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STUDY ON DUAL-MODE MODELING APPROACH OF CAXA

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ABSTRACT

This paper presents a dual-mode modeling approach based on innovation design and engineering design, which is applied to the design of belt conveyor. Dual mode modeling method fusions innovation design pattern and engineering design mode, and realizes a combination of liberalization design and precision design, while the traditional parametric modeling is restricted by single thought, which exists a strictly relationship of father and son between part elements, but dual mode modeling approach breaks the restriction. This paper firstly described the characteristics of dual-mode modeling method and the function of 3D sphere uniquely owned by software Computer Aided X Alliance(CAXA); then the theoretical design process of belt conveyor was introduced, which included driving power calculation for drum, selection of driving motor, selection of gear reducer and confirmation for idler diameters; the modeling process of belt conveyor was described through the application of the dual-mode modeling method, the whole product modeling design has included module design and assembly design, and has accomplished the driving device module, and roller device module, and transmission device module design. The results show that the modeling speed with dual mode modeling approach can increase one time compared with the traditional methods, and all the technology application above can improve the design efficiency, reduce design error, thus greatly improve the design efficiency, and highlight the liberalization and accuracy characteristics of the modeling process.

Keywords: *Dual-mode Modeling Approach, CAXA, Belt Conveyor, Innovation design Method, Engineer Design Method, Three Dimensional Sphere, Modular Design*

1. INTRODUCTION

Belt conveyor is the most important transportation facility and the ideal equipment for high-speed, automation, continuous operations for long-distance transportation of the bulk materials, which is widely applied in industries such as electric power, metallurgy, chemical engineering, coal, mine, ports and foodstuffs. With the development of industrial demand, the design of belt conveyor aims at long distance, high speed, great capacity and high-power directions [1, 2, 3]. Meanwhile, with the rapid development in computer technology and the application of modern design methods, product design has transformed from 2D to 3D modeling technology [4]. Wang X.J. [5, 6] presented modern design method of the belt conveyor. Many researchers investigated the modeling methods with different technology. For example, Zhou M.Y. presented an approach of modeling and representation of heterogeneous objects based on STEP [7], A novel dynamic autonomic modeling method for 3D standard part library is presented by Tong.X.F [8], Wang,Y.G[9] described a modeling technology using automatically reconstructable assemblies in his paper. In order to establish an appropriate model, a variety of modeling methods are applied.

This paper is organized as follows. Firstly, this paper presents the characteristics of dual-mode modeling approach based on software CAXA, and then designs a belt conveyor applied to transport

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iron ore. The design process consists of theoretical design and modeling design, and the latter is the main work of the paper. The theoretical design mainly includes the calculation of driving power, the selection of drive motor and gear reducer, and the confirmation of idler diameter, which is not our mainly work of the paper. The modeling technology of belt conveyor is the most important in this article. The modeling design mainly consists of innovation design, parameter design, assembly design and modular design.

The main purpose of the paper is to fusion innovation design and engineering design in the process of product design, and give a full play for liberalization design from innovation design mode and accuracy design derived from engineering design pattern, short the period of product design and improve the design efficiency and accuracy, the use of unique 3D sphere assist for the designer's job, the fusion of the technology and the application of different function from software CAXA are the main work of this paper.

2. DUAL-MODE MODELING APPROACH

2.1 Dual-mode Modeling of CAXA

Currently, solid modeling technology mainly contains two design modes, which consist of engineering design mode and innovation design mode. CAXA is a dual-mode design software integrating innovation design mode and engineering design mode, and fusions the advantages of two modes and provides convenient for designers. CAXA is the market leader of industry software and service in china, which mainly supplies with 2D&3D design software and product life circle managing solution (PLM), it means "Computer Aided X Alliance - Always a step Ahead".

Engineering design mode is also called feature modeling or parametric modeling, which is a parametric modeling scheme based on characteristic and owned by popular 3D modeling software, such as UG, Pro/e, CATIA and so on. In the process of design, it is more convenient to edit and modify model, and integrates the characteristics of parametric modeling and provides conditions for realization of precision design.

Innovation design mode is a particular design pattern only owned by software CAXA, which does not have a strictly relationship like father and son between part elements. It is convenient to edit some features without influencing others for designers, and has the characteristics of open, simple, direct and quick. The most important is to break the traditional 3D software which is restricted by our thought, and realize open design.

