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Developments in Technology as Applied to River Equipment

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ABSTRACT

A substantial program of structural research has been carried out in the United States during the past thirty years. The marine transportation system operating on the inland rivers represents a significant portion of the domestic marine business, yet none of this research has been aimed specifically at problems associated with the river business. This paper relates some of the reasons for this phenomenon and describes how some of the research done for others has been applied to river problems. A brief discussion of how research and development is carried out within the industry is also included.

INTRODUCTION

During the last thirty years, a substantial program of research and development work on ship structures has been performed on a continuing basis in the United States. It is interesting to note that despite the fact that the river business represents a significant portion of the domestic marine business, virtually none of this research and development work has been aimed at problems associated with the river business.

In order to understand this phenomenon better, it must be remembered that this program was originally started in an effort to solve the brittle fracture problem that developed during World War II. In the beginning, the entire effort was directed to solving this problem. As the years passed, the amount of effort in this area was reduced, but a substantial amount of work is still being done today and vessels are still being lost due to brittle fractures. In addition, the great amount of interest evident today in the carriage of cargoes at cryogenic temperatures has served to create a demand for more work in this area.

The problem of catastrophic failures due to brittle fracture is associated with ocean-going vessels and not river equipment due to the differences in the environment in which the two operate. In view of this, the people who were responsible for overseeing this structural research work in the beginning were those involved with the design, construction and operation of ocean-going vessels. Furthermore, the money for this research was supplied by organizations that were primarily concerned with the construction, classification and operation of ocean-going vessels.

Given this background, it is easy to understand why there has been little interest in the river business. The nature of the river business itself is such that it serves to perpetuate this tendency. Since this business has never had to cope with foreign competition, it has become highly competitive and there has not been any reason for shipyards or operators or both to work together to compete with some outside force. The only exception to that has been in the area of legislation and governmental regulation.

Many of the operators of river equipment are still private individuals. The investment for a used towboat or a barge is much less than for a ship and is still within the means of an enterprising individual. Given all of these factors, we find that a highly competitive, self-reliant attitude is prevalent. With this attitude, it is not surprising that the people in this business are suspicious of any programs that are government sponsored or even government related. Since the business has generally been quite profitable, there has been no reason to look to the government for economic assistance.

While there has been very little structural research aimed directly at problems associated with the river business, some of the work that has been done is either directly or indirectly applicable. This paper describes some of the occasions where the output of the ship structures research and development program has been useful in the design, construction or operation of river equipment. In addition, there is a discussion of research done by others where it is of particular significance to the river business.

As one might expect, the most significant development work that has been done has come from within the business. There are a number of factors associated with the river business that makes this approach more attractive than would be the case in the ocean-going industry.

The individual units of equipment are much smaller, much less expensive and can be built much more quickly. This permits the designer to experiment more on actual production units or with full-scale models because the financial consequences of this experimentation are much smaller. In addition, the shorter construction time for full scale units usually permits the designer, builder or operator to get reports back within a year of the time it was decided to proceed with the experiment. This allows any program to move ahead at a much more rapid pace and tends to preserve the momentum.

The geographical limitations of the business and the physical environment in which the units operate are also advantages. Since the operations of this business are totally within the bounds of the continental United States, there are no language barriers involved in communicating with shipyards, owners agents, etc. Communications and travel facilities are excellent so that it is easy to inspect units and to monitor the progress of the various programs.

The river environment is usually less dangerous, should a failure occur. If there is a failure on a towboat that causes it to lose control of a fleet or to reduce the amount of control it has over a fleet, it is usually possible to maneuver to the river bank and tie off until the failure can be repaired. There are numerous areas, however, where this is not the case and the continuing passage of numerous barges over dams substantiates the existence of these hazards.

Finally, the business atmosphere that was discussed earlier makes it easier to convince someone to try something new. Where business is highly competitive, people are always looking for some idea that will give them a competitive edge, if even for only a short time. The larger number of individual operators, as compared to large corporations, also makes it easier to be more innovative.

