Development of Parametric Design Software for Shearer Spiral Drum

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Abstract. In order to improve the design efficiency of the shearer drum and achieve rapid optimization, it is proposed to establish a parametric design system for the shearer spiral drum centered on design, optimization system and parametric modeling technology. The overall idea of implementing the system, the function and design analysis of each module are expounded, and the key technologies are discussed. Using Solidworks as the platform, the parametric design of the shearer spiral drum was developed with VB.Net, including the modification of the drum size, the automatic drawing of the cutting diagram, the load calculation of the pick and the automatic generation of the loading blade parts and their unfolding engineering drawings. Finally, it was verified with a 1800x630 roller. Tests prove that the system can quickly optimize the shearer drum, improve the speed and accuracy of drum development, and reduce costs.

Keywords: Shearer; Spiral drum; Parametric design.

1. Drum Size Modification

The spiral drum is the core component of the drum shearer. Shearer spiral drum main function is performed off the coal and coal loading, main components include cylindrical ring collar, end plate, spiral blade, cutter, teeth, with teeth boots, end caps and lands like [1].

The design of the spiral drum is closely related to the coal seam conditions, the working parameters and the functional requirements of the shearer, and the parameters are mutually restrictive. At present, the drums produced by various manufacturers in the actual application are individually designed, and have not yet reached the parameter Practical stage of design. The use of personalized design requires designers to be proficient in various calculation methods, formulas, design manuals, product standards, and technical requirements. And working in such a process will cause a lot of repetitive work, and the level of designers cannot be greatly improved.

1.1. Part Size Division

This article divides the part size into active size and driven size. The active size is the design size determined by the designer according to the different design requirements of the spiral drum, including the three diameters of the spiral drum, the drum width, the blade spiral angle, the number of spiral blade heads, the number of cutting teeth and the cutting line distance, etc. Requirements are generally based on coal seam conditions and customer needs. The driven size is automatically modified according to the relationship with the active size, including the height of the spiral blade, the diameter of the connecting disc and the diameter of the end panel [2]. This division is helpful for designing the interface during software development. The active size will be placed in a man-machine
interactive window for the designer to determine, and the driven size is modified in the background of the program.

1.2. Determination Method of Driven Size

1.2.1. Blade height

Figure 1. Blade height dimension diagram.

Figure 2. Blade and hub assembly drawing.

Figure 1 is the height dimension of the spiral drum blade of the shearer. Figure 2 is an assembly drawing of the blade and the coil ring. Helical blade and the cylindrical drum circle fitted together, fitted relationship with the inner edge of the spiral blade cylinder circle of the outer wall of the fit, the top side of the helical blade cylinder circle mounting surface and the end plate coincide. When the drum width of the spiral drum changes, the thickness of the end disc is basically unchanged, and the width of the drum circle will increase with the increase of the drum width. With the change of the drum circle width, in order to meet the original drum circle and the relationship between the spiral vane assembly, the height of the spiral blade will also change, the relationship between the equation (1).

\[ H_B = W_r - W_p \]  

Where:
- \( H_B \) —— the height of the screw blade, unit m;
- \( W_r \) —— roll width of the spiral drum, unit m;
- \( W_p \) —— the width dimension of the upper end plate spiral drum, unit m.

When the size of the spiral drum of a certain type of shearer \( W_r \) changes, the width of its end disk \( W_p \) is basically unchanged. Therefore, in the parametric design system of the spiral drum designed in this paper, the width of the end disk in this type of spiral drum \( W_p \) is first obtained, and then According to the equation (1), the new height dimension of the spiral blade after the change of the drum width is obtained.

1.2.2. Spiral Blade Diameter

Figure 3. Spiral blade diameter dimension diagram.

Figure 3 is a schematic diagram of the diameter of a spiral blade. A spiral blade diameter as driven dimensions, in order to meet with the cylindrical blade circle fitting relationship, which should be as zone diameter cylinder variation and change, the blade and the cylindrical ring as shown in FIG assembly relationship, screw diameter blade and The relationship between the diameter of the cylinder ring is shown in the equation (2):

\[ D_{\text{blade spiral}} = D_g \]  

(2)
3

Where:

- \( D_{\text{blade spiral}} \) — screw diameter of the blade, unit m;
- \( D_g \) — screw drum cartridge ring diameter, unit m.

The equation (2) shows the relationship between the driven size blade spiral diameter \( D_{\text{blade spiral}} \) and the basic size spiral drum barrel diameter \( D_g \). The equation (2) is solidified in the program. When the designer enters the barrel diameter, the system will According to the equation (2) to obtain the new blade spiral diameter size value, then drive SolidWorks to modify the spiral diameter parameter of the spiral blade part to obtain the blade part under the new size.

