

# Analysis of Multi-flexible-body Modelling of Remote Weapon Station

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**Abstract.** Based on the analysis of the tube and the frame seat structure on the Remote weapon station virtual prototype, this paper use the Modal Integration method to model tube and frame seat, then analysis their free mode, we get the characteristic of the tube and the frame seat structure, and demonstrate the validity of the model. The research could provide reference value of remote weapon station multi-flexible-body modeling.

## Introduction

Remote weapon station is a complicated system, it has many performance indexes, based on the virtual prototype technology to analysis and evaluate its performance indexes has become a new way. However model multi-flexible-body is a difficult problem when model virtual prototype of remote weapon station. In this paper, starting from virtual prototype of remote weapon station, to analysis the method of modeling multi-flexible-body, then modeling tube and frame seat structure through the Modal Integration method, at last this paper analysis their free mode and get the characteristic of the tube and the frame seat structure.

## The method of modeling multi-flexible-body

Multi-flexible-body dynamics is the synthesis and promotion of multi-rigidbody dynamical, mainly focuses on the effect of flexible. There are many methods to analysis multi-flexible-body, this paper introduce Flexible-body Discretization Method and Modal Integration Method based on ADAMS. ADAMS describe object's spatial configuration with Cartesian coordinates and Euler parameters and solve sparse matrix with Gear rigid integral algorithm ADAMS/View 与 ADAMS/Solver.

### 2.1 Flexible-body discretization method

Flexible-body Discretization Method proposed by Houston in 1981 firstly, and Amirouche, Zhang Da-jun and Liu You-wu improve this method. The basic idea is using imaginary flexible connection to connect limited number of rigid body, and using discrete rigid body to describe mass and inertia characteristics of flexible body. At last, dynamics equation is established by the elastic and damping characteristics of the flexible body. Because of using Finite segment method to build multi-flexible-body model as rough as using rigid body modeling, so it is not applicable for modeling complex multi-flexible-body model.

### 2.2 Modal integration method

Modal Integration Method regards multi-flexible-body as the nodes of finite model, linear motion of every node could approximate by linear superposition of modal or modal vector. Modal Integration Method could build complex shape flexible body, more applicable to the modeling of complex multi-flexible-body system.

ADAMS provides two method to model flexible body, one is exporting modal neutral file by Nastran, ABAQUS, ANSYS, I-DEAS and other professional finite element analysis software. The other is using modal neutral file to generate flexible body directly by ADAMS. The above two ways are needed to establish modal neutral file which include geometric information, node mass and inertia, modal, modal mass and modal stiffness and other information about flexible body. Modal integration method can model complex flexible body which has shape parts, and Finite segment method is mainly used to model simple flexible body.

Then, based on modal integration method, this paper will build the flexible body model of frame

seat and the tube of by import the MNF modal neutral file into ADAMS which generate by the ANSYS Workbench software.

### Flexible body modeling based on Workbench

The frame seat is the main part to bear capacity on weapon station, when we build the dynamics model of weapon station, we should concern about the influence of the frame seat deformation on weapon station dynamic characteristics. Gun tube is a slender rod, the main modal focus in the low order frequency, bend and twist are easily arouse, so we will build the flexible body modeling of tube and frame.

#### 3.1 Simplified model

Model simplification only simplified off bolt hole and chamfering, retention model of overall structure as far as possible, for truly reflect the structural characteristics. Application *RBE2* unit to establish a *MPC* (Multi Point Constraint) of the tube and bracket, *MPC* is a constraint on the node, for the flexible body rigid connection here. The flexible body model of tube and bracket are shown in Figure 3 and Figure 4.

Three *MPC* is set on the body tube, The 1 is the connection of body tube and the tail of the casing body, 2 is the connection of tube hoop and gas, 3 is the connection of tube and recoil device. Seven *MPC* is set on the bracket, 1-2 is the connection of the trunnion and cradle, 3 is the connection of elevating mechanism, 4 is the connection of the control box, 5 is the connection of turret race, 6-7 is the connection of smoke launcher. By setting the rigid connection point, shooting load can make the true transfer between the rigid body and flexible body. In addition to other photoelectric instrument and equipment is installed on the bracket, they change the quality and moment of inertia of the whole weapon station, and affects the dynamic characteristics of the whole system, so putting them as a whole construction which is fixedly connected on the bracket.

