SYSTEM AND METHOD FOR STOWAGE OF HAZARDOUS LIQUIDS ON VESSELS

BACKGROUND

[0001] The present invention relates generally to the operation of transportation vessels, and more particularly to a system and method for arranging hazardous liquids in bulk that takes into consideration various conditions including, but not limited to, cargo quantity, cargo weight, vessel tank compatibility, vessel tank layout, cargo chemical compatibility, cargo temperature compatibility, and previous cargo suitability.

[0002] Chemical tankers such as merchant vessels are designed to carry specialized liquid cargoes in bulk, such as vegetable oil, polymers, lubrication oils and animal fats. These vessels are typically smaller than crude or product carriers and contain a large amount of tanks of variable size (e.g., 12 to 54 tanks) that are separated by a single wall ("bulkhead") positioned side-by-side.

[0003] Cargoes that are loaded onto a vessel are susceptible to the particulars of nearby cargoes due to possible leakage between tanks. As a result the United States Coast Guard publishes Federal regulations for the stowage of chemical cargoes with regard to their chemical reactivity to one another. Certain materials by law are prohibited from being stowed adjacent to certain other types of materials in case there is damage to a bulkhead. Another danger that may result is that the mixing of incompatible cargoes may result in noxious fumes or explosion.

[0004] In addition, some cargoes may be subject to temperature incompatibility. Materials such as acetone, for example, can be damaged by proximity to a conductive heated cargo such as soybean oil. Soybean oil is subject to internal heating coils in order to shorten cleaning time and aid in discharge.

[0005] Generally the temperature requirements of cargoes is achieved by experience, and in some cases regulated as a pollution prevention measure by the International Convention for the Prevention of Pollution from Ships ("MARPOL"). In the latter case some cargoes require heat prior to discharge in order to reduce the amount of residue that is accumulated during cleaning, and subsequently discharged overboard in approved areas. Mitigation of heat conductivity is achieved through separation of the sensitive materials by other cargo, diagonal stowage with regard to tank layout, separation by an empty tank, or limiting the time that the cargo is subjected to high heat.

[0006] A further consideration when creating a load plan is the undesirability of placing an edible cargo in a tank that has been used as storage for a cargo that is dangerous to human or animal health. One scenario would be benzene, which is a known carcinogen, as a last cargo to molasses fit for animal consumption. An up-to-date list of such cargoes is maintained by The Federation of Oils, Seeds and Fats Associations ("FOSFA"). Typically these tanks would need to be flushed with three cargoes amenable to edible oils prior to stowage of edible oils.

[0007] Lastly, and perhaps of most interest commercially, is the ability to split and commingle cargoes in order to optimize total stowage. For example several parcels may be split among many tanks. This event is an exercise in combinatorial optimization that can become a complex and dynamic endeavor, especially with regard to adjacency issues as discussed above.

[0008] Typically, a commercial manager of chemical tankers (" vessel managers") when preparing to book cargoes for carriage will, using pencil and paper and various reference materials, create a rough stow plan. This process may include various specialists - to include the vessel's senior management and outside consultants - in order to assess the suitability of the load plan. The event can take between 5 minutes to several hours, depending on the manager's time constraints and level of expertise with various cargoes, and is subject to human error.

[0009] To date there does not appear to be a system or method of generating a stow plan based on the criteria as described above.

SUMMARY OF THE INVENTION

[0010] The present invention demonstrates a system and method for preparing and executing a load plan for vessels such as chemical tankers that take into consideration the various properties of the vessel and the materials to be transported to create a cargo arrangement that complies with all established regulations and safety measures while optimizing space for increased efficiency. Factors that may be considered when establishing the load plan include cargo quantity, cargo weight, vessel tank compatibility, vessel tank layout, cargo chemical compatibility, cargo temperature compatibility, and previous cargo suitability. Among the objects of the present invention is to ensure that: cargoes are stowed safely with regard to chemical compatibility and last cargo suitability; cargoes are stowed in such a manner so as not to damage one another due to high temperature; cargoes are stowed efficiently with regard to weight and volume; cargos are split in certain conditions to optimize the allotted space; and recommendations are made as to the suitability of a vessel for future cargoes. These and other objects of the present invention will best be understood in view of the detailed description of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 an exemplary cargo list generated by a user interface of the present invention;

