中国科学院高能物理研究所
Institute of High Energy Physics
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Design and Analysis of CSNS-II Primary Stripper Foil

J. X. Chen, L.Kang, J.B.Yu, G.Y.Wang, L.Liu, Y.J.Yu, J.S.Zhang, J.Y.Zhang

Dongguan, 523803, P.R.C.

Abstract: Stripper foil is a key equipment for converting negative hydrogen ions into protons in the RCS injection zone of CSNS. The structure of the CSNS primary stripper foil adopts a rotating steel strip structure, requiring operators to carry out maintenance work in close proximity for a long time. The energy of CSNS-II injection beam has significantly increased from 80MeV to 300MeV, and the radiation dose in the injection area will also increase, making it impossible to maintain the equipment in close proximity for a long time. Therefore, it is necessary to redesign the primary stripper foil.

INTRODUCTION

According to physical requirements, the CSNS-II stripper foil still adopts two sets of stripper foil devices, including one primary stripper foil and one secondary stripper foil, which have the same function as the CSNS stripper foil. However, due to the increase in radiation dose, it is impossible to maintain the equipment in close proximity. Therefore, a new overall foil store quick replacement mechanism must be adopted and a new maintenance plan must be redesigned.

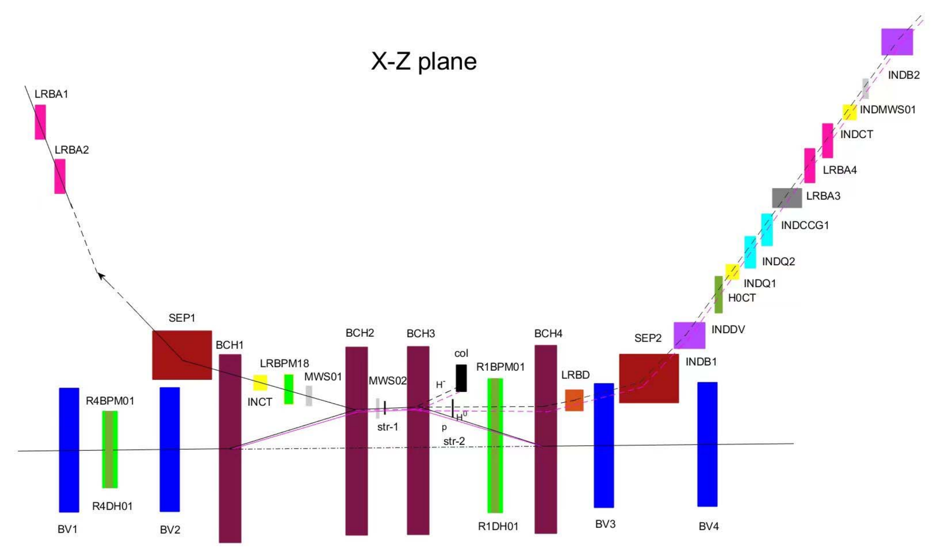

Fig.1 CSNS-II Injection Zone Layout

ANALYSIS OF THE FOIL DURING BEAM INJECTION

In order to maintain the stripping efficiency of 99.7%, the thickness of the primary stripper foil needs to be increased from 100 μg/cm2 to 260 μg/cm2.

