TIMING ADJUSTMENT OF EIGHT KICKERS AND A METHOD TO CALIBRATE THE KICKER CURRENT CURVES DURING THE BEAM **COMMISSIONING FOR CSNS***

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Abstract

author(s), title of the work, publisher, and DOI The extraction system is a key part of the China Spallation Neutron Source (CSNS) accelerator. It consists B of two kinds of magnets: eight kickers and one 2 lambertson. During the beam commissioning, the timing attribution adjustment of eight kickers is a very important problem. In the paper, firstly, the timing adjustment, including the overall timing adjustment of eight kickers and the independent timing adjustment of different kickers, was naintain studied. The adjustment methods were applied to the beam commissioning. Secondly, during the timing \vec{z} adjustment of the kickers, a possible method to calibrate the kicker current curves was developed and would be confirmed in the future beam commissioning.

INTRODUCTION

distribution of this work China Spallation Neutron Source (CSNS) is the first high power proton accelerator-based facility in China [1]. Its technical acceptance had been completed in March 2018. The accelerator consists of an 80 MeV H-Linac and a 1.6 GeV rapid cycling synchrotron (RCS). The RCS accelerates the 80 MeV injection beam to the designed 8 energy of 1.6 GeV and extracts the high energy beam to 20 the target. The design goal of beam power for CSNS is 100 kW and capable of upgrading to 500 kW [2].

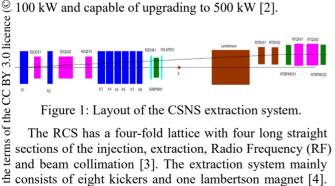


Figure 1: Layout of the CSNS extraction system.

The RCS has a four-fold lattice with four long straight sections of the injection, extraction, Radio Frequency (RF) and beam collimation [3]. The extraction system mainly consists of eight kickers and one lambertson magnet [4]. under Figure 1 shows the layout of the CSNS extraction system. The fast one-turn extraction is used in transfer of the proton beam from the RCS to the target [5].

In the early stage of CSNS beam commissioning [6], þe the beam power and extraction beam size are relatively mav small. In order to extract the beam from the RCS as soon work as possible, simple timing adjustment of eight kickers, including the relative timing of different kickers and the Content from this overall timing adjustment of eight kickers, was made

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which can make the beam loss of the extraction system at a relatively small level. Latter, in order to reduce the beam loss and make the two extracted bunches have the same extraction coordinates, the independent timing adjustment of different kickers was studied and made in detail. Finally, during the timing adjustment of the kickers, a possible method to calibrate the kicker current curves was developed.

TIMING ADJUSTMENT OF EIGHT KICKERS

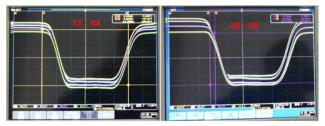


Figure 2: Current curves of eight kickers.

Device	Width		Delay		NS Dealy(step:5ns)			PS Dealy(step:1000ps)			Reference Value		
	Set(us)	Read(Cnt)	Set(ns)	Read(Cnt)							61MeV	80MeV	1.6GeV
Ext-Kick1	100.000	8100	575	575	Start	action	End	Start	action	End	0	0	0
Ext-Kick2	100.000	8100	570	570	Start	action	End	Start	action	End	16.701	14.788	6.184
Ext-Kick3	100.000	8100	564	564	Start	action	Ind	Start	action	End	50.01	44.283	18.51
Ext-Kick4	100.000	8100	510	510	Start	action	End	Start	action	End	55.149	48.833	20.42
Ext-Kick5	100.000	8100	592	592	Start	action	End	Start	action	End	60.094	53.211	22.25
Ext-Kick6	100.000	8100	440	440	Start	action	End	Start	action	End	64.845	57.418	24.01
Ext-Kick7	100.000	8100	426	426	Start	action	ted	Start	action	trd	69.353	61.41	25.67
Ext-Kick8	100.000	8100	403	403	Start	action	End	Start	action	End	73.619	65.188	27.255
10 Select 23Hz 23Hz 1-200 cycle Ext 20ms Ext			1Hz 20ms Ext			1Hz 1~200 cycle Ext			Current Mode				
1~200 cycle	1~200		Set 0	20ms Ext				1 Ext Kicke	-200 cycle Ex			25Hz 20n	

Figure 3: Control interface of the extraction timing system.

During the beam commissioning, in order to extract the RCS beam to the target smoothly, the timing of eight kickers need to satisfy suitable conditions. Figure 2 shows the current curves of eight kickers. The timing adjustment of eight kickers is essentially the translation of different kicker current curves. It consists of two parts: the overall timing adjustment of eight kickers and the independent timing adjustment of different kickers. Figure 3 shows the control interface of the extraction timing system. It can be seen that the timing of eight kickers can be modified in the control interface.