[0012] FIG. 2 is a flow chart of an optimization logic conducted by the present invention; and

[0013] FIG. 3 is an exemplary data map of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] **Definitions and Acronyms**

Adjacency	A tank that is next to another tank. If the tank is connected diagonally (the corners are touching) it is not considered adjacent.
Aft	The back part of the vessel
Annex	MARPOL pollution category. An Annex I cargo is typically an oil-based cargo such as lubrication oil. An Annex II cargo is chemical based. Each Annex has different handling requirements with regard to disposal of residues.
Athwartships	Across the vessel from port to starboard
Bulk	A large quantity
Cargo	An IMO Annex I or II liquid cargo
Cargo Name	A name as designated by the IMO, industry convention or a trade name.
Category	A particular of a chemical that denotes what type of vessel the chemical may be carried on.
Certificate of Fitness	A document listing cargoes able to be carried by a class of vessel
Chemical Compatibility	A number assigned to a chemical cargo by the U.S.C.G. as found in the C.F.Rs. Certain numbers are incompatible with others, and some are compatible.

Chemical Exceptions	Exceptions to the U.S.C.G. Chemical Compatibility list.
Chemical Tanker	A type of tankship designed to transport chemicals in bulk
COF	Certificate of fitness
Commingling	Combining two or more cargoes
Down by the head / stern	The bow is lower in the water that the stern, and vice-versa, respectively.
Fix	The booking of a cargo by a commercial broker
Fore	The forward part of the vessel
FOSFA	Federation of Oils, Seeds and Fats Association Ltd.
GUI	Graphic user interface
Hazardous Liquid	Liquids deemed hazardous for shipment by water by the International Maritime Organization
IDE	Integrated development environment
IMO	International Maritime Organization
Last cargoes	Cargoes preceding a cargo to be loaded in a particular tank.
Mapping	A method of organizing data in the form of a dictionary
Marine tank vessel	Chemical Tanker
MARPOL	Maritime Pollution Regulations as outlined by the International Maritime Organization
Module	Computer code that accomplishes a task
Parcel	A single cargo
Particulars	Characteristics of an object. For example the total length of a vessel.
Prewash	The requirement wash a cargo after discharge ashore to mitigate slops discharged to sea. This event can be mitigated by discharging the cargo at high temperature.
Slops	Residual cargo that is sometimes mixed with wash water.
Split cargo	Separating a single cargo into two or more cargoes
Tank layout	Vessel tank layouts are generally two dimensional, side-by-side tank layouts that extend fore and aft. Occasionally there will be deck tanks and midships tanks as well.
Temperature	Temperature in Celsius
TPI	Tons per inch immersion. The number of tons necessary to sink the vessel one inch.
Volume	Volume of a cargo in cubic meters
Weight	Weight of a cargo in metric tons

[0015] In one aspect of the present invention, a data input device is used to enter data into a computer for storage and manipulation. The computer is loaded with a program that includes logic to receive the information from a user and create a loading plan for a vessel in accordance with the objects listed above and in compliance with all applicable regulations and laws. In a preferred embodiment, the computer program is constructed using Python, a high-level programming language. The code used to construct Python is C, which is compiled into machine code. The operation of the computer program relies on three components: (a) a user interface; (b) a database; and (c) conditional logic ("back-end" or "algorithm"). Each of these are discussed in turn.

[0016] User Interface

[0017] The user interface is cross-platform interactive module that allows a user to input data regarding a cargo. The operational inputs include cargo name, cargo weight, and whether cargo may be commingled with like cargoes. The user interface produces a result in the form of a cargo list with a suggested stow as shown in Figure 1 (below).

