Application of SketchUp in Coke Oven Three-Dimensional Digital Modeling

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Abstract

Coke oven, which is a large industrial furnace, is complex in structure. A two-dimensional structure diagram can hardly help one observe the inner structure of a coke oven or master its working principle comprehensively. In order to solve this problem, a complete 3D digital model of a coke oven is generated by assembling the three-dimensional models of coke oven components created with SketchUp. It enables users to section the various components of the cove oven. The outer appearance and inner structure of the oven components also can be displayed visually from several different orientations. Moreover, it is convenient to storage and carry, operation easily and fast. It can be displayed on an ordinary computer and occupies no space at the laboratory. Meanwhile, a large sum of money that used for purchasing a physical coke oven model can be saved.

Keywords: SketchUp, Coke Oven, 3D Digital Model, Animation.

1. Introduction

Coke oven is the main equipment for a coking plant. It is mainly used to produce such chemical products as raw gas and coke which is indispensable for blast furnace ironmaking, cupola melting iron and nonferrous metal smelting by isolating coal from the air for dry distillation [1, 2]. Coke oven is a large industrial furnace and complex in structure. It is composed of four parts: regenerator, ramps, the coking chamber & combustion chamber and furnace roof [3]. The structures of all the four parts are complex, especially the ramp area in which thousands of ramps are laid intricately for gas, air and waste gas to pass respectively [4]. There are 56 combustion chambers in a 55 holes JN60 coke oven, each of which has 32 flues. As each flue is connected with two independent ramps, the whole ramp area has 3584 ramps. In addition, a coke oven with two kinds of heating methods includes another 1792 vertical brick gas roads [5].

Therefore, a two-dimensional structure diagram can hardly help one observe the inner structure of a coke oven and master its working principle comprehensively. In order to solve this problem, a set of 3D digital models of coke oven were created in this program with SketchUp software.

The created 3D digital models of coke oven are based on a WH43K coke oven which is designed by the Design and Research Institute of Wuhan University of Science and Technology. The main structural features are: double flue, exhaust gas recirculation and two kinds of heating methods. The models of each part can be classified into two types: the bricklaying model of the coke oven components and the overall model of the coke oven components.

2. A Brief Introduction of SketchUp

SketchUp is a 3D design software program developed by @Last Software Company mainly used for 3D modeling. It also has an outstanding performance in modeling technology, material editor, animation creation and post-processing. The modeling process of SketchUp is so easy and fast compare with 3DMAX and PROE that it is widely used in architecture modeling [6, 7]. It can be used to create photo-realistic images and excellent animation works [6, 8]. In addition, it is convenient to generate sectional views and dissection animation that used for demonstrating from any orientation. Therefore, it has been widely applied in architecture, planning, landscape, indoor, and industrial design [9].

3. 3D Modeling of Coke Oven and Animation Creation Based on SketchUp

3.1 3D Modeling of Ramp Area of a Coke Oven

The ramp area is the most complex part in a coke oven whose inner structure is extremely irregular with many curved surfaces and notches. Therefore, it is also the most difficult and important part in 3D modeling. The process of generating a 3D model of a coke oven is exemplified by its ramp area in this paper.

The bricklaying model of coke oven components. The modeling of the ramp area is done layer by layer from the bottom to the top. As the ramp area consists of many brick layers, and the bricks in every layer are quiet different in

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202

type and size, a large amount of 3D model monomers should be built in accordance with different brick types during the process of building each brick layer, which is shown by a large number of brick components in SketchUp. The process is as follows.

A. Some rectangle bricks are pulled out for later use according to the size of each brick in the CAD drawing.

B. The 3D model of the whole ramp area are generated strictly in accordance with the contours of the ramps in CAD Bricklaying Figure.

C. The above prepared bricks and models of ramps are precisely positioned according to their relative positions. The real brick types are created by using some SketchUp commands such as Intersect with Model. As there are a large number of expansion joints and sliding slits in the ramp area, it is necessary that a large number of guides should be drawn in SketchUp for precise positioning so as to ensure that each brick type is accurate.

D. Material, texture and color are given to each of the bricks above, which are precisely assembled according to the order of modeling process. Some important parts such as ramps and tube bricks can also be cut as required.

The bricklaying model and cutaway view of the Ramps are shown in Figure 1.
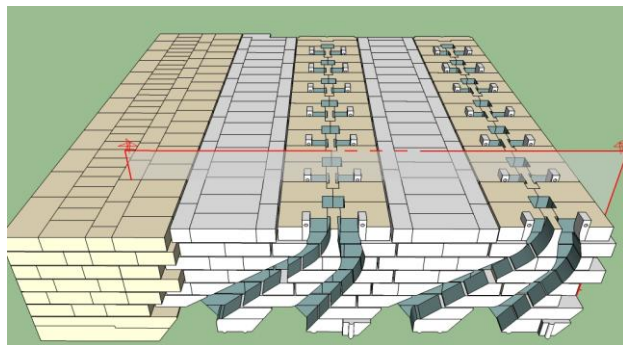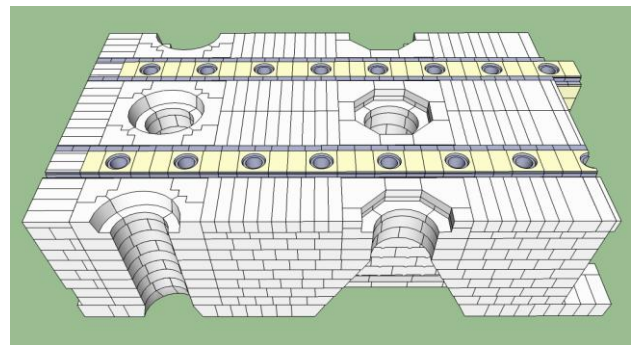