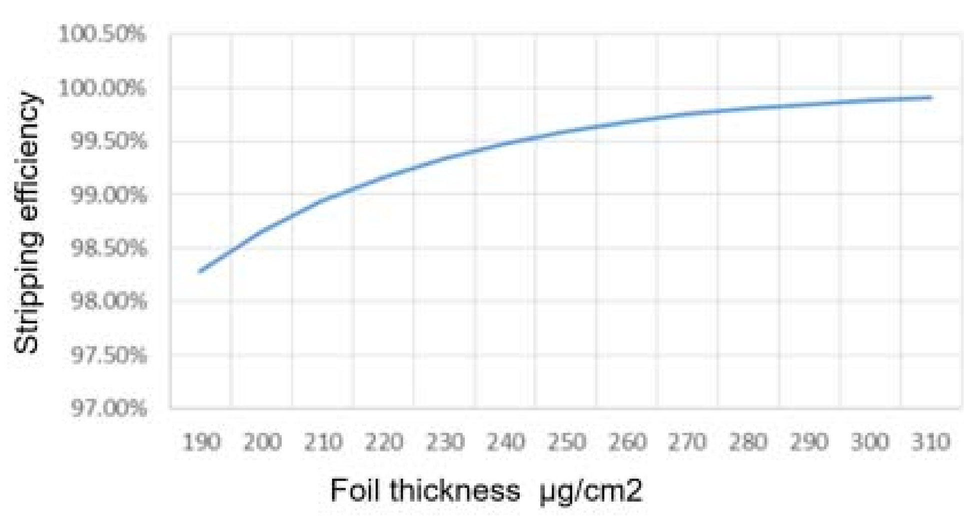

Fig.2 Stripping efficiency

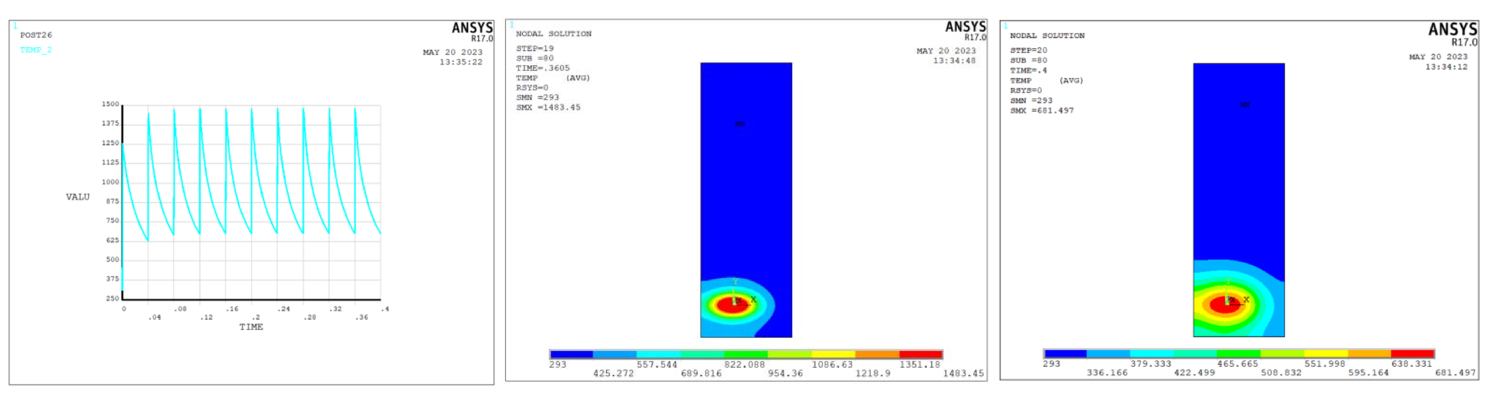

Figure 3: Temperature of stripper foil

From the figure 3, it can be seen that after ten cycles, the temperature trend remained stable, with the highest temperature being 1483K and the lowest temperature being 681K. The temperature distribution is shown in Figure 4, and the melting point of the carbon film is about 3800K, so the temperature is within the range that the film can withstand.

STRUCTURE SCHEME OF STRIPPER FOIL

Due to the high dose in the injection area and the high risk of personnel operating in close proximity, the CSNS-II stripper foil is planned to adopt an automatic replacement foil store structure and have remote maintenance capabilities, in order to complete the maintenance and repair of the stripper foil with minimal personnel intervention.

