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Dynamic analysis of the large horizontal tensile testing machine

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Abstract. The 12000 kN horizontal tensile testing machine was analyzed by dynamic simulation, considering the requirements of marine steel structures in fracture tests. Parameters of tested parts were monitored in the test process, in order to investigate the impact procedure and the machine's dynamic response to the fracture impact force. The simulated results showed that the machine was stable when the impact occurred, but the stress in some parts exceed material's limit, and bulking folds arise. Based on the analyzed data, buffering methods were suggested for the machine's security including hydraulic methods and mechanical methods.

Key words. Marine structure, test machine, fracture test, dynamics, impact force.

1. Introduction

In modern international trade, marine transport accounted for more than 80% of the proportion of goods transported, the import and export of China is more than 90% rely on shipping[1,2] In order to save the transportation cost, the ship development tends to be large, the tanker, ore carrier and container ship is most obvious, but once a large ship is wrecked, it caused very serious environmental pollution and property, so the safety of the navigation of large ships has been paid more and more attention. To ensure the safety of navigation of ships, emergency towing device, anchor chain, cable and other mechanical properties of steel structure must be safeguarded[3]

Mechanical properties of steel structure should not only be determined in the design phase, in the factory inspection, and even in the use of the necessary tests to

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ensure its safety performance. The mechanical properties of the ship's steel structure must be tested by a large horizontal tensile testing machine[4]. Therefore, the overall strength testing machine should meet the requirements of the test steel maximum load. In addition, in chains, cables and other components of the breaking test, or the measured part sudden failure in the test procedure, testing machine is extremely easy to have a huge impact. Therefore, static strength of the testing machine cannot meet the requirements of the check, the dynamic analysis must be carried out according to the actual working conditions, with optimize the body structure, and perfect the design of the buffer mechanism, in order to complete the corresponding component testing, and to ensure the safety of the use of the testing machine.

In this paper, to meet the International Maritime Organization (IMO) MSc will (MSc) of the 63rd session of the general assembly by the MSC.35 (63) resolution "a tanker emergency towing device of Guide" and the international maritime safety of life convention (SOLAS) 12000 kN of large horizontal tensile testing machine for dynamic analysis, of steel members breaking process of the testing machine bearing beam displacement, velocity, acceleration monitoring, and analyzes the body of impact load response and buckling changes, on the basis of the body structure was optimized and the buffer structure of the implementation of the proposed program.

2. Establishment of virtual prototype of testing machine

2.1. Analysis of tensile test process

During the testing process, the loading time is long and the load changes slowly with time. Therefore, the testing process of the test machine is quasi-static, and the static analysis of the body cannot fully reflect its actual working conditions. When the test object is in the test, it is very easy to produce the impact load to the testing machine [5]. At the same time testing machine itself can anchor breaking test, namely under static loading conditions, according to relevant provisions of the chain code, according to the cable specifications, the different levels of the, extraction of the anchor chain tricyclic group corresponding tensile load is applied, the cable sample produce plastic deformation but does not allow the signs of a fracture test anchor for brittle materials, breaking test, easy to have an impact. In addition, but also to the steel wire rope breaking test, it is generally believed that the wire rope is similar to plastic materials, yield stage, can control the pulled off, avoiding breaking caused by the impact, but the existing control system doesn't timely accurate flutter catch the yield stage and interrupt test. Therefore, the test machine under the workpiece to be tested breaking off caused by the impact is inevitable.

This article conducts the research on the dynamic process of tensile test machine, and analyse the stress situation of the machine and bearing beam in the moment of fracture. Therefore, the establish of virtual prototype is mainly for dynamic impact response, it is reasonable simplification based on three dimensional model of testing machine, and hold back the key parts of independence, and combine the fixed constraint and non-critical components.

2.2. dynamic model of virtual prototype

To study on the dynamic characteristics of testing machine – impact dynamic response, The impact load of the testing machine breaking test was obtained, and the virtual prototype of 12000 kN tensile testing machine was established by multi-body dynamics software ADAMS, and the breaking test process was simulated to obtain the impact load caused by breaking.

