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A study on Applicability in Super Cavitation with SLBM of North Korea

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Abstract

This study is about technical analysis in launching SLBM of North Korea. We expect that North Korea develop ICBM and SLBM by improving the technique called R-27. Also it is expected that they attempt to achievement in covertness and ambush by completing technique of cold launching. Recently, SLBM of North Korea rised 40 ~ 50 m on surface after launching in an underwater when they showed the scene of firing SLBM. We expect that they actively use not general technique but super cavitation technique. Also, they might improve the launching technique by doing SLBM launching test. This type is about that whole rocket is separated two parts and ignited with high velocity and we might think that 1st rocket is used in solid propellant to maneuver in high velocity in an underwater. After then, they might use liquid propellant for the long-range ballistic missile.

Key Words : SLBM(Submarine Launched Ballistic Missile), Supercavitation, Follower force

1. Introduction

Follower force faces the problem of structural mechanics occasionally. Especially, it is occurred in the field of aerospace engineering which uses the huge trust with having demand of weight lightening. Structural instability becomes vibration and it can causes divergence or flutter. Because of this problem, the need of structural mechanics optimal technique is increased for weight lightening of structures and kinematic precise control. Mostly, follower force is handled in aerospace engineering or structural mechanics. But, it is recently handled in an underwater and issued. The technical analysis in launching SLBM of North Korea is finished a lot. Regardless of the fact of rocket and launching type, we analysis in possibility of technical success and the background. Figure 1 is about SLBM with hot launching which loads in Yankee-1 type in the former Soviet Union navy in 1970s.

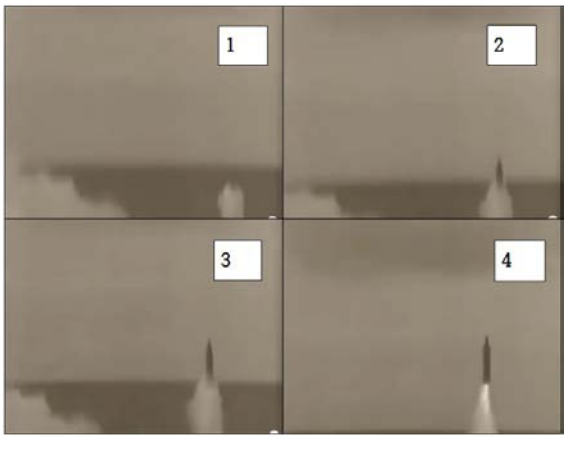

Fig. 1 R-27 SLBM launching test

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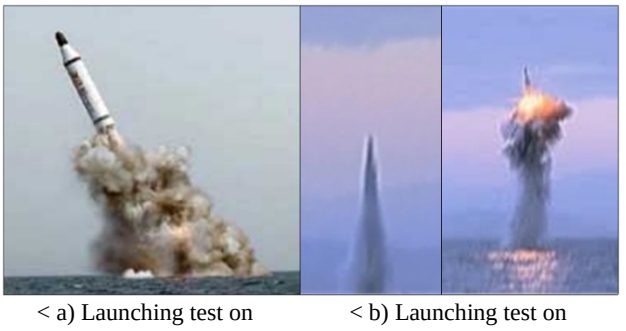
North Korea improve the technique called R-27 to develop ICBM and SLBM. The former Soviet Union improved hot launching to cold launching in R-27 and North Korea adopts the submarine called G-II type from the former Soviet Union. Naturally. they attempt to achievement in covertness and ambush by completing technique of cold launching. Especially, they actively use the cold launching technique in the submarine call SINPO type of North Korea to load SLBM.

Figure 2-a is the picture of SLBM in 2015. This is evaluated that it adopts the technique called R-27 in the former Soviet Union. By analyzing the firing scene, it is different from existing cold launching. it is much longer and the degree of firing is vertical. Especially, the height of ignition is more higher after launching in an underwater.