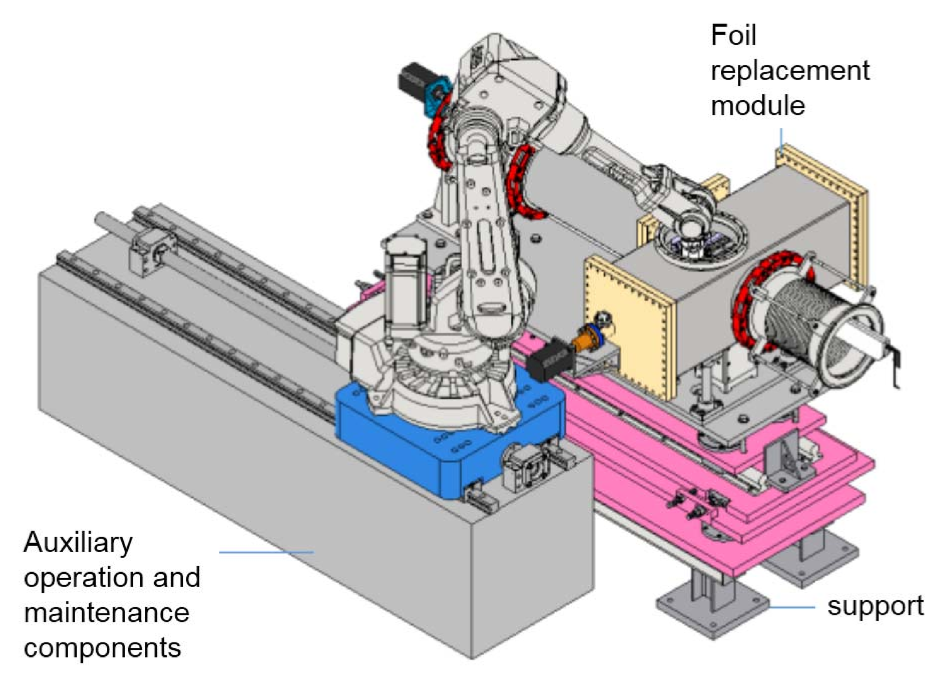

Fig.4 CSNS-II primary stripper foil

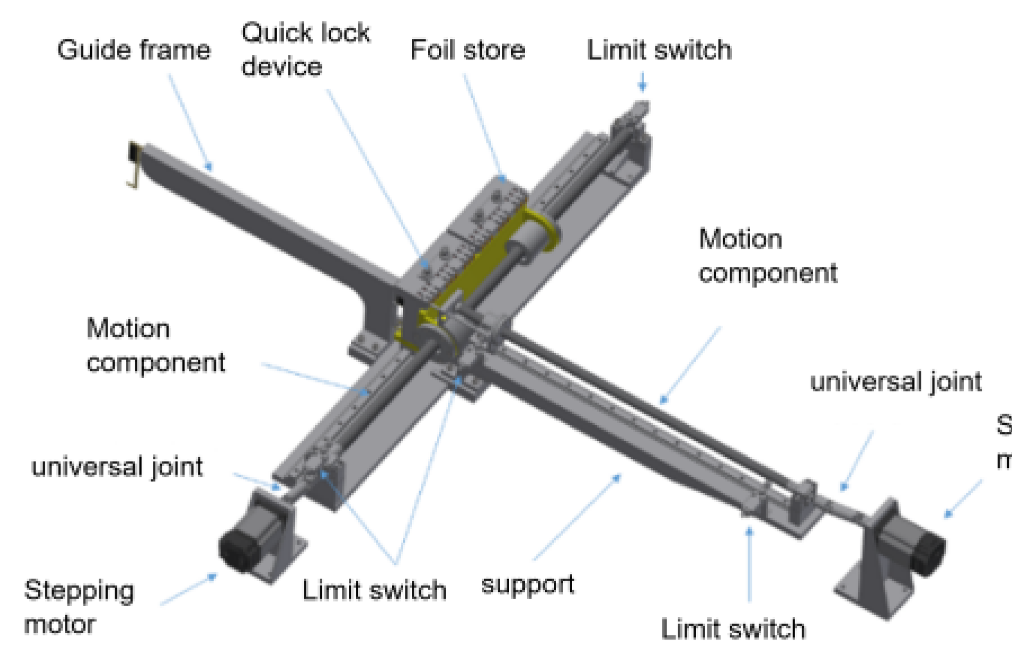

Fig.5 Internal structure of foil replacement module

In order to achieve rapid replacement of the stripper foil, a design scheme of an integral foil store was adopted. During maintenance, the maintenance of the stripper foil system can be completed by simply replacing the entire foil store, greatly reducing maintenance time and reducing residual radiation dose to personnel. After evaluation, the foil replacement time is saved by more than 80% compared to the foil replacement time of the steel strip structure.

