A test method of the fast closing valve for PEFP beam lines

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1. Introduction

In the PEFP (Proton Engineering Frontier Project) the 100MeV linear accelerator is being developed for 20MeV and 100MeV user facilities [1]. Also the individual beam line of the user facilities will be installed. In the 3 beam lines of 20MeV and 100MeV an exit window will be mounted respectively in the end of the vacuum beam tube for the external beam. The exit window made of the aluminum-beryllium alloy (AlBeMet) and determined as 30cm diameter and 0.5mm thickness [2]. The exit window can be broken by high beam power of a peak current 20mA. To protection of an accelerator and a vacuum system we are consider to establish a FCV(Fast Closing Valve) in the beam lines. A closing time of the FCV is 15ms with 10cm diameter of the beam tube. In this study the test method of a closing time and of a shock wave of the air inrush using the FCV are introduced.

2. Methods and Results

In this section our vacuum system in a beam lines and a fast closing valve system are introduced. The test method of an air inrush velocity and a closing time by using a fast closing valve are described.

2.1 Beam line vacuum system

A drawing of the PEFP beam lines as shown in Fig. 1. The vacuum components will be installed in this beam line of the PEFP. The vacuum components includes a TMP(Turbo Molecular Pump) set, a ion pump, a vacuum gauge, a gate valve and a beam tube.

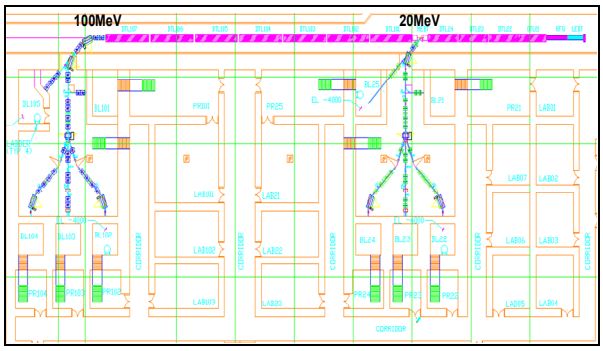

Fig. 1. Schematic lay out of the PEFP beam lines.

The beam line length from an accelerator to a target is 30m. The beam tube length from an AC magnet to a target is around 13m in the straight line. The inner size of a vacuum beam tube is 10cm diameter. We were considered about the beam tube length and inner tube size for vacuum pumping system. When the TMP is reach to the pressure up to 10^{-6} torr, the ion pump will be turned on. After that, we will turn off the TMP set. The ultimate pressure of the beam lines are around 10^{-8} torr of UHV.

The exit window will be installed the 6 beam lines for external beam utilizations such as TR102, TR103, TR104 in 100MeV and TR22, TR23, TR24 in 20MeV.

A FCV needed for the protection of the beam line vacuum of using exit window and an accelerator as an emergency. Before the FCV will be installed in this beam line, we will be studying about the preliminary test at a part of the 1 beam line.

2.2 Fast closing valve system

The FCV system (VAT - series 75) are consist of a FCV, a power supply, a FCV module, a control module, a sensor module and a FV(Fine Vacuum) sensor. A valve body was made of AlSl 304L and a gate of the valve is tungsten of 3mm thickness as shown in Fig. 2. When the solenoid inside an actuator is received a trigger signal from a valve module, the gate of the FCV is closed by venting of a compressed air.

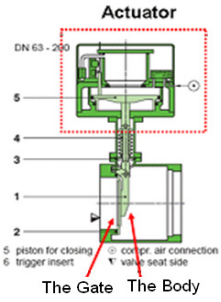

Fig. 2. Schematic lay out of a fast closing valve.

A closing time of the FCV is 15ms of a flange size of DN100 as shown in Fig. 3. It is appeared a total time except the getting signal from the FV sensor.
The response time of the FV sensor is 1ms per a cable length of 20m. The total time is 16ms. The FV sensor type is a glow discharge gauge as a kind of the low vacuum gauge. The FV sensors send a trigger signal at the pressure of the 10^{-2} mbar generating the glow discharge.

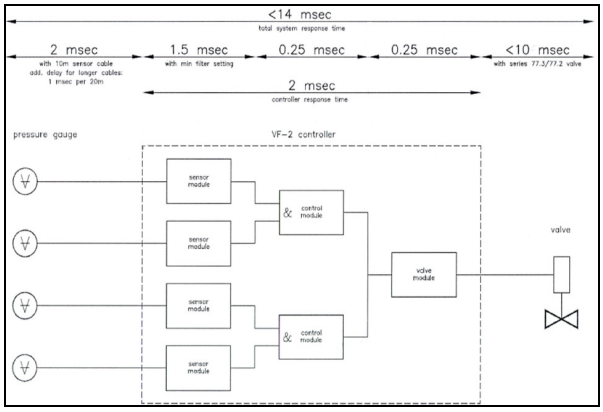

Fig. 3. Schematic diagram of the signal response time for the fast closing valve.

