GENERAL PRINCIPLES FOR THE DEVELOPMENT OF MECHANICAL EQUIPMENT FOR PRODUCTION OF BUILDING MATERIALS ON THE BASIS OF DIFFERENT CONFIGURATIONS

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Abstract

In this article considered the variant design technology for the cement industry equipment. There are a number of machines, which have common assemblies. In a single machine, there are also identical subassemblies. By combining these components with each other, we can get various configurations of the equipment. Considered technology for a ball mills: for breakage raw materials (3x8 m) and for milling cement (3x14 m). Configurations of these mills are derived from a single digital model developed in NX software. Configuring mills variants was carried out in the product lifecycle management system Teamcenter, Siemens PLM Software. Thus, six different electronic digital models as the raw material and cement mills with different types of drives were obtained. This technology allows to unify and accelerate the process of designing and manufacturing equipment industry of building materials.

Keywords: Ballmill, cement, productstructure, option, lifecycle.

Introduction

The cement industry is one of the most dynamic sectors of our economy. Analysts estimate the positive prospects of the industry against the background of Russia's modernization of infrastructure and the further realization of the state housing construction program. With the decline in co-operation with foreign companies, including manufacturers of equipment for the cement industry, as well as considering that the delivered equipment is much more expensive than home, it is an issue of the revival of the engineering industry, including cement engineering.
The apparent advantage of foreign equipment is a high degree of automation, process control and operational performance, both individual machines and in general the whole production line. With regard to the operational reliability of the home equipment, it is quite comparable with foreign analogues.

To solve these problems, along with production facilities industry we needed the highly skilled experts - designers, knowing modern technologies of complex multiversion design.

In the Belgorod State Technological University named after V.G. Shukhov for more than 10 years are trained PLM/CAD/CAE-engineers on a specialty "Mechanical equipment of building materials, products and structures" specialization "Computer technology in the design of the equipment".

At this moment computer-aided design technology can control the product structure. For example, you can change the product structure to modify the configuration of the actuating device of jaw crusher.[1-3]

In this article we will show one of the variant for comprehensive approach to the design of ball mills.

Methods and Discussion

The main aggregates in the production of cement are ball mills. Thus, based on the conditions of cement technology is used simultaneously as a raw mill for the manufacture of clinker sludge and dry grinding mill during grinding of clinker, i.e. in the last stage of cement manufacturing.

Existing types of ball mills can be classified according to the following basic principles:

- on the basis of work – cycling or continuous;
- on the grinding the method – dry mill or wet milling;
- on the design and shape of a drum – on cylindrical single-chamber, multi-chambered and tapered;
- on the method of loading and unloading – on the mill loading and unloading through the manhole; the side discharge; with a central loading and unloading through shell central shaft;
- on the drive design – side or central drive;
- on the work scheme – open- or closed-circuit system.[4,5]

Analyzing the structure of ball mills, it can be said that in all of its types there are both the same and different elements (nodes) that ultimately be unified. With the help of computer-aided design, you can build a digital product of a ball mill, which would include a variety of components that determine the construction of the mill. Then it can be configured the different product structure of the ball mill corresponding set parameters. It is necessary to accelerate the process of designing the mill and product yield to the market.
In the software market, assigned for computer-aided design, there are many solutions. From computer-aided design of low-level to high-end systems, which include the full cycle development of future products. These systems include Autodesk Inventor, SolidWorks, SolidEdge, Catia, PTC Creo, NX, Compass, T-Flex. Also to develop new products there are data management and lifecycle management software, which are intended for the organization of collective work on.[6]

With its broad functionality, they can be used to solve a large number of tasks related to the management of product life cycle, including the control and, therefore, change the structure of the future product. In this article we look at how to apply for the management of product structure technology using NX and Teamcenter software from Siemens PLM Software.

As an example, we show how it is possible, by controlling the product structure, to obtain various versions of tube ball mills. Consider the design of mills that perform different operations: 3x8 m raw mill to prepare a slurry which is used as a raw material for burning of clinker and cement mill 3x14 m, which is designed for clinker grinding.

Any design of the mill consists of the same components, such as:

1. Inlet;
2. Outlet;
3. Drive;
4. Mill drum with internal fittings
5. Slide bearing.

Consider the example of the construction 3D model of the mill, which includes two products: raw mill size 3x8 m and cement mill 3x14m.

Studying of construction of both mills the following main components of these units have been identified.

