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STRUCTURE DESIGN OF A MULTI-WIRE TARGET*

Xiaojun Nie †, Anxin Wang, Jilei Sun, Taoguang Xu, Ling Kang, Jiebing Yu, Huayan He, Jia-xin Chen, Donghui Zhu, Lei Liu, Changjun Ning, Guangyuan Wang, Yongji Yu, Junsong Zhang, Dongguan Branch of the Institute of High Energy Physics, Chinese Academy of Science(CAS), 523803 Dongguan, China

Abstract

Introduce a structure design of a Multi-Wire Target. The plan of wire alignment was decided by analysis. The wire tightening device with interlaced alignment was used to solve the wire alignment in narrow space. The vacuum chamber was designed by optimization. The displacement pickup was used to make the movement control of translation stages.

INTRODUCTION

The multi-wire target is a device which is used to measure the section of beam. The measuring mental wire is bombarded by the beam and gets the low-energy electron. The low-energy can output the voltage signals. The multi-wire target can use this signal to measure the density of beam section. The mental wires are aligned according to the beam measuring requirement.

The multi-wire target has a complex structure, which includes measuring part, vacuum chamber, moving part and so on. It also demands high motion accuracy to reach high measuring accuracy. According to the running requirement of China Spallation Neutron Source, one multi-wire target (RDMWS) is demanded on the ring to dump transportation to the beam section[1-2].

WIRE ALIGNMENT PLAN

Wire alignment plan is the wire distribution pattern. Two group wires, which are vertical each other, are designed to detect two directions of beam. The horizontal and vertical directions are selected the wire directions to simplify the structure of multi-wire target. According to the beam parameter, the dimension of beam section can be reached. The dimension（1 σ）of horizontal direction is 20mm,while the dimension（1 σ）of another direction is 10mm. The wire alignment plan can be concluded by the above information, which is stated as the following.

(1)Wire direction: horizontal and vertical directions.

(2)Wire quantity on horizontal direction: 35 wires are distributed on this direction. The distance between the wires is 7mm. The width of covered area is about 238mm. 17 wires are include in 6σ range (σ_x=20mm).

(3)Wire quantity on vertical direction: 41 wires are distributed on this direction. The distance between the wires is 6mm. The width of the covered area is about 240mm. 10 wires are include in 6σ range (σ_y=10mm).

† Email address : niexj@ihep.ac.cn

The wire distribution figure can be reached by the plan, which is illustrated as Figure 1.

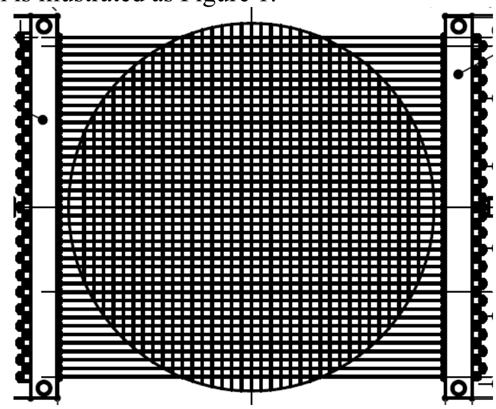

Figure 1: Wire distribution plan.

DESIGN OF WIRE TIGHTEN COMPONENT

Design Requirements

Wire tighten component is an important part for the multi-wire target, which is used to locate and fix the wires. It is important to optimize this part because of the dense distribution of wires in narrow space.

The component should fix and locate wires reliably. Any two components should avoid position interference each other. The material for this part should not be hard. Otherwise it is easy to harm the wires. Meanwhile any two wires should be insulated each other. The vacuum working condition should also be considered for design.

Structure of Wire Tighten Component

Wire tighten component is composed of wire tighten clamps, located blocks and tighten bolts. The oxygen-free copper was selected as the material of wire tighten clamp, while the ceramic was selected for the located block. Each wire is strained by the spring and fixed by bolts. The tungsten wire is used for measurement, which has good electrical conductivity and mechanical property. But the diameter of the wire is very small to ensure the measuring precision. So the stretching force of the spring should not be too high.