Dynamic model of testing machine includes two parts: testing machine body and the model of the tested parts. Testing machine ontology model to actual prototype of a 3D model based frame is established, bearing beam, moving beam, a pull rod, a cylinder key bearing parts and drive parts of 3D model, and give material properties and other rigid parts are reasonable merger or as constraints simplify. Taking into account the breaking test as a quasi-static process and impact, establishing the spring component as the object of the test. The final model is shown in Fig. 1.

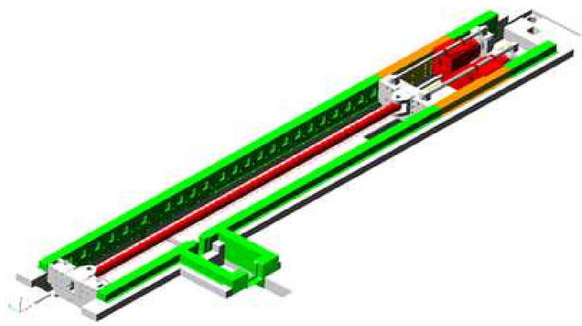

Fig. 1. Dynamic model of virtual prototype

According to the principle of the program, it is known that the quality of the components, the position of the center of mass, the inertia moment, and the inertia product of the simulation software are consistent with the actual components. So the 12000 kN tensile testing machine breaking test in the simulation process, the model and the way of blessing is simplified. After the model was simplifined and defined, and the boundary conditions (constraints, loads, and contact) were applied, the model was simulated and analyzed [6].

3. Simulation analysis of fracture test

3.1. Simulation process

The dynamic simulation of test machine model shown in fig. 1 make the necessary settings on the basis of the model, especially the contact between key parts and the condition monitoring of key stress points. The simulation test method and process are as follows:

1) 12000 kN tensile testing machine bearing beam is installed at the end of the machine body, and its extended square pin is inserted into the square pin hole and

contact with the bearing surface. The solid-to-solid contact is established in the software??both can be separated;

2) the moving beam, the dynamic beam and the four bar are consolidated to a single part;

3) the piston rod and the power beam establish solid-to-solid contact, when the piston rod movement, through the contact action in the dynamic beam; when the impact, the two can be separated;

4) in the fuselage, the side moving beam and the bearing beam between the establishment of two part (Micro ball), the two establish the ball;

5) One end of the spring is connected to a central marker, and the other end is connected to the ball marker part which is set up; the relevant parameters are defined.

6) Set the sensor to a certain time load to 12000kN, spring failure, view the information of the entire system.

3.2. Simulation results of breaking test

12000 kN tensile testing machine virtual prototype defined material properties, kinematic pair and load, completed the first treatment, the simulation analysis, kinematic pair of relative displacement can be computed. The velocity, acceleration, the constraint force and load, and arbitrary marker point displacement, velocity and acceleration are data. In the process of simulation component broken off time screenshots as shown in Fig. 2. Using ADAMS/Postprocessor post processing module output some Kinematics / dynamics parameters characteristic curve and data as shown in Fig. 3 and Fig.4.

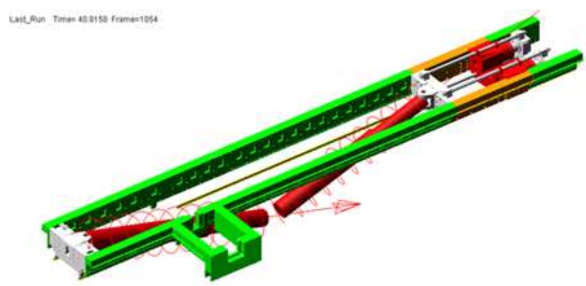

Fig. 2. Simulation diagram of test machine breaking test

Fig. 3 shows that testing machine at the speed of 0.003 m/s tensile test, in 40 seconds when the load reached 12000 kN and broke. Forward displacement velocity and acceleration of mobile 0.01 M, Jitu occurred after a few times after a rebound, stop, tends to zero.

