Virtual Prototype modeling studying of breech mechanism based on the software Pro/Engineer and ADMAS

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***Abstract*—By the CAD software Pro/Engineer and dynamics simulation software ADMAS, the XX breech mechanism virtual prototype is established. At first, the 3D modeling of the XX Breech Mechanism is generated with the parametric design and virtual assembling, then the restriction and dynamic power is added on the generated 3D modeling so as to generate experiment platform of Virtual Prototype including various conditions. At last, the qualitative and quantitative analysis is performed on the proposed virtual prototype, the experiment results validate that the designed breech mechanism virtual prototype is proper and appropriate.**

Keywords-Virtual Prototype; Breech Mechanism; Dynamic Characteristic; Pro/E;ADAMS

I. INTRODUCTION

As the crucial component of artillery launching, breech mechanism is to lockout bore, shoot and take out cartridge. According to investigating result, breech mechanism trouble is made up of the 30 percent of the artillery', so it is necessary to build virtual prototype modeling of breech mechanism in order that we can improve breech mechanical design and provide scientific gist for technical question. The Virtual prototype technology can perform lots of experiments that can't be done with physical prototype, such as repeatedly modifying the system model, also by which the researchers can process various experiment of different designs so as to find out the best one, and verify one scheme whether it is the best or not. So the Virtual prototype contributes to shorten the weaponry designing cycle, to reduce cost, and to improve weaponry designing and producing quality. In this paper, by the CAD software Pro/E and dynamic simulation software ADAMS, the XX breech mechanism virtual prototype is established. The model covers a variety of working conditions of the breech mechanism such as the training and the actual combating circumstances. The qualitative and quantitative analysis is performed on the proposed virtual prototype. The experiment results verify that the designed breech mechanism virtual prototype is proper and appropriate.

II. 3D solid modeling

Based on XX breech mechanism drawings, three-dimensional solid modeling for the transmission system is established with the CAD software Pro/E, the modeling process is as follows:

The first step is the geometric modeling, which is to obtain the correct geometry according to the drawings.The second step is to obtain the physical properties, which is to obtain the correct physical properties of parts, such as the quality, the centroid, the rotational inertia according to the property settings of the parts and materials; The third step is the assembling, which is to assemble various parts together on the basis of their dynamical relationship. The above solid modeling work is the important foundation of establishing the dynamics model of transmission system and virtual prototype.

The breech Mechanism primarily consists of the switch latch mechanism, firing recockling mechanism, cartridge extractor mechanism, detent catch mechanism and insurance mechanism. Its two main member is gun breech(Figure 1) and bolt body(Figure 2).

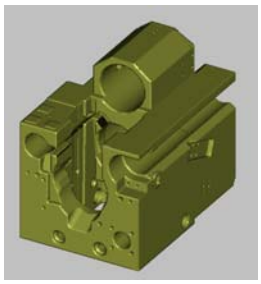

Figure.1 The gun breech

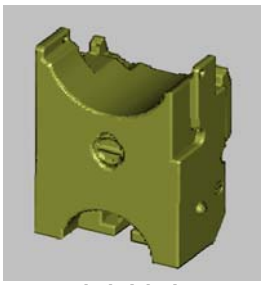

Figure.2 The bolt body

The most basic function of switch latch is up and down movement of the bolt body in the middle of the breech.

The other parts are mounted in the two major components, so that these two members make mutual movement or they use the movement of these two members to complete some necessary action.

The switch latch mechanism guides the bolt body to move relatively between breech, with the recoil energy of artillery's recoil part when it is the time of automatic unlatching, or with the arm pressure to open latch. The energy is stored in the process of compressing close spring, then the latch is closed by these energy.It includes the following major parts, such as opening latch plate, crank, rod, opening lever, crank shaft, crank, closing lever, supporting tube, closing spring and opening latch handle.

Firing recockling mechanism is used to release the striking pin and fire when off latch is in place, thus the striking pin is launched, or it is used to dial the striking pin back when the firing isn't valid. It is composed of firing pin, striker spring, back pin spring, toggle sub-axis, shifting fork, toggling sub in tied, recockling toggling sub, emission grip,

pushing rod.

The pumping tube works with switch latch structure together, in the switch latch process pre-pumping tube is performed, and cartridge is drawn out and filled at the end time of the open latch. Its main components include left and right extractor, left and right pressure tie, left and right spring, extractor axis.

Defending catch mechanism is used to prevent the projectile falling while loading ammunition, and to assist cartridge extractor mechanism to be extracted, its main parts includes defending catch board, retaining catch board axis and defending catch board dialing axis.

As the insurance of the gun, Insurance mechanism is to ensure not to execute firing when off latch is not in place. The main components are securing leverage and its axis.

The above sets of mechanisms work with one another in accord with time and space, and form a complex mechanical system.

Overall assembly of breech mechanism is shown in Figure 3, the internal components are shown in Figure 4.