2.2 Three-dimensional Sphere of CAXA

Three-dimensional sphere tool of CAXA provides a method of flexible, accurate direction and fixed position for translation, rotation, mirror image, copy, array and a variety of complex 3D transforms, it can realize flexible operation of 3D model with the help of geometry intelligent capture tool and perspective transformation for all kinds of complex 3D model, and makes the operation of dual-mode modeling more convenience. Figure1 shows the shape of 3D sphere tool.

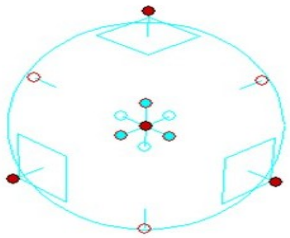

Figure1.3D Sphere Tool

Therefore, dual-mode modeling approach of CAXA combines visualization open design with precise design, and makes product design break the constraint of traditional parametric modeling software-CAD. It supports the whole design process of product from concept design to detailed design. Meanwhile, in the process of modeling, 3D sphere tool of CAXA assists modeling work for designers more convenience and makes creative thought of designers performed more incisive.

3. DESIGN EXAMPLE

3.1 Total Design Requirements

In order to realize automatic function, the overall product must be a continuous line including feeding equipment, conveying device, discharging device and other functions, in this design scheme, we only consider structure design of device, control system is not our mainly purpose.

3.2 Design Scheme

The function of belt conveyor is to smoothly transport material, loading, unloading and so on. So the following design schemes can be considered.

3.2.1 Head discharging mode

There exists two basic schemes shown in fig.2 (a) and (b).unloading where driving roller and feeding nearly reversion roller are the characteristic showed in fig.2 (a), the hammer tension device closing to transmission roller is used, while screw

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tensioning device is the only difference between fig.2 (b) and (a).

3.2.2 Tail discharging mode

This unloading mode also includes two design schemes. According to Figure2 (c) and (d), the similarity is the position for unloading and feeding goods which are opposite of the head discharging mode. Screw tension device is applied in the design of belt conveyor shown in Figure2 (d), while the third scheme shown in Figure2 (c) uses hamper type tension device.

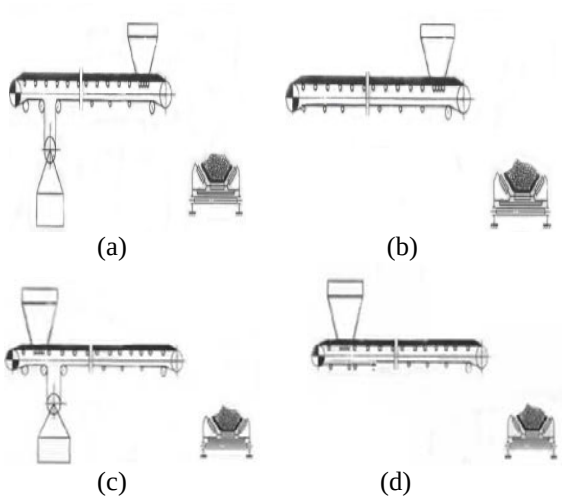

Figure2.Total Design Scheme

From the four schemes above we can see, the only difference are the discharging mode and tension device. Considering the economic factors and the simplicity of structure, a screw fastening device is adopted. Due to the existence of fraction between transmission cylinder and leather belt when unloading at the head of transmission cylinder by reverse motion, considering above all, it is reasonable to select the fourth design scheme as shown in Figure2 (d).

4. THEORETICAL DESIGN

Theoretical design is the foundation of modeling design, which mainly includes the calculation of driving power, the selection of driving motor, gear reducer and idlers. The following is the main theoretical design process of belt conveyor.

4.1 Initial Design Parameters

In this paper, the belt conveyor is applied to transport iron ore, the original parameters is showed in table1.

Table1.The Original Parameters

Length (m)	Width (m)	Lift Height (m)	Transport Capacity (t/h)	Material
10	1	10	200	iron ore

According to the design requirements, we mainly calculate the transport power of the driving drum, selection of drive motor, gear reducer and the determination of idler diameter.

4.2 Calculation of Driving Power

The drum withstands the axial input torque and conveyor belt load which wind on the drum, the drive power of driving drum is important for belt conveyor. The following is the calculation process [10].

The total transport power of belt conveyor is mainly determined by three factors, which are the horizontal transport length, max transport capacity and the lifting height of belt conveyor, respectively showing in the table2, table3 and table4.