Fig. 4 shows that during the test, the load bearing beam is in the state of wave, and the load is in a state of fluctuation, and the maximum acceleration and velocity are obtained, and the maximum displacement of the beam is 0.0126m.It is also known that the loading process must be gradually loaded, or will cause a great impact on the bearing beam, the body and the bearing beam itself will cause great

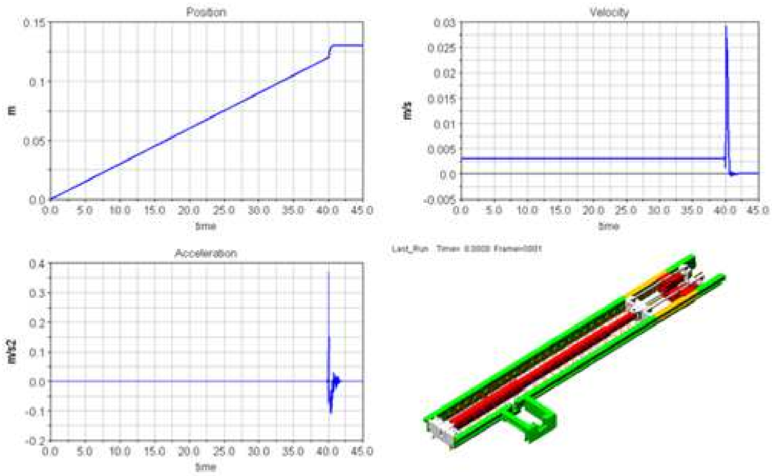

Fig. 3. Dynamic part of the analysis of the curve

damage.

Through the above dynamic simulation analysis, it is found that the testing machine have a greater impact on the breaking test and cause significant damage to the testing machine itself. it also see the bearing beam in testing process to ensure that its square pin and square pin hole in the bearing surface has good contact, otherwise under heavy load, the bearing beam will also have a big impact, causing unnecessary damage.

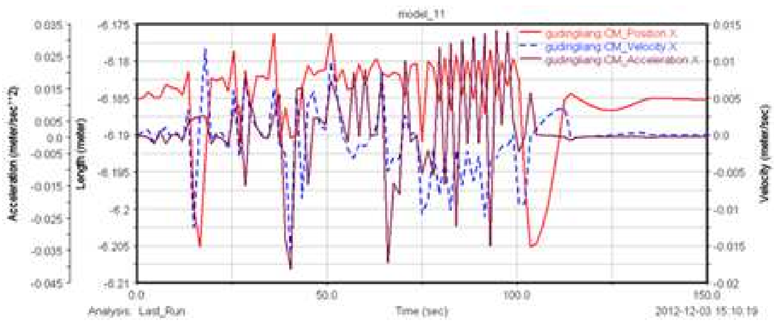

Fig. 4. Analysis of bearing beam

4. Analysis of impact response and fuselage buckling

Impact load belongs to transient load, its role in the analysis of the test machine belongs to the transient dynamics analysis, only breaking moment analysis the load and time history obtained by section of the ADAMS simulation software, analysis from the above diagram, taking the time course for 0.05 s. The results of the analysis and after treatment are shown in the following figure.

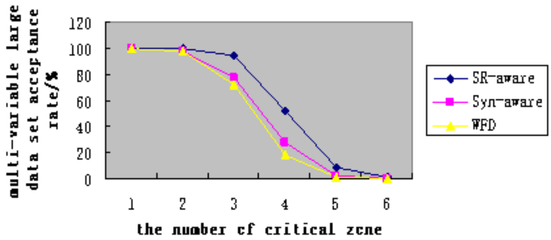

Fig. 5. Geometry of considered trapezoidal plate

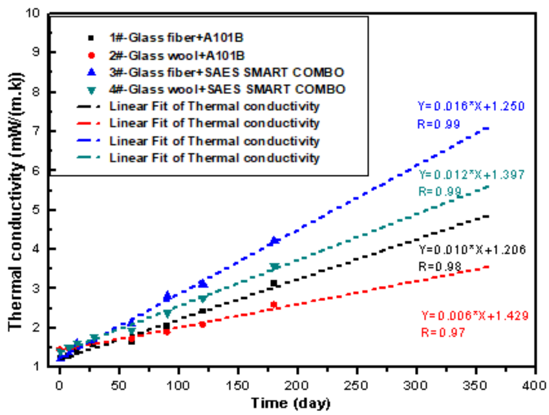

Fig. 6. Geometry of considered trapezoidal plate

Fig. 6 and fig. 5 for the fuselage of the main plane of the lower path displacement curve, from which can be clearly seen in the body, whether it is from the fixed near the end of the region and the far end of the phenomenon has appeared obvious fold. Fold phenomenon is sometimes one of the characteristics of the occurrence of buckling, the following according to the impact of the buckling criterion to determine whether the body buckling.