1. Three types of shells (ordinary, with manhole, with holes for discharge).
2. The two types of drive (central and side).
3. Two types of inlets.
4. Three types of outlets.
5. Mill drum which has a different length (8 and 14 meters).
6. Five types internal fittings.
7. Five types of lining.
Then there were worked out different versions of the mill structure, as shown in Fig. 1.

**Fig. 1 Block diagram of the structure options of ball mills.**

The digital 3D model has been built in the CAD / CAM / CAE-system with NX "Skeleton assembly" technology. In the first stage by means of auxiliary elements such as the coordinate axes and the plane defined by the overall structure of which is shown in Fig. 2.

**Fig. 2 Mill assembly skeleton.**

Coordinate planes determine the number of shells belonging to a particular structure, and coordinate axis indicates the central axis of the future product. Using this structure it can be carried out and edit interface between different components. The digital model includes all components for both mills. Digital model of mill components shown in Fig. 3-7.

**Fig. 3 Side and central drive.**
Fig. 4 Sleeve: ordinary, with manhole, with holes for discharge.

Fig. 5 Inlets and Outlets.

Fig. 6 Internal fittings: silo grate, outlet grate, classifier, lifter device.

Fig. 7 Types of linings.

PLM-system from Siemens PLM Software Teamcenter allows to control the product structure. Application "Structure Manager" purposes for this aims. [7] Fig. 8 shows the product structure, which comprises all the possible variants of performance of the mill.

Fig. 8 Product structure in "Structure Manager" Teamcenter.
Product structure management[8] is done through using of variant structures that describe a particular structure of the previously mentioned rules. In this case, these rules are:

- mill type: cement or raw materials,
- drivetype: central or side,
- diaphragm type: inclined, vertical or not,
- internal fitting type: with classifier or not.

By managing the product structure, you can configure 6 different mills options:

1. Cement mill 3x14 m, type of drive – central, diaphragm type – inclined and vertical (Fig. 9 a);
2. Cement mill 3x14 m, type of drive – central, diaphragm type – vertical (Fig. 9 b);
3. Cement mill 3x14 m, type of drive – side, diaphragm type – vertical (Fig. 9 c);
4. Cement mill 3x14 m, type of drive – side, diaphragm type – inclined (Fig. 9 d);
5. Raw mill 3x8 m, type of drive – side, internal fitting type – classifier (Fig. 9 e);
6. Raw mill 3x8 m, type of drive – side, internal fitting type – no classifier (Fig. 9 f).

All possible variants of mills are shown in Fig. 9.

![Fig. 9 Modifications of ball mills.](image)

a - cement mill 3x14 m, type of drive – central, diaphragm type – inclined and vertical;
b - cement mill 3x14 m, type of drive – central, diaphragm type – vertical;
c - cement mill 3x14 m, type of drive – side, diaphragm type – vertical;
d - cement mill 3x14 m, type of drive – side, diaphragm type – inclined;
e - raw mill 3x8 m, type of drive – side, internal fitting type – classifier;
f - raw mill 3x8 m, type of drive – side, internal fitting type – no classifier.
Thus, six different structures of the mill can be configured by the above technology. Special functional of Teamcenter can help to create a 3D digital model of each mill. Since the foundation of modern design is the electronic digital model, but now there is information for further analysis of the resulting construct. For example, consider the calculation of the strength of the mill body to determine the number and thickness of the sleeves.

Fig. 10 shows the stress-strain state of one of the configured mill 3x14 m. The following loads were applied at the mill body: weight of the mill lining, weight of internal fittings, weight of materials and balls. The mill was designed in NX Advanced Simulation using finite element method. Connections between components of the mill were simulated using surface-to-surface contact.[9, 10]. The FE analysis identified maximum stress 57 MPa, the maximum displacement – 2.5 mm. After making changes to the design, shell weight decreased by 3% and the total weight of the mill decreased by 5%.

Fig. 10 Displacement distribution in the mill body and in the mill shell.

After the calculation of all parts and assemblies of the mill produced documentation, which includes drawings and text documents. Mills and view isometric view of assembly drawing shown in Fig. 11, 12.
Fig. 12 Mill isometric view.

Drawing of half-girth gear shown in Fig. 13.

Fig. 13 Drawing "Half-girth gear".

Conclusion

Using this design principle, it is possible to obtain the product structure for almost any mill size and any internal fittings. This technology can significantly reduce design time, expand its range of output and reduce the time-to-market, which increases the company's competitiveness.

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