Abstract: Cone pyrolysis liquefaction reactor is the key core device of biomass energy production equipment. The study of the dynamics of the cone is of great significance to the bioenergy conversion technology. Proper control of the movement time of the heat carrier in the cone can prevent it. Biomass superheated carbonisation can increase the ratio of gas and liquid formation. It is a difficult and key technology in the design of the cone pyrolysis liquefaction reactor. The kinetic differential equation of the relative motion of heat carrier particles can be obtained by kinetic analysis and calculation. It can play a key role in the in-depth study of the structural size design of the cone and the optimisation of the structural size parameters. This study conducts a dynamic simulation of the physical simplification model of biomass energy production equipment. The computer simulation software was used to simulate the running process of the simplified cone mechanism model. A reasonable physical prototype that meets the process parameters is designed. In view of the above complex dynamic phenomena, it is necessary to comprehensively analyse various methods of dynamics, and use appropriate numerical analysis and computer-aided design methods to carry out system equipment research and design.

1 Introduction
The key equipment for biomass pyrolysis to produce biofuels is the cone pyrolysis liquefaction reactor. The design and research problem of this equipment is a major problem in the development of production equipment [1–5]. The structural parameters of the cone pyrolysis liquefaction reactor, internal coating, Factors such as the angular velocity of rotation and the particle size of the material have a great influence on the ‘oil yield’, and the optimisation of these parameters cannot be obtained through real experiments. To solve the above problems, only by using institutional analysis, dynamic analysis and virtual simulation technology can be achieved. Therefore, the virtual simulation research on the heat carrier of the cone reactor is an important step to promote the biomass energy conversion technology to ‘engineering’ and ‘commercialisation’ and to the scale. This is of great significance for in-depth research and the wider application of biomass liquefied fuel. The design of the rotary cone rapid cracking liquefaction reactor is the key to the research of this technology [6–10].

This paper focuses on the time control of biomass cracking reactions. The two key elements involved are the thermal energy required for biomass cracking and the time control of cracking [11–15]. Only by fully optimising of these two elements, the equipment can work efficiently. The time control problem needs to be completed by dynamic theory combined with mechanical system optimisation design. With the multi-body dynamics simulation technology, experimental design, simulation dynamics analysis and experimental results demonstration, a variety of dynamic simulation results can be obtained, and finally, the time control optimal design of biomass cracking reaction can be realised [16–19].

2 Role of mechanical system dynamics analysis and simulation in the design of the rotating cone of the energy equipment

2.1 Application of dynamic analysis of modern mechanical systems
Mechanical system dynamics analysis is especially important in the analysis of various characteristics of digital functional prototypes. It is based on the mechanical system that a digital functional prototype can be constructed from the system level. It is precisely because of the maturity of mechanical system dynamics analysis and simulation technology that virtual prototyping technology has entered the analysis at the system level. The mechanical system constitutes the subsystems of other subsystems in the product system, such as hydraulic, control, electronics, etc. The results of mechanical system dynamics analysis provide boundary conditions for other characteristics analysis. Specifically, the execution system of the hydraulic control system and the electronic control system is generally a mechanical system, and only the analysis of the hybrid mechanical system and the hydraulic control system or the electronic control system performs a true system-level analysis. Furthermore, in the finite element static or dynamic analysis of complex components, it is necessary to perform a dynamic analysis of the mechanical system, including these components, to obtain a reaction force, thereby providing boundary conditions for finite element analysis.

2.2 Role of dynamic design in biomass conversion technology
The study of the dynamics of the cone-shaped pyrolysis liquefaction reactor is of great significance to the bioenergy conversion technology. The structural size parameter design and dynamic relationship of the cone pyrolysis liquefaction reactor are various design parameters of the cone. The kinetic problem of the heat carrier is closely related, and the movement time of the heat carrier in the rotating cone is properly controlled, i.e. the carbonisation of the biomass can be prevented, and the proportion of gas generation can be increased, which is a difficult point in the design of the cone pyrolysis liquefaction reactor. The key technology, how to get the motion law of the heat carrier relative to the cone in the rotating cone, has become a problem that must be solved. The kinetic differential equations of the relative motion of the heat carrier particles can be obtained by the analysis and...
should at least reach of the whole. If the radial velocity is zero when particles move relative function between particles should not be ignored. The calculation of the kinetics, which can play a key role in the in-depth study of the structural size design of the cone and the optimisation of the structural size parameters.

In view of the above complex dynamic phenomena, various methods of dynamic analysis are needed, and appropriate numerical analysis and computer-aided design methods are used for research design.

### 3 Model and dynamic differential equations

#### 3.1 Working principle of the cone thermal cracking reactor

The mechanism performs the circulation of the heat carried by the pneumatic device of the throat principle and the cyclone separator. The cone pyrolysis liquefaction reactor is the main reactor, and the reactor has inner and outer cones, a feeding system and a separator interface. The heat preservation device and the power input shaft are composed of the mechanism, and the mechanism is appropriately simplified to grasp the main contradiction for design calculation.