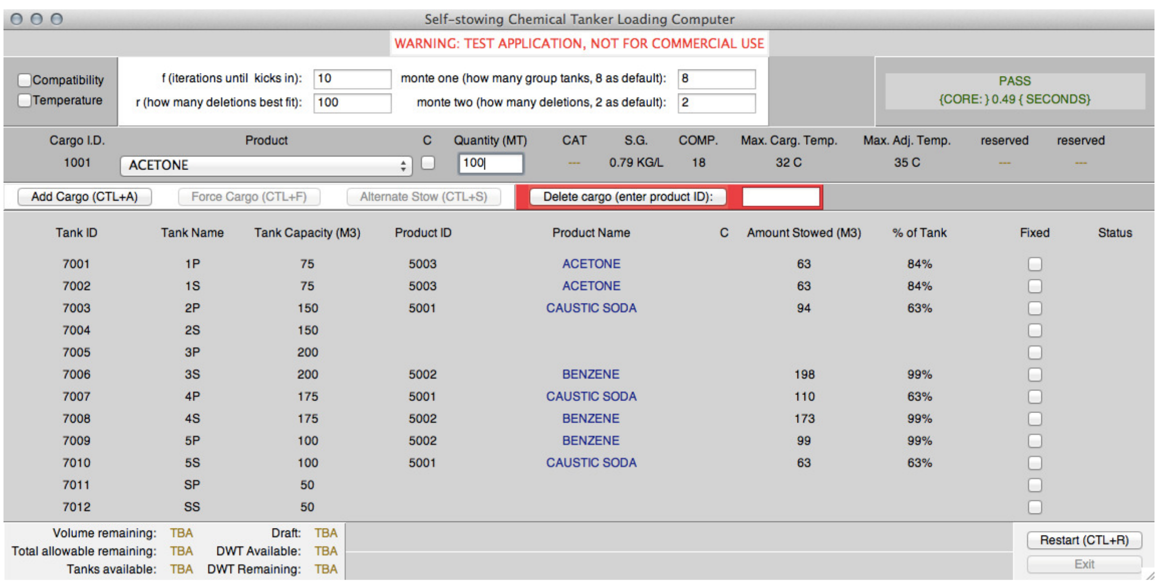

FIG. 1

[0018] Database

[0019] The database includes information and details of the cargo contents. Examples of cargo information include: (a) Specific Gravity in kilograms per cubic meter; (b) Chemical Compatibility Number; (c) Chemical Exception Number(s); (d) Maximum permissible temperature; (e) Normal operating temperature, to include pre-heating in anticipation of discharge; (f) Name, either generic or trade; (g) FOSFA data; and (h) Prewash requirements.

[0020] Also included in the database are the vessel particulars. Tank information may include: (a) Tank layout; (b) Tank size(s) in cubic meters; (c) Maximum permissible temperature in tanks; (d) Allowable weight, measured in specific gravity in kilograms per cubic meter; (e) Certificate of Fitness; (f) Deadweight; (g) Draft; and (h) Tons per inch immersion.

[0021] <u>Conditional Logic</u>

[0022] The back-end is mapping software that places the cargoes in the correct tanks. The back-end consists of programs or subroutines that perform: (a) Tank mapping with regard to individual cargoes; (b) Tank mapping of cargoes vis-à-vis other cargoes; (c) Conditional mapping with regard to compatibility; and (d) Optimization mapping. A flow chart detailing the optimization logic conducted by the back-end mapping is shown in Figure 2 (below).

[0023]

