Study on Feed System of Iodine Cusped Field Thruster

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Abstract: The deep space exploration missions and rapid development of microsatellites have placed higher demands on the electric propulsion system. Studies find that the use of iodine propellant can reduce the mass of the storage system and launch cost compared with the traditional xenon propellant. However, iodine propellant characterized by being easy to condense at normal temperature and strong corrosiveness brings great difficulty to the design of the feed system. After thorough investigation, this paper analyzes various technical difficulties and establishes a feed system suitable for iodine propellant with high temperature resistance, corrosion resistance, good airtightness, easy observation and the ability to control temperature and flow. At the same time, the exhaust gas treatment part is designed for the system to reduce pollution. Thermal analyses are done using the designed three-dimensional diagram of the system. According to the calculation results, the heating power, temperature measurement position and system materials of each part are determined. Furthermore, in this paper the system is used to carry out the experiment of compatibility of iodine propellant, and ignition of the cusped field thruster to realize flow control. The experimental results show that the iodine cusped field thruster can be ignited successfully.

I.Introduction

AT present, the small satellite platforms in china all adopt chemical propulsion, and the jet speed is low, which causes the satellite to carry more fuel and less payload, which limits the function and application of the small satellite. Compared with chemical propulsion technology, electric propulsion ejects high-speed charged particles, which can greatly reduce propellant fuel, prolong satellite life and improve satellite positioning accuracy. But at present, the mainstream ionic and Hall thrusters generally use inert gas Xe as working fluid, which requires ultra-high pressure storage, large tank thickness and weight, and complex flow control system. As a result, the dry weight of the system is large and it is not suitable for small satellite missions.Therefore, it is of great significance to study the alternative propellant of Xe.

A. Advantages of Iodine Propellant

Alternative propellant need to meet the requirements of convenient storage, easy ionization, non-toxicity, low price and so on. As early as the 1960s and 1970s, Hg was studied as a propellant, but it was not used because of its toxicity. Recent studies on alternative propellant have been carried out in Europe, America, Russia and other countries, mainly focusing on Kr, I and other metal propellant such as Mg, Zn, Bi and so on. The properties of these propellant are shown in Table 1 [1].

Table 1 Alternative propellant property[1]

propellant	melting point /℃	boiling point /℃	ionization energy /eV	atomic mass(amu)	Cost per kg in 2005
bismuth（Bi）	271	1559	7.3	209.0	$ 6
cadmium（Cd）	321	765	9.0	113.4	$ 25

cesium（Cs）	29	685	3.9	132.9	＄40000
iodine（I）	113	182	10.4	126.9	＄484
krypton（Kr）	—	—	14.0	83.8	＄295
mercury（Hg）	-39	357	10.4	200.6	＄4
xenon（Xe）	—	—	12.1	131.3	＄1138

From Table 1, it can be seen that metal propellant have the advantages of low ionization energy and low price, but the melting point of metal propellant is very high, which brings great difficulties to the design of the supply and storage system. In addition, the low evaporation pressure of metal working fluids can easily lead to short-circuit deposition caused by working fluids deposition in various parts of spacecraft, and then cause system faults. As an inert gas, krypton is inexpensive, but its ionization energy is higher and its relative atomic mass is smaller. Therefore, the thrust and efficiency of krypton propellant will generally decrease. In addition, krypton storage pressure is low, requiring large storage tank volume. Compared with the above working fluids, the sublimation temperature of iodine working fluids is lower and the thermal design of the system is less difficult. Pipeline pressure is low and easy to control. In addition, iodine working fluid has lower ionization energy and higher relative atomic mass. As a substitute for iodine propellant, the thruster has better efficiency, thrust and other parameters, and the price is not expensive.

B. Cusped Field Thruster

Unlike the Hall thrusters, the Cusped field thruster (CFT) uses the same-pole permanent magnets to form a magnetic field to constrain the electrons [2, 3], as shown in Figure 1. This thruster was first proposed by THALES Electron Devices GmbH (TEDG) in Germany [4,5], with a long service life [6], and the thrust is continuously adjustable in a wide range. It is expected to be applied to the drag free control in space missions such as gravitational wave detection. [7, 8, 9].

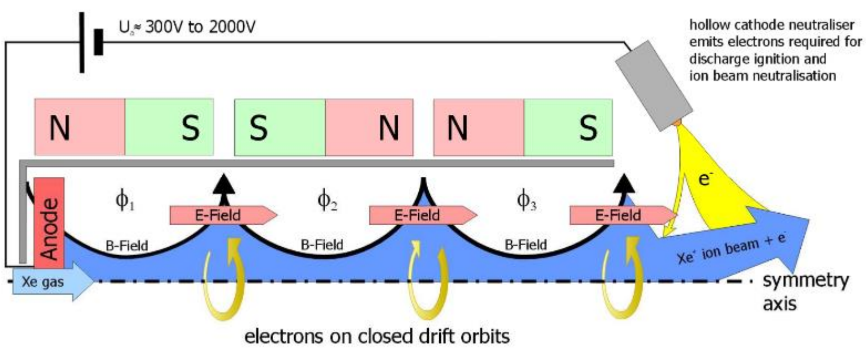

Figure 1 Principle diagram of cusped field thruster[2,3]

C. Research Progress on Feed System

Seen from the international development situation, iodine has received extensive attention as an electric thruster. At present, various countries have shifted their focus to iodine. Various key issues in engineering applications have been resolved since 2011, and flight tests are about to take place, and are expected to be widely used in the near future. However, there are relatively few studies on electric thrusters based on iodine as propellant in China.

At present, there are mainly three methods for flow control, including tank temperature control method, thermal throttling method and pressure control method.

