Study on Virtual Simulation of the New Screw Pile Hammers Based on a Combination of Multi-software Platforms

Yangyang Su, Li Bo, and Dingfang Chen

Research Institute of Intelligent Manufacture & Control, Wuhan University of Technology, Hubei, P.R.China,430063
{suyangyangwhut,whlibo163}@163.com
dfchen@whut.edu.cn

Abstract. This thesis uses the virtual simulation of the new screw pile hammers as an example, and puts forward a virtual simulation method based on a combination of multi-software platforms. It simply introduces how to design the size of the machine, and check the strength of each part with the help of ANSYS. Then focuses on the introduction to the working process of this virtual simulation method, achieves the goal of seamless connection of different software, the build of 3d model of the pile hammer, and the production of the virtual pile hammer. Meanwhile, the virtual simulation of four processes demonstrates the functions of the new screw pile machine in different stages and the principle of piling. Compared with the traditional method which stimulates and analyzes with a single software, the practical applications demonstrate that, the virtual stimulation method based on a combination of multi-software platforms is easier to operate, more flexible to modify and more authentic.

Keywords: multi-software platforms, virtual simulation, pile hammers.

1 Introduction

With the rapid development of mechanical manufacturing industry, machinery is more and more powerful in function and the parts of the machine are more and more complex. Therefore, new requires on virtual simulation are unavoidable. Nowadays, there are various kinds of software in the world, which have disadvantages and advantages[1,2,3]. We face the problem how to combine different kinds of virtual simulation software effectively to achieve the virtual simulation, which gives birth to a virtual simulation method based on a combination of multi-software platforms.

2 Background

The new screw pile machine structure design adopts advanced floating technology, planet gear load uniform and reasonable, gear carrying capacity is high, long service life, economical.

Q. Zu, B. Hu, and A. Elçi (Eds.): ICPCA-SWS 2012, LNCS 7719, pp. 439–446, 2013.

According to the demand of customer, we need to do the following two points:

- Calculate a series of data (especially the spindle size of reducer).
- Make the virtual prototype of the pile hammer and its videos.

It is of great importance to research on the virtual simulation of the new screw pile hammers. The prototype can promote the interaction between manufacturer and client (especially the non-technical staff). Through the video of the prototype, clients can learn about the new type of the machine such as its advantages, structure and principle without going out, which contributes to the promotion of the products as well.

3 Calculation and Analysis

3.1 Calculate the Power and Torque of the Output Shaft

Given conditions :

The output torque of the reducer is $\mathrm{T} = 25\mathrm{T} \times \mathrm{m}$;
The output speed of the reducer is $\mathrm{N} = 3.981\mathrm{r/min}$;

- **Calculate the output power.**
- The input power of the reducer is:

$$\mathrm{P}_1 = \frac{\mathrm{T} \times \mathrm{N}}{9549} = \frac{25 \times 10^3 \times 9.8 \times 3.981}{9549} = 102.141\mathrm{kw}$$

In the above formula:

Efficiency of the bearing[4] η_1—we can check the value of $\eta_1$is 0.98~0.99,than take 0.98 as η_1.

Efficiency of the gear[5] η_2—we can check the value of η_2 is 0.98~0.995,than take 0.99 as η_2.

Efficiency of the planetary gear[5] η_3 —we can check the value of η_3 is 0.97~0.99,than take 0.98 as η_3.

Efficiency of the gear coupling[6] η_4—we can check the value of η_4 is 0.99.

- The output power of the reducer is:

$$\mathrm{P}_2 = \frac{\mathrm{P}_1}{2{\eta_1}^2{\eta_2}^2} = \frac{102.141}{2 \times 0.98^2 \times 0.99^2} = 54.256\mathrm{kw}$$

- The input power of the motor:

$$\mathrm{P}_3 = \frac{\mathrm{P}_2}{\eta_1\eta_2\eta_3\eta_2\eta_3\eta_4} = \frac{54.256}{0.98 \times 0.99 \times 0.98 \times 0.99 \times 0.98 \times 0.99} = 59.411\mathrm{kw}$$

Conclusion: we can calculate the output power is 59.411kw based on the given condition ($\mathrm{T} = 25\mathrm{T} \times \mathrm{m}$), which is less than the rated power (75kw)of the motor, that means the maximum output torque of the pile hammers can be achieved to 25 $\mathrm{T} \times \mathrm{m}$.