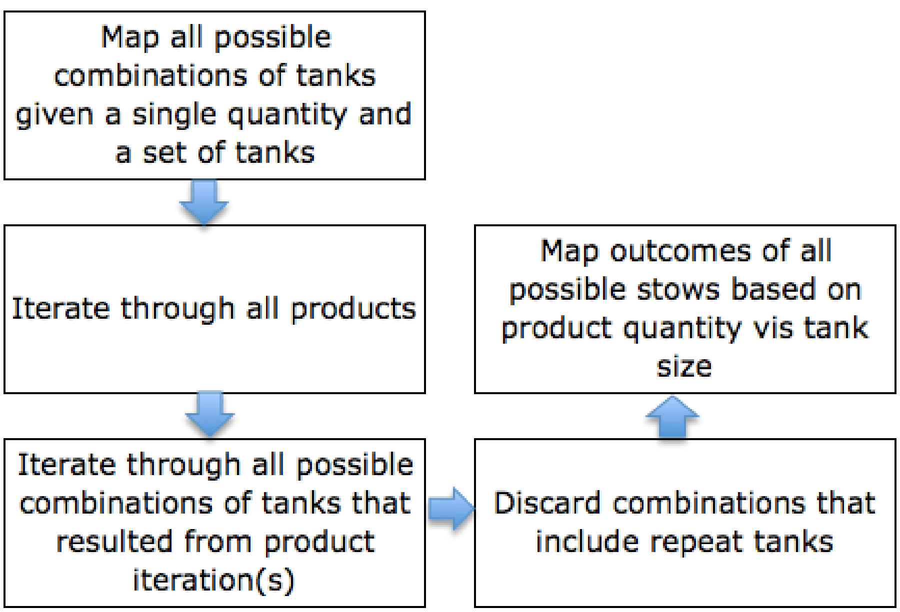

FIG. 2

[0024] <u>Tank Mapping with Regard to Individual Cargoes</u>

[0025] In one embodiment of the present invention, the system will begin by finding nearly all possibilities of stowage for any particular cargo. By finding these possibilities the system becomes flexible with regard to finding esoteric solutions. For example if there are three tanks that are 50 M3, 100 M3 and 200 M3 and a candidate cargo of 125 M3 is to be placed in tank(s), the present invention begins by determining how many options are available. The solution can then be deduced, i.e., the loading condition 1. 200 M3 and 2. 100 M3 + 50 M3. An incorrect option would be 1. 200 M3 + 50 M3 due under capacity, and likewise, 1. 50 M3 alone would not be an option due to over capacity.

[0026] Continuing with the example, one might suggest that a stow of 2. 100 M3 + 50 M3 would be the ideal solution as there will be 25 M3 of tankage remaining as opposed to option 1. 200 M3 where there is 75 M3 remaining. However due to the fact that there could be adjacency issues, tank compatibility issues, or the need for an additional tank, the former solution may be found to be less than ideal. Unless the system maps all possibilities in concurrence with one another the final solution cannot be known.

[0027] The present invention calculates all scenarios for any particular cargo. Although at all times flexibility is key with regard to initial mapping, the system is restricted to the following conditions.

[0028] The system will not map cargoes that are excessively unequal to one side of the vessel. An example, for a 12-tank vessel, would be placing a cargo in two or more tanks on one side of the ship than the other side. This is an effort to mitigate stability concerns. This option can be removed.

[0029] The system will not map cargos that have excessive fore and aft stowage. For instance if a large cargo is placed aft the ship may be unable to pump the entire cargo due industry-standard placement of pumps is aft and the vessel will become down by the bow. This option can be removed.

[0030] The system attempts to stow cargoes athwartships. This is an effort to share cargo lines on a small chemical tanker. This option can be removed should the athwartships tanks fail to share lines.

[0031] The number of maps maybe constrained by a modified Monte Carlo method due to the often times excessive number of maps that are created which can become odious. The restriction is accomplished by limiting the number of available tanks.

[0032] *Example*

[0033] In a 12 tank chemical tanker, the present invention is used to map tanks for a single parcel. The system checks for athwartship possibilities while avoiding excessive fore and aft and port-to-starboard stows. The tanks are then narrowed to a system-determined maximum sample and the map is constructed accordingly. The mapping is collected in the system and recursively used to determine future mappings. The size of the sample is determined by the system, however which tanks are to be mapped, and which fit the aforementioned criteria, are selected by the system. The mapping is then iterated enough times to produce a sample that closely matches all possible outcomes.

[0034] <u>Tank mapping with regard to all cargoes</u>

[0035] Each cargo's tank map is layered over other cargo's tank maps to produce an outcome. This is accomplished by finding the Cartesian product of all tank combinations for any particular cargo.