The temperature of the iodine working fluid satisfies the corresponding relationship with the saturated vapor pressure, as shown in Fig. 2 [10]. Therefore, the tank temperature control method refers to indirectly controlling the pressure and flow inside the pipeline by controlling the temperature of the tank. However, this control method has a long response time and poor control accuracy. The US Busek company has tested this method and found that the discharge current oscillation is more severe. By adjusting the tank temperature, the instability of the discharge current can be reduced to a few percent, but this process lasts for several minutes [11].

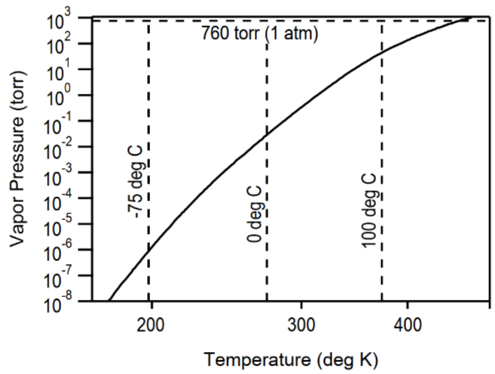

Figure 2 The vapor pressure curve for molecular iodine （I2）[10]

The structure of the thermal throttling device is shown in Figure 3. Iodine is stored in a storage tank, and iodine is heated by a heating resistor and then sublimated into a thermal throttle valve in the sublimator. The method controls the gas temperature to change the viscosity of the gas, affecting the pressure drop of the gas inside the tube, thereby achieving the purpose of controlling the flow rate.

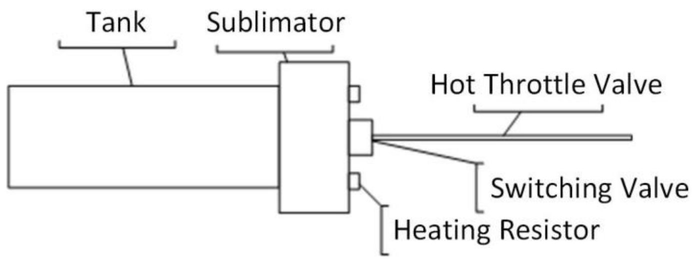

Figure3 Schematic diagram of heat throttling device[12]

The thermal throttling method is simple in principle and has no moving parts. It has been used by Busek's iodine propellant Hall thruster prototype and is used to perform BIT-3 RF ion space missions. In addition, the University of Pisa has adopted this solution. However, the thermal response time of this scheme is long, the flow rate is greatly affected by the upstream and downstream pressures, and the control precision is low. At present, the thermal throttling combined with the pressure feedback is used to improve the control precision, and the control system is shown in Fig. 4.

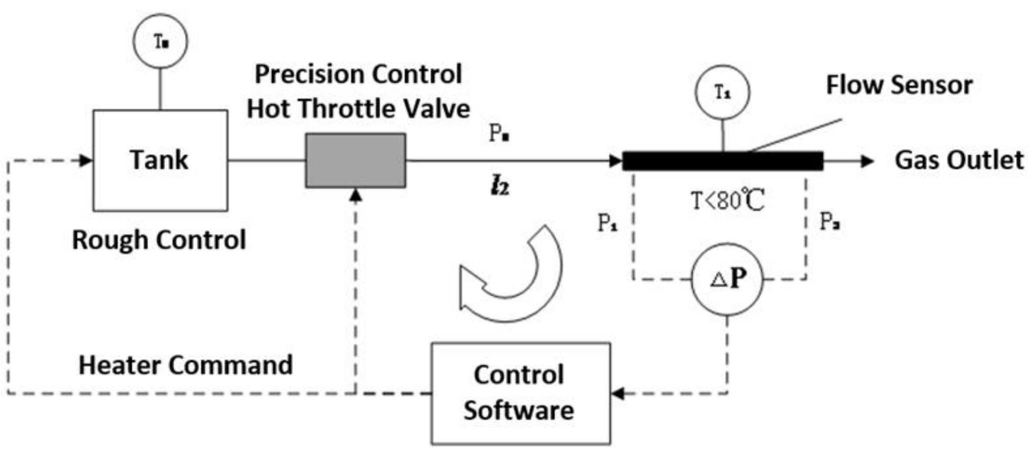

Figure 4 Schematic diagram of thermal throttle control system with thermal pressure feedback

The flow rate is coarsely adjusted by adjusting the temperature of the iodine tank. In order to reduce the reaction time, precise control can be carried out in the form of thermal throttling. This is like a proportional flow control valve, and feedback can be provided by pressure, current, and other means.

When the flow of gas is in a stagnation state, the flow is approximately proportional to the pressure. In order to take advantage of this relationship, we first establish the relationship between the flow and the upstream pressure by means of the propellant, and then calibrate the relationship between the flow of the iodine propellant and the upstream pressure of the syringe by means of the compressible acoustic wave equation [13].

The pressure control method is to control the flow rate of the front end of the valve through a proportional control valve to achieve the purpose of controlling the flow. Generally, the front end pressure is 100 Torr, the tank temperature is 90 ° C, and the line temperature is maintained at 130 ° C. This control method is shown in Figure 5 [14, 15]. The system uses a discharge current as a feedback control temperature controller.

