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On the Özemre's Approach to the Problem of Reflected Media*

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With 3 Figures in the Text

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Summary. It is shown that the global method proposed by Özemre for reflected media is based on a *tacit* assumption which can not hold in general but which turns out to be a fair approximation. The comparison of this method with the two group and the modified one group theories *suggests* that it occupies a place between them.

In a paper published in Nukleonik, A. Y. Özemre proposed a global method [1] for the calculation of a multiplying medium surrounded with a reflector and gave for the effective multiplication factor k'_{ef} of the reflected medium the following formula

$$k'_{\text{ef}} = \frac{k_\infty}{1 + (1-\beta)\, L^2 B_g^2}, \qquad (1)$$

where β is the albedo of the reflector and B_g^2 the geometrical buckling of the core.

The purpose of the present article is double. On one hand, we will try to clarify an implicit assumption made in the derivation of (1) and, on the other hand, we will apply this method to a simple concrete case in order to compare its validity with the modified one group theory and the two group theory.

Özemre first established in his paper that

$$k'_{\text{ef}} = \frac{k_\infty}{1 + (1-\beta)\,\dfrac{N_{\text{esc}}}{N}}, \qquad (2)$$

where N_{esc} is the number of escaping neutrons from the core and N that within the core. N_{esc} would be given by

$$N_{\text{esc}} = k'_{\text{ef}} \iint\limits_S \vec{J}_{\text{out}}(\vec{r}, t) \cdot d\vec{S}, \qquad (3)$$

and N by

$$N = k'_{\text{ef}} \iiint\limits_V \Sigma_a\, \Phi(\vec{r}, t)\, d\vec{r}, \qquad (4)$$

where $\vec{J}_{\text{out}}(\vec{r}, t)$ is the current density vector of neutrons directed towards the reflector. In the case where there is no reflector, as the current of incoming neutrons $\vec{J}_{\text{in}}(\vec{r}, t)$ to the core is zero, it may be written

$$\left.\begin{aligned} \iint\limits_S \vec{J}(\vec{r}, t) \cdot d\vec{S} &= \iint\limits_S [\vec{J}_{\text{out}}(\vec{r}, t) - \vec{J}_{\text{in}}(\vec{r}, t)] \cdot d\vec{S} \\ &= \iint\limits_S \vec{J}_{\text{out}}(\vec{r}, t) \cdot d\vec{S}. \end{aligned}\right\} \qquad (5)$$

* This work was performed under the anspices of the Turkish Atomic Energy Commission.

This special case enables us to write rigorously $N_{\text{esc}}/N = L^2 B_g^2$ [1]. However, in the case of a reflected medium the exact expression of N_{esc}/N would be obtained after having calculated the values of $\vec{J}_{\text{out}}(\vec{r}, t)$ on the surface S of the core. In order to avoid the difficulty of the computation of $\vec{J}_{\text{out}}(\vec{r}, t)$ on S, Özemre tacitly admits that, even in the case of reflected core, the relation (5) is still valid and therefore $N_{\text{esc}}/N = L^2 B_g^2$.

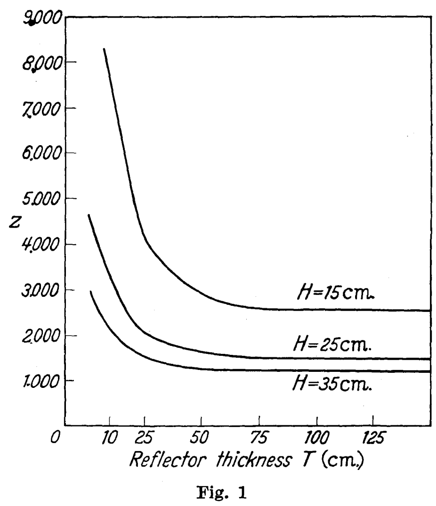

Fig. 1

Now it is obvious that this assumption can not hold in general but it may very well turn out to be a fair approximation. That this assumption is not true in general may easily be understood when we remark that for the same multiplying medium with reflector the neutron population near the interface S is more dense than in the case without a reflector. Therefore the number of neutrons really crossing into the reflector will be greater than the number of neutrons escaping into the vacuum if there were no reflector. Thus the already mentioned tacit assumption underestimates, in some way, the number of neutrons escaping from the core. Accordingly, the critical dimensions determined according to the formula (1) are expected to be systematically much less than those given by one group theory.

To test this conclusion we have taken into consideration an infinite homogeneous slab reactor of thickness H in which the fuel is assumed to be pure U-235 and the moderator is beryllium. This core is also assumed to be reflected by a graphite

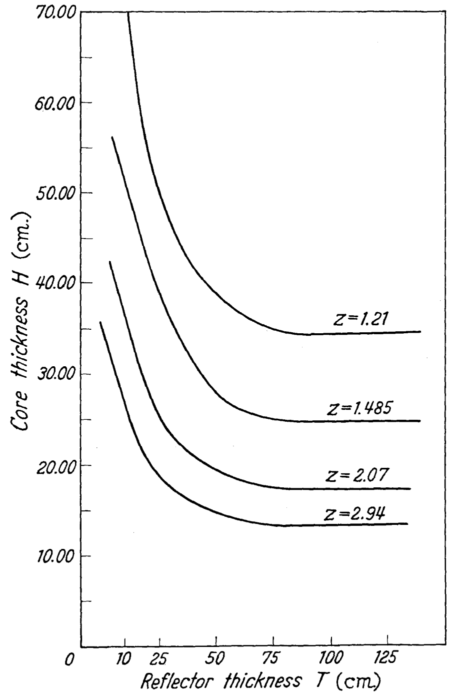

Fig. 2

reflector of thickness T from each side. We calculated by Özemre's global method the reflector thickness via the concentration of the fuel (fig. 1), the core thickness via the reflector thickness (fig. 2) and finally we compared the results given by the modified one group theory and those given by the two group theory with the results obtained by the global method slightly modified to take also into account the neutrons escaping during the moderation process.

It is seen from the figure 3 that the results for this specific example obtained by the global method occupy a place between those of the modified one group theory and those of the two group theory. This comparison suggests that the Özemre's approch to the problem of reflected media would be preferable to the modified one group theory because of its quickness and ease in hand calculations and estimations of critical dimensions.

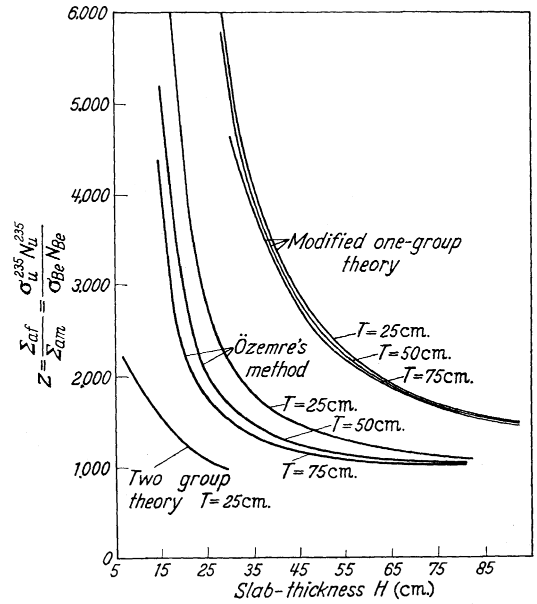

Fig. 3

I would like to express my gratitude to Dr. A. Y. Özemre for having suggested the subject of this article.

References: [1] Özemre, A. Y.: Nukleonik 5, 31—33 (1963).

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