RESEARCH DIRECTLY APPLICABLE

The first project to be discussed probably comes the closest to being research aimed specifically at the river business. This program was initiated in an effort to determine the interaction between long, cylindrical cargo tanks and the hull which carried them. The load distribution between the tanks and the hull had to be determined, in order to calculate saddle loads, tank and hull stresses, etc. The first phase of this work was reported in Ship Structure Committee Report SSC-205 entitled <u>Structural Design Review of Long, Cylindrical, Liquid-Filled Independent Cargo Tank Barges</u>. This report was primarily a review of the knowledge available on the subject and a series of recommendations with regard to where further work was needed. It is my understanding that further analytical work was begun, but this author is not aware of any published information on that work.

This project was initiated at the request of the U. S. Coast Guard. Prior to the time that the project was begun, cylindrical cargo tanks had been relatively short and the interaction effects had generally been ignored. In an effort to reduce costs, designers and builders were increasing the length of cylindrical tanks. At the same time, the Coast Guard was taking a much more active interest in the carriage of hazardous products and these products were often carried in cylindrical tanks. In reviewing these designs, the Coast Guard found that there was very little information available on the subject of interaction, particularly with regard to vessels in a seaway, and so the project was undertaken.

As it turned out, the design information that was made available was never used, to any great extent, on river equipment. At about the time that this investigation was going on, the Coast Guard published new regulations governing the marine transportation of extremely hazardous products, which would normally be carried in cylindrical tanks. These regulations were so restrictive, as compared with those imposed on rail transport by a different governmental agency, that it was no longer competitive to move these products by water and no new construction has been undertaken.

Two barges were designed and constructed prior to the completion of the first phase of this project which are typical of situations where this work can be very helpful despite the fact that they are not the type of barge for which it was intended. These barges were designed to carry asphalt which is not classed as a hazardous product. Prior to the construction of these barges, asphalt was usually carried in double-skin tank barges having rectangular, integral tanks with the usual square corners, tee joints etc. The problem with normal double-skin barges was that asphalt is normally loaded at temperatures ranging from 300° F. to 425°F. The thermal shock caused by the hot liquid flowing over the bottom of the cold tank almost inevitably resulted in fractures in corners and other joints and leakage of product into the void spaces surrounding the tanks. The maintenance costs associated with moving this product in barges of this kind was simply unacceptable.

This problem was solved by designing a barge fitted with two long cylindrical tanks nested side by side in the hull as shown in Figure 1. Since these tanks were not subject to pressure, the wall thickness was only that necessary to maintain the circularity of the tanks. Interaction effects were determined by a trial and error approach. The later work done under the direction of the Ship Structures Committee, which was referred to earlier, would have facilitated this work and would probably have led to a more optimum saddle arrangement. Thermal expansion and contraction was accommodated by anchoring the tanks at one end and allowing them to slide freely over the remaining saddles.

Another project that has direct applications to the construction of river craft is the work done on the interpretation and recording of ultrasonic methods of inspecting welded joints. The use of radiographic methods of inspecting welds is quite common in shipyards that construct ocean-going vessels and most of these yards are equipped for this method of inspection. In contrast, this procedure is very seldom used in river yards and none of them, to my knowledge, are equipped for it. If radiographic inspection is required, as it sometimes is by the American Bureau of Shipping or other regulatory bodies, a testing laboratory is usually employed to do the work and this is both inconvenient and expensive.

The reason why radiography is not a common tool is that the material generally being joined in river yards is quite thin and the production welds made are usually considerably larger then is required for strength considerations. Hence the quality of this welding can be somewhat lower without endangering the structure of river vessels.

Since there is not sufficient need for radiographic inspection to warrant having equipment available in the various river yards and since getting outsiders to do it has a number of disadvantages, an effort has been made to use ultrasonic inspection techniques in lieu of radiography. This equipment has the advantages of being less expensive, more portable and easier to operate. It has two major disadvantages, however, and these are that the results are less definitive and more subject to interpretation and that there is no permanent record of the inspection.

The Ship Structures Committee in publishing their report SSC-213 A Guide for Ultrasonic Testing and Evaluation of Weld Flaws have done much to eliminate the first of these disadvantages by establishing standards. A second study which was reported in