One group stepped holes were designed on the located block. The stepped holes can be used to locate the wire tighten clamps and install the springs. The distribution of wire tighten clamps are very dense. So they are aligned by interlaced alignment to get a gap between two clamps and avoid short circuit for the rotation of wire tighten clamp. In order to make interlaced alignment, two type clamps

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have been considered. One type clamp takes the spring, while another type does not take spring. The two type clamps were illustrated as Figure 2&3.

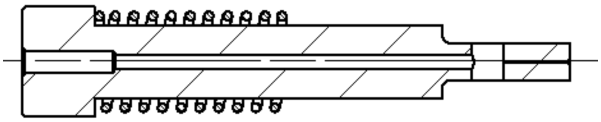


Figure 2: Clamp with spring.

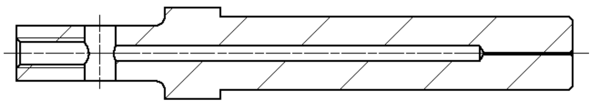


Figure 3: Clamp no spring.

The final Wire tighten component is shown as Figure 4. It is clear that the interlaced alignment of the two type clamps has made the clamps avoid each other.

Figure 4: Final assembly of wire tighten component.

DESIGN OF VACUUM CHAMBER

Structure of the vacuum chamber

The vacuum chamber is another important part of the multi-wire target. It is used to maintain the vacuum condition and support the weight of above part of the multi-wire target. The section of vacuum chamber has many types, such as the circular section, rectangular section, irregularly shaped section and so on. The concrete section depends on the working condition.

The vacuum chamber of the multi-wire target should contain the measuring component and leave enough space for movement. The section of the vacuum chamber has been designed as rectangle for the section of the measuring component of the multi-wire target is rectangular [3].

Finite element analysis of vacuum chamber

The vacuum chamber has a big space and bears the atmospheric pressure and the weight of the above part of multi-wire target. It is important to optimize the vacuum chamber structure. Three type structures, which include the chamber without rib reinforcement, the chamber with horizontal rib reinforcement and the chamber with horizontal and vertical rib reinforcement, have been designed for optimization.

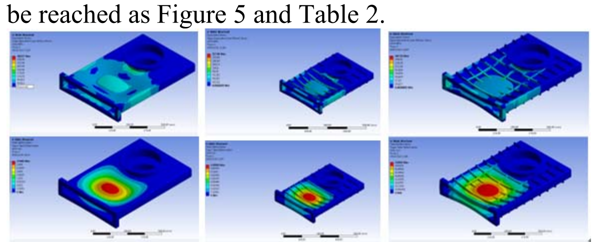
It is a valid method to make the finite element analysis for different vacuum chamber structures. Finite element method is a scientific calculation method. This method divides the whole engineering structure as many discrete element models, which are connected by nodes. The force acting on the element model is replaced by the force on the node. In this way, the calculation can be simplified and the computational accuracy can be improved [4].

The following is the edge-restraint condition of the vacuum chamber. The bottom of the vacuum chamber will be fixed with the bracket. And the two end faces will be connected with other devices. So this two spot can be considered fully constrained. The outside of the chamber bears the atmospheric pressure. The top plate bears the weight of the above part of the multi-wire target. The material of the vacuum chamber is 316L. The characteristic parameter can be reached as Table 1 [5].

Table 1: 316L Characteristic Parameters

Tensile Strength, Yield (MPa)	Modulus of Elasticity (GPa)	Poisson ratio	Density (g/cm^3)
290	193	0.28	8

Three vacuum chamber structures were designed to compare. The first structure is the chamber without rib reinforcement (NB). The second is the chamber with horizontal rib reinforcement (HB). The third is the chamber with horizontal and vertical rib reinforcements (HV). The stress and deformation of the vacuum chambers can be reached as Figure 5 and Table 2.



(a)NB (b)HB (c)HV

Figure 5: Distribution of stress and deformation of the vacuum chamber.