2.3 The test method of a velocity of a shock wave

At the simulation of the 1 beam line we have a ~8m beam tube length. The overall closing time of a FCV (16ms) is needed the distance of 5.5m by using the velocity of shock wave (~300m/s) [3]. The 1st FV sensor is posited after the vent valve and the 2nd FV sensor is located before the FCV as shown in Fig. 4. The mounted aluminum window will be broken by an operated knife using a switch. We will measure the air inrush velocity by using the distance of the 2 FV sensors and the individual time of the 2 FV sensors. The time can be reading by an oscilloscope as a voltage signal of 5V.

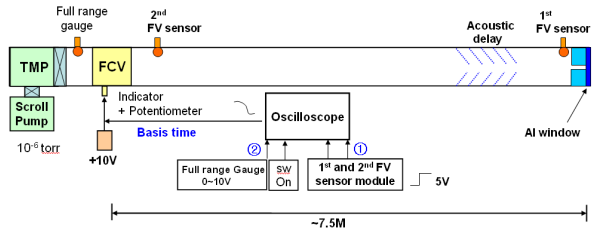

Fig. 4. Block diagram of the test method for a measurement of a velocity of the shock wave and a closing time of the FCV.

In case of the velocity was faster than the estimated results, we will mounted the acoustic delay of structure to reduced the speed of the sonic [4].

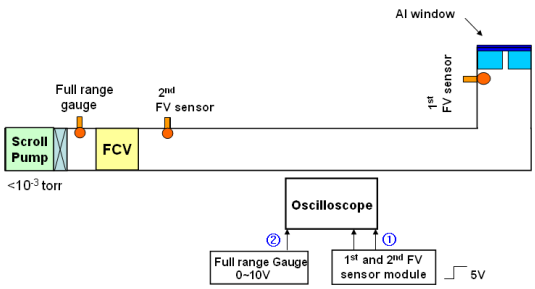

Fig. 5. Block diagram of bending beam tube to reduce a velocity of the shock wave.

Also we are considered about the bended beam tube at the inlet of the air inrush as shown in Fig. 5. In this case the vacuum pressure condition is 10^{-3} torr. To measurement of the pressure rise the full range gauge are used for whole air inrush time from the start switch. The full range gauge are equipped after the FCV and can be reading by an analog voltage of 0~10V output signal. Another gas can be applied to this test system such as Hydrogen, Helium and etc [5].

2.4 The test method of a closing time

Typically the closing time of the FCV is measured by using a position indicator on the actuator. The indicator is change the position according to the movement of the gate. The changed resistance of a potentiometer by an indicator position are generate to the output voltage signal as shown in Fig. 4. We are used to this method as the verification of the closing. As a starting point of the closing time the 1st FV sensor are used and as an ending point the full range gauge also used. When the FCV is closed, the pressure of the full range gauge will be decreased. The total closing time has to16ms.

3. Conclusions

In the beam line design the vacuum protection system is needed. The FCV will be installed for the protection of an accelerator and a vacuum in the beam line. Thus we have to the test of the FCV before the installed. The test method of this FCV is considered by 2 methods. One is measure of the air shock wave velocity by using 2 FV sensors and the other is measure of the closing time by using the 1 FV after the exit window and the full range vacuum gauge after the FCV in the around 7.5m tube length region. To reduce the velocity acoustic delay and bended vacuum tube are considered.

Acknowledgement

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REFERENCES

[1] Y.S. Cho, H.J. Kwon, J.H. Jang, H.S. Kim, K.T. Seol, D.I. Kim, Y.G. Song, I.S. Hong and Y.H. Kim, J.Korean Phys. Soc. 52, 3, 721(2008).
[2] B.S. Park, Y.S. Cho, J.Korean Phys. Soc. (Will be published).
[3] M. Abdel-Bary, S. Abdel-Samad, N. Dolfus, K. Kilian, T. Sefzick, Nuclear Instruments and Methods in Physics Research A 538(2005) 154-158.
[4] R.C. Wolgast, J. W. Davis, Particle accelerator conference, Washington DC, 1969.
[5] E.L. Brodsky, W.Hamiliton, G.Wells and F.Cerrina, M.Corradine, Rev. Sci. Instrum. 63 (1), January 1992.