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Driving Parts Optimization Design for Radiation Shielding Doors of Proton Accelerator Research Center

J. M Nam, Y. G Han, G. P Jeon, Y. S Min, S. S Park, J. S Cho, K. J Mun, S. W Cho, J. Y Kim
Proton Engineering Frontier Project, Korea Atomic Energy Research Institute,
Daedeok-Daero 989-111, Dukjin-Dong Yuseong-Ku, Daejeon, 305-353, Korea
**Corresponding author:namjm@kaeri.re.kr*

1. Introduction

PEFP(Proton Engineering Frontier Project) was Launched in 2002 as one of the 21st Century Frontier R&D Programs of MOST(Ministry of Science & Technology). Gyeongju city was selected as the project host site in March, 2006, where 'Proton Accelerator Research Center' was going to be constructed. After starting the design in 2005, the Architectural and Civil design work has been performed by 2010. Since the Earthwork was started in 2009, the Construction works of Accelerator Facilities has been going smoothly to complete by 2012.

In this paper, we describe driving Parts optimization design for radiation shielding doors of Proton Accelerator Research Center.

2. Radiation Shielding Door Design

According to the radiation zone classification, we installed 2 sliding doors and 13 plugging doors in Accelerator & Beam Application Research Building of PEFP, which are described in Fig. 1.

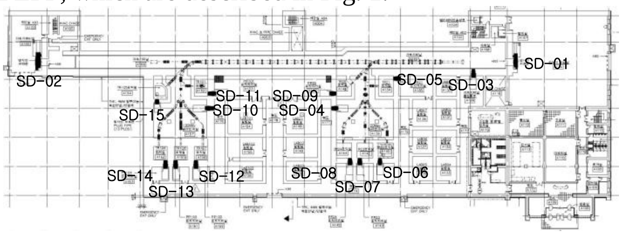

Fig. 1 Radiation Shield Doors plot plan

As shown in Fig. 2, the shielding doors are divided into two types. : sliding door type and plugging door type. SD-01 and SD-2 are sliding door type, and SD-03~SD-13 of plugging door type.

In case of enough space for installation and large size shielding, sliding type door is selected. In the other case, of small space for installation, plugging type door selected.

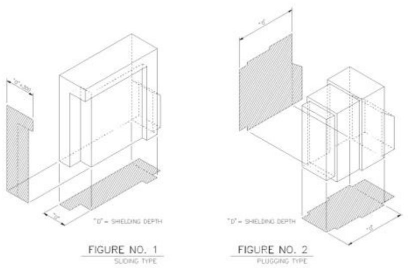

Fig. 2 Types of Radiation Shield Door

Especially to keep radiation shielding, the plugging type doors of SD-11 ~ SD-14 including Iron shielding are designed as shown in Table. 1 and Fig. 3.

Table 1 The Radiation controlled Area Classification

No. of Door	Thickness		
	df	dc	dr
	Conc.	Steel	Conc.
SD-11	500	900	650
SD-12	500	900	650
SD-13	500	900	650
SD-14	500	900	650

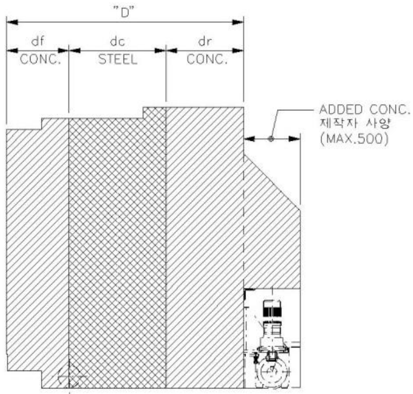

Fig. 3 The Plugging Type Door including Iron shielding

3. Driving Parts Design

The driving parts design was made as below following given standards.