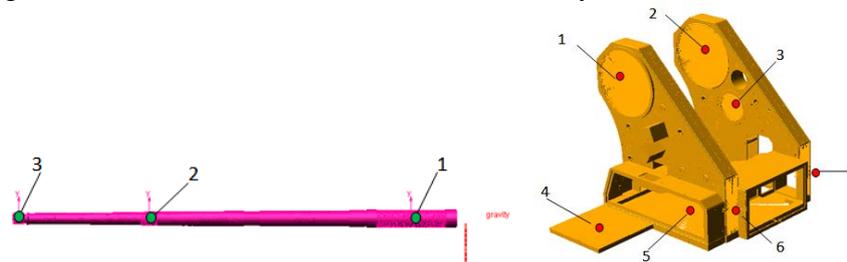


Fig.2: The flexible model of tube Fig.3: The flexible model of bracket

#### 3.2 Analysis of tube free modal

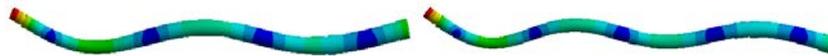
Select the first 20 order modals. First 6 order modals of tube are rigid modal (modal value is zero), the 7-20 order modals as shown in table 1, vibration type as shown in figure 4.

Table 1: The frequency of first 20 order modal of tube

order	frequency	Remarks	order	frequency	Remarks
7	174.47	Bending	14	1401.3	Bending
8	174.47	Bending	15	1722.2	Torsion
9	446.37	Bending	16	2041.3	Bending
10	446.39	Bending	17	2041.5	Bending
11	860.87	Bending	18	2703.3	Torsion
12	860.92	Bending	19	2775.0	Bending
13	1401.2	Bending	20	2775.3	Bending



The 7 modal of vibration The 9 modal of vibration



The 11 modal of vibration The 13 modal of vibration

Fig.4: Tube vibration diagram

### 3.3 Analysis of bracket freemodal

Select the first 20 order modals. First 3 order modals of tube are rigid modal (modal value is zero), the 4-6 order modals are local modal, the 7-20 order modals as shown in table 2, vibration types as shown in figure 5.

Table 2: The frequency of first 20 order modal of bracket

order	frequency	Remarks	order	frequency	Remarks
7	67.744	Bending	14	281.48	Bending
8	90.005	Torsion	15	301.31	Local
9	109.24	Torsion	16	322.47	Torsion
10	134.56	Bending	17	335.55	Torsion
11	225.13	Torsion	18	364.76	Torsion
12	233.39	Torsion	19	383.89	Local
13	244.68	Torsion	20	398.71	Local

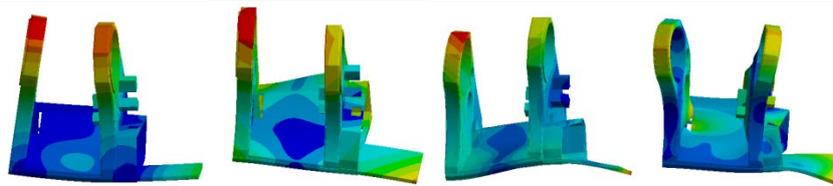


Fig.5: vibration diagram (The 7, 8, 10, 14 modal of vibration of Bracket)

### Conclusions

Through the analysis of modal:

i) The first 20 order modals of tube is mostly bending modal, the order modal of low frequency is mostly bending modal, this indicates that tube is easy bend deflection. The tube is an axisymmetric structure that the ratio of length to diameter is relatively large, so that the bending frequency is usually appears in pairs in two mutually perpendicular planes.

ii) The first 20 order modals of bracket is mostly torsion modal, the order modal of low frequency is mostly torsion modal, this indicates that tube is easy torsional deflection. The bracket is an axisymmetric structure that has complex shape, so that the torsional frequency is relatively complex, usually appear in the planes of trunnion and bottom.

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