Analysis of Shock Resistance for Shipboard Equipments on Underwater Vehicle

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ABSTRACT

Consider the situation created by a nuclear or chemical underwater explosion attack upon a surface ship or submarine. There is within the vessel myriad equipment and machinery that must continue to function if the vessel is to survive and fight. And the Dynamic Design Analysis Method (DDAM) is the U.S. Navy ’ s specified analytical method of qualifying non-testable equipment and supporting structures to withstand the effects of shock. The technique is based on experimental investigations conducted in the 1960 ’ s. Availablity of powerful computer codes, advances in computer technology and analytical correlation studies conducted during recent shock trials has not changed the basic credibility of the DDAM. The DDAM has been used for more than 40 years as part of the U.S. Navy ’ s efforts to shock-harden heavy shipboard equipment. This spectral method, which has been validated several times, employs normal mode theory, modal effective mass and shock design values. DDAM prescribes a modal analysis approach that utilizes these shock design values in three orthogonal directions and takes into account the type of vehicle and equipment location, that is, hull-mounted, deck-mounted, and shell plate mounted. Radar mount system, Deisel-Electric engine mount and propulsion shaft are defined as Grade A equipment which are essential for the safety and continued combat capability of the submarine. Therefore in order to evaluate shock resistance under shock environments, this thesis adopts DDAM in conjunction with a shock design spectrum inducted by U.S. Navy after performing full-scale trials in establishing a shock response spectrum analysis, to - viii - be coordinated by using finite element ’ s discrete and calculating procedure. The simple support beam was used to take the explosion shock as an example to verify the effectiveness of the proposed numerical procedure. Analysis results demonstrate a sufficient correlation. Also described herein in detail are the shock responses of Radar mount system, Deisel-Electric engine mount and propulsion shaft. Analysis results provides a valuable reference for shipboard equipment shock resistant design. In addition, the shock mounts are adopted to support the Nave equipment, and isolate shock impact caused by underwater explosion and which are studied in detail. Three MIL-S-901D navysea mounts with diffeent rubber durometer (durometer 30, 50, and 70) are mounted in a Diesel-Electric engine bottom to study the abilities of shock resistant. The research results in this subproject are a valuable reference for shock resistant design of shipboard equipment after considering different potential threats.