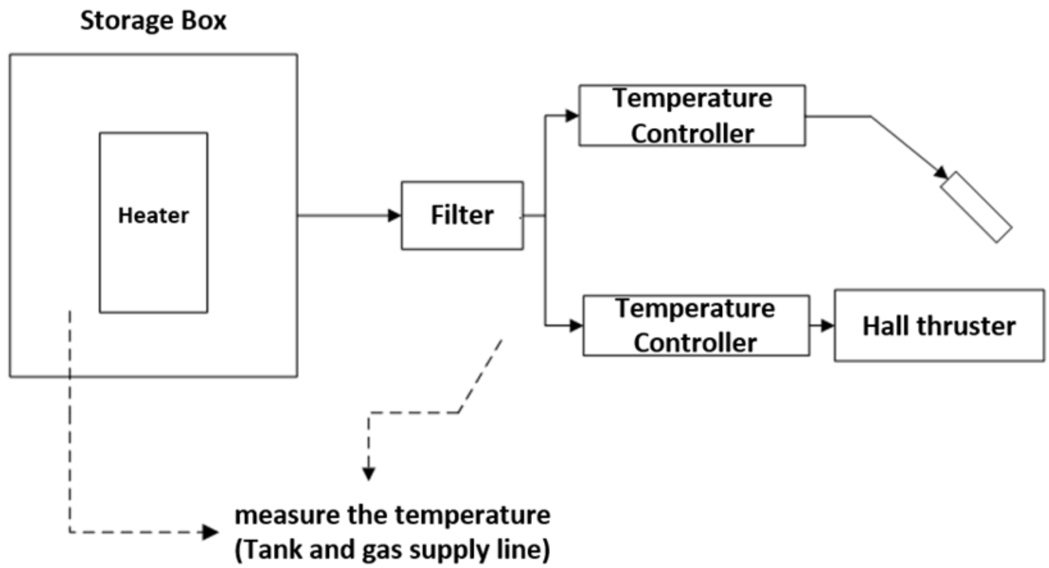

Figure 5 Schematic diagram of pressure control system

The ISAT mission uses a pressure control method based iodine propellant feed system design, and its structure is shown in Figure 6 [16]. There are two flow proportional control valves in the system for flow control of the cathode and thruster.

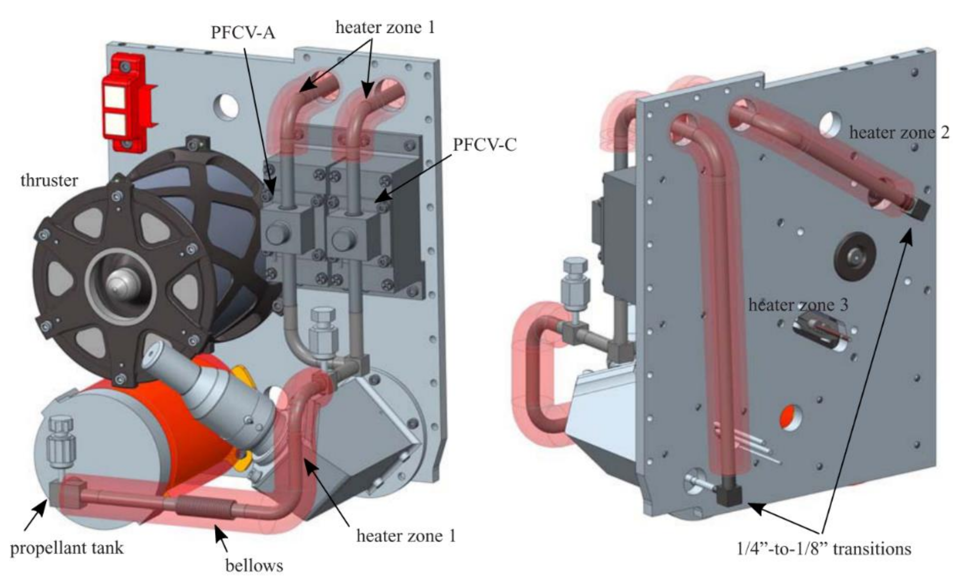

Figure 6 Schematic diagram of iodine feed system[16]

The storage system has a total of six heating zones, each of which is individually controlled. The iodine tank and two flow control valves occupy three of them, and the remaining three are used to heat the piping, one on the front and the other two on the back. There are three heating systems in the pipeline temperature control because the front is facing the space environment and the back is facing the interior of the spacecraft. The difference in ambient temperature between the two causes a large difference in the amount of heat radiation, so different heating systems are required for heating.

Although the pressure control method has higher precision and faster response, the structure is complicated and the system quality will increase. In addition, during the test, it was found that the proportional control valve was prone to problems under the action of iodine. Timothy et al. experienced an abnormal change in discharge current during an 80-h test period. Later, after analysis, it was found that this problem was caused by the corrosion of the valve by the iodine propellant [17].

D. The Main Content of This Paper

This paper explores the design of the iodine cusped field electric thruster feed system, and concludes a set of feed systems which can overcome the high temperature and iodine vapor corrosion, and has good airtightness, easy observation and temperature and flow control. At the same time, the exhaust gas treatment part was designed for the system to reduce pollution. The ANSYS thermal analysis was used to determine the heating power, temperature measurement position and part selection of each part. Furthermore, the ignition experiment of the cusped field thruster was carried out to realize the initial flow control.

II.Feed System Design

The design of the feed system is very important for the smooth operation of the iodine cusped field thruster.The design difficulties of feed system mainly lie in material selection, flow control and temperature control.Next, solve these problems one by one.