(a) The view of the Ramps.
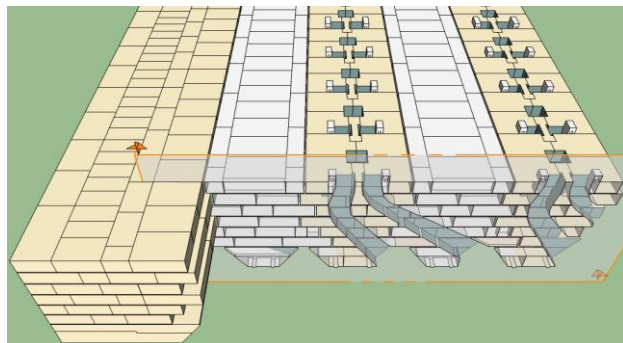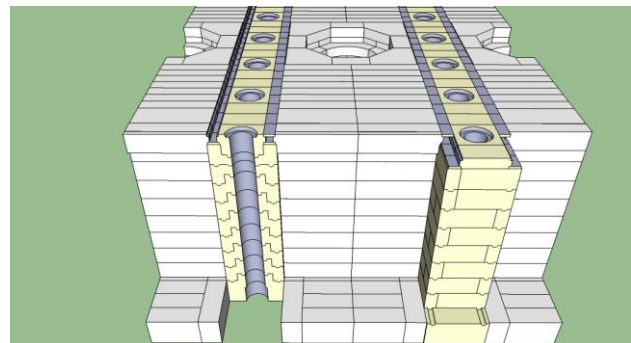

(b) The cutaway view of the Ramps.
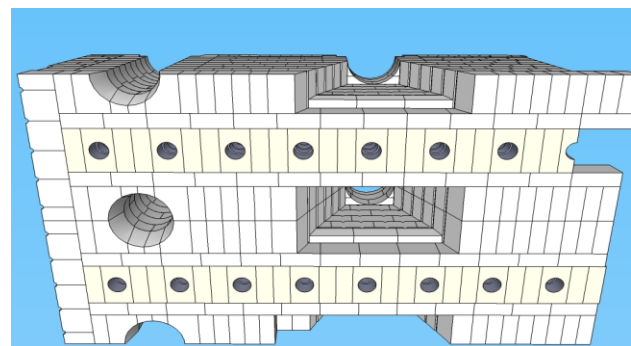

(c) The bottom view of the ramps.

Fig. 1. The bricklaying model of the Ramps.

(a) The view of the furnace roof.

(b) The fire hole of the furnace roof.

(c) The bottom view of the furnace roof.

Fig. 2. The bricklaying model of the furnace roof.

The overall model of coke oven components. Compared with bricklaying model, modeling of the overall structure of coke oven is easier. First, a rough 3D model of the ramp area is drawn according to the overall size of the ramp area in SketchUp. The 3D model of the ramps is built in accordance to the contour and size of ramps. Last, the ramps are generated by using Intersect with Model command after precise positioning, and the overall 3D model of the ramp area is obtained. In the 3D model of overall structure, expansion joints and sliding joint are not presented.

