A NEW GAS STRIPPER DESIGN FOR PKUAMS

Peng Shixiang*, Liu Kexin, Guo Zhiyu, Ma Hongji and Yuan Jinglin

Institute of Heavy Ion Physics, Peking University &

Key Laboratory of Heavy Ion Physics, Ministry of Education, Beijing 100871, China

Abstract

The design of gas stripper assembly in a tandem terminal of AMS facility is a compromise giving consideration to the conflicting requirements of stripper gas thickness, beam transmission and vacuum conditions inside acceleration tubes. A new stripper arrangement is being under developed for PKUAMS. The foil stripper will be moved to the position behind the gas stripper, a wider canal will be used as the stripper channel and an AST100 hybrid pump will be installed in the terminal to recirculate the stripper gas. Calculation has been carried out for the design and showed good results. The gas pressure in center of stripper tube could be enhanced by a factor of 2, and the vacuum conditions in both the LE and HE acceleration tubes could be improved 2 and 1.5 orders, respectively. The beam acceptance of the stripper could be enlarged due to using a wider channel.

1 INTRODUCTION

For precise and efficient radionuclide measurements using accelerator mass spectrometry (AMS) it is important to have a high transmission and efficient electron stripping in the terminal of the accelerator. With the use of heavier ions the good vacuum in acceleration tubes and the higher stripper density are required. Using a suitable size stripper canal and installing a pumping system at the terminal are the best way to satisfy the requirements. Unfortunately, those AMS-facilities that developed from the old tandem accelerators did not concern these aspects too much at the beginning of the modification. Around 1982, the first recirculation gas stripper system with a terminal pump was installed at ISOTRACE [1]. From then on, many AMS labs have installed or are planning to install this system on their facilities [2][3][4][5].

On PKUAMS facility, a non-recirculation gas stripper arrangement has being used. The gas stripper canal is a 700mm long conical asymmetrical stripper tube with a diameter of 5.5mm at its ends and 3.5mm in the center. Most of the stripper gas that flows out of the long and slim stripper canal is pumped through the HE accelerator tube (HE tube) because a differential pumping tube is installed between the foil stripper and the LE acceleration tube (LE tube). During routine operation, the vacuums at the ground ends of HE and

LE tubes are 2.0×10^{-4}Pa and 2.0×10^{-5}Pa, respectively. Measurements showed that, the beam transmission efficiency of the ^{12}C ions stripped to 3+ with Ar is close to 30% [6]. This is significantly lower than the maximum equilibrium stripping yield (about 55%) for ^{12}C at that energy [2]. Recently, a new recirculation gas stripper system was designed for our EN tandem and the bench test is on the way.

This work presents our design rationale, the structure of the new circulation stripper system and the pressure distribution along the acceleration tubes with the new and old stripper assembly.

2 BASIC CONSIDERATION

The PKUAMS is a shared facility and radiocarbon dating takes about 60% of the available accelerator time. Measurements were carried out with charge state 3+ around 3MeV. To get C^{3+} at that energy, the best stripper medium is Ar gas [2] and the optimal stripper thickness to reach the equilibrium is between 0.8~1.5μg/cm^2 [8].

The stripper gas flow, pumped mainly through HE tube, results in a pressure about 2.7×10^{-2}Pa in the housing surrounding the stripper channel and high pressure in HE tube in current PKUAMS system. Such a high pressure both degrades the performance of the accelerator tubes and causes significant beam losses due to multiple scattering and charge exchange. Although the conical asymmetrical stripper canal could reduce the gas flow to some degree for a given stripper thickness, the small size at its entrance reduces the beam accepting angle and decreases the beam transmission efficiency. With a terminal pump and a wider stripper canal, the new recirculation stripper arrangement will allow a higher gas density inside the stripper canal and a larger accepting angle at its entrance, and the vacuum conditions in the accelerator tubes will be improved.

Before starting the design, the following problems have to be considered: all components have to withstand the high pressure of the insulting gas(15atm), the space available to install the gas and foil strippers and pumping system is very narrow and the electric power available is limited. The design is based on the following two tenets: 1)when the terminal pump is not running or fails, the pressure conditions through the accelerator can be maintained the same as with the old stripper system; 2)be sure to make as few changes as possible to existing components.