Table2.The Power P1 (KW)

Width (mm)	Fixed Length of Belt Conveyor LC(m)										
	10	20	30	40	50	80	100	140	180	240	300
500	0.4	0.49	0.6	0.7	0.79	0.99	1.2	1.58	1.9		
650	0.49	0.6	0.7	0.79	0.99	1.29	1.49	1.9	2.4	2.9	3.4
800	0.7	0.79	0.9	1.1	1.2	1.7	1.99	2.49	3.1	3.8	4.4
1000	0.9	1.1	1.29	1.49	1.7	2.3	2.69	3.4	4.19	5.09	6
1200	1.1	1.4	1.49	1.9	2.1	2.9	3.4	4.39	5.3	6.5	7.6
1400	1.49	1.79	2.2	2.49	2.9	3.89	4.5	5.8	7.09	8.63	10.1

The table2 shows the driving power of belt conveyor, according to the table2, the conveyor width and the fixed length of belt conveyor, the driving power of conveyor can be calculated.

Table3.The Power P2 (KW)

Transport Capacity (t/h)	Fixed Length of Belt Conveyor LC(m)										
	10	20	30	40	50	80	100	140	180	240	300
10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.19	0.19	0.19
20	0.09	0.09	0.09	0.09	0.09	0.19	0.19	0.3	0.3	0.4	0.49
50	0.19	0.19	0.3	0.3	0.3	0.49	0.49	0.7	0.79	0.99	1.2
100	0.4	0.4	0.5	0.6	0.7	0.89	1.09	1.4	1.6	1.99	2.4
200	0.7	0.89	0.99	1.2	1.29	1.79	2.1	2.69	3.3	4.1	4.69
500	1.7	2.1	2.49	2.9	3.3	4.5	5.3	6.7	8.17	10.1	12
1000	3.5	4.3	5	5.8	6.59	8.8	10.4	13.4	16.3	20.2	23.6
1500	5.3	6.4	7.43	8.68	9.86	13.4	15.7	20.1	24.4	30.4	35.3

According to the transport capacity and the fixed length of belt conveyor, the power P2 can be gain from the table3.

According to the transport capacity and the lift height of belt conveyor, the power P3 can be gained from the table4.

Then the total transport power can be calculated by the following Eq.1

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P=1.2(P1+P2+P3) (1)

Table4.The Power P3 (KW)

Transport Capacity (t/h)	Lift Height of Belt Conveyor H(m)									
	1	2	5	10	15	20	25	30	40	50
10	0.09	0.09	0.19	0.3	0.4	0.6	0.7	0.79	1.1	1.34
20	0.09	0.09	0.3	0.6	0.79	1.1	1.4	1.6	2.2	2.69
50	0.19	0.3	0.7	1.4	2.1	2.69	3.4	4.1	5.5	6.79
100	0.3	0.6	1.4	2.69	4.1	5.5	6.79	8.17	10.9	13.7
200	0.6	1.1	2.69	5.5	8.17	10.9	13.7	16.3	21.6	27
500	1.4	2.69	6.79	13.7	20.5	27	34.1	41	54.5	68.2
1000	2.69	5.5	13.7	27	41	54.5	68.2	81.7	109	137
1500	4.1	8.17	20.5	41	61.4	81.7	101	123	134	205

4.3 Selection of Driving Motor

According to the driving power that we calculate above, we can select the driving motor which is the power source of the conveyor. In this design, the type of motor is elected for Y12M—6.

4.4 Selection of Gear Reducer

In accordance with the placing location of gear reducer, structure, transmission ratio and so on. For the selection of gear reducer, large-scale calculation needs be conducted, such as the shaft speed, power and torque. Finally, we select a type of SCH175 gear reducer.

Table5.Relationship between Idler Diameters and Belt Widths

Idler diameters/mm	Belt width(mm)										
	500	650	800	1000	1200	1400	1600	1800	2000	2200	2400
63.5	√										
76	√	√									
89	√	√	√								
108		√	√	√	√	√					
133			√	√	√	√	√	√			
159				√	√	√	√	√	√	√	√
194							√	√	√	√	√
219									√	√	√

4.5 Selection of Idlers

Idlers are the main parts in belt conveyors, which are quite expensive. There are various types of idlers and they are mostly used. Whether the choice of the idlers is reasonable will directly affects the earlier investment, the usage and the reparation of them. So it is very important to choose and utilize idlers. According to the diameter of roller and loading capacity, the roller is divided into three types, such as light type, medium and heavy type. Idlers are also divided into carrying idler and return idler by the role of roller. When select the idler, belt width and turning speeds are considered. Table.5 shows the relationship between idler diameters and belt widths. Table.6 shows the relationship between idler diameters and turning speeds [11, 12, 13].