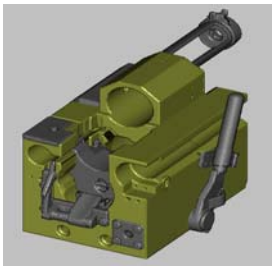

Figure.3 verall assembly

Fig.ure 4 internal components

Generally speaking, this breech mechanism has following characteristics in the structure: (1) geometrical figure is very irregular, because the force and motion is transmit by relying on the outline of components, so many parts' outline is more complicated, such as crank(Figure 5)and recockling toggle sub(Figure 6).

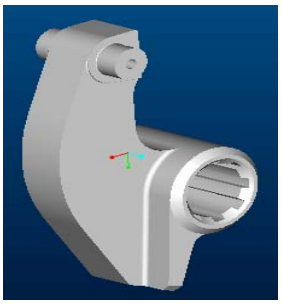

Figure.5 The crank

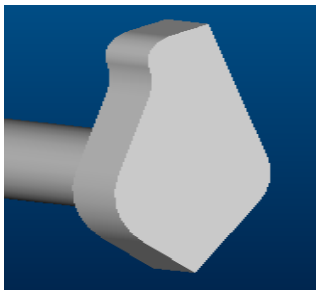

Figure.6 The recockling toggle sub

(2) The assembly relationship is more complex, more than 100 parts are concentrated onto the main and tail, these parts are connected, tangent, offset or collided one another.

(3) The quality of the parts are quite different, such as the quality of the main body is 60 to 70 kilos, but some of the widgets in the main parts, which is important to complete its function and can not be ignored, is less than 0.01 kg.

Because of the above structural features, only with dynamic simulation software ADAMS it is difficult to complete the modeling task, so we must require the help of other professional 3D CAD modeling software to design various solid models of the parts along with different sizes, and to perform assembly precisely. In this paper, the CAD software Pro / E is used to complete the solid modeling and assembly work.

III. The design of the virtual prototype

A. Modeling scheme

As above mention, the characteristics of breech mechanism need us to adopt the professional CAD software and professional mechanical system dynamics simulation software during its design, and these two softwares must have a good interface.

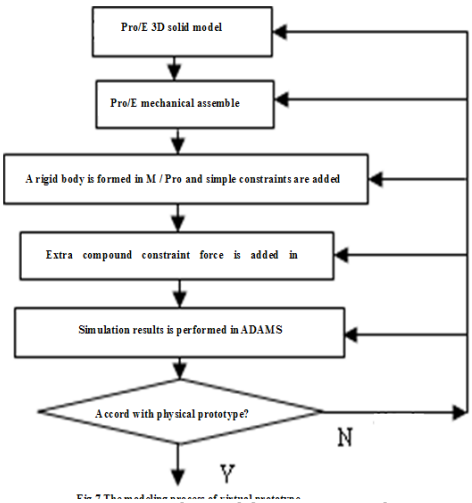

Figure .7 The modeling process is shown

By Comparison, we select common dynamic simulation software ADAMS made in MDI developed company and the CAD software Pro/E made in the United States, PTC's, the interface between them is specific interface modules Mechanism/Pro (abbreviated as M/Pro), developed by MDI. The modeling process is shown in Figure 7.

B. Virtual prototype model

Based on the above modeling scheme, firstly 3D solid models of the breech mechanism is established in accordance with the drawings, and assembly of the various components form one sub-assembly at all levels, and the final assembly is finished (see Figure 3), then a rigid body is formed in M/Pro, and constraints are added, and finally perfects more compounded constraints in ADAMS environment.

Because the switch latch mechanism's size and quality are much different from parts of firing recockling mechanism, insurance mechanism and defending catch mechanism. When performing simulation on the overall

simulation model, we find that not only the equations have huge number, but also the equations cause severe pathological so as to not be solved.

During solving the equations, we investigate that the energy consumption is relatively small among the firing recockling institutions, insurance mechanism and defending catch mechanism on the switch latch process, so the mechanism model is dismantled to the main and sub models. Then we take into account that the mission of the breech mechanism is consisted of designing and training, so we study training movement of the breech mechanism by the time series which is constituted by the process of manual latch, manually shut latch and shut latch in place blank firing the latch.

In short, for a training mission, we set up one system model, one is the main model whose center component is manually switch latch, the other is the auxiliary model which includes the corresponding firing model, the defending catch model and the insurance model. Otherwise we also establish public recockling and firing model with two mission section.

In allusion to time series, it goes along 0.7 seconds during a total simulation of various models from preparation to open latch to shut latch firing completion. The switch latch model is shown in Figure 8, the corresponding firing model and insurance model is shown in Figure 9 and Figure 10 respectively.