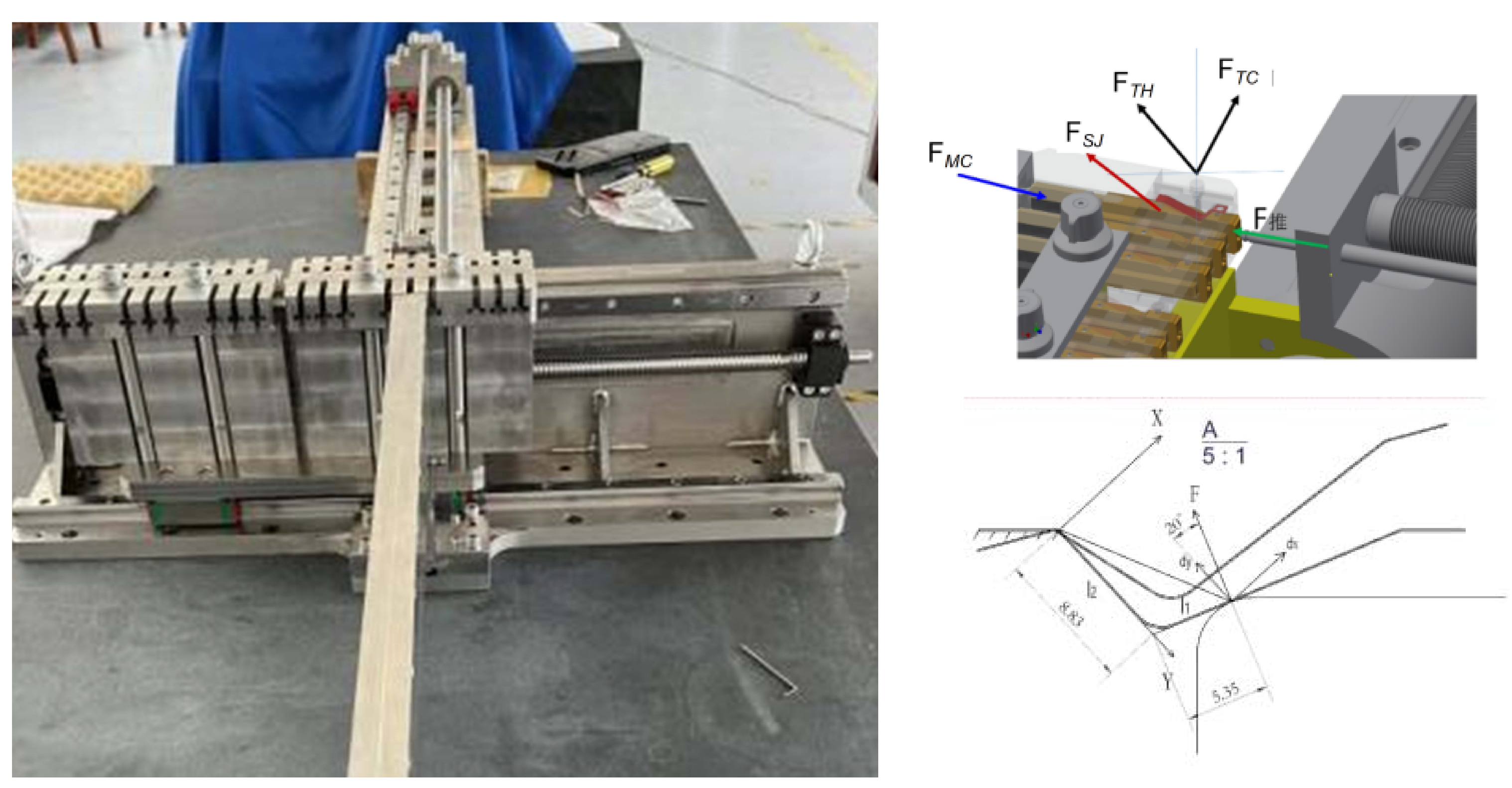

Figure 6: Prototype of stripper foil motion mechanism

When the guide rod pulls the slider back to the foil store for self-locking F_{TH}=15.1N , F_{TC}=6.3N and when the guide rod inserts the slider for self-locking. Actual measurement results F_{TH}=14.25 N , F_{TC}=7.37N .

The guiding mechanism has reciprocated more than 2000 times, and the repeated positioning accuracy is better than ± 0.1mm. The lateral motion accuracy of the foil magazine is better than ± 0.007mm.

SUMMARY: The injection power of the CSNS-II primary stripper foil has been increased to 300MeV, and the foil’s thickness is 260 μg/cm2. Using a combination of uniformly distributed and elliptical Gaussian analysis, the highest temperature on the foil is 1483K, which is within the acceptable range of the foil. Due to the increase in injection power, the regional dose will increase. Adopting an overall foil storage structure design combined with the use of series robots for operation and maintenance work will effectively reduce maintenance time. It has been proven that the structure has good stability and high motion accuracy, meeting the requirements for the foil system.

Email: chenjx@ihep.ac.cn

Chinese Spallation Neutron Source (CSNS),
Institute of High Energy Physics (IHEP), Dongguan, 523803, P.R.C.