Table6.Relationship between Idler Diameters and Turning Speeds

Idler Diameters (mm)	Turning Speeds/m.s^{-1}									
	0.8	1	1.25	1.6	2	2.5	3.2	4	5	6.5
89	172	215	268	344	429	537				
108	142	177	221	283	354	442	557			
133		144	180	230	287	359	453	575		
159		120	150	192	240	300	379	481	601	
194			123	158	197	246	310	394	492	
219							275	349	436	567

According to table.1, the idler diameter can be preliminary ensured. But in the condition that belt width is assured, speed of roller can't too fast. Under the same life, the higher the speed, the shorter the runtime will be, on the contrary, the lower the speed, the longer the runtime. But the roller diameter can't be too big, otherwise, the size of the whole conveyor doesn't match, and the investment will be also too large. Considering all the factors, the roller diameter is selected for 133 mm.

When basic calculation is over, it is easy to design the model of belt conveyor. The detailed process of modeling is described as follows.

5. MODELING DESIGN

5.1 Design Procedure

Design of the belt conveyor includes three phases, respectively is scheme design, detailed design and assembly design. In the schematic design and assembly design stage, the innovation design mode and engineering design mode are applied for exchange. When design the overall module, the application of innovation design mode plays a role of quickly modeling for designers. Designers drag element with a pattern of "building blocks" from the design element library to create the model, and this realizes the freedom design. In this process, the universal 3D sphere tool can help us realize variable complex transformation on the design of model. During the detailed design stage, engineering design mode helps us realize accuracy design and edition or modification of arbitrary parameters of the model, thus the parametric design of parts is completed. The key point in the design process is that the features under innovation mode are independent with each other, so that the feature sequence of innovation mode can be adjusted, while there is a strictly relationship of father and son between features under engineering mode,

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therefore, the combination of two modes makes design more smoothly.

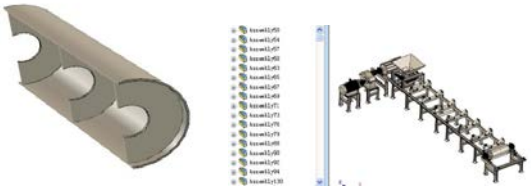


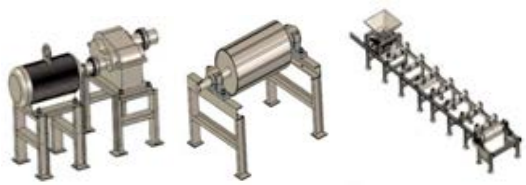
Figure3. Drum 3D Sectional View Drawing
Figure4. Total Assembly Drawing

In the process of assembly design, CAXA provides a function of three dimensional sectional views, which can be applied to observe the internal structure of the model, and it provides a visual view for designers. Figure3 shows the drum 3D sectional view drawing.

In addition, intelligent assembly is another particular function of CAXA. In the process of product assembly, with the combine of design library and parametric design with the function of deformation, a point is attached t the part so as to easily realize parametric intelligent assembly, and thus assembly of product is completed. Figure4 shows belt conveyor total assembly drawing.

5.2 Modular Design

In this section, we introduce the integral design of the system and analyze the module design [14]. Modular design is one of the green design methods and also is an important part of modern design method. It can shorten the period of product design. It is conductive to realize standardized design, and greatly improve design efficiency. Modular design can be applied to the design of any large, complicated 3D models and it is mainly classified from the function and also from the point of view of the structure to distinguish. The belt conveyor can also be designed based on different functions from the modular design views and divided into three parts, including driving module, drum device module and transmission device module. Module design of the belt conveyor is shown in Figure5.



Driving module drum module transmission module

Figure5.Module design of the belt conveyor

6. CONCLUSIONS

This paper has presented the results of the design of belt conveyor using dual-mode modeling method based on CAXA. In the design process, theoretical calculation is an essential part of the whole design. The design results show the advantage of dual mode modeling approach, the main purpose of the paper is to improve the design efficiency. The author uses the freedom design of innovation mode, precision design of engineering mode and modular design in the design process of belt conveyor. The results show that the design speed with full use of unique dual-mode modeling method increases one time than the traditional methods, and the accuracy of the design result is also greatly improved, and the process of product design is subject to restrictions, the most important is that this modeling method breaks the limitation of the traditional 3D parametric modeling methods. Therefore, a variety of modern design methods of comprehensive are undoubtedly preferred strategy to contemporary design engineer.

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