I. Inverter specification

S_1 (rotational velocity) = $\frac{R}{r1 \times r2}$

$\frac{d1 \times s1}{60}$ $I \geq 2m/min$ (door's moving velocity)

d1 : wheel circumference
R : motor rotational velocity
r1 : motor transmission rate
r2 : worm transmission rate
I : inverter Hz

II. Bearing Safety rate

S(bearing safety rate) = $\frac{Cor \times N}{W}$

Cor : bearing live load
N : the number of bearings used
W : door load

III. Axis deflection

δ(axis deflection) = $\frac{Wl^3}{48EI}$

I = $\frac{\pi}{64}d^4$

W : door load

I : moment of inertia

IV. Motor Power

T = $\frac{1}{2}D \cdot \mu W$

T : motor power

D : wheel diameter

μ : bearing coefficient of friction

W : door load

V. Motor Torque

$T[kgf \cdot m] = 716.2 \times \frac{HP[PS]}{N[RPM]} \times \Delta\Xi$

T : motor power

D : wheel diameter

μ : bearing coefficient of friction

W : door load

$\Delta\Xi$: motor efficiency

VI. Gear Head Durability

$Tc = T_1 + T_2$

Tc : maximum permissible torque

T_1 : moment of inertia torque

T_2 : output torque

$T_1 = \frac{GD^2 \times N}{375 \times t} \times Sf$

$T_2 = W \times \frac{D}{2}\ (\mu \times 8)$

As shown in Table 2, driving parts design including inverter specification, bearing safety rate, axis deflection, motor power, motor torque and gear head durability is satisfied with requirements.

Table 2 Result of Driving Parts Design

	SD-01	SD-02	SD-03	SD-04~09, 15	SD-10	SD-11~14
Inverter specification(Hz)	67	67	54	54	54	54
Bearing Safety rate	4.59	3.15	3.34	4.32	3.57	3.11
Axis deflection(mm)	0.045	0.09	0.02	0.016	0.02	0.025
Motor Power(kgf· m)	4.3	8.87	1.62	1.28	1.55	1.98
Motor Torque(kgf· m)	619.51	961.50	413.01	413.01	413.01	413.01
Gear Head Durability(kgf· m)	624.47	1287.9	626.32	496.14	601.76	626.54

4. Driving Parts Products Selection

When designing the motor & Gear Head, motor torque[T] should be more than output torque[T_2], less than gear head maximum permissible torque[T_c].

As shown in Table 3, Product Selection Results according to Motor & Gear Head Torque are described.

All driving materials including motor, gear head, bearing, wheel, shaft and so on are selected considering compatibility.

As motor for driving part, heavy load motor is adopted because its safety ratio coefficient is about 40% higher than that of motor for general load.

Table 3 Product Selection Results according to Motor & Gear Head Torque

	Motor			Gear Head		Inverter Type	output Torque [T_2] (kgf·m)	Motor Torque [T] (kgf·m)	Gear Head Maximum Permissible Torque[T_c] (kgf•m)
	Product code	Reduction rate	HP	Product code	Reduction rate				
SD-01	FVB30-2	1/30	2	MTW-155	1/30	VVVF	129.02	619.51	624.47
SD-02	FVB30-3	1/30	3	MTW-155	1/30	VVVF	266.11	691.50	1287.98
SD-03	FVB20-2	1/20	2	MTW-120	1/30	VVVF	48.55	413.01	626.32
SD-04	FVB20-2	1/20	2	MTW-120	1/30	VVVF	38.46	143.01	496.14
SD-05	FVB20-2	1/20	2	MTW-120	1/30	VVVF	38.46	143.01	496.14
SD-06	FVB20-2	1/20	2	MTW-120	1/30	VVVF	38.46	143.01	496.14
SD-07	FVB20-2	1/20	2	MTW-120	1/30	VVVF	38.46	143.01	496.14
SD-08	FVB20-2	1/20	2	MTW-120	1/30	VVVF	38.46	143.01	496.14
SD-09	FVB20-2	1/20	2	MTW-120	1/30	VVVF	38.46	143.01	496.14
SD-10	FVB20-2	1/20	2	MTW-120	1/30	VVVF	46.65	143.01	601.76
SD-11	FVB20-2	1/20	2	MTW-135	1/30	VVVF	59.56	143.01	626.54
SD-12	FVB20-2	1/20	2	MTW-135	1/30	VVVF	59.56	143.01	626.54
SD-13	FVB20-2	1/20	2	MTW-135	1/30	VVVF	59.56	143.01	626.54
SD-14	FVB20-2	1/20	2	MTW-135	1/30	VVVF	59.56	143.01	626.54
SD-15	FVB20-2	1/20	2	MTW-120	1/30	VVVF	38.46	143.01	496.14

4. Conclusions

In this paper, we describe driving Parts optimization design for radiation shielding doors of Proton Accelerator Research Center considering inverter specification, bearing safety rate, axis deflection, motor power, motor torque and gear head durability.

Acknowledgement

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