< a) Launching test on May in 2015. > < b) Launching test on December in 2015. >

Fig. 2 SLBM launching test of North Korea

Like figure 3, general SLBM is located 1 ~ 10m on the surface after launching in an underwater. Higher ignition height is expected that it uses more energy or another technique. With higher altitude, it can save time and get the stability. Also, it stay stably in the track and can increase the range. But, to rise the height, more acceleration is needed in firing and it is very difficult. So, super cavitation technique might be applied to launching SLBM in 2015.

2. Necessary of technique application in super cavitation of SLBM

The purpose of Super cavitation technique is to decrease surface tension of underwater vehicle which maneuver in high velocity. Generally in an underwater, it needs eight times trust energy to increase two times velocity. But, those trust few over the maximum speed(180km/h). Increase of Propellant technique, underwater resistance decrease technique to high speed technique are sometimes cause about the rapid loss of efficiency, velocity limit and unstability of follow force.

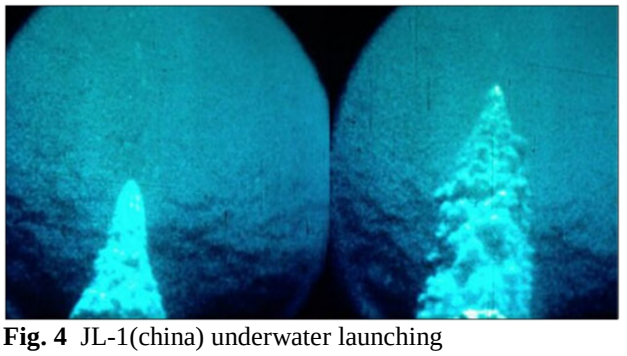


Fig. 4 JL-1(china) underwater launching (cavity bubble shape)

Figure 4 is the picture of JL-1. Because of underwater firing, Cavity occurs and it surround the rocket and has the huge friction resistance. Huge friction resistance demands the big trust and the big trust causes to the structural stability. Seeing figure 5, the SLBM which develop in china is launched and exploded because of structural unstability in follower force. In an underwater, the optimal technique is required in order to retain structural stability by

<JL-1(china)> < Trident(USA)>

Fig. 3 Ignition way after launching of general SLBM

Fig. 5 Explosion by unstability of follower force in SLBM of China

Fig. 6 Longer Range Under Water Launched Ballistic Missile(K4)

Fig. 7 Process of 2nd Separation/Ingnition in SLBM of North Korea

follower force and increase velocity by reducing surface friction. To resolve this underwater problem, super cavitation technique is developed consistently. Super cavitation technique was developed to improve torpedo's speed. But, it is expanded to warships and submarines and so on nowadays. For this trend to application, we think that North Korea who deals weapons with Russia or Iran might adopt super cavitation technique and apply SLBM.

Figure 6 shows such possibility of technique. It is India's LRUWLBM and it is described about super cavitation launcher on the international patent.

Especially, like figure 7, North Korea might progress the existing technique. SLBM is accelerated in an underwater and whole rocket is separated two parts and ignited with high velocity and we might think that 1st rocket is used in solid propellant to maneuver in high velocity in an underwater. After then, they might use liquid propellant for the long-range ballistic missile. This stage separation process shows that it is the proof of technical application about cold launching in an underwater.

3. Theoretical background about possibility of supercavitation application

Many researchs has done to resolve about technical difficulty of guidance control way. In super cavitation, guidance control way is demanded to resolve many technical problems in fluid characteristics and modification by cavitor or TVC are demanded to alternatives. But, environment of super cavitation is

