SHORT NOTE
New Proposal for a Gas Centrifuge Rotating Differentially, (II)
Non-Rotating Side Wall

Takuya MATSUDA
Department of Applied Mathematics and Astronomy, University College*
Department of Aeronautical Engineering, Kyoto University**

Received November 18, 1976

KEYWORDS: gas centrifuges, chain centrifuges, isotope separation, uranium enrichment, differential rotation, Stewartson layers

In the previous note a differentially rotating gas centrifuge for the separation of isotope mixtures such as uranium was proposed[1]. By differentially rotating we mean that the angular velocities of the top and bottom end plates, $\Omega_1$ and $\Omega_2$, respectively, are not the same as that of the side wall, $\Omega_3$. It was argued that the case $\Omega_1, \Omega_2 > \Omega_3$ is particularly interesting because we can obtain a high separative power while at the same time there are less mechanical difficulties when $\Omega_3$ is kept moderately low. In the present note we expand this idea by discussing the case of $\Omega_3 = 0$, and propose a more concrete design for such centrifuges. The concept of a chain centrifuge is also proposed.

If $\Omega_3$ is zero, i.e., the side wall of the centrifuge is at rest, this drastically eases the many mechanical difficulties associating with high $\Omega_3$. Firstly we can choose fairly freely the radius, the length and the material of the side wall due to the absence of centrifugal forces. Secondly the injection of the feed gas from the side wall, which is advantageous because mixing loss is reduced by choosing an appropriate feed position, is easily achieved. Thirdly the withdrawal of the waste and product gases can be easily effected by inserting scoops from the side wall or possibly even from the end plates into the inner core rather than from the central axis. Finally the counter current, which is often produced by a temperature difference between the end plates, could be produced by a mechanically driven meridional flow produced by a difference between $\Omega_1$ and $\Omega_2$ (or both methods could be used to enhance the counter current.) The magnitude of the counter current can then be easily controlled by varying $\Omega_1 - \Omega_2$. The concept of the proposed design is illustrated schematically in Fig. 1.

![Fig. 1 Schematic diagram of proposed centrifuge](image)

A possible leak of gas through the slits between the end plate and the side wall is not serious if we combine the proposed centrifuges to make a long chain as shown in Fig. 2. This is nothing but a square cascade with a simplified layout. With this "chain centrifuge" one can increase the separative power of a single "chain centrifuge" by increasing the number of units.

The most serious disadvantage of the proposed centrifuge will possibly be due to loss

---

* Cardiff, CF1 1XL, U.K.
** Yoshida, Sakyoku, Kyoto.
However, energy loss due to viscous dissipation in the boundary layers could be partly compensated by a heat engine effect since the heat produced by the energy loss could be used to reinforce the rotational velocity of the gas in the inner core if we remove the heat from the end plates. The reason for this is that the temperature difference between the side wall and the end plates produces an azimuthal thermal wind which has the same direction as the general rotation. If we remove the heat from only one end plate, we have also a temperature difference between the end plates, which produces a counter current.

The loss of angular momentum, however, may be more serious. The question is: does the gas in the inner core rotate as quickly as the end plates even if the gas circulates through the Stewartson layers and lose angular momentum there? As far as a linear analysis is concerned, the answer is yes. The gas must rotate with the angular velocity, \((\Omega_1 + \Omega_2)/2\), except in the very narrow Stewartson layers, otherwise spin up currents occur to adjust the velocity of the gas. In this argument we have neglected complicated thermal effects. However, in the case of \(\Omega_3=0\), the equations are non-linear, and the prediction based on the linear analysis may not be correct. Although, since the Rossby number, which is the ratio of the inertial force to the Coriolis force and is a measure of non-linearity, is only of the order of unity in this case, the degree of non-linearity may not be very big.

It is essential, however, to know the flow field in the case of \(\Omega_3=0\) in order to precisely evaluate the efficiency of the proposed device; and since analytic calculation of the flow field would be very difficult due to the non-linearity, we must wait for either physical or numerical experiment to evaluate it. The proposed device is very easy to construct from the technical point of view, and the author believes that the undertaking of such a project should be worthwhile.

The author would like to thank Dr. A. H. Nelson for his careful reading of the manuscript.

---REFERENCE---