

RESEARCH ON MECHANICAL ICE-BREAK METHODS AND RELATED EQUIPMENTS

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Abstract: In the paper, we introduce the mechanical methods of the ice-break, and present the load capacity of the ice. The idea and the concept of the ice-break vehicle are also given out according to the certain ice situation. It can provide the guidance for the ice-break vehicle maker and the will do help in the prevention of the ice run.

Key word: Ice-break; Mechanical Method, Equipment Design, Research.

1. Introduction

Through research and analysis of the ice-break methods and equipments in recent years, and analyzing existing amphibious ice-breaker equipment around the world, The design and develop a kind of amphibious ice-breaker equipment is necessary and urgent , it can be based on the current relatively mature technology products, which can be regarded as a kind of economic, practical, the feasible methods.

The application study of mechanical ice-break method is an important research content, mechanical ice method is mainly refers to use the external mechanical forces to destroy the ice caps, and the residual crushed ice are easily melt or flow away. The method includes cutting method, drill hole method, and other mechanical crushing method, e.g. the method of hammer hit and pull down method, etc.

1.1 Cutting method

When the ice sheet has certain thickness, and it has enough load capacity, we can use the cutting equipment such as disk saw, chain saw, etc. which are configured on the ice mechanical platform, and take ice sawing operation method according to certain rules cutting slot, which can damage the overall structure of the ice, weaken the strength of ice. The

operations above will do help in the ice sheet and avoid occurrence too big size ice in the process of ice melting. So through the method, it can realize the purpose of smooth thawing with manual intention.

Adopting the method cutting ice caps to prevent ice bar, there have been more many research tests and successful practical applications. Relevant tests show that cutting in any directions which are not the vertical the river bank direction is effective, it can effectively prevent the formation of ice in the narrow bend jam. Since the 1990 s, the cutting method has become the main method in prevention and control of ice run of the government of Finland.

1.2 Hole method

Drilling hole method is similar to the cutting method, through the ice hole way, it damages the overall structure of the ice. Drilling hole method can not only weaken ice caps through mechanics way, but also it can accelerate the melting ice in the hole.

The application experiments show that a month before the river thaw, dilling out many column diameter about 20cm the holes in the bend of a river, the bridge pier, channel state place, they can significantly reduce the probability of large size ice, and they can avoid and delay the formation of ice jam.

1.3 Mechanical crushing method

The hammer hit method and the crush methods are direct broken ice methods, they can open the ice channel method quickly. The above methods are the most ideal methods to avoid ice block method, but work efficiency of them are relatively low, consumption of the energy is large.

As known when the operations are conducted on the ice and its requirements of bearing capacity are also higher, risk of operation is big, it should ensure produce a large number of crushed ice and prevent the collapse smoothly. This method is suitable for short dangerous channel where is easily form the feezed dam, thickness ice is thin, and in the special period when the ice operation is forbidden.

At present, the mechanical methods are mainly adopt the multi-function environmental protection ice-break ship, the through the crushing method in the water to implement ice-broken operation. The research and application of ice broken method on the ice is less.

2. Load capacity of the ice

In natural ice conditions, its load capacity of the tracked vehicles and wheeled vehicles can be estimated according to the table.1above, In the calculation, the smallest ice thickness value should be taken in into consideration, when the ice layer is muddy, the 1/2 value of thickness should be taken into consideration, the thickness of melted ice should not be calculated.

Table.1 reflects the load capacity when the ice is intact, if the ice is broken, its load capacity will be reduced. The load capacity of the rupture ice sheet is only about 1/3 of the intact ice sheet. The above relationships between the load and ice thickness can be applied to the winter, when in the thawing time of spring, temperature is improved and ice load capacity will be deduced largely.

It has been proved in the experiments that the vehicle speed will influenced the ice sheet, if the speed of the vehicle is too fast, it will produce violent vibration on the surface, and the ice will be vulnerable to be fractured. Only when the load is not reach 1/2 of the load capacity of the ice, the vehicle of speed is not restricted. Due to the corner, shallow, pool ditch and so on, the ice presents the uniform distributions. The ice thickness prediction value is hard to meet the need, the ice thickness measuring and load capacity calculating, should be conducted, in order to guarantee the safety of different tonnage transport vehicles.