1.2.3. Diameter of Connecting Disc

![Figure 4. Dimensional diagram of the connecting plate and assembly drawing with the hub.](image)

As in Figure 4, in the spiral drum shearer, the connecting plate and the cylindrical mounting ring inner wall surface of the outer edge of the spiral drum shaft rings, fitted relationship bonding lands, i.e., the diameter of the outer edge of the disk to maintain a connection with the The diameter of the inner wall of the drum is equal, so after the diameter of the spiral drum is changed, the diameter of the inner wall of the drum changes, and the diameter of the outer edge of the connecting disc is also automatically modified accordingly. The outer edge of the land diameter of the helical coil diameter of the drum cartridge relation as equation (3) shown.

\[
D_{\text{Outer edge of connecting plate}} = D_g - 2T_{\text{Tube hub}} \tag{3}
\]

Where:

- \( D_{\text{Outer edge of connecting plate}} \) — the helical outer edge of the land roller diameter, unit m;
- \( D_g \) — the spiral turns diameter drum cartridge, unit m;
- \( T_{\text{Tube hub}} \) — the spiral turns of the drum cartridge wall thickness, unit m.

By the equation (3) found: In a certain type of spiral drum, shaft rings thickness is a fixed value, not as the cylindrical diameter of the zone change varies, i.e., the outer edge of the land diameter of the barrel The difference between the ring diameters is a fixed value. After the system imports the model, the cylinder wall thickness value of the model is obtained. Then, after the cylinder diameter of the spiral drum model is modified, the new size of the outer diameter of the connecting disc is obtained according to the equation (3).

1.2.4. End Panel Diameter

![Figure 5. Dimensional diagram of end plate and assembly drawing with hub.](image)

As in Figure 5, the spiral drum shearer, shown in the end disc plate and tubular ring assembled together, the end disk plate in the cartridge ring outer end disk plate inner wall of the barrel ring outer wall overlapped, the end disc plate diameter of the inner wall Associated with the diameter of the cylinder ring , after the diameter of the spiral drum cylinder is modified, the diameter of the inner wall of the end plate must also be automatically modified accordingly. End disc plate and an inner wall diameter of the helical coil diameter of the drum cartridge relation as equation (4) shown.

\[
D_{\text{Inner diameter of end panel}} = D_g \tag{4}
\]
Where: $D_{inner \, diameter \, of \, end \, panel}$ — Diameter of the inner wall of the end plate;  
$D_{spiral}$ — spiral drum diameter of the cylindrical ring.

According to equation (4), when a new barrel diameter size is entered into the system, the system can obtain the new inner wall size of the end plate itself, and modify the end panel parts accordingly through the new inner wall size of the end plate to obtain end plate parts.

2. Parametric Design of Cutting Diagram

According to the design specifications of the cutting chart, this article has written a program for the parametric design of the cutting chart based on the mathematical model of the caving line of the shearer drum pick, which can not only calculate the entire cutting process of the shearer spiral drum and analysis, you can also draw the cutting diagram of the spiral drum throughout the cutting process, a program as in Figure 6.

![Figure 6. Cutting diagram module parameterized design thinking diagram.](image)

3. Parametric Design of Load Analysis for Picks

The force of the roller pick has a great influence on the working performance and service life of the roller. In this chapter, according to the load model of the pick of the drum under different working conditions, a program is written to calculate the force of the drum pick under the new size to further verify whether the spiral drum under the new size is reasonable.

This function module also uses human-computer interaction design. After the spiral drum designer inputs the relevant parameters of the coal seam and pick, the system automatically adjusts the design parameters of the spiral drum, then calculates each influence coefficient according to each parameter, and finally automatically calculates the cutting during the pick force the module design concept as in Figure 7.
4. Parametric Design of Loading Blades

In this paper, the relevant structural parameters of the blades loaded by the spiral drum are also divided into two categories, namely the active size and the driven size. The active dimensions of the loading blade include the outer diameter of the loading blade and the thickness of the loading blade; the driven dimensions include the diameter of the inner wall of the loading blade, the height of the loading blade and the pitch of the loading blade.

Loading idea embodied as leaf unfolding function in Figure 8. First, remind the designer whether to use the function of generating and expanding the loading blade. After the designer confirms the use, he needs to enter the relevant basic dimensional parameters, such as the outer diameter of the loading blade and the thickness of the loading blade. The basic dimension parameters and the driven dimensions such as the height of the loading blade and the diameter of the inner wall of the loading blade, which are determined based on the basic dimensions of the diameter and width of the spiral drum, update the size of the loading blade model to generate new loading blade parts. The actual situation decides whether to generate the unfolded drawing of the loaded blade and the corresponding engineering drawing.