A. Iodine Tank

Iodine tanks are used to store iodine and require long-term contact with iodine. Therefore, all parts that are in direct contact with iodine are made of corrosion resistant materials. And the gas supply is realized by heating the iodine tank, and the high temperature makes the iodine element sublimate, and the material with high temperature and corrosion resistance is selected in the design. The tank itself consists of two flanges and a quartz tube, and the upper and lower flanges are connected by four bolts. The purpose of this configuration is to easily observe the state of iodine in the storage tank. In order to explore the factors affecting the flow rate, the parameters of the temperature and pressure in the iodine tank were measured, the temperature was measured by a thermocouple, and the piezoresistive gauge was used to measure the pressure. Due to the special nature of the propellant, both thermocouples and piezoresistive gauges are corrosion resistant and high temperature resistant. The actual design of the tank is shown in Figure 7.

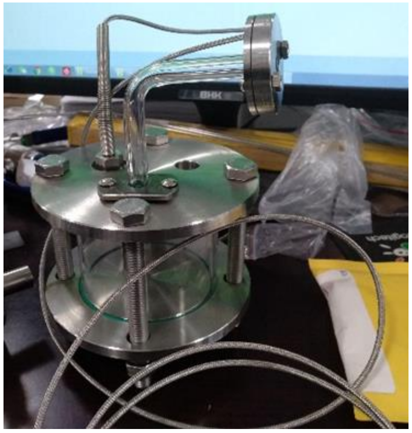

Figure 7 Iodine tank

Using this tank experiment, it was found that the system was not easy to disassemble, and it was difficult to measure the quality of iodine working medium in the storage tank. And after the tank is removed, the system is not sealed and will leak iodine vapor. In order to reduce the volume of the tank and facilitate heat transfer, the thermocouple and the piezoresistive gauge are removed. At the same time, in order to facilitate the flow calibration, the new tank designed is shown in Figure 8.

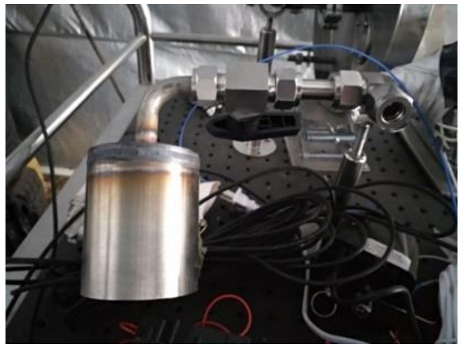

Figure 8 New iodine tank

B. Gas Guiding Line

Due to the various needs, the air guiding line is not only a variety of tubes. The first is the difference in the material of the pipe, and secondly, in order to obtain the parameters of certain parts and safety considerations, vacuum valves, piezoresistive gauges, etc. are added. Need to consider the problem of connecting the tube to each device.

The tubes are mainly composed of quartz tubes and metal tubes. Because you want to observe the state of iodine vapor inside some parts of the pipe, you need to use a transparent material. Heating distributes the entire pipeline, so the tube is resistant to high temperatures and corrosion. Considering economics, quartz was finally chosen. But the disadvantage of quartz tubes is that they are brittle. After observing the gas in the tube in the first experiment, a preliminary understanding of the state of the gas in the can was obtained, and it was found that the quartz tube was indeed easily broken. In the second test, the quartz tube was replaced with stainless steel 316, which increased the system strength.

Valves are used in many places in the system, and their functions are different. The valves are made of corrosion resistant stainless steel 316 and are leak proof. The specific function of each valve is described in detail in the Flow Calibration section below.

The piezoresistive gauges are selected according to their respective needs. Due to the different requirements of different measurement positions of the system, we have selected a variety of models. The main indicators are measurement range, heat resistance and corrosion resistance.

C. Heating System

A digital thermostat was used during the experiment to adjust and ensure that the temperature of the iodine meets the requirements. The temperature regulator uses PID control. The temperature regulator external circuit includes a temperature sensor, a heater power supply, a heating wire, an AC contactor, etc., and each object is insulated. The accuracy of the temperature regulator is determined by the resolution of the temperature sensor, and the actual temperature of the tank temperature regulator is shown in Figure 9.

Figure9 Heating system

D. Thermal Throttling Tube

In order to precisely control the flow through the thruster, a capillary tube is used here as a thermal throttle tube and the flow rate is controlled by controlling the wall temperature. There are many types of capillary type applications, and the thermal throttling tube in Fig. 10 is 2 x 0.2 mm and the length is 200 mm. The material is stainless steel 316. The thermal throttling tube is heated by winding a heating belt, and the temperature is controlled by PID. Piezoresistive gauges are added to the upstream and downstream of the thermal throttling tube to measure the upstream and downstream pressure difference, which is convenient for studying the influence of temperature and pressure on the flow.

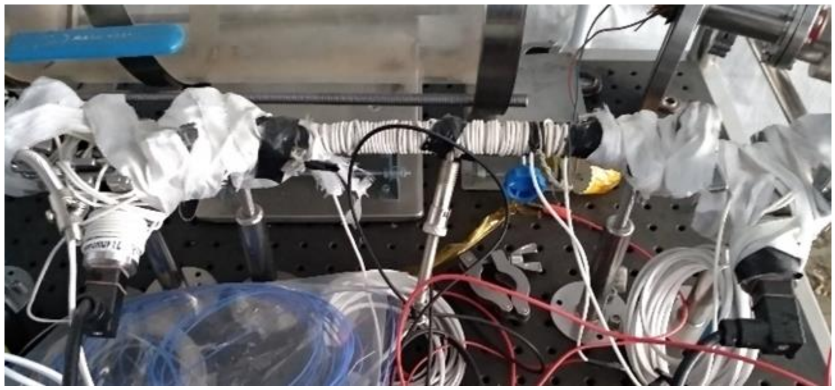

Figure10 Thermal throttling tube

III.Key Technologies in The Experiment

After designing the system, the accuracy of the control part is very poor, the temperature distribution is extremely uneven and even the instrument is damaged.The heating power of each part should be determined.Moreover, the relationship between temperature and flow rate is not known.Therefore, it is necessary to design a set of control and flow control scheme to find the suitable working range of thruster.At the same time, the compatibility of the materials was also verified.

