Andrii Murdza

- *Master student at Moscow Institute of Physics and Technology (MIPT), Department of Ocean Thermohydrodynamics*
- *External master student at UNIS*

Principal supervisor: Prof. Vladimir Zhmur

UNIS supervisor: Prof. Aleksey Marchenko

Title of the project: Analytical methods for the calculation of loads on the moving structure in ice channel with broken ice

Analytical methods for the calculation of loads on the moving structure in ice channel with broken ice

Résumé

Due to the modern level of icebreaker technologies development, one of the possible ways of transportation on water bodies covered with floating ice is creation of a channel in the ice fields. In particular, the problem of transportation of various types of structures are important for activities related to oil exploration and production in the Arctic regions. In this connection, there is need to investigate characteristics of objects the movement in the ice channel with broken ice.

During this project the existing models of drifting ice cover and sea ice interactions were analysed. Assessment of the shape of accumulated compacted ice floes in front of the structure depending on inflow ice compactness was made. An attempt to get the analytical loads estimation on slowly moving objects in broken ice with different properties was made and results are preparing to be received.

The results of this investigation may be useful for determination of the optimal conditions for transportation in water bodies covered with ice.

Let us consider a problem of structure movement in broken ice (Figure 1). Presumably ice floes will accumulate in front of the structure in a shape of wedge. Thus, this wedge of ice floes will be stable to a certain extent. Further, the wedge will interact with other ice floes which surround moving structure. Considering ice floe collision with a wedge with corner angle of 2α and assuming stationary discontinuity which occurs during wedge flow, the relationships across the discontinuity can be written in the form

$$A_1 V_1 \sin\theta = A_2 V_2 \sin(\theta - \alpha)$$

$$V_1 \cos\theta = V_2 \cos(\theta - \alpha)$$

Where A_1 and V_1 are compactness and velocity of the ice cover which flow into a discontinuity; A_2 and V_2 are parameters after the discontinuity, θ – angle between direction of discontinuity and x axis (Figure 2). Here ice also assumes of a homogeneous thickness h = *const* and without ridging processes.