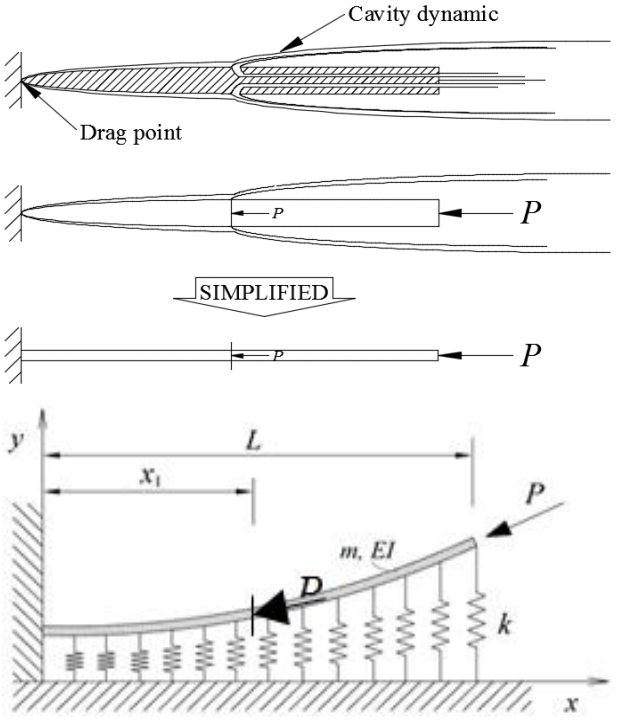


Fig. 8 Beck's Beam on the elastic foundation with follow force at lumped mass

limited and has huge difficulty in guidance control way. This phenomenon is due to increase in kinematic unstability of structures when structures are contacted on the fluid boundary. For this reason, we consider about the way of super cavitation guidance by using ignition gas at a certain position by expanding of environment of super cavitation. After forming super cavitation by cavitor, second environment of super cavitation is formed by using ignition gas at a certain position. At this situation, the range of fluid boundary is expanded and we think that it is more possible to handle wide position control than modification by cavitor or TVC. Especially, it can prevent about the re-entrant in the outside structure. Also we think that it can minimize the vibration of drag by cavitation shedding. It is shown in figure 8(simplified underwater vehicle). We studied by mathematical modeling and supposed that additional follower force is occurred at the partial position. It is shown at figure 9. We schematized analysis values about variation of elastic foundation k at section of $\xi_1 = 0.1 \sim 1$ (pos). Irrespectively section of $\xi_1 = 0.1 \sim 1$ unstability of flutter type is occurred at critical follow force at $p_{cr} = 10.02$ and the native number of vibrations are increased by increasing of k. In other words, if the mechanism which can occur super cavitation at a certain position can be adopted, it is possible to form super cavitation for whole vehicle with small trust relatively. After looking into this characteristic, it is possible to application of super cavitation technique in SLBM and we think that it is compatible technique the long-range ballistic missile. because energy consumption rate is small relatively.

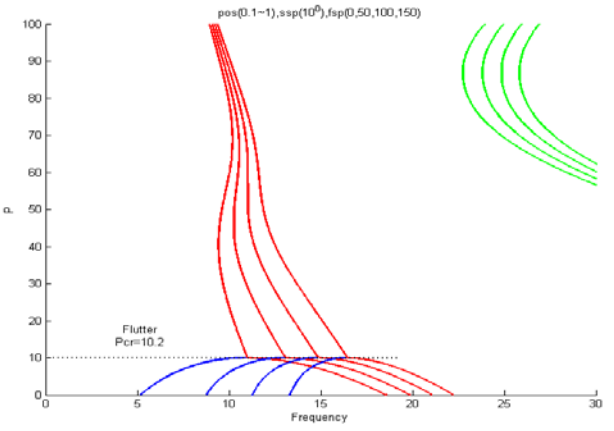


Fig. 9 First, second and third frequency curves for follower forces when $\xi_1 = 0.1 \sim 1, k_1 = 10^0$, $k = 0,50,100,150$

3. Conclusions

This study is about technical analysis in launching SLBM of North Korea. We expect that North Korea develop ICBM and SLBM by improving the technique called R-27. Also it is expected that they attempt to achievement in covertness and ambush by completing technique of cold launching. Recently, SLBM of North Korea rised 40 ~ 50 m on surface after launching in an underwater when they showed the scene of firing SLBM. We expect that they actively use not general technique but super cavitation technique. Also, they might improve the launching technique by doing SLBM launching test. This type is about that whole rocket is separated two parts and ignited with high velocity and we might think that 1st rocket is used in solid propellant to maneuver in high velocity in an underwater. After then, they might use liquid propellant for the long-range ballistic missile. This stage separation process shows that it is the proof of technical application about cold launching in an underwater.

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