- **Calculate the output torque**.
- Input torque of the gear:

$$T_1 = \frac{9549 \times P_3}{n_2} = \frac{9549 \times 59.411}{1000} = 569.096N \times m$$

In the above formula:

$$n_2 — \text{rated speed of the motor},1000r/min$$

- Input torque of the reducer:

$$T_2 = \frac{9549P_3\eta_4}{n_2} = \frac{9549 \times 59.411 \times 0.99}{1000} = 561.639N \times m$$

- Input torque of the gear shaft(high-speed shaft):

$$T_3 = \frac{9549P_3\eta_3\eta_4\eta_3\eta_2\eta_3\eta_2}{n_3} = 26270.32N \times m$$

In the above formula:

$$n_3 — \text{rated speed of the gear shaft}$$

$$n_3 = \frac{n_2}{\tau_1\tau_2} = \frac{1000}{8.7692 \times 5.6667} = 20.124r/min$$

In the above formula:

The first level ratio of the planetary gearbox:$\tau_1 = 8.7692$

The second level ratio of the planetary gearbox:$\tau_2 = 5.6667$

- Output torque of the gear shaft (high-speed shaft):

$$T_4 = \frac{9549P_3\eta_4\eta_3\eta_2\eta_3\eta_2\eta_1}{n_3} = 2.627\ T \times m$$

- Input torque of the gear shaft (low-speed shaft):

$$T_5 = 2 \times \frac{9549P_4\eta_2\eta_2}{n_4} = 2 \times \frac{9549 \times 54.256 \times 0.99 \times 0.99}{3.981} = 26.031\ N \times m$$

In the above formula:

$$P_4 — \text{stands for the output power of the planetray gearbox}$$

- Output torque of the gear shaft (low-speed shaft):

$$T_6 = \frac{9549P_5}{n_4} = \frac{9549 \times 102.141}{3.981} = 24.500\ T \times m$$

Conclusion: T_6 is less than the given torque ($T = 25T \times m$).

3.2 Finite Element Analysis

Output shaft, planet carrier (low-speed), planet carrier (high-speed) and the support body are the key components of the reducer. Their mechanical properties directly affect the reliability of the gear reducer safety work and performance. We need to analyze their mechanical properties using the ANSYS software.

- Calculate the allowable stress [σ]

According to the material mechanics knowledge, we can calculate the material allowable stress:

$$[\sigma] = \frac{\sigma_s}{n}$$

In the above formula:

σ_s— stands for the allowable stress of the material

n— stands for the safety factor

The allowable stress of the key mechanical components of the new screw pile hammers are shown in table1.

Table 1. Allowable stress of the key mechanical components

Name of each component	Material	Yield limit (MPa)	Safety factor n	Allowable stress (MPa)
Output shaft	42CrMo	930	2	465
planet carrier (low-speed)	ZG42CrMo	490	2	245
planet carrier (high-speed)	ZG42CrMo	490	2	245
Support body	QT600-3	370	1.33	278
Reducer housing	Q235-A	235	1.33	177

- Check the strength of the output shaft

Build the three-dimensional finite element model of the output shaft using the solid45 as element type and analyze the force of it. The stress drawing and displacement drawing are shown in figure1 and figure2.