Keywords : DDAM, shock design values, duroeter, mount

Table of Contents

REFERENCES

[1] Keil A. H.,“ The response of ships to underwater explosion ”, The annual meeting if the society of Naval architects and Marineengineering, New York(1961.) [2] Biot, M.A.,“ Analytical and Experimental Method in Engineering Seismology ”, Trans. ASCE, 108-365(1943).
[3] Charles E. C., Vibration and shock isolation 4th, Associate Professor California institute Technology, John Wiley & Sons, Inc, New York, pp314~320(1959).
[4] Belsheim, R.O. and O'Hara, G.J. "Shock design of shipboard equipment-dynamic design analysis method," NAVSHIPS 250-423-30, May(1961).
[5] O'Hara, G.J., and Belsheim, R.O., "Interim design values for shock design of shipboard structures", NRL-MR-1396 (1963).
[6] Belsheim, R.O., O'Hara, G.J., "Shock design of shipboard equipment, part 3 experimental evaluation of the dynamic design analysis method," NRL. Rep. 6478, Washington, DC, pp. 331-354 (1967).
[7] "Guide for Mathematical modeling and dynamic shock analysis of Rudder, Rudder Stocks and Bearings" Supervisor of Shipbuilding, Conversion and Repair USN, 3'd Naval District (1967).
[8] "Mathematical modeling and dynamic shock analysis guide for main propulsion shifting," Supervisor of Shipbuilding, Conversion and Repair USN, 3'd Naval District, Rep. No.SUPSHIP280-1 (1967).
[9] Joseph J. T. and James T. H.,“ DEG7 class mathematical model report for dynamic shock analysis of main propulsion shafting ”, Report No.M68-2(1968).
[10] Mathematical modeling and dynamic shock analysis guide for mast," Supervisor of Shipbuilding, Conversion and Repair USN, 3'd Naval District, Rep. No. SUPSHIP280-6 (1972).
[11]Dave S. Steinberg, Vibration Analysis for Electronic Equipment, A wiley-interscience publication, John Wiley & Sons, New York, pp15~18(1973).
[12] Hurwitz, M.M., "The dynamic design analysis method (DDAM) in Nastran," David Taylor Naval Ship Research and Development Center (1981).
[13] O'Hara, G.J., P.F. Cunniff,“ Dynamic design analysis of a foundation undergoing unequal support shock motion ”, NRL. Rep. 5154, Washington, DC 20375,(1983).
[14] Remmers Gene,“ Maurice Biot 50th Anniversary Lecture The Evolution of Spectral Techniques in Navy Shock Design ”, Davie Taylor Navy Ship Research and Development Center Bethesda, Maryland,(1983).
[15] Dimaggio, F.L., and Ranlet, D.,“ On Improving and Extending The Design Shock Spectrum Used in DDAM ”, NTIS Rep. AD-A139304(1984).
[16] Webboa, G.M.“ Variable of Structure Response to Underwater Explosion with Charge Standoff and Un-symmetric Loading ”, NTIS AD-A139304(1984).
[17] Bort, R.L.,“ Masses of Normal Modes for Structures with Multiple Supports ”, NTIS AD-A175974(1986).
[18] Bort, R.L.,“ Revised Impact Dynamic Design Analysis Method ”, NTIS AD-A190497(1988).
[19] 林振聲，“ 海軍技術命令-裝備振動及噪音測試規範介紹 ”，海軍後勤司令部發行，(1988)。
[20] Harris, C. H., John J. H., Charles J. L.,“ Application of Isolators ”, Shock and Vibration Handbook, 4th edition, McGraw-Hill, p34-6 (1988).
[21] Military specification MIL-STD-901D(Navy), Shock test, H. I. (High impact) Shipboard Machinery, Equipment and Systems, Requirements For, March (1989).
[22] 鍾慶富，“ FFG-7級艦爆震設計與測試之研究 ”， 海軍學術月刊，第二十四卷，第十期，第80-89頁，(1990)。
[23] 王康生，“ FFG-7 級艦主要船段結構強度設計 ”，海軍學術月刊，第二十四卷，第八期，第81-91 頁，(1990)。
[24] Cunniff, P.F. and O ’ Hara, G.J.,“ Feasibility of a Transient Dynamic Design Analysis Method ”, shock and vibration, Vol.1, No.3, pp.241-251(1994) [25] 廖建義，“ 衝擊試驗規格與衝擊反應頻譜分析 ”，第三屆軍艦 工程研討會論文集，第92-96頁。
[26] Olofsson, U., T. Svensson and H. Torstensson,“ Response Spectrum Method in Tank-Vehicle Design ”, International Journal of Fatigue, Vol.19:2, pp.185(1995).
[27] McCarthy R.H.,“ Shock Design Criteria for Surface Ships ”, NAVSEA 0908-LP-000-3010, Naval Sea Systems Command.(1995) [28] Remmers, M.G., O ’ Hara, G.J., Cunniff, P.F., Review Dynamic Design Analysis Method , shock and vibration, Vol.3, NO.6, pp.461-476(1996).
[29] 李雅榮、郭真祥、林輝政、薛文証、梁卓中、夏曉文、鄧作樑、陳正雄、邱啟舜、廖建義、馬豐源，“ 艦用系統介面軍 規之研究 ”，經濟部八十六年度科技研究發展專案/船舶技術發展五年計畫，1997 年。
[30] 林澄貴，“ 爆震因子在水雷作戰上之應用 ”，海軍學術月刊，第三十六捲，第十期，第58-67 頁，(2000)。

[31] 沈士鈞，“針對潛艦設計設計系統與其關鍵性技術進行探討”國防大學中正理工學院，造船工程研究所碩士論文，(2001)。
[32] Yunhe Yu, Nagi G.. N. and Roa V. D.,“A literature review of automotive vehicle engine mounting systems”, Mechanism and machine theory 36. pp.123-142(2001).
[33] 梁卓中，戴毓修，“以反應譜分析法探討船艦舵部之爆震反應”，中國造船暨輪機工程學刊，第二十卷，第三期，1~16 頁(2001)。
[34] C.C. Liang, M.F. Yang, T.S. Tai,“Predction of Shock Response for a quadrupod-mast using response spectrum analysis method”, Ocean Engineering, Vol.29 No.8, pp887-914(2002).
[35] John E. Miesner,“Shock and Acoustic Mount ”, Smart Materials Bulletin. (2002).
[36] Talley M. A. and Sarkani S.,“A New Simulation Method Providing Shock Mount Selection Assurance”, shock and Vibration 10,pp.231-267,(2003) [37] Coats T., M., Arden K. Cooper, and Russell F.,“Component representation for shock qualified foundation structure”, Shock and Vibration 10, pp.71-80, (2003).
[38] 梁卓中、鄧作樑、徐慶瑜、戴毓修、任展勇、劉子豪，“船艦在爆震力下之結構動態反應與裝備防震策略”，經濟部92 年 度科技專案研發成果-船舶技術發展第二期四年計畫，(2003)。
[39] Chopra, A. K.,“Dynamics of Structures: Theory and Applications to Earthquake Engineering,” Prentice-Hall, Inc., (1995).
[40] NAVSEA 0900-LP-097-4010,“Structural Design Manual for Naval Surface Ships”, 1976.
[41] General Specifications for Ships of the United States NAVY, section 072, Naval Sea System Command, Washington, DC 20362-5101, 1991.
[42] 林東成，“艦艇噪音與反潛作戰之關係”，第三屆軍艦工程研 討會論文集，pp. 124-131, (1995)。
[43] Design Data Sheet 072-1“Shock Criteria”.
[44] 張國安，”軍規在軍艦設計應用上之探討”，財團法人聯合船舶設計發展中心，造艦軍規研究成果發表會，pp.87-101，1998.