Efforts on stable operation of the HIMAC irradiation system

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Introduction

HIMAC outline

Heavy Ion Medical Accelerator in Chiba (HIMAC) is the first accelerator in the world specially constructed for researches on heavy ion radiotherapy. Since 1994, HIMAC has carried out the clinical trial of cancer treatments using carbon beams. Treatment with scanned carbon beam was started in 2011 to provide more patient-friendly cancer therapy. The total number of patients is about 9,900 in March, 2015. HIMAC has 3 treatment rooms / 4 ports and a new treatment-facility has 2 treatment rooms / 4 ports.

HIMAC annual schedule
- Treatment, experiment, R&D
- Summer maintenance (1 month)
- Winter maintenance (0.5 month)

HIMAC typical weekly schedule
- Treatment Tue. To Fri. 8:30–19:30
- Experiment, R&D Tue. To Fri. 21:00–7:00
- Sat.
- Maintenance Mon. (every other week)

*Maintenance
Suspend accelerator operation for maintenance such as checking multiple equipment or replacing small parts.

Stable operation is critical for the clinical use as normal treatment schedule continues for several weeks. In order to avoid irradiation interruption, HIMAC treatment room has two same ports for both horizontal and vertical ports within three treatment rooms. In case of machine trouble of irradiation system of one port, the other port acts as backup port to perform treatment. Therefore, treatments have been successfully performed without interruption by rescheduling the treatment room in case of trouble. Through this 10-year operation, there was almost no treatment that was postponed due to device failure. (There was one day interruption due to failure of power-supply unit of scanning system only at new treatment facility. And some treatments were rescheduled within a day due to machine trouble.) In this presentation, our maintenance program and some examples how we have improved the program are shown.

Overview of maintenance program

Maintenance program

At HIMAC, the period of semi-annually maintenance has become shortened in accordance with increase of treatment cases. 53 days (2004) → 45days (2014) As a result, the ratio that can be assigned to semi-annually maintenance has decreased from 16% to 11%.

We mainly implement three kinds of periodical maintenance program: daily, weekly and semiannually in order to maintain the soundness of equipment within a limited time. We are using record sheets to perform each maintenance program.

Maintenance schedule

Weekly maintenance
- Visual check and operation check of equipment
- Simple check of alignment of X-ray imaging equipment
- Mechanical accuracy check (Precision check of reference parameters for driving equipment)
- Required spot maintenance (parts replacement, etc.)

Semiannually maintenance (0.5 – 1 month work time / 3 rooms)
- Accuracy check of equipment (speed of operation, driving force, stroke)
- Precise alignment
- Condition check, cleaning and adjustment of equipment by overhaul/decompostion

Example of maintenance program

Equipment layout

Multi leaf collimator (MLC)

Field size: 150 mm × 220 mm
Leaf pitch: 6.5 mm
Leaf gap: 0.25 mm
Leaf pair: 23 pairs
Stroke: +130 mm – -55 mm
Driving speed: 80 mm/sec

Maintenance program of MLC

Daily maintenance: Check of anomalous/collision sound by simple movement
Weekly maintenance: Numerical check of MLC control parameter.
Gap check between leaves in the completely closing position
Semianually maintenance: Grease up of drive parts, Torque check of MLC motor, Precise alignment of each leaf

Review of maintenance program of MLC

Layer stacking irradiation has been performed since 2008. This irradiation required multiple field size variation using MLC. It was clear that the frequency of MLC movement per day would increase.

Lifetime review of MLC components
- Motor/Encoder: Already exceed a shortest estimate of lifetime
- A least lifetime recommended by manufacture assumes continuous moving operation. This assumption cannot simply apply to motor/encoder equipped in MLC. So we decided to keep using them.

We set up the maintenance program according to the prediction of lifetime of MLC. But the problem has not been solved yet. So we must rethink the function and the way setting of the devices. We should improve the system and the program for the future.

Trouble of MLC

Trouble detection

Main trouble
- Step-out of motor/collision
- Irregular (big) sound in leaf movement
- Failure of cooling fun for drive motor
- Failure of detected position

The revised maintenance program obviously reduced the frequency of failure during treatment.

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Example of failure detection during maintenance

Treatment room C (March, 2015)
Friction measurement failure (leaf R14: 4.0 kgf)
*Acceptability criteria at maintenance 1.5 kgf

Action 1: Condition check of equipment → grease up and visual check → still 4.0 kgf
Action 2: Replace motor → Improved to 0.6 kgf.

Disassemble the motor and confirmed that bearing movement was irregularly heavy. We concluded this was the cause.

Summary

We have succeeded to maintain the equipment for 20 years by performing and reviewing the maintenance programs. Recently, due to increase of frequency of use and aging of equipment, it was required to check many parts in detail. It is crucial to detect equipment failures in routine daily/weekly check beforehand as the long maintenance span is less available. Generally, our maintenance program is going well, however, we believe that it is important to revise the maintenance programs according to the frequency of equipment use etc.