations are usually similar as assignment statements, which may include mathematical symbols as well as all sorts of universal functions such as trigonometric functions. If necessary, branching structure such as "IF…ENDIF" can also be employed.

"Family Table" is an ensemble of parts with the same essence but different sizes. By using the command "Family Table", users will be able to create and save large quantities of objects. Meanwhile, the generated parts are standardized and it's unnecessary to modify the model. Besides, dimensions in the model can also be altered from the family table. (Zhang, 2007)

As for a set of parts (large quantities), the first step for designers is to define all the required parameters and establish a family table, the next step is modeling. Use the command "Relation" to assign the values of parameters or equations to dimensions (variables) when creating sketches or features, so that the dimensions shall be driven by parameters. Thus, only one model is required for each set while any size in this set may be generated and saved as an individual duplicate (product). If we have generated and saved all, then the entire series of products are completed. In all, the procedure of gear units' parametric design is displayed in Figure 2.

3. Creating a parameterized model of gear unit

3.1 Defining parameters and establishing family table

As for Flender's gear units, the main parameters involve the case's length, width and height, the diameters and lengths of input and output axis, the horizontal distance between the two shafts, the distances from the axis towards the left side, right side and the bottom of the case, etc. Therefore, the first step is to define the parameters above in the part before modeling and assign the default values to them according to original dimensions. The parameters' type should be real number.

The next stage is to import these defined parameters to the family table, and type the whole set's all dimensions into the table line by line. The accomplished family table is shown in Figure 3.

3.2 The modeling of a parametric gear case

The entity of a gear unit consists of two sections: one is the fundamental shape, the dimensions of which are all given; the other is the external embellish, including the bosses around the axes, the oil gallery for lubrication, the inspecting hole, and so on. The dimensions of the external embellisher's features are to be determined by designers so as to make the case's appearance harmonize and artistic.

3.2.1 The model's parameterization

All the dimension constraints except angles in each sketch need to be assigned by corresponding parameters or expressions. Besides, each feature's dimension, such as the height of extrude, the depth of cutting, and the diameter of fillet, are all to be driven by parameters or expressions as well.

3.2.2 The fundamental geometric model of the case

It includes the principal part of the case: the cube, the input and output axis with journals and keys, the positioning screw holes and so on. The involved dimensions of the above sketches and features are all given and to be assigned by the corresponding parameters directly.

3.2.3 The external embellish and its features

Dimensions in this section are determined by designers. For the purpose of harmonize and artistic appearance, a principle needs to be followed: to make sure that each feature's size is consistent in the whole set. In another word, designers should try to make each dimension proportional to the same direction's overall dimension (the length, width or height of the case).

(1) There are several bosses around the shafts, which are used for the shaft's installation and removing. Originally there is an input axis and an output axis in both the front and the back side, but actually not all of them are necessary. In operation, therefore, the redundant shaft can be removed. The sizes of these bosses may be settled according to shafts' diameters and their distance, so that the corresponding dimensions should be assigned by equations containing diameters and distance. Thus, the bosses around the shafts are harmonized in all directions and uniformly distributed without any interference.

(2) If the two drive shafts are vertical rather than parallel, then the input axis should be installed on the left side, as well as a boss around the axis.

(3) The oil galleries for lubrication are located in both the front and the back surface of the case and above the screw holes at the bottom. The galleries have to be interlinked with screw holes so that screws can normally cross the hole when fixing. With lubrication, the wear, heat, and possibility of seizure of gears inside shall be diminished. (Spotts, Shoup & Hornberger, 2007, p.203).

(4) On top of the case there is an inspecting hole and a tank cover. As the given height refers to the distance from the peak to the bottom, we have to cut rather than extrude when creating these features. In addition, keep the thickness of cover proportional to the case's height.

(5) Add some irregular shallow pits on each surface, so as to prevent the case from being rigid.

(6) Add the feature of the text "FLENDER" in both the front and the back surface and keep them symmetrical (extrude or cut with the text as sketch), which is significant for Flender's gear case to embody its commercial value.