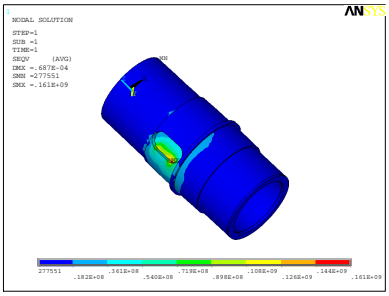

Fig. 1. Stress drawing of the output shaft

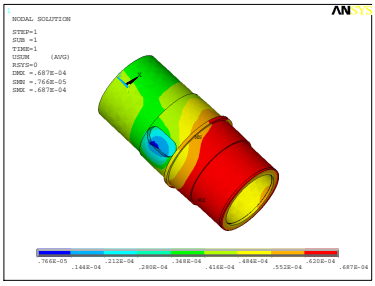

Fig. 2. Displacement drawing of the output shaft

Conclusion:$\sigma_{max} = 161\text{MPa} < [\sigma] = 465\text{MPa}$, strength meet the requirements.

Use the same methods to check other components' stress and make sure their strength meet the requirements.

4 Introduce of the Working Process of the Virtual Simulation Method Based on a Combination of Multi-software Platforms

Take the virtual simulation of the new screw pile hammers as an example. The flow chart of the virtual simulation method is as follows in figure3:

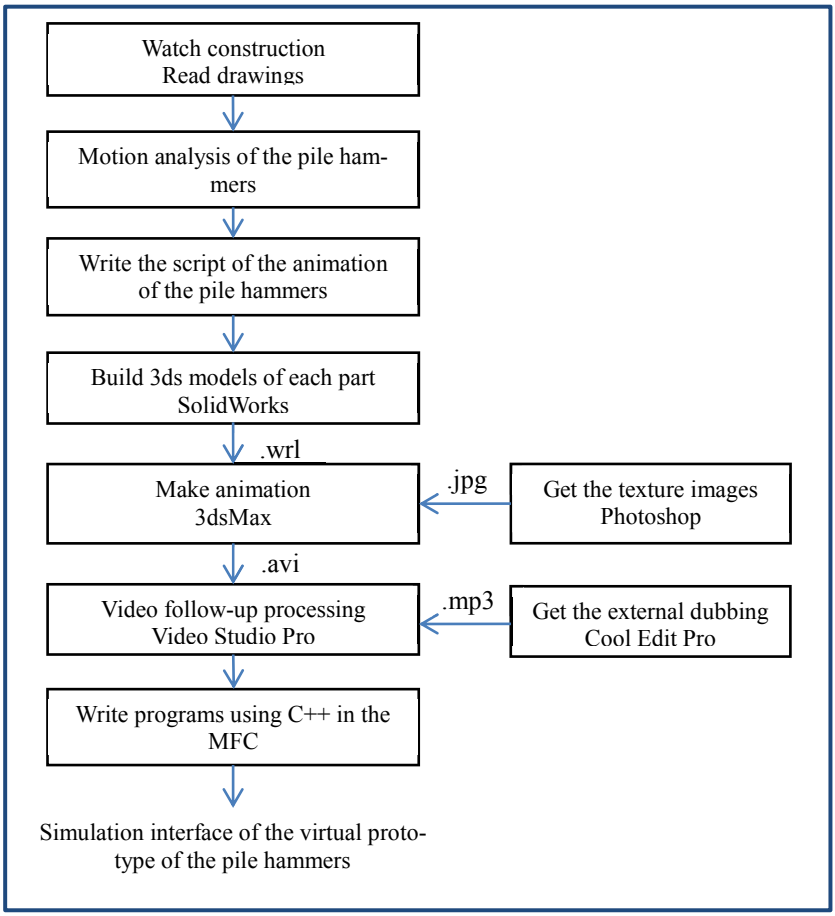

Fig. 3. Working process

1. Analyzes the state of function in all stages, and takes down the scripts which are required for the making of virtual simulation video.
2. Establish the 3d models of the parts in the environment of SolidWorks software based on the calculation, then save them as wrl format.