3.2 3D Modeling of Other Parts of the Coke Oven

The other parts of a coke oven such as regenerator, the coking chamber & combustion chamber and furnace roof are simpler in structure when compared with ramp area because they do not have irregular curved surfaces. Consequently, modeling of these parts are much easier, and the needed models can be created only by some basic commands in SketchUp such as Pull/Push, Intersect With Model. The modeling process is similar to the ramp area, which is not repeated here as to the paper length. Models of the various parts of the coke oven are shown in Figures 2, 3, 4, and 5.
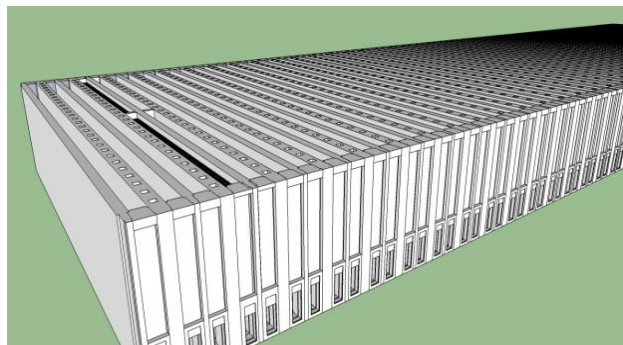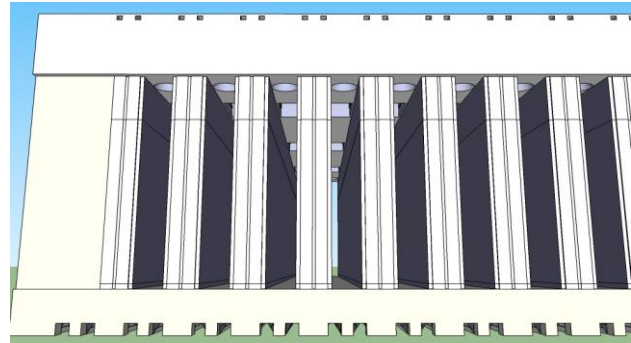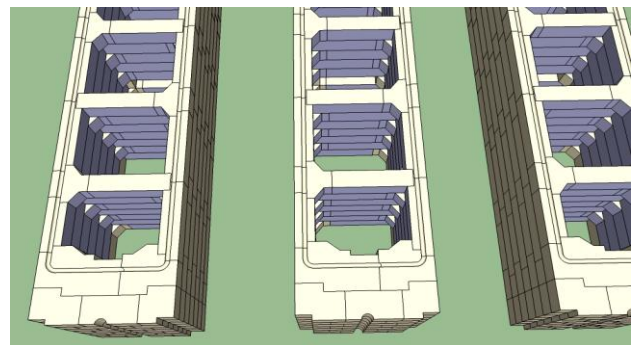
(a) The regenerative chamber's overall model.

(b) Partial bricklaying model of the regenerative chamber.

Fig. 3. The 3D model of the regenerative chamber.

(a) The coking chamber & combustion chamber's overall model.

(b) Partial bricklaying model of the coking chamber & combustion chamber.
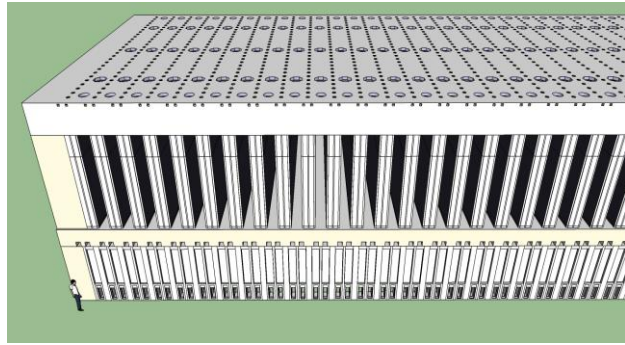
Fig. 4. The 3D model of the coking chamber&combustion chamber.

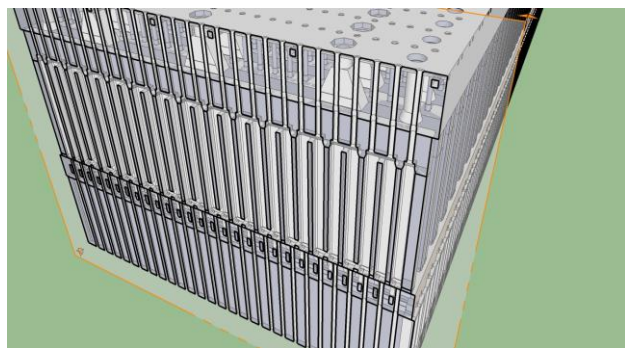## 4. Animation Creation Based on 3D Digital Model of Coke Oven

SketchUp, which owns the feature of animation, can automatically generate smooth animation according to a variety of perspective views which can be set after the scene is created. Its animation is easy to achieve in which the obscure concept of keyframe is avoided [8]. In addition, SketchUp can also conveniently create sectional views from any orientation and generate dissection animation for display [10]. Moreover, the animation can be exported in AVI, Quicktime and MOV files [9].

In this program, there are 48 AVI animations in total. The content of the animations involve the movement and rotation animation of various parts of the coke oven, dissecting display, the growth animation of the coke oven, as well as the display of the structures of such coke oven parts as checker bricks, grate brick and furnace column etc. The animation vividly displays the relative positions of various parts of the coke oven as well as its complex inner structure.

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204

(a) The regenerative chamber's overall model.

(b) The cutaway view of the coke oven.

Fig. 5. The 3D model of the whole coke oven.

In addition, the relation between the smoothness of the animation and size of AVI file should be balanced. So the size of AVI files should be decreased as far as possible on the premises of aesthetic appearance and clear display of the structure. If the size of the AVI file is too large, it will not only occupy a large disk space, but more importantly consumes a large amount of system resources which may cause inconvenience in animation exportation [9, 11]. Accordingly, two measures can be taken. First, the material which is sensitive to light and occupies a large space should be avoided when the 3D model is given the materials. Second, the time frame in the animation output should be strictly restricted. This design adopts 20 frames per second.

5. Conclusions

The created 3D digital model has many merits. First, the various parts of the coke oven could be sectioned and visually displayed. It enables users to observe the outer appearance and inner structure of the coke oven from many different perspectives. Second, it is convenient to storage and carry, and it can be displayed on any ordinary computer. Last but not the least, it occupies no space in the laboratory and saves the money that used for purchasing a physical coke oven model.

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