* Corresponding Author. Tel: +86-10-62753093; Fax: +86-10-62751875. Email address: sxpeng@ihipms.ihip.pku.edu.cn

2 THE NEW STRIPPER SYSTEM

Figure 1 gives a schematic view of the new stripper design. The gas stripper canal is a 500mm long uniformity cylindrical tube with an inner diameter of 8mm. It is supported at each end by a flange perforated 4 holes with a diameter of 50mm to give a high vacuum conductance. A terminal pump is connected to the stripper housing to recirculate the gas flowed out from both ends of the stripper channel via a volume of high conductance. The type of the terminal pump is ATS 100 Hybrid pump that is manufactured by the Alcatel Company. This series pumps have been used as terminal pumps successfully in other lab[5]. The pumping speed is 125 l/s for N_2 when pumping against a fore pressure of 40 mbar. Passive cooling is sufficient for the terminal pump at 15atm. The beam enters and leaves the stripper housing through LE and HE differential pumping tubes (DP tubes). Both of them are 150mm long with an inner diameter of 8mm. The LE DP tube is attached to the supports near the inlet end of the gas stripper housing and extents through the bellows between LE tube and the gas stripper and into the region of the tube end flange. The HE DP tube is connected to the exit of the foil stripper and forwards to the bellow in frond of the HE tube. Both of the DP tubes are very important in this design. The LE DP tube could reduce the beam losses due to change exchanging from $C^{-}\rightarrow C^{0}$ in the LE tube. The supporting flange of HE DP tube could form a vacuum barrier between the stripper and the HE tube so that the only conductance between them is that of the DP canal itself. The new gas stripper housing is an all-new component. It has the same overall length, diameter and end flange details as the existing one, but is provided with a 100mm diameter side port for the pump, a 15mm port with NW 15 coupling for the gas inlet line and two 25mm ports with NW 25 coupling for a Penning gauge and a roughing connection for operation tests on the bench as well as in the tandem with the tank open. The conductance of the backing-line is larger compared with the conductance of the two ends of the gas stripper in parallel so that the pump can have a high efficiency with low pressure at the exit of it. If the pump is not running, the backup-line will be closed through an electromagnetic valve. The gas inlet from the reservoir through a fine thermoleak valve will supplement the stripper gas that pumped away through the accelerator tubes.

The foil stripper in new assembly is moved directly behind the gas stripper. In such a case the acceptance is mainly defined by the HE tube and is higher than original one, which is only defined by the stripper channel itself. With this arrangement and thinner C foils the equilibrium can be reached and the beam losses due to angular straggling can be avoided, so the transmission with foil stripper for all isotopes will be greatly enhanced. With ATS 100 pump running and almost no additional stripper gas, the vacuum in the foil stripper is improved and the pressure inside the stripper canal is raised. The latter makes it possible to get adequate high gas density to dissociate the molecules inside the stripper canal so that the coulomb explosion can be reduced.