3. Deal with the pictures of screw pile hammers and other relative pictures with the help of Photoshop, then get the required texture maps in the jpg format.
4. Import the wrl files into 3dsMax, map and render the 3d models of the parts of the new screw pile hammers, then make the video and save it in the avi format.
5. Record the sound that requires when the machine works in the environment of Cool Edit Pro and save it in the mp3 format.
6. Import the video and the sounds into Video Studio Pro and approach them further and save the final video in the flv format.
7. Use C++ language program in MFC framework to make the simulation interface.

4.1 Analyzes the Motion State of the New Screw Pile Hammers

Observe and analyze the whole process in which the pile machine is transported, assembled, constructed, disassembled and transported. At the same time, read the drawings of the machine, learn about the joint state of each part, and especially take down the notes on their relative motion in different stages. After that, make a form. In order to help clients learn about the new type of machine directly and clearly, the function of the machine in reality is divided into four stages: assembly-pile-transposed construction-disassembly. Organize the notes carefully and write the script of the simulation flash.

4.2 Build the 3D Models of the New Screw Pile Hammers Base on SolidWorks

In the environment of SolidWorks, establish the 3d models of the parts of new screw pile hammers based on the calculation.

There are two ways to establish the model-top to the bottom and bottom to the top. The aim here is to make simulation animation and the assembly process of some parts need to be done in 3dsMax, therefore we adopt the bottom to the top way to establish the models. That is to say, we disassemble the machine into individuals and establish them one by one. The newly-built 3d models should be imported to 3dsMax, so the models of the parts should be saved in the format of wrl.

The models of those parts which need to be assembled in the 3dsMax should be saved in the format of wrl. Others can be assembled in the environment of SolidWorks, the assembly models should be saved in the format of wrl.

4.3 Make the Simulation Videos of Virtual Prototype Base on 3DsMax

According to the written script, import the models into the environment of 3dsMax to make simulation animation.3dsMax is a commonly used software to make 3d video. During the process of virtual simulation, it is used to do the followings:

- Set the working scene of the new screw pile hammers

In order to achieve a convincing effect, we can set the working scene of the new screw pile hammers in the environment of 3dsMax, such as the ground with yellow soil, the street behind the site, the trees and the buildings in the city. Schematic diagram is shown in figure4.

Fig. 4. Interface of 3ds Max software

Fig. 5. The new screw pile hammers

- Map and render the models

The models established in SolidWorks are colorless, so there is need to render texture. The final models are shown as the figure4, which has strong visual impact.

- Make the virtual simulation video files of the new screw pile hammers

Import the rendered models into the working scene and achieve the relative motion between each part and between the pile machine and the working site according to the working principle of the machine in reality. Figure5 shows the relative rotation of the hammers under the construction site. Debug the related motion parameter, and export the video in the avi format.

4.4 Post Processing of Animated Video

Corel Video Studio Pro software is a video processing software, through which we can put static pictures and dynamic video files together to create a new video file. We mainly do the following treatment to the avi format video files in the environment of the Corel Video Studio Pro software: the treatment of color brightness; adding the suitable background music, associated subtitles and dubbing commentary. Through this way we can get a new video file with strong impact both in visual and hearing. The audiences especially the non-technical staff can easily have knowledge of the characteristics and advantages of the new screw pile hammers through watching the video file.

4.5 Make the Simulation Interface

According to the needs, use C++ language program in MFC framework to make the simulation interface. Virtual simulation interface as shown in figure6, there are four buttons in the top right corner of interface which mean the machine assembly, piling, transposed construction and pile hammer removal. Click on the buttons to play the corresponding video animation.

Fig. 6. Virtual simulation interface

5 Conclusion

This thesis uses the virtual simulation of the new screw pile hammers as an example, and puts forward a virtual simulation method based on a combination of multi-software platforms. It focuses on the introduction to the working process of this virtual simulation method, achieves the goal of seamless connection of different software, the build of 3d model of the pile hammer, and the production of the virtual pile hammer. Meanwhile, the virtual simulation of four processes demonstrates the functions of the new screw pile machine in different stages and the principle of piling. Compared with the traditional method, the new method is more flexible to modify and more authentic.

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