PARAMETERS CALIBRATION AND COMPENSATION-REMATCH OF FAILURE CAVITIES IN CADS INJECTOR*

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Abstract

Now when a failure on the China Accelerator Driven System (CADS) is detected, the beam will be stopped by the machine protection system (MPS) immediately. But because of the demand of the beam trip (more than 5 min) rate which should be less than 50 times per year [1], it is important to avoid cutting beam down or recover the beam in a short time. The compensation and rematch is of great importance. To get better compensation results, parameters calibration is the first priority. If the failure is on a cavity, the other cavities should retune to compensate the beam energy, position and phase in order to recover the beam in short time depending on the time of online calculation.

INTRODUCTION

The CADS is a complex system as the Fig. 1, so this article only focuses on the method and the feasibility of compensation-rematch. To rematch and compensate a faulty cavity in CADS, simulation and verifying test require more accurate data of the parameters. So the calibration of the physical distance and the energy at key positions by beam is considered as a part of compensation. The beam dynamics simulation and analysis shows that the demanded redundancy of CADS. The result of simulation test in the CADS illustrates the feasibility of compensation-rematch.

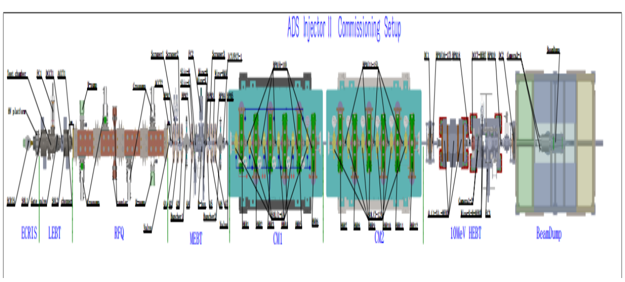

Figure 1: 10MeV China Accelerator Driven System (CADS).

THE BPMS CALIBRATION EXPERMENT

The experiment is applied in the medium energy beam transmission (MEBT), aiming to calibrate the distance between BPMs and the outlet energy of the radio frequency quadruple (RFQ). The simulation is forming a field model of a cavity, changing the amplitudes (101.6KV, 96KV, 88.9KV, 82KV, and 75KV) and synchronous phase (-90°, -60°, -30°, and 0°) of the cavity to change the β of the bunch, and calculating the theoretical BPMs phase by using the outlet energy and distance by physical measurement.

In the verifying test, get the phase difference between two adjacent BPMs of the MEBT of CADS for 5 times under the same situations as the simulation to calculate the average as Table 1, Table 2, and Table 3.

Table 1: Average Phase Difference between BPM2 and BPM3

Amp.(KV) / Syn. Phase(degree)	101.6	96	88.9	82	75
-90	253.3	253.4	253.2	253.4	253.3
-60	213.7	216.7	216.7	220.7	222.7
-30	200.4	203.1	205.7	209.1	212.1
0	193.1	195.9	199.3	202.5	205.7

Table 2: Average Phase Difference between BPM3 and BPM4

Amp.(KV) / Syn. Phase(degree)	101.6	96	88.9	82	75
-90	54.7	54.6	54.8	54.5	54.3
-60	340.3	342.3	344.3	346.3	348.3
-30	330.3	333.2	335.7	339.0	342.2
0	328.1	330.7	334.4	337.4	340.1

Table 3: Average Phase Difference between BPM4 and BPM5

Amp.(KV) / Syn. Phase(degree)	101.6	96	88.9	82	75
-90	353.5	353.3	353.2	353.3	353.3
-60	328.8	330.8	332.8	334.8	338.8
-30	318.2	320.7	324.4	327.4	330.1
0	313.1	315.9	319.3	322.5	325.7

And calibrate the outlet energy and distance by calculating from the data by a script by Matlab contracting with the outlet energy and distance by physical measurement as Table 4 and Fig. 2.

The parameters get from beam calibration are more matched than the parameters get by referring to historical data as Table 5 and Fig. 3. So this method to calibrate parameter can be considered to use in CIADS [2].

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Table 4: Distances and Outlet Energy by Beam Calibration and Physical Measurement

	BPM2-BPM3 (m)	BPM3-BPM4 (m)	BPM4-BPM5 (m)	E (RFQout) (MeV)
Beam Calibration	0.7013	0.3665	0.48915	2.118
Physical Measurement	0.701	0.367	0.4895	2.12

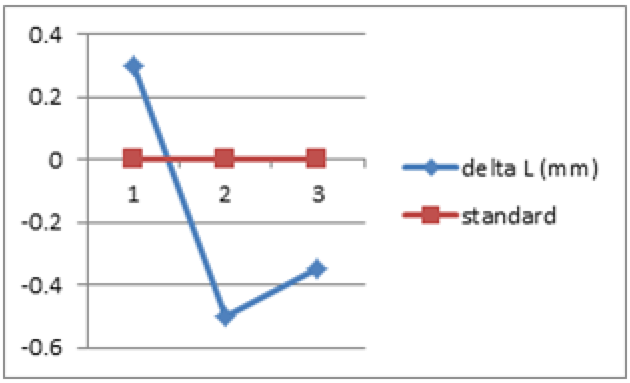

Figure 2: Distance gap between beam calibration and physical measurement.

