SSC Project Recommendation for FY 2017

Investigation of Fatigue and Fracture Characteristics for High Manganese Steel Considering Temperature Effects

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1.0 OBJECTIVE.

1.1 The objective of this project is to investigate fatigue and fracture performances of high manganese steel with consideration of temperature effects. The results of this research can provide more accurate structure design for liquefied natural gas (LNG) storage and fuel tanks and less conservative/cost effect structural integrity assessment (SIA) of LNG vessels.

2.0 BACKGROUND.

2.1 Recent efforts to avoid serious environmental pollution reinforced the International Maritime Organization (IMO) regulations for nitrogen oxide (NOx). In particular, the Marine Environmental Protection Committee (MEPC) of the IMO agreed upon progressively stricter limitations for NOx emissions from ocean going vessels. This latest trend has led to increased demand for LNG.

2.2 One of the most important issues in the design of LNG vessel is the structural integrity of storage tanks. Considering the operation temperature of LNG vessel, storage tanks are typically manufactured with low temperature materials such as Al-5083, SUS304L, Invar alloy, nickel steel and high manganese steel.

2.3 In particular, it is well known that high manganese steel has good strength and outstanding toughness. In addition, high manganese steel has attracted interest because they are potentially less expensive than other low temperature materials. However, fatigue and fracture performances of high manganese steel are insufficient, especially for welded joints. In this respect, it is necessary to evaluate fatigue and fracture performances of high manganese steel with consideration of temperature effect for LNG vessel application.

2.4 Many researchers studied SIA procedures for various welded structures. The existing codes and standards employed in SIA showed that the design of welded structures is affected by mechanical properties, fracture toughness and fatigue crack growth behavior. In this respect, the research results from this study with consideration of temperature effects and fracture/fatigue performances will significantly contribute for less conservative and cost effective applications of high manganese steel for LNG vessels.

2.5 The justification for this project is to evaluate fatigue and fracture performances of high manganese steel with consideration of temperature effects for LNG vessel application. In addition, fatigue and fracture performances of high manganese steel will be compared with other low temperature materials.

3.0 REQUIREMENTS.

3.1 Scope.

3.1.1 The Contractor shall conduct a literature survey of existing fatigue limit, fatigue crack growth rate, fatigue crack growth thresholds, fracture toughness and research trends of low temperature materials for LNG application.

3.1.2 The Contractor shall design and fabricate test specimens for the evaluation of high manganese steel including welded joints.

3.1.3 The Contractor shall test these specimens under various temperatures, recording relevant fracture toughness, fatigue limit, fatigue ductile-brittle temperature (FDBT), material constants and threshold values

3.1.4 The Contractor shall compare fatigue and fracture performances for high manganese steel with those for other low temperature materials.

3.1.5 The Contractor shall document the results of the project in a report.

3.2 Tasks.

3.2.1 The Contractor shall review the literature for (a) application trend of low temperature materials in codes, (b) fatigue and fracture performance of low temperature materials and (c) current research trends of high manganese steel.

3.2.2 The Contractor shall design and fabricate each test specimens according to the relevant American Society for Testing and Materials Standards (ASTM). The dimension and condition of the specimen shall be documented.

3.2.3 The Contractor shall perform the required tests such as tensile, fatigue crack growth and fracture toughness of high manganese steel in base metal, heat affected zone (HAZ) and weld metal (conducted flux-cored arc welding) at various temperatures, in the range between 25 and -163°C and record the results using the proper equipment.

3.2.4 The Contractor shall determine the fatigue and fracture characteristics of high manganese steel based on the obtained data and compare with reference data of other low temperature materials.

3.2.5 The Contractor will apply the fatigue and fracture characteristics for structural integrity assessment in an exemplary structure and demonstrate the significance of the proposed research.

3.3 Project Timeline.

3.3.1 Literature survey and specimen design : 3 months

3.3.2 Fabrication of specimen and conducting a test : 7 months

3.3.3 Comparison and evaluation with fatigue and fracture performances of other low temperature materials and prepare a report : 2 months

4.0 GOVERNMENT FURNISHED INFORMATION.

4.1 Standards for the Preparation and Publication of SSC Technical Reports.

5.0 DELIVERY REQUIREMENTS.

5.1 The Contractor shall provide quarterly progress reports to the Project Technical Committee, the Ship Structure Committee Executive Director, and the Contract Specialist.

5.2 The Contractor shall provide a print ready master final report and an electronic copy, including the above deliverables, formatted as per the SSC Report Style Manual as posted on the website http://www.shipstructure.org.

6.0 PERIOD OF PERFORMANCE.

6.1 Project Initiation Date: date of award.

6.2 Project Completion Date: 12 months from the date of award.

7.0 GOVERNMENT ESTIMATE. These contractor direct costs are based on previous project participation expenses.

7.1 Project Duration: 12 months.

7.2 Total Estimate: $ 100,000

8.0 REFERENCES.

8.1 Azzara A., Rutherford D. and Wang H., 2014, "Feasibility of IMO Annex VI Tier III implementation using Selective Catalytic Reduction", The International Council on Clean Transportation, 4, pp 1-9.

8.2 Oh D.J., Lee J.M., Noh B.J., Kim W.S., Ryuichi A., Toshiyuki M. and Kim M.H., 2015, "Investigation of Fatigue Performance of Low Temperature Alloys for LNG Storage Tanks", Journal of Mechanical Engineering Science, 0(0), pp 1-15.

8.3 Park J.Y. and Kim M.H., 2016, "Fatigue Crack Propagation Characteristics of 3.5 of 9% wt% Nickel Steels for Low Temperature Applications", Proceeding of ASME 2016 35th International Conference on Ocean and Artic Engineering

NOTE:

- Please do not submit any proprietary information in this outline. This will be posted on the SSC Website regardless if the project is selected to be funded.

- All projects will be competed via Government Services Administration (GSA) or Commerce Business Daily (announced)