Table 2: Maximum Stress and Deformation of the Vacuum Chamber

Vacuum Chamber	Maximum Stress (MPa)	Maximum Deformation (mm)
NB	400	2.7
HB	217	0.9
HV	167	0.5

It can be concluded that the rib reinforcement can improve the stress state of the vacuum chamber significantly. The vacuum chamber with horizontal and vertical rib reinforcements (HV) has the best stress state.

DESIGN OF VACUUM CHAMBER

Movement Control by the Displacement Sensor

The measuring part of the multi-wire target is above of the beam on the free time. It just comes to the position of the beam when working. The measuring part is fixed on the slider of the translation stages. The movement of slider can take the measuring part to the working position.

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It is necessary to check if the measuring part has reached the working position. The displacement sensor is used to check and control the movement.

Displacement sensor is also called as linear sensor, which can translate the movement to the electrical signal. LVDT displacement sensor can be selected as the control sensor for its simple structure, good endurance to the bad environment and high working reliability [6]. The structure of this sensor is shown as Figure 6.

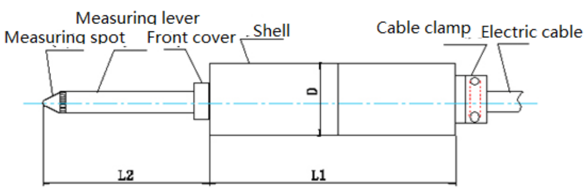

Figure 6: Structure of displacement sensor.

The output of displacement sensor is voltage signal, which is proportional to the movement of the measuring spot. The value of output voltage (V) and displacement (D) were provided by the seller, which is listed as table 3.

Table 3: The value of Displacement and Output Voltage

D/ mm	0	2	4	6	8	10
V/ mV	0	500	1000	1500	2000	2500
D/ mm	12	14	16	18	20	
V /mV	3000	3500	4000	4500	5000	

The correlation of the displacement vs the voltage is shown as Figure 7. So the voltage signal of the displacement sensor can be used to control the position of the measuring part of the multi-wire target. The deviation between the computed displace and the real displace is within 0.05mm by the spot test. It can demand the control requirement.

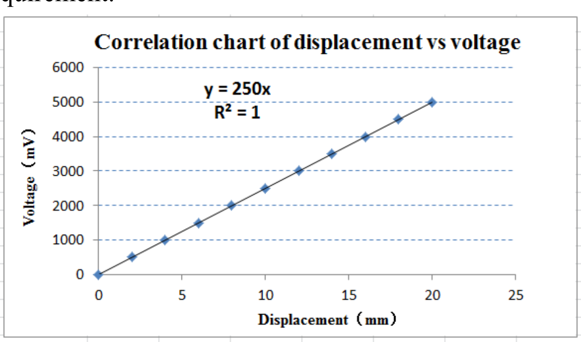

Figure 7: Correlation chart of displacement vs voltage.

Assembly of the Displacement Sensor

The displacement sensor should be located accurately and replaceable after assembly. If the displacement sensor is broken, it can be replaced by another one without adjustment. V-type block can be applied to locate the displacement senor and realize the replacement. The located mechanism is shown as Figure 8.

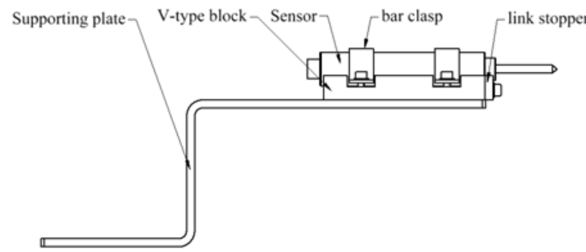

Figure 8: Located mechanism of displacement sensor.

CONCLUSIONS

Multi-wire target is an important beam testing device, which is used to check the section shape of the beam. The wire alignment plan, wire tighten component, vacuum chamber and the movement control have been discussed preliminarily in this article. It can provide some reference for the design and manufacturing of the similar devices.

ACKNOWLEDGMENTS

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