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Ph.D. Topic: “Optimization of Marine Transportation of Compressed Natural Gas”

Summary

The most popular methods of natural gas transportation are onshore pipelines, underwater pipelines and Liquefied Natural Gas (LNG). In addition to these, a new technology for transporting larger volumes of gas in compressed form by ships or barges has come to forefront in recent years.

The history of marine transportation of Compressed Natural Gas (CNG) dates back to 1960. When SIGALPHA started transporting gas in steel cylinders placed on ships. This idea, later led to the development of new more technically improved and more economical and safe vessels called Carrousel or Coselle.

Maritime transportation of CNG is regarded as a competitor to other traditional methods of gas transportation at distances from about 500 to 2500 miles and the quantity of gas to be transported varies from 1 to almost 4 billion m³ annually. However, if the demand of gas at the recipient end is much greater, or the distance is longer than 3000 miles, then, it's better to transport gas in liquefied form. This technology is, therefore, not competitive on the intercontinental scale. It is designed primarily to serve local markets. It is much favorable to be used during peak-shaving period as well. Almost 60% of natural gas deposits are in stranded form, which can be economically exploited by marine CNG.

To transport gas as CNG, the raw gas is compressed up to a pressure of 25 MPa and stored in special pressurized cylinders (modules), which are then transported to receiving terminals by ships. At the receiving terminal, the transported gas is either stored in underground storages or directly fed to the consumers after adjusting the pressure according to their requirements. A budget of a typical CNG project basically depends upon 3 processes, compression of raw gas, transportation of compressed gas and turbo-expansion of gas at the recipient end. Therefore, transportation consumes a handsome proportion of overall budget.

The Principal Focus of Thesis: Optimizing the sailing route of marine transportation of CNG and optimization of operating parameters of ship engines which reduces the cost of transportation of gas.

In this project, it is assumed that the costs of marine CNG transportation are a function of only the amount of fuel consumed by the ship engines and this, in turn, depends on the length of sailing route and on the operating parameters of the engines.

In case, if there is a single production source of gas and several receiving destinations, we have to deal with so-called the shortest path rule. The goal is achieved by creating an algorithm with spotlight apex (points of delivery of gas) on a graph showing all shortest paths between the selected vertex and all the others, and hence, minimizing the cost of transportation.

While, when we have a few points of gas supplies and a few / several recipient destinations, we have to deal it as a common problem of transport.

In our situation, the calculated minimum total cost of transportation is considered as the sum of the unit cost of transportation and the sum of cost of individual points of supply and demand.

Optimization of operating parameters of the ship engine is the task of nonlinear constrained optimization. Non-linear objective function is based on the functioning parameters of the ship engines. The purpose of optimization is to determine optimal engine load for a given deadweight and the rotational speed of each of the engines, which minimizes the objective function and comply with equality and inequality constraints.

Key-words: Optimization, CNG Technology, Maritime transportation

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