In the early stage of beam commissioning, the beam power and extraction beam size are relatively small. In order to extract the beam from the RCS as soon as

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possible, simple timing adjustment of eight kickers was made and the beam loss of the extraction system was controlled at a relatively small level. Firstly, the relative timing of different kickers was adjusted and the relative timing errors were controlled at a small level. Figure 4 shows the current curves of eight kickers after the relative timing adjustment of eight kickers. It can be seen that the relative timing errors of different kickers were small and reasonable. Secondly, the overall timing adjustment of eight kickers was made and the beam loss of the extraction system was relatively small. Figure 5 shows the two extracted bunches which set at different positions of the current curves of eight kickers. It can be found that, by the overall translation of the current curves of eight kickers, the two extracted bunches can be placed on the flat tops of the eight current curves, as shown in the sub graph (c) of Fig. 4. After that, the two bunches can be extracted from the RCS smoothly.

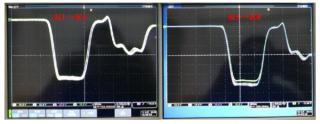


Figure 4: Current curves of eight kickers after the relative timing adjustment of eight kickers.

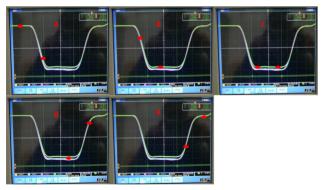


Figure 5: Two extracted bunches which set at different positions of the current curves of eight kickers.

During the beam commissioning, if one extracted bunch or two extracted bunches are not placed on the flat tops of the current curves of some kickers, the two extracted bunches would have different extraction coordinates which can be measured by the BPMs on the beam transport line from the RCS to the target (RTBT). In addition, there may be large beam loss on the RTBT which can be detected by the BLMs. In order to reduce the beam loss and make the two extracted bunches have the same extraction coordinates, the independent timing adjustment of different kickers was studied and made. Figure 6 shows the two extracted bunches which set at different positions of the kicker current curve. It can be found that, by the translation of the kicker current curve, the two extracted bunches can be placed on the flat tops of the kicker current curve, as shown in the sub graph (c) of Fig. 6. If the two extracted bunches can be placed on the flat tops of the current curves of eight kickers, they would have the same extraction coordinates and can be extracted from the RCS smoothly. Figure 7 shows the beam loss display of the RCS and RTBT. It can be known that the beam loss of the extraction system is very small.

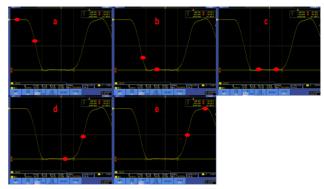


Figure 6: Two extracted bunches which set at different positions of the kicker current curve.

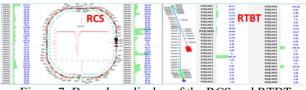


Figure 7: Beam loss display of the RCS and RTBT.

A METHOD TO CALIBRATE THE KICKER CURRENT CURVES

By adjusting the timing of the kicker, the current curve of the kicker would be translation. Then, the extracted bunch can be placed on different positions of the current curve and the BPM (such as RTBPM01) on the RTBT can measure different position information of the bunch. Therefore, after adjusting the timing of the kicker, by using the position information measured by the BPM on the RTBT, the kicker current curve can be calibrated.

During the calibration experiment of the kicker current curves, the timing of eight kickers should be adjusted well firstly. In addition, to make the experiment simple, single bunch mode would be selected, as shown in Fig. 8. By measuring the position information of the bunch, the position of the kicker current curve where the bunch placed on can be calculated. Figure 9 shows the single extracted bunch which sets at different places of the kicker current curve. It can be found that, if all the positions of the kicker current curve are calculated, the kicker current curve can be calibrated. This calibration method can be applied for all the eight kickers and will be confirmed in the future beam commissioning.

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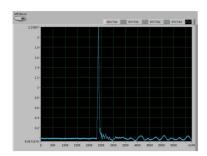


Figure 8: Display of the single extracted bunch measured on the RTBT.

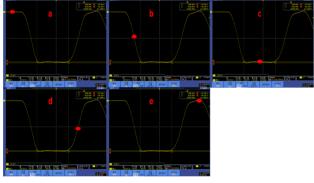


Figure 9: Single extracted bunch which sets at different positions of the kicker current curve.

CONCLUSIONS

During the beam commissioning, the timing adjustment of eight kickers is a very important problem. It consists of two parts: the overall timing adjustment of eight kickers and the independent timing adjustment of different $\hat{\omega}$ kickers.

In the early stage of beam commissioning, the beam \odot power and extraction beam size are relatively small. In g order to extract the beam from the RCS as soon as g possible, simple timing adjustment of eight kickers, including the relative timing of different kickers and the

overall timing adjustment of eight kickers, should be made which can also make the beam loss of the extraction system at a relatively small level. Latter, in order to reduce the beam loss and make the two extracted bunches have the same extraction coordinates, the independent timing adjustment of different kickers was studied and made.

During the timing adjustment of the kickers, by using the position information measured by the BPM on the RTBT, a possible method to calibrate the kicker current curves was developed. This calibration method would be confirmed in the future beam commissioning.

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