A. Temperature Control

The temperature of the storage system is controlled by the PID to sublimate the iodine in the tank and not deposit in the pipeline. However, the weak part of the system that is prone to deposition and the location where heat is concentrated are not clear. In order to understand the temperature control of the feed system in a deeper level, the thermal analysis of the feed system was carried out. The calculation results provide a theoretical basis for material selection, because some components are currently not available in the market for high temperature resistance and are easily damaged. In the improvement, the parts which are prone to iodine deposition and heat accumulation are respectively treated accordingly. It also has a guiding role in the selection of the heating belt, and the approximate power of the heating belt is obtained.

Create a thermal model in SolidWorks and analyze it using ANSYS. The system thermal model is shown in Figure 11, including iodine tanks, conduits, on-off valves, three-way connector, vacuum quick-connect fittings, ferrule fittings, hoses, and thermal throttling tubes.

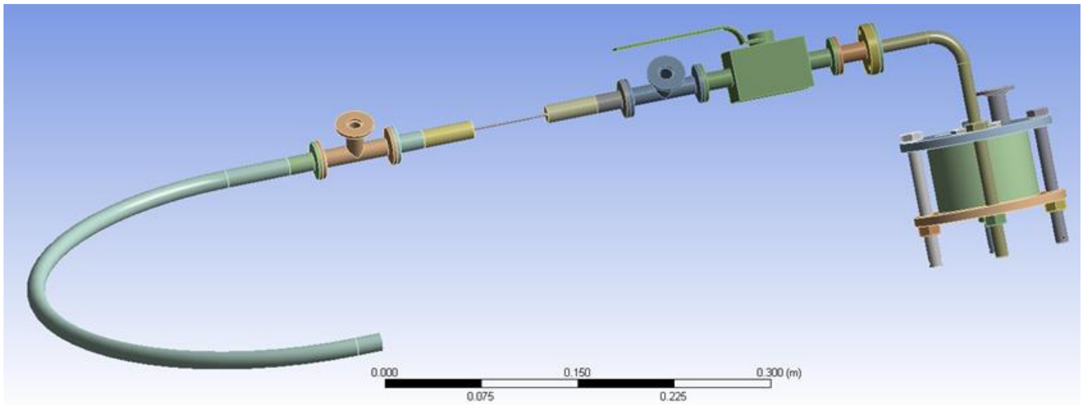

Figure11 The thermal model

Thermal control components include thermocouples, heaters, insulation, and PID controllers to ensure that the propellant flows into the propeller and cathode to the desired temperature range. The iodine tank, the upstream pipe of the hot throttling pipe, the downstream pipe of the hot throttling pipe and the hot throttling pipe have their own independently controlled heaters and insulation layers. The iodine tank, the hot throttling tube and the upstream and downstream pipelines of the hot throttling tube are heated by an electric heater, and the temperature of the iodine tank is adjusted by the temperature of the saturated iodine vapor measured inside the iodine tank to make the iodine tank temperature Stay within the required range.

The engineering software ANSYS is used to analyze the heating condition of the storage system, and the temperature distribution of the storage system is obtained. The Anysys thermal analysis process is as follows:

（1）Building the model: Because the model built in anysy is very complicated and the function is not complete, we use Solidwords 3D software to build the model and import it into the workbench. Parts such as small screws have no effect on the thermal design and are therefore neglected when performing thermal design.

（2）Setting physical property parameters: In the steady-state thermal calculation, the main physical parameters include the thermal conductivity of the material, the emissivity of the material, the density of the material, and the specific heat capacity. The thermal conductivity generally varies with temperature, so focus on it. The material library lacks the parameters of the materials needed for the simulation, so we only need to set the thermal properties of the stainless steel 316, iodine and other materials. After consulting the thermal manual and relevant online data, the relevant physical parameters are obtained.

Table2 Stainless steel characteristic

strength of extension（MPa）	offset yield strength（MPa）	elongation（%）	density（g/cm^3）	melting point（℃）
515-1035	205	40	7.93	1398-1454
specific heat capacity（$KJ\cdot kg^{-1}\cdot K^{-1}$）	heat conductivity（$W\cdot m^{-1}\cdot K^{-1}$）	expansion factor（$10^{-6}\cdot K^{-1}$）	specific resistance（$10^{-6}\Omega\cdot m$）	longitudinal modulus of elasticity（KN/mm^2）
0.5	16.3	17.2	0.73	193

Table3 Quartz glass property

compressive strength（MPa）	rupture strength（MPa）	strength of extension（MPa）	density（g/cm^3）	Young modulus（Gpa）

800-1000	65	49	2.53	82
specific heat capacity (cal·g^{-1}·K^{-1})	heat conductivity (W·m^{-1}·K^{-1})	expansion factor (10^{-7}/℃)	Poisson's ratio	dielectric constant
0.018	1.5	5.5	0.17	3.7

(3) Define the model parts materials: According to the materials of different parts of the thruster, set the materials in the material library: stainless steel 304, stainless steel 316 and iodine.

(4) Set the contact conditions: the relevant parts are too close, the software will automatically generate the contact surface, however some contact surfaces do not exist, so we must check each contact surface one by one, especially between the storage tank and the iodine vapor Contact surface. We can set the contact thermal resistance to 0 for the surface we want to divide the part into for the convenience of setting up the heat source.