Table.1 Relationships between ice thickness and load capacity

Allowable load T(ton)	ice thickness under the condition of average temperature in three day and night (cm)			minimum distance Load workshop The (m)
	Below -10 ⁰ C	-5 ⁰ C	0 ⁰ C	
Tracked vehicle				
4	18	20	23	10
6	22	24	31	15
10	28	31	39	20
16	36	40	50	25
20	40	44	56	30

30	49	54	63	35
40	57	63	80	40
50	63	70	88	55
60	70	77	98	70
Wheeled vehicles				
4	22	24	31	18
6	29	32	40	20
8	34	37	48	22
10	38	42	53	25
15	18	53	60	30
20	55	60	68	35
25	60	66	75	40
30	67	74	83	45
35	72	79	90	50
40	77	85	96	55

3. Design of the equipment

Ice-broken equipment should have strong land, water habitat driving and operational capability, which is similar to amphibious vehicle platform, which can configure the ice detection equipment, ice cut broken equipment, ice drilling equipment, blasting content delivery equipment according to the actually situation. The communication equipment, safety protection equipment and related function module, which can form the independent operation or joint operational capability of the multifunction ice -break platform.

3.1 Analysis of amphibious vehicle

From the related research and investigation, the Swedish amphibious vehicle as shown in the Fig.1 ,its design idea, structure, function and principle, control mode, etc., have good reference and it is quite similar to the ice-break vehicle we designed.



Fig.1 Swedish ice-break vehicle

First, ice-break vehicle should be adopted light weight design, with material of good aluminum alloy, which can guarantee the lighter weight for the biggest buoyancy reserves and redundancy to meet the operation needs, and at the same time, the reduce the track of the pressure, which make it is adapt to the river levee and beaches, such as the ice sensitive region. Second, the independent motor ability of the vehicle is strong. Good amphibious characteristics, in order to ensure the certain land independent motor capacity and water self-help escape ability of the vehicle, it can satisfy the complicated environment and security need in the operation. Third, the modular operation tools, quick connection systems, remote control mode of operation, trailer device can be directly adopted and reference. The load and power can satisfy the launch saw, cut, drill and ice operation tools, etc. The power consumption is low, energy efficiency ratio is high. Fourth, the maintenance of the vehicle should be simple, cost of maintenance should be low, the special training is unnecessary, the common driving personnel can operate, and its maintenance is without special materials and technology, Fig.2 is the amphibious ice-break vehicle we designed.

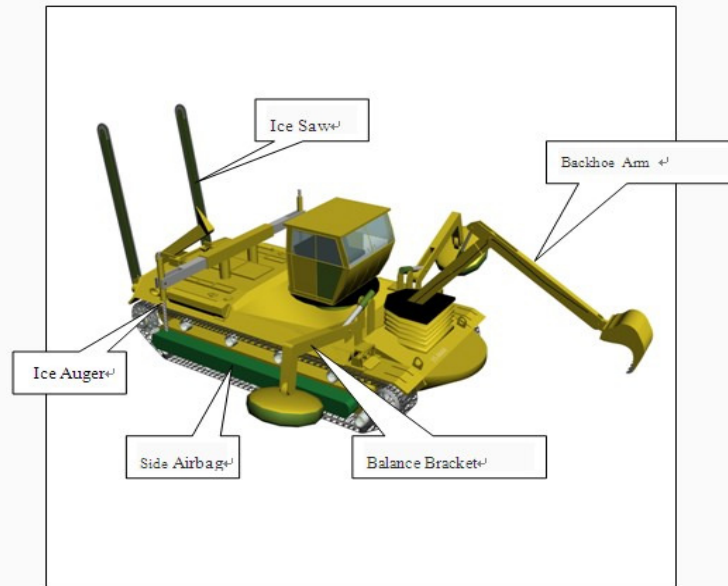


Fig.2 Designed ice-break vehicle

3.2. Existing problems

First, the heating of caterpillar friction should be solved. The caterpillar track is made of synthetic materials, and its motion process is realized through dry friction. When the caterpillar vehicle works on land or ice for long time, and the wear resistance, high temperature resistant performance, and if there exists the possible of deformation and fracture or affect the other parts of the performance.