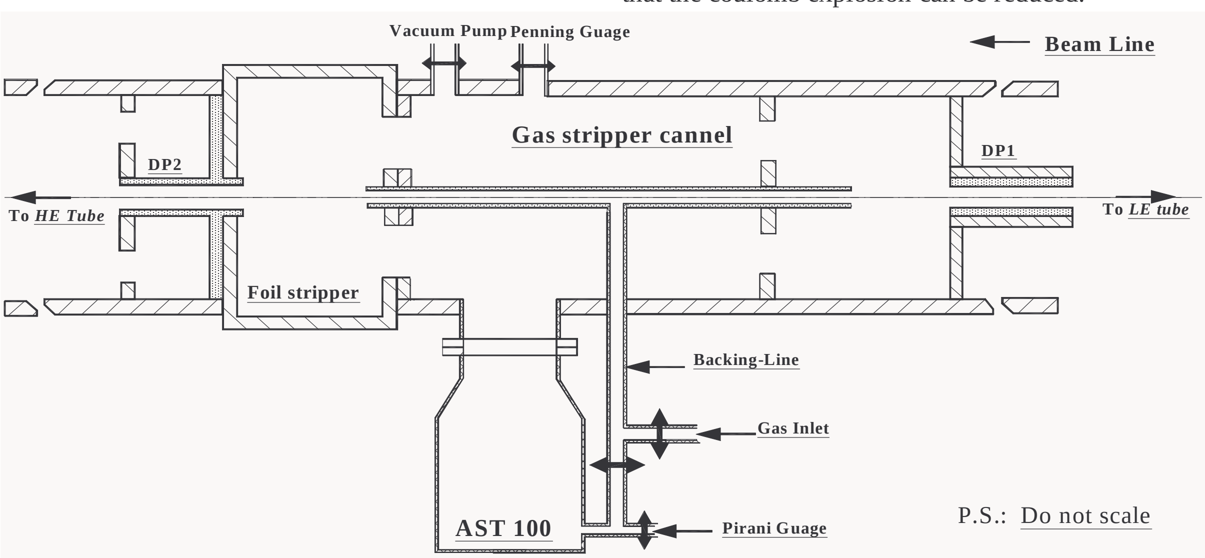

Fig. 1. Schematic design of the new stripper configuration.

3 PRESSURE PROFILE

Calculations were carried out to determine the pressure distribution along the acceleration tubes with the new and old stripper system. The calculation foundations are difference between them. For the old stripper, the calculation was based on the measured pressures at both ends of the accelerator tubes in routine operation, whereas for the new one, it was carried out for a suitable stripper thickness either with or without the terminal pumping. The gas stripper thickness was selected at 1.2μg/cm^2 for this calculation. Formulae for the conductance have been taken from Roth[7]. The calculation results are plotted in fig. 2.

As figure 2 shown, the pressure conditions inside the stripper channel and in the acceleration tubes have been changed over the previous setup. When the terminal pump is working, the stripper gas density inside the stripper channel can be enhanced by a factor of two, the pressure inside the stripper housing can be decreased by a factor of 2, and the vacuum in HE and LE accelerator tubes can be improved about 2 and 1.5 orders, respectively. More than 99.3% stripper gas has been recirculated with the new system. Once the terminal pump fails, the pressure through the accelerator can be maintained almost the same as that with the old stripper system except in the LE tube.

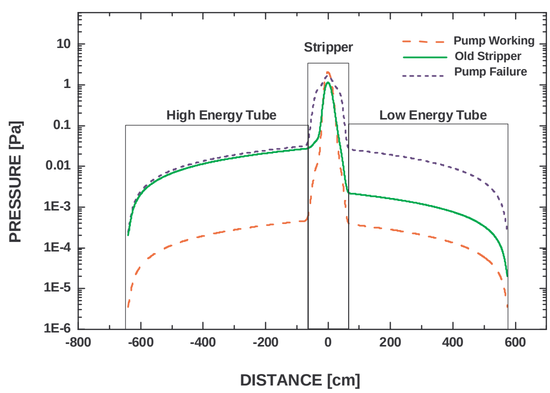

Fig. 2. Pressure characteristic through the accelerator of the old and new stripper arrangement with/without terminal pump. In the new system, the corresponding stripper thickness is about 1.2μg/cm^2. In the old one is based on the measured pressure during ordinary operation (the equal stripper thickness is about 0.93μg/cm^2)

4 DISCUSSION

Installing a recirculation stripper arrangement in accelerators is a compromise giving consideration to solve the conflict between the need of high stripper densities in the stripper canal and good vacuum conditions in the acceleration tubes. With this new recirculation stripper assembly, the vacuum conditions could be increased 2 and 1.5 orders in the HE and LE tubes, the stripper gas density in the stripper tube could be enhanced by a factor of 2, and the stripper gas consumption will be significant reduced. On the other hand, a wider stripper canal could reduce beam losses due to angular straggling at its entrance. With those improvements, a higher beam transmission and electron stripping efficiency could be obtained over the old setup. Installing a new recirculation stripper system is the way to get a better precision and higher efficiency on PKUAMS measurements.

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