(5) Dividing the grid: For parts that are not important, the grid is set to a larger size and the grid is smaller. Due to the small size of the tank and the conduit, our grid association center is set to refine, the global unit size is set to the default value, the transition is set to slow, and the span center angle is set to refine (36°~12°). Since the mesh of the vacuum valve and the tank is not detailed enough, the local unit refinement of the grid is performed. As the grid quality criterion, the average value of the skewness generated by the above parameters is 0.31817. The specific distribution map of various distortion elements is as follows. The smaller the distortion is, the better the grid effect is, so the grid is reliable. We use an unstructured grid and then generate a mesh.

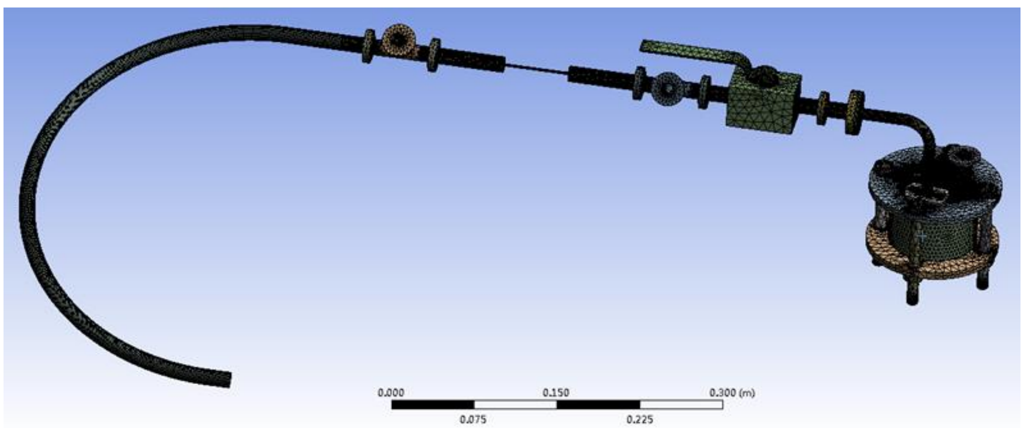

Figure12 Feed system after grid division

(6) Setting boundary conditions: According to the characteristics of the work of the storage system, the boundary conditions are set. The tank contains both iodine solids and sublimed iodine vapor, and the flow of iodine vapor affects the temperature throughout the system. The heating system and the outside world also perform convection to generate energy loss. The convective heat transfer set in the simulation is the total energy provided by the heater minus the energy carried away by the iodine medium and lost to the outside world. The storage tank, the upstream and downstream piping of the hot throttle tube, and the thermal throttle tube each have their own heat source, for a total of four heat sources. The ambient temperature is set to the default value of 22 °C. The heat flow rate of the storage tank is set to 25w, the heat flow rate of the upstream pipe of the hot throttle pipe is set to 7w, the heat flow rate of the hot throttle pipe is set to 0.4w, and the heat flow rate of the downstream pipe of the hot throttle pipe is set to 7w.

In addition to this, there is radiation from the outer casing to the space, and face to face radiation of space is formed inside the feed system. We set the parameters according to the emissivity found through the literature and the network. Note that the number of each space is different for face-to-face radiation.

The results of the thermal analysis are shown in Figures 13 and 14. The temperature of the storage tank is constant at about 100 °C. After the temperature in the pipeline stage is about 135 °C, the temperature starts to be constant, and all aspects meet the requirements. The simulation result is the distribution when the storage system works for a certain period of time to reach a relatively stable state.