Table 5: BPM Phase by Calculation and from Historical Data

	BPM2 (°)	BPM3 (°)	BPM4 (°)	BPM5 (°)
Calculation With Old Parameter	54.3	292.5557	279.6596	262.9494
Calculation With New Parameter	54.3	294.3873	280.5387	263.4799
Historical Data	54.3	294.7	280.2	263.7
ΔOLD	0	-2.1443	-0.5404	-0.7506
ΔNEW	0	-0.3127	0.3387	-0.2201

COMPENSATION OF THE CAVITY

The simulation of the cavity failure is applied in the CM1 and CM2. Rematch-compensation contains two ways that global compensation and local compensation. The simulation with a little lower energy, considering the safety of machine and the cavities of CADS with their own accelerate ability and redundancy.

When the lattice is proper and the cavities are working. The envelope is appropriate and the out energy is 3.60 MeV as the Fig. 4 and Fig. 5.

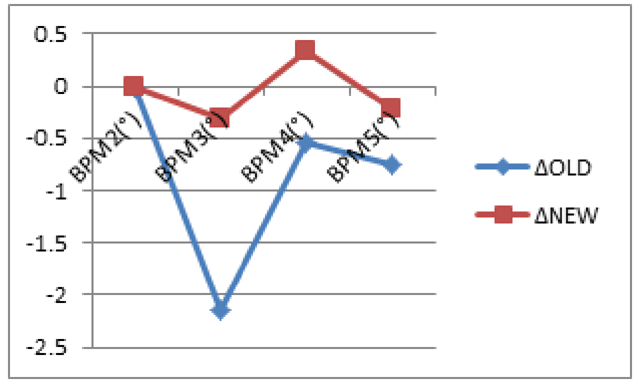

Figure 3: Phase Gap Compared to Experiment Data with Parameters by Beam Calibration and Physical Measurement.

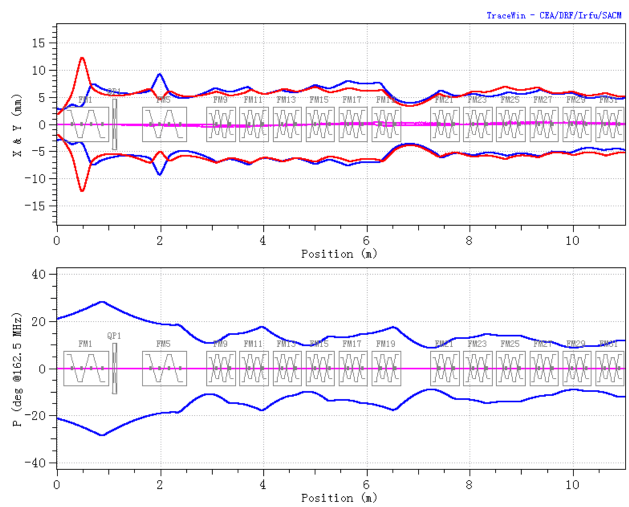

Figure 4: Envelope before cavity failure.

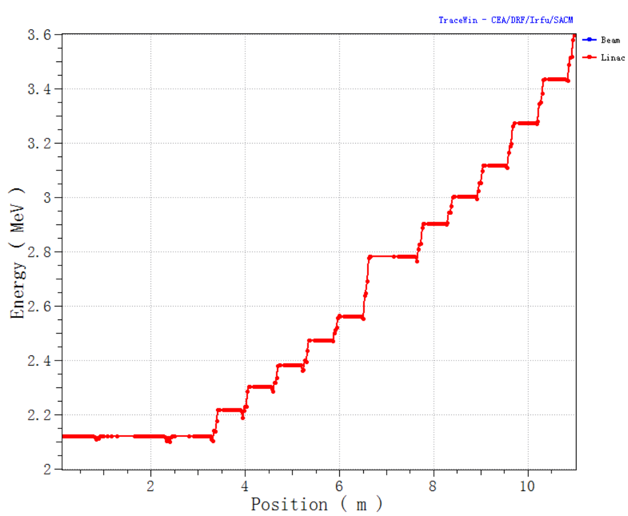

Figure 5: Energy before cavity failure.

Set a failure on the forth cavity, the envelope increases and the out energy is 3.49 MeV as Fig. 6 and Fig. 7. The envelope increase will lead the beam loss [3], so the rematch and compensation is essential.