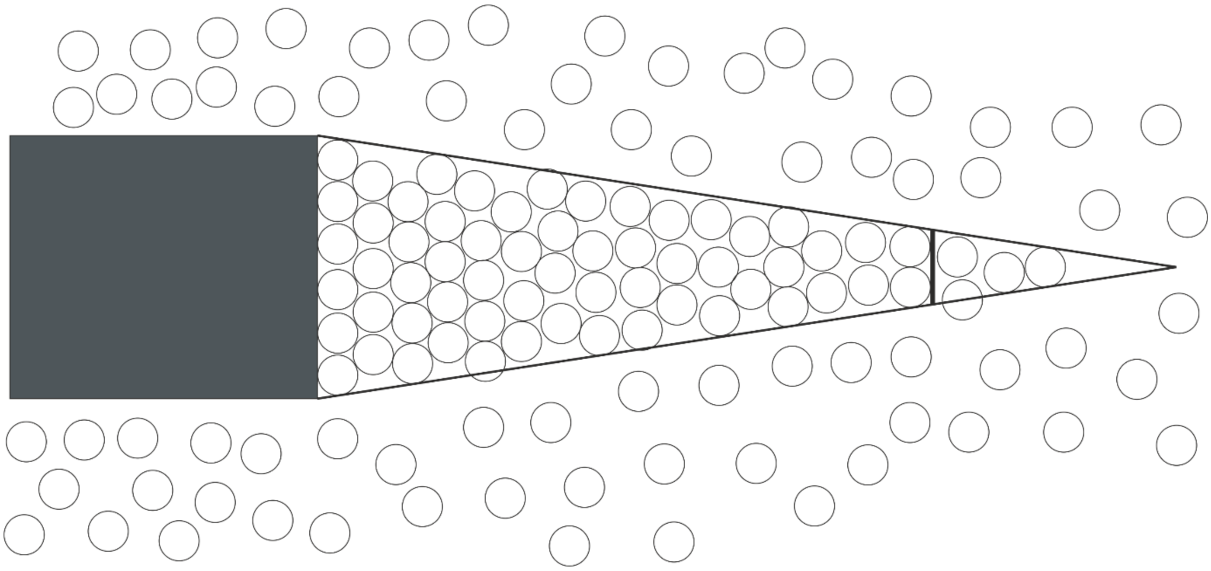

Figure 1: Movement of a structure in broken ice

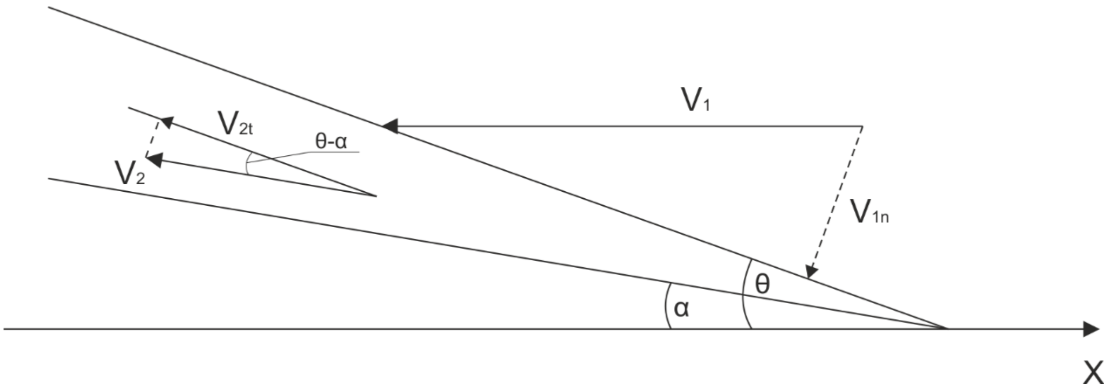

Figure 2: Scheme of the discontinuity during wedge flow

Considering critical ice compactness after the discontinuity ($A_{cr} = \frac{\pi}{4}$) we obtain

$$A_1 \tan\theta = A_{cr} \tan(\theta - \alpha)$$

For different incoming ice compactness's dependencies θ(α) are shown in Figure 3.

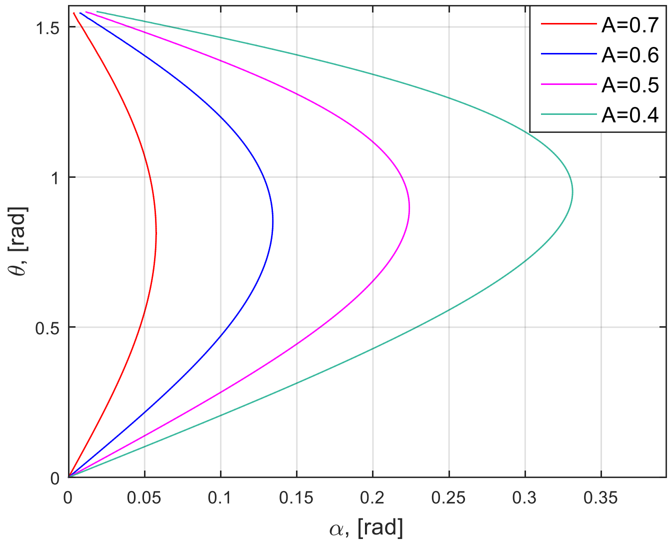

Figure 3: Discontinuity angle as a function of wedge angle for different inflow ice compactness's

For $A_1 = 0.7$ for the most stable shape we take maximum of α. As a result, a corner angle of the wedge equals 3.15^0.

The end of the wedge is narrow and evidently very unstable. Therefore, it is necessary to shorten it to the place where, for instance, two ice floes can be located. Let us estimate the length of the wedge L. Assuming structure width a=120m, corner angle of the wedge $\alpha=3.15^0$, average floe diameter d=20m according to similarity of triangles we obtain:

$$\frac{a}{d} = \frac{a/\tan\alpha}{a/\tan\alpha - L}$$

$$L = \frac{a-d}{\tan\alpha} = 1818m$$

Hence, during slow motion in front of the structure approximately 1.8 km of ice floes in the shape of a wedge will be accumulated.