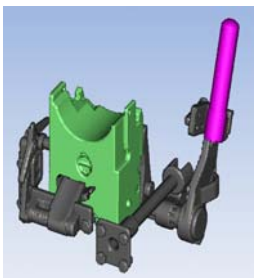

Figure.8 The switching latch model

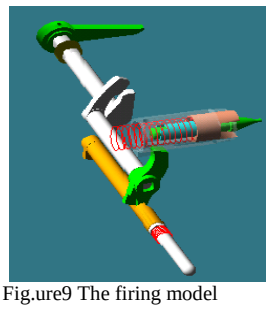

Fig.ure9 The firing model

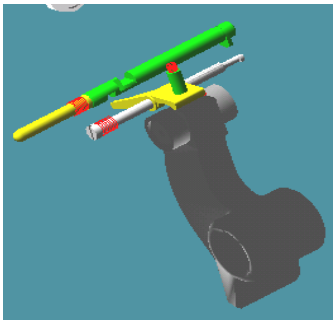

Figure 10 The insurance model

IV. Virtual prototype verifying

In order to verify the accuracy and correctness of the proposed model, we perform checking on the proposed model from the qualitative and quantitative aspects

A. Qualitative check of the virtual prototype

Qualitative check has three aspects:

1) we observe whether the animation of the virtual prototype model, the action sequence and modes of various agencies are accordant to physical prototype or not, such as whether the latch in the open latch goes down firstly to the maximum displacement, and then goes up a short distance, at last holds the latch in the open state or not.

In the process of switch latch, whether the dialed and reset of recockling toggle sub and defending catch board dialing axis are normal or not.

2) Then we need to observe whether the force and movement of the symmetrical components are the same or not, such as the force between the two crank pulley bolt body and the pulley groove in the switch latch model is the same or not, and the symmetrical variation of the multiple collision force among left and right pumping tube is consistent or not. By the means we can find some problem which is most difficult to be found in the usual checks.

3) With the engineering assessment idea, we can observe the force and movement of the various components in the model, thus we can see whether they are in accord with the engineering practice, if a little component is taken on tens of thousands of force so that we can confirm that the model is incorrect.

On the basis of above three aspects, we verify the proposed virtual prototype model of breech mechanism in the paper. We conclude that the model is in line with the above three qualitative requirements.

B.The quantitative check of virtual prototype

With breech mechanism design manual we can perform quantitative checking for the proposed virtual prototype of XX breech mechanism. Though the theory of design specification compared with many-body theory is rough and the experiment data is fewer, the experiment result is verified by revision and checked in the simulation, so it is feasible and economically for verifying virtual prototype model, and it is also only and one available method.

For XX breech mechanism, the basic movement is the recoil movement of the breech, unlatch movement of the bolt body and the extracting movement of extractor. Movement of other parts is based on above three main movements. So we perform quantitative check about these three movements on the center system model, namely switching latch model.

1) The figure 11 is the recoil speed comparison between the result obtained by the virtual prototype model and the calculated result by the design specification.

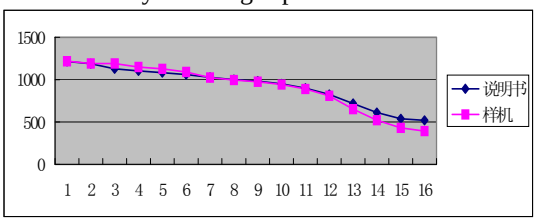

Figure. 11 recoil speed comparison

2) The breech mechanism specification has given the transmission ratio in the situation, by converting the data, we obtain the speed of the opening latch. The figure 12 is the comparison between the result obtained by the virtual

prototype model and the calculated result by the design specification.

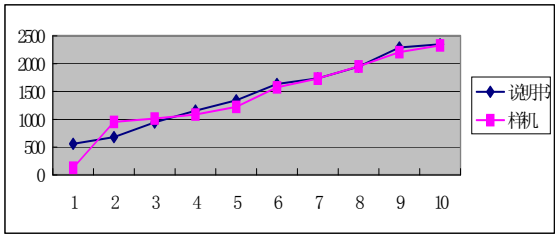

Figure. 12 the opening latch speed comparison

3) Similarly, on the basis of the breech mechanism specification, we get the cylinder pumping speed of the proposed prototype. The figure 13 is the experiment result.

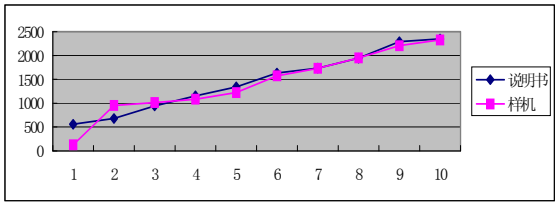

Figure 13 the cylinder pumping speed comparison

From the above experiment results, we can see that the degree of similarity is more than 90 percent between the experiment result and the design specification, the experiment result validate that the proposed virtual prototype is pretty good.

V. CONCLUSION

On the basis of the structural characteristics of the XX breech mechanism, firstly we analyze the necessity to design prototype. Then with dynamic simulation software ADAMS and the CAD software Pro/E, we establish the three-dimensional structural model of the XX breech mechanism and assemble components to complete the final assembly by Pro/E. At last, we verify the virtual prototype model from the qualitative and quantitative aspects. From the simulation results of the recoil movement speed, the speed ratio of opening latch and the pumping cylinder speed, we can conclude that the proposed virtual prototype is consistent with the theoretical analysis. The establishment of the virtual prototype model provides a reference in the aspects of further structural optimization and performance improvement for the breech mechanism.

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