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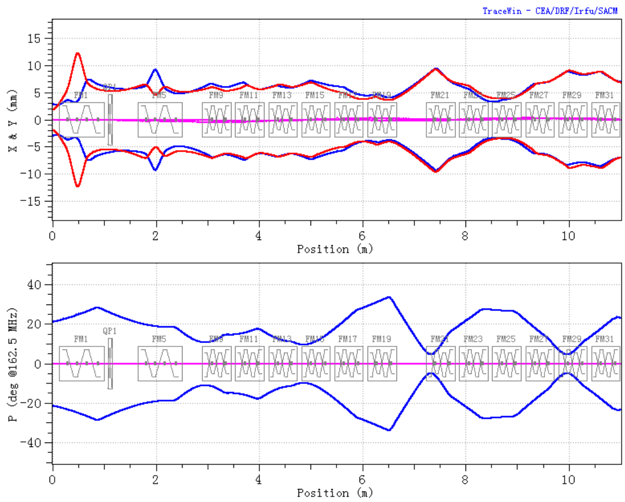

Figure 6: Envelope after the forth cavity failure.

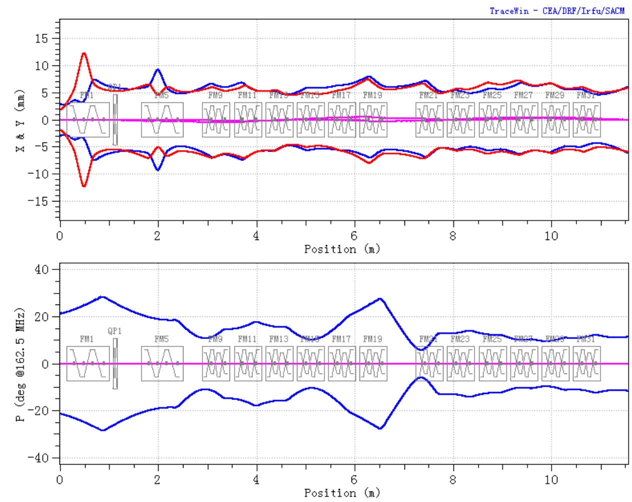

Figure 8: Envelope after rematch.

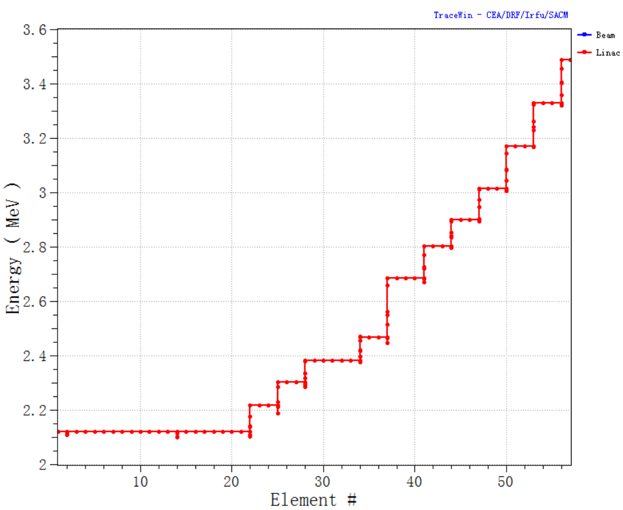

Figure 7: Energy after the forth cavity failure.

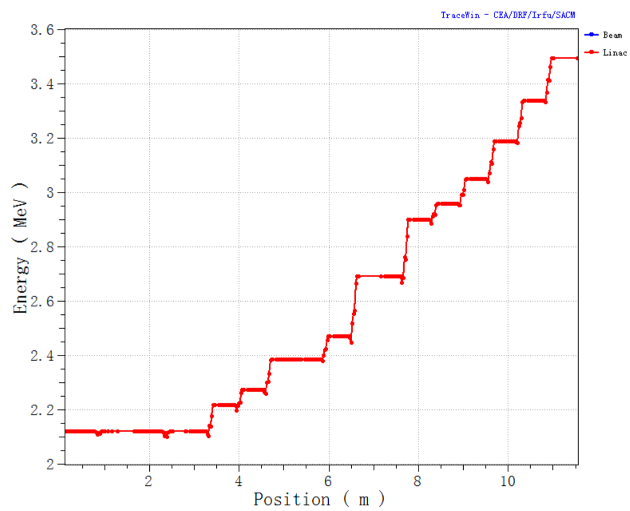

Figure 9: Energy after rematch.

Then rematch and compensate the faulty cavity. After the rematch and compensation, the out energy is 3.50 MeV as Fig. 8 and Fig. 9.

At the energy 3.60MeV, this rematch and compensation try to control the envelope focusing on beam quality. When in CIADS [2] project, the energy can be compensation in the section with higher energy.

SUMMARY

The parameters get from beam calibration is reliable, and calculate with the parameters get from beam calibration is more matched with the experiment in different situation. The failure of cavity can cause beam loss. Since the energy is from 2.118 MeV to 3.60 MeV which is not high, the rematch and compensation focus more on beam quality than energy compensation. The rematch and compensation is feasible in CADS because it is possible to get the almost identical energy, phase and Twiss parameter in the key position when simulation.

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