(7) Never forget to add chamfers and fillets after completing the embellisher.

(8) Add material at the end of modeling. Select the option "ptc-metallic-steel-light", so that the model presents an appearance of steel's light, approaching the reality.

So far, a parameterized model of gear unit has been accomplished. As Figure1 presents, the ultimate product is harmonize, artistic and close to the reality as expected.

4. Generating gear cases with various sizes

As for gear units in a same set, having finished parametric modeling according to the method above, each size in this set is contained in this completed model. This chapter tells how to generate various sizes of models.

When the model has been saved as a part and opened again, a message box which lists all the examples will emerge, from which the user may select any one to open, then the corresponding size of model is generated, when saved as a duplicate, an individual part (gear case) is created. Another way is to open the common model first, then select an example from the family table and open it. Thus, when all of the examples have been saved as an individual model, the entire series' gear units are all created. Obviously it's much faster than to model or

modify dimensions respectively.

As there are quite a few dimensions, it's hard to avoid mistakes when inputting statistics into the family table. Yet the errors can be corrected directly in the table and the model's corresponding dimension is always matching with the current value. Besides, it doesn't matter if a model with mistake has been generated because we may correct the wrong value in the family table and regenerate it.

In this issue, there are 2 or 3 values of transmission ratio for each set of cases. Different values correspond with different diameters and lengths of input axis. We just need to alter the corresponding parameters' values in parameter table and regenerate the model, then save it as a duplicate. Figure 4 reflects the distinction in diameter and length between the two input axes respectively on 2 cases with the same size but different transmission ratios.

5. Conclusions

This essay has illustrated the procedure of parametric design, modeling and generation of Flender's gear units' specific products using Pro/Engineer. Since there are above 150 gear cases altogether, if we were to model them one by one, a lot of time and energy would be consumed. However, with the application of parametric design, we just need to establish one family table for each set, then create the model with parameters assigned to dimensions, so that products of all sizes in each set can be generated, which may greatly increase the productivity. If we had modeled these gear cases respectively but eventually came to realize that only a few of them are necessary, we would probably regret doing a fool's errand. On the contrary, when applying parametric design in modeling, the entire series' products will be included in one model. No matter which size the customer requires, the corresponding gear case can be generated directly. Even if we had to generate all sizes indeed, perhaps it would cost only 2 hours. Therefore, only a little workload shall be capable to satisfy all sorts of requirements.

In summary, to adopt parametric design in batch products will probably save a lot of time and energy. Furthermore, it can substantially enhance the productivity. We believe that parametric design will inevitably obtain increasing developing opportunities in mechanical engineering domain.

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Figure 1. Flender's Gear Unit

Figure 2. The Procedure of Gear Units' Parametric Design

			DD1	L1	GG1
	FLENDER_CLX_H2SH_13_22	qq.prt_INST8	100.0	205.0	330.0
	FLENDER_CLX_H2SH_14	qq.prt_INST	100.0	205.0	330.0
	FLENDER_CLX_H2SH_15	qq.prt_INST1	120.0	210.0	365.0
	FLENDER_CLX_H2SH_16	qq.prt_INST2	120.0	210.0	365.0
	FLENDER_CLX_H2SH_17	qq.prt_INST3	125.0	245.0	420.0
	FLENDER_CLX_H2SH_18	qq.prt_INST4	125.0	245.0	420.0
	FLENDER_CLX_H2SH_19	qq.prt_INST5	150.0	245.0	475.0
	FLENDER_CLX_H2SH_20	qq.prt_INST6	150.0	245.0	475.0
	FLENDER_CLX_H2SH_21	qq.prt_INST7	170.0	290.0	495.0
	FLENDER_CLX_H2SH_22	qq.prt_INST8	170.0	290.0	495.0
	QQ_INST9	qq.prt_INST9	*	*	*

Figure 3. Family Table

Figure 4. Comparison of shafts on 2 gear cases with the same size but different transmission ratios