5. Interface Design

This section will take the modification of the MG250 / 600-WD1 type shearer drum as an example to introduce the interface design of this software and related functions of this software in detail. MG250 / 600-WD1 is an electric traction drum shearer. The thickness of the cut coal seam is generally 2.0-3.5m. The relevant parameters of the spiral drum are shown in Table 1. According to these parameters, the MG250 / 600-WD1 shearer is established. Three-dimensional model of the spiral drum, as in Figure 9.
Table 1. The parameters of the spiral drum of MG250/600-WD1.

| Parameter                              | Value         |
|----------------------------------------|---------------|
| Drum diameter                          | 1800          |
| Barrel diameter                        | 980           |
| Roller width                           | 720           |
| Outer circle diameter of end disc      | 1490          |
| Main blade outer diameter              | 1400          |
| Spiral blade angle                     | 14.02°        |
| Intercept                             | 80            |
| Number of blade heads                  | 3             |
| Number of blade picks                  | 6             |
| Pick arrangement                      | Sequential    |

Figure 9. The spiral drum of MG250/600-WD1.

5.1. Input Key Parts and Their Size Name Interface

Figure 10. The interface of inputting key parts’ names and key dimensions’ names.

After copying the model file to the location where the software stores the model, you need to enter the names of the key parts and key dimensions in the spiral roller model. The software will use this as the basis, and then modify and rebuild the imported model.

5.2. Parameter Input Interface

Figure 11. The interface of inputting the parameters.

Figure 11 is the parameter input interface of the shearer spiral drum design software. After the model is imported, the drum model entered when importing the model will be saved in the software, and the
drop-down box of "model selection" in the parameter input interface, and then enter the new size parameters.

5.3. Drawing Cutting Interface
Figure 12 is a drawing cutting interface. After adjusting the structural parameters of the spiral drum, the cutting diagram under the new structural parameters of the spiral drum should be drawn to verify whether the cutting form of the spiral drum pick under the set of structural parameters meets the design requirements.

5.4. Calculation of the Load on the Blade Pick
Figure 13 and Figure 14 are the force diagrams of the cutting teeth of the new spiral drum when cutting pure coal.

Figure 12. The cutting pattern diagram of spiral drum under new structural parameters.

Figure 13. The load on the new pick.

Figure 14. The load on the old pick.
5.5. Loading Blade Parameter Input Interface

Figure 15. The interface of inputting loading blade’s parameters.

Figure 15 is an input interface for loading the active size of the blade. After inputting the relevant dimensions of the blade loading, loading the software will be generated and expanded drawing the blade part, as Figure 16.

Figure 16. The part drawing and the expanded drawing of the loading blade.

After generating the blade loading, the system will modify the size of the original model of the spiral drum, generate a new spiral drum assembly, as in Figure 16 shown.

Figure 17. The assembly of the modified spiral drum.

6. Conclusion

In this paper, the parameterized design software for the spiral drum of the shearer was developed, which achieved the purpose of quickly modifying the key dimensions of the spiral drum and performing a rational analysis of the drum at the new size. The conclusion is as follows:

1. Through the analysis of the drum structure and key dimensions, in order to show the driving relationship between the part dimensions and the logical relationship of the size modification in the software, the dimensions are divided into active dimensions and driven dimensions. The designer only needs to enter the value of the active size in the software visual interface, and the software quickly generates the roller assembly that meets the requirements, greatly reducing the design time.

2. Through the analysis and research on the formation process of cutting graph, explored the reasonable shape of cutting graph. The mathematical model of the cutting chart was established, and the visual interface of the cutting chart was compiled based on this model. The function of the software to draw the cutting chart according to the new drum size parameters is implemented to check whether the new size drum has good cutting performance.

3. Through the analysis and research on the pick force of the drum during the cutting process, the force model of the pick when the drum is cut under different working conditions is established, and the visualization of the calculation of the load of the drum blade pick is compiled based on this model interface. Through the calculation of the force of the drum pick under the new size, it is verified whether the new drum structure is reasonable.
4. Through the research on the assembly relationship of the drum and the unfolding drawing of the curved surface parts, a visual interface for generating the loading blade and unfolding engineering drawing is compiled. After the designers modify the roller parameters, the software can generate the loading blades that meet the assembly requirements and the expanded processing engineering drawings according to the new size, which shortens the design and processing cycle of the loading blades.

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