Where gravity $G$ is a mixed particle composed of heat carrier and biomass, friction $F = fN$, $N$ is the positive pressure, and the impeding inertial force of the particle is $F_e^*$, the Coriolis inertial force is $F_c^*$. By the dynamic analysis of the overall kinetic energy and work of the mechanism, the following relationship can be obtained. We have to considerate from the overall, because the motions of particles which just to the cone bottom are extremely complicated, the initial position and velocity are uncertain, the relative function between particles should not be ignored. The motion state of most particles can be regarded as the motion state of the whole. If the radial velocity is zero when particles move upward following the cone surface, then the angular velocity should at least reach $\omega_0$.

There is some motion situation mainly. Particles move to the rim zone from the bottom circular surface centre zone, when $\omega$ raises to $\omega_0(\omega_0 < \omega_0)$. After particles move to the rim zone, particles will move upward following the cone surface because of the radial velocity. The radial velocity will reduce in the upward process. If the angular velocity $\omega$ rises to $\omega_0$ in this process, particle motion enters the next period of the conical surface. If radial velocity reduces to zero and angular velocity $\omega$ is not increased to $\omega_0$, then particles will slip downward following the conical surface until angular velocity $\omega$ increases to $\omega_0$ and enter the next period of motion on the conical surface. We suppose the later situation not to exist, the anterior batch particles which are downward and the later batch ones which are upward will clash into each other, and then particles will enter the next period of motion after rising appropriate height. The condition of entering the next period first stage is

$$r = r_0$$

$$r = r_0 + \Delta r$$

$$r = 0$$

$$\omega = \omega_0$$

#### 3.2 Parametric model and solution for mixing particles in a rotating vertebral body

To achieve the optimal design of the cone, it is first necessary to establish a parametric model so that parametric analysis can be performed. ADAMS provides powerful parametric modelling capabilities that are set to design variables that can be changed by determining the design variables associated with the optimisation goals based on the requirements of the optimised design. When optimising the design, as long as the value of these design variables is changed, a new virtual prototype model can be obtained. In addition, the value range of the design variables can be designed in advance, and it is convenient to carry out the historical simulation experiment when optimising the design.

Multi-rigid systems have a variety of parametric modelling methods: parametric point coordinates, parametric design variables, parameterised expressions, parametric motion patterns, etc. This simulation uses parametric design variables, which will rotate the cone; the taper angle $\alpha$, the cone height $H$ and the upper base radius $R$ of the cone are set as design variables. When the parameter value of the above design variable is changed, the properties of the object associated with the system are also updated; parameterised the model allows the user to easily modify the model without considering the association changes between the models and can achieve the purpose of optimising the model. If parameterised point coordinates are used, the point coordinates should be used for the geometry, the position of the constraint point and the position of the drive. When the point coordinates are optimised, the value is modified and the associated object is automatically modified. Parametric expressions are the most basic way to model parameterisation. This method can solve the problem of parametric modelling of various models.

### 4 Results

For the above kinetic calculations, the spatial three-dimensional motion trajectory of the mixed carrier of the heat carrier and the biomass can be obtained by computer simulation. Using computer software to simulate and analyse the dynamic equations [18, 19]. In the following simulation graphics, we can get the force analysis of the heat carrier along the horizontal plane in Fig. 2, and the force analysis of the heat carrier along the vertical plane in Fig. 3, the Test design process setup in Fig. 4, the Optimize settings of the experimental design process in Fig. 5–9.

### 5 Conclusion

i. In this paper, the detailed analysis of biomass reuse was carried out, and the key equipment for biomass bio-flash production of bio-fuels in the biomass utilisation method was studied. In particular, the movement of biomass in rotating vertebral body under media-driven conditions was studied in detail. Studies have shown that the time and motion of the power rotating device are controllable. In this way, the time of the biomass flash cracking process can be controlled according to a plurality of production-related factors, thereby achieving the purpose of high-efficiency oil production and reducing exhaust gas pollution.

![Fig. 1 Force analysis of the heat carrier along the slope of the cone](image1)

![Fig. 2 Force analysis of the heat carrier in the vertical direction](image2)
ii. The multi-body dynamics of a mechanical system is used to study the dynamics of rotating vertebral body. The dynamic model and computer trajectory simulation of the complex system are established based on the movement of biomass and carrier in the rotating vertebral body and computer simulation technology. The results show that the device system can be described by dynamic theory and can obtain accurate computer trajectory simulation conclusions.

iii. With the progress of national air pollution control, this technology will inevitably play a greater role in future environmental protection. The equipment can be used to regenerate biomass cracked fuel and can also be used for flash cracking of various domestic garbage. In order to reduce the amount of underground landfill for waste, it is also suitable for environmental protection equipment for underground pollution control. Through reasonable reasoning and improved optimisation design, combined with experimental techniques, the system logic theory of the flash cracker can also be used in other chemical production processes.

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