Second, the weight of platform or load problem should be solved. Through Sweden existing amphibious vehicle as shown in the Fig.1 is very light in weight about 1.4 ton, but its load ability is limited no more than 500 kg. As known that the blasting operation should add explosive conventional equipment, the drilling equipment, blasting equipment, etc., its total weight is expected to reach 1.2 ton, so the platform should be designed to meet the requirements above. Considering the operation is conducted on ice, and the ice load capacity is limited, the whole weight of the platform should be controlled in 3 ton, and its load should within 1 ton. Therefore, how to control platform of weight, strengthen its body stiffness, and improve the load carrying capacity. At the same time, we should consider the load capacity of the track, ensure the platform can perform normal motor and operation, all above all should be focus on and be solved.

Third, the power problem of the vehicle, the existing amphibious vehicle power such as the shown in Fig.1, it is about 29 horsepower (21.3 KW), we should take the needs of motor and saw, drilling operation into consideration. In order to meet the normal operation of transmission, we can choose bigger, suitable power for the engine, thus increase the total power of the ice-break vehicle.

Fourth , there is no too much additional requirements on the size of the vehicle , as long as it can satisfy the condition that it can not fall, which can be solved through adding the balloon on both sides of the vehicle and support arm solve the problem. So the size of platform, should be meet the basic functional requirements, and has good mobility, agility, under the premise of safety.

Fifth is the problem of ice operation machine. When the vehicle is designed, we should concerned on selection and design ice-break tool. The design ice-break machine should not be too complicated, it can choose the ice saw or ice drill as equipment, according to the ice-break effect, we can adopt optimized and improved equipments.

4 Analysis of Some Dangerous Situation

4.1 Crack of the Small Ice sheet area

If the small area of ice is collapsed, the vehicle's unilateral track may card into the ice inside, if load capacity ice is enough, relying on the both sides of the support arm of the vehicle, the vehicle platform can climb up to the surface.

4.2 Collapse of Large Ice

If the ice crack area is suddenly collapsed, the vehicle may fall into the water from different angle and position, the following are the typical water state. As to the situations above, the vehicle must be able has its own buoyancy reserve which can prevent the vehicle from upsetting in the water. When vehicle go into water, it can be able to rely on their own water mobility or through its own self-help ability. Therefore, in the design process, in order to ensures the waterproof performance of the vehicle, besides the enough buoyancy reserve, we should focus on the design and calculation of the vehicle's center of gravity, buoyancy, and make the safe assessment of the system design.

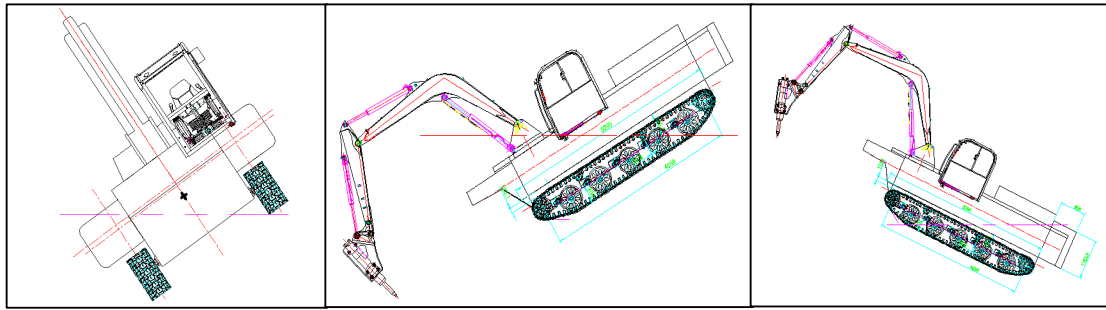


Fig. 3 Three typical water states

5. Conclusion

The ice-break through can operation independent or in a joint operation way, it can meet all-weather, all operation requirements. It is can work in all-weather conditions and the temperature effect on it also is small, whether in night or day, it can implement homework; no matter near the ice, water, bridges or ice accumulation, ice jam , we can adopt the ice-break vehicle to perform the related implementation; The third is that the ice-break vehicle can meet different periods process of ice-broken, before the thawing time it can be adopted on the weakening of the whole structure of the ice sheet, in the middle and last period of the thawing ,it can clear large ice sheets, break up the ice jam or ice bar timely. In addition, when in emergency situations or when it is not suitable for mechanical ice-break method, we can also adopt the delivery explosive method through ice-break vehicle.

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