According to the total potential energy criterion of the impact buckling, the total potential energy of the fuselage is extracted, and the total potential energy (total strain energy) and the buckling time of the test machine are shown in Fig. 7.

In Fig. 7, solid body in the buckling load of the total potential energy curve dotted lines under impact loading of total potential energy curve, it can be seen from the figure, the total potential energy under impact load has more than the buckling load of the total potential energy, can determine the body impact buckling, and the emergence of the phenomenon of fold. Although there is a phenomenon of fold, but in the constraint support, the body to maintain a better deformation. This phenomenon should be avoided; the impact of the fold will seriously affect the body's stiffness and testing machine testing accuracy.

The above analysis of transient dynamics of the body shows that the body has a good impact resistance, not sudden instability, but on the motherboard of the fuselage appears obvious wrinkle phenomenon, on the fuselage and the test machine

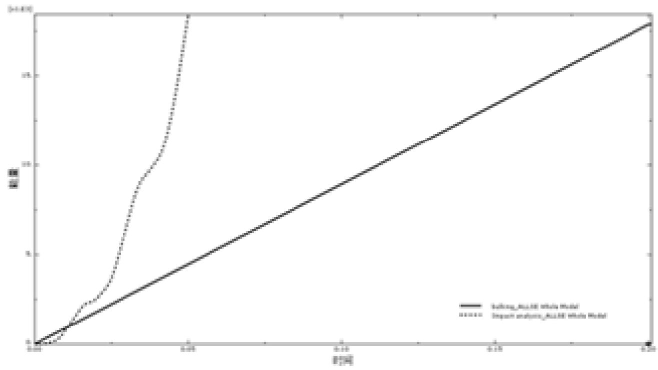

Fig. 7. Total potential energy curve

damage, affect the working performance of the testing machine, so it is necessary to buffer device of testing machine design.

5. Test machine buffer solution

According to the result of dynamic simulation, it can be known that the breaking impact will cause serious damage to the testing machine. In order to ensure the safety of the testing machine in breaking test, the method should be designed from the mechanical, hydraulic and other aspects.

1) hydraulic buffer: dynamic testing machine by hydraulic system and direct by the hydraulic cylinder drive power beam on the measured object applied load, so in breaking test takes advantage of the hydraulic system to absorb impact energy essential. Combining with characteristics of the testing machine horizontal structure, the four groups of damping piston cylinder and a dish shaped spring group consisting of composite structure, when the chain fracture moment, two loading oil cylinder storage cavity pressure oil liquid is need to release the main energy and damping cylinder and overflow valve consume their power. Finally, a disc spring group and the horizontal bearing frame reset. This buffer first through the loading of the cylinder before the cavity of the hydraulic damping, accumulator, relief valve buffer, after the valve is closed, the relief valve for energy consumption, to achieve the purpose of the buffer.

2) mechanical buffer: mechanical buffer from two aspects to achieve. On the one hand the body of the floating structure, which may be moving in the direction of the testing machine load test, achieved by the body of the anchor bolts and rooted foundation anchor bolts with; on the other hand, bearing between the beam and the fuselage matching of the sales and increase the contact area and at the time of the impact bearing beam has enough space to slip, and the impact of energy consumption in the larger contact surface, reduce the impact force.

6. Conclusions

In this paper, the dynamic simulation and analysis of 12000kN large horizontal tensile testing machine are carried out according to the requirements of the mechanical performance of large structural members. On the basis of the three-dimensional model of the testing machine, the dynamic model is established, and the breaking simulation test is carried out. By monitoring the bearing beam on the measured piece broken in the process of displacement, speed, acceleration, analyze the impact on the test machine. On the basis of this analysis, the response of the fuselage to the impact load and the buckling deformation are analyzed. The analysis results show that the test machine has high stability, but it will cause local damage when the impact is limited, which is not conducive to the long-term use of the testing machine. In order to ensure safety of the testing machine, we must design aimed at breaking test of the buffer device and the method. This paper according to the data analysis, put forward in line with the horizontal tensile testing machine hydraulic buffer and mechanical buffer scheme, on the testing machine hydraulic drive system and mechanical structure of overall optimization

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