[0036] *Example*

Cargo 1 map: (Tank 1, Tank 2), (Tank 7)

Cargo 2 map: (Tank 4), (Tank 5, Tank 6), (Tank 7)

Cargo 3 map: (Tank 4), (Tank 5, Tank 6), (Tank 8)

[0037] In above example there are several outcomes. For example: Cargo 1 in (Tank 1, Tank 2), Cargo 2 in (Tank 7) and Cargo 3 in (Tank 8). Alternatively Cargo 1 in (Tank 7), Cargo 2 in (Tank 4) and Cargo 3 in (Tank 5, Tank 6).

[0038] The above is accomplished by testing each cargo's element (i.e. '(Tank 4)') against another cargo's element and determine if there are any repetitions. If there is a repetition the set would be thrown out. For example one unsuccessful Cartesian product would be Cargo 1 in (Tank 7), Cargo 2 in (Tank 7), and Cargo 3 in (Tank 4). This combination would not work as cargo 1 and 2 are in the same tank.

[0039] <u>Conditional mapping with regard to compatibility (compatibility with regard to all properties)</u>

[0040] Once a set of possible stows is produced, the cargoes in each stow are checked for compatibility with regard to all properties. This module tests whether two incompatible cargoes are stowed next to each other, in which case the stow is discarded.

[0041] *Example*

[0042] If Caustic Soda, with a U.S.C.G. Compatibility of 2, is adjacent to – or a prior cargo of - Sodium Hydroxide, with a U.S.C.G. chemical compatibility of 5, it would be in violation of the Code of Federal Regulations and the stow is discarded. Likewise if a high heat cargo such as molasses, which may be discharged at a temperature of 60 degrees Celsius, is adjacent to a heat sensitive cargo, such as acetone, the stow is discarded.

[0043] <u>Optimization mapping</u>

[0044] The final product(s) are tested to find the most optimal stows with regard to (1) the amount of tanks available and (2) the volume available – which may or may not be the same. In some cases it may be desirable for the user to have a plan to maximize available tanks in order to fit multiple cargoes. Alternatively the user may want as much volume as possible so as to maximize one cargo. The final result is then sent to the user interface. The system is designed to be scalable. The tank layout, tank number, volumes and acceptable tank weights, among other parameters, are extendable. Side effects of scale will be the time required to calculate outcomes and possible loss of fidelity.

[0045] <u>Data</u>

[0046] Data is defined as any information that is used by the conditional logic algorithm to produce outcomes. Data can be, but is not limited to, cargo chemical properties, cargo temperatures and size of tanks. An example of a vessel data map is shown below in Figure 3.

FIG. 3

[0047] The present invention can handle up to 200 - 300 sample cargoes or more. The system is not intended to accumulate data on its own, i.e. through web scraping or third party management, but rather the data is inputted by the user and managed accordingly by the system's conditional logic. Alternatively, however, the present invention is capable of receiving scrape user's information into a collective database that is shared amongst members. The quality of the data will be collected, ranked by qualified users, moderated by super-users and issued accordingly.

[0048] The system in a first preferred embodiment is not 100% accurate with regard to compartmental optimization. This is a result of the modified Monte Carlo procedure during the cargo mapping method (step 4) to limit the number of permutations that the system must handle. There is currently no data to support an exact figure as to what percentage of outcomes is correct, although though experience the system is likely to be conservatively around 90-95% accurate for 12 tanks and unlimited cargoes. With regard to overall compatibility, the system is 100% correct subject to correct user inputted data.

[0049] An object of the present invention is to ensure that, prior to a chemical tanker loading various chemical cargoes, the following is accomplished: (a) the cargoes are stowed safely with regard to chemical compatibility and last cargo suitability; (b) the cargoes are stowed in such a manner so as not to damage one another due to high temperature; (c) the cargoes are stowed efficiently with regard to weight and volume; (d) the system will commingle or split like cargoes for purposes of optimization; and (e) the system should be able to make recommendations as to the suitability of a vessel for future cargoes. The system maintains a whitelist and blacklist for cargoes for any particular class of vessel. Thus, if a cargo is not acceptable to a class of vessel, or to other cargoes, the user will be able to flag the cargo in order to correct its behavior.