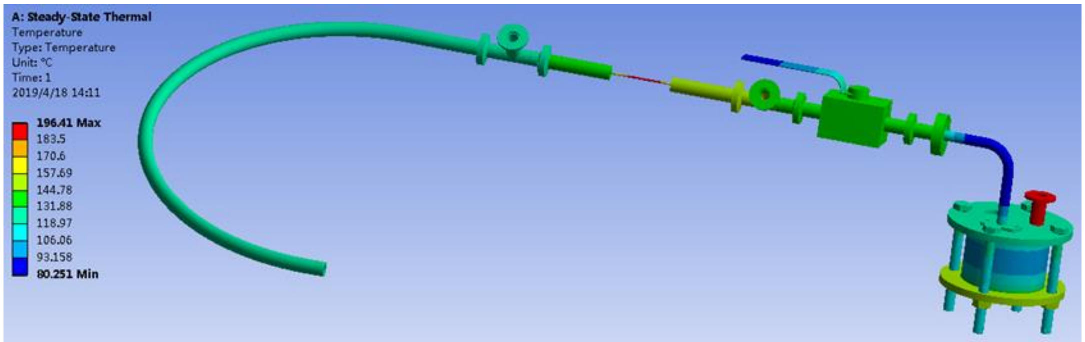

Figure13 Thermal analysis results of feed system

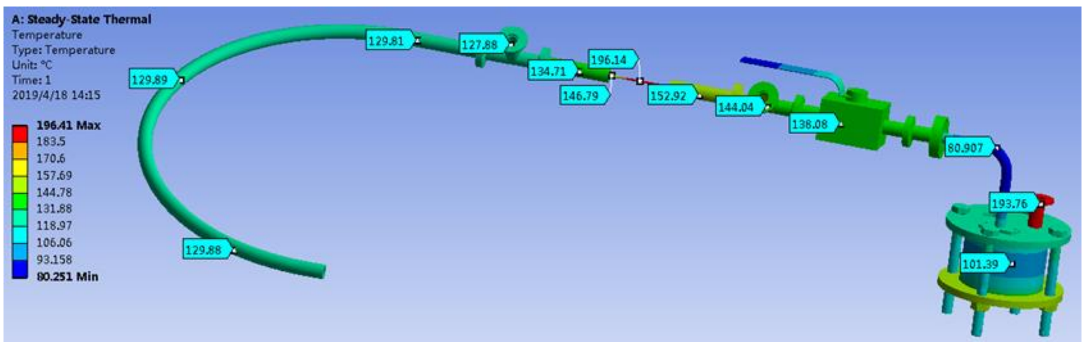

Figure14 Thermal analysis results indicating temperature at key locations

The calculation results show that the superheat in the middle of the hot throttling tube reaches about 195 °C, and the temperature distribution of the whole thermal throttling tube is uneven, and the edge is around 145 °C, which has an effect on the thermal throttling effect. It is necessary to adjust the heating power of different parts of the thermal throttle to make the temperature as uniform as possible. Secondly, the temperature of the glass elbow is about 80 °C, and the heat dissipation is easy to deposit. In actual operation, the temperature is raised as much as possible. In addition, heat build-up at the vacuum quick-connect joint above the iodine tank reached approximately 194 °C. This makes it difficult to select a pressure measuring device. The corresponding measures taken are sparse when wrapping the heating belt. In addition to the above three, the temperature at other locations is relatively stable at approximately 130 °C.

B. Flow Control

Analysis of common flow control methods and found that all three control schemes have advantages and disadvantages. The tank temperature control method indirectly controls the pressure and flow inside the pipeline by controlling the temperature of the tank. The response time is long, the control precision is poor, and the working process is unstable. Although the pressure control method has higher precision and faster response, the structure is complicated and the system quality will increase. In addition, it has been found that proportional control valves are prone to problems under the action of iodine.

The thermal throttling method is simple in principle, has no moving parts, has higher control accuracy than the tank temperature method, and is much less likely to fail than the pressure control method. Although this scheme has a large thermal response time and the flow rate is greatly affected by the upstream and downstream pressures, these disadvantages can be overcome by combining the pressure feedback. Therefore, thermal throttling becomes the preferred solution for our flow control.

The designed storage system is shown in Figure 15. There are two main places where the flow can be controlled. One is the storage tank and the other is the hot throttling tube. The temperature change of the storage tank controls the sublimation speed of the iodine element, and the temperature change of the hot throttle tube affects the viscosity of the gas inside the tube to control the flow rate. These are qualitative changes, and in order to quantitatively control the flow, the storage system needs to be calibrated. The system was calibrated with argon. In addition, the survey found that many current flowmeters are calibrated with nitrogen, and argon is a coefficient relationship. The significance is that after finding the relationship between the two, it is not necessary to study the flow control problem through the iodine propellant, and directly through the argon gas research. Because the parameters such as the iodine propellant flow pressure are not easy to measure, the system may be corroded during the experiment and may be toxic after leakage.

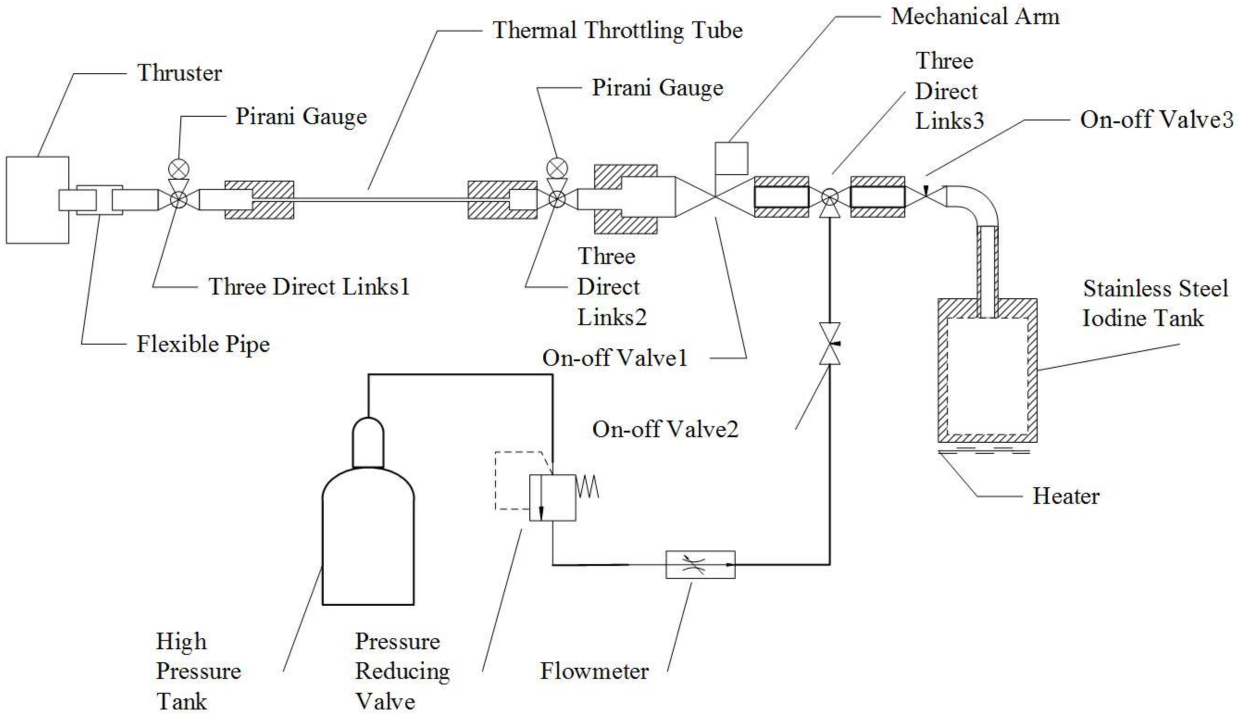

Figure15 Flow calibration system

Drawing on previous experimental experience, I designed a set of operational procedures to avoid the problems I encountered before. The operation process is as follows:

(1) Measuring the quality of the iodine tank before the experiment, installing the test bench

(2) Close the on-off valve 2, open the on-off valve 1 and the on-off valve 3, and vacuumize.

(3) The switching valve 3 is closed after a certain degree of vacuum is drawn.

(4) Heating the storage system, passing argon to remove residual iodine deposits and other gases. This process can take a long time. (If you are afraid of removing residual iodine, the gas will corrode the flowmeter, and the volatilization of the iodine will affect the quality measurement. You can remove the iodine and then open the canister but do not open the switch valve 3 to ensure the inside. Vacuum, then measure the mass, then install the flow meter. Then vacuum, then argon gas)

(5) Control the temperature of the system, keep it relatively constant, pass argon gas, measure the flow of argon gas. Some data points were obtained to facilitate comparison with iodine working fluid.

(6) Close the on-off valve 2, protect the flowmeter from corrosion, vacuumize, and set the temperature of the system to be the same as the argon gas just measured for comparison. After the temperature has stabilized, the on-off valve 3 is opened, timed, and gas is introduced. After a certain period of time, the on-off valve 3 is closed, the timing is stopped, and the quality is removed. Argon gas is used to clean the residual gas and deposits in the channel. This is a data point operation, the other points are the same.

(7) Compare the measured iodine with argon flow to find the relationship between the two. (probably there is a proportional relationship, the coefficient is obtained)

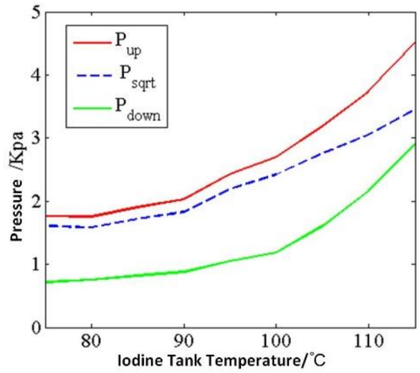

Figure16 Variation law of iodine tank temperature with upstream and downstream pressure of thermal throttling tube

Analysis of the experimental data, found that the data of the argon calibration has a certain regularity. When the flow rate is large, the upstream and downstream pressures and back pressure of the thermal throttle tube are increased. The increase in temperature of the upstream and downstream pipes of the hot throttling pipe or the hot throttling pipe will increase the pressure upstream and downstream of the thermal throttling pipe, but has little effect on the back pressure. The iodine vapor experimental data found that the data has the above argon characteristics. In addition, the flow rate of the storage tank is less than 50 ° C, the flow rate is almost unchanged, the temperature rises slowly from 60 ° C to 90 ° C, and the flow rate increases above 90 ° C. By querying the iodine sublimation formula, it is found that the temperature and flow are nonlinear, and the trend is the same, which can explain the above phenomenon.

IV.Ignition Experiment

The ignition test was carried out after the completion of the basic research work necessary for the experiment. Due to the small volume of the vacuum tank, the experiment used tungsten wire as the cathode. During the first experiment, both cathodes failed to ignite, and eventually the tungsten wire broke. It was found that the tungsten wire was blown when the pressure inside the vacuum tank was 400 Pa. When the temperature is around 20pa, the tungsten wire will emit light. The reason is that the vacuum is not enough. In the next test, a pump should be replaced to a higher vacuum. In addition, after the cathode tungsten wire is energized, the current of the cathode is always lowered. Turn off the power after reducing it from 0.18A to 0.063A. When turned on again, the cathode tungsten wire can no longer be brightened. This is because the vacuum is not enough to accelerate the evaporation of the tungsten wire. It has also been found that the cathode angle may be problematic and needs to be changed to a cathode that is perpendicular to the anode at 90 degrees for further investigation. More problems have appeared in the cathode, and it is intended to replace a mature cathode.

Drawing on the lessons of the first experiment, the vacuum was improved in the second experiment, and various problems were dealt with accordingly. The ignition experiment phenomenon is shown in Figure 17.

Figure17 Ignition experiment

The ignition was successful, but the discharge time during the ignition test was not long enough for about 40 s, and the discharge was stopped due to the break of the tungsten cathode. The reason for this may be that the tungsten wire is too close to the exit of the thruster channel and is broken by the plume. Due to the short discharge time, only two sets of data were measured. When the thruster is discharged, the back pressure is 0.7pa, the iodine tank temperature is 71°C, and the theoretical calculation corresponding flow rate is about 6.3sccm. The anode voltage and discharge current were 300V, 0.017A and 350V, respectively, 0.034A. Analysis of the volt-ampere characteristics found that the power variation was very big at a very small voltage change, which may be due to unstable flow.

V.Conclusion

This paper first investigates the advantages and disadvantages of the iodine cusped field thruster and its research status, then analyzes the design principle of the storage system of each country, and designs a feed system that controls the flow by thermal throttling. Thermal analysis of the entire system using ansys found that the glass tube was prone to deposition, and the iodine canister resistance gauge and the hot throttling tube were prone to overheating, and these places were treated accordingly. An appropriate heating line was selected based on the calculated power for the experiment. The experiment verified the results of the thermal analysis. Since the thermal analysis results are not very accurate, multiple attempts are still needed to find reasonable values. The performance of the flow calibration section has obtained some performance data, which proves that the thermal throttling is effective, and argon gas can calibrate the iodine working fluid, and several sets of experiments are needed to carry out further research. Finally, the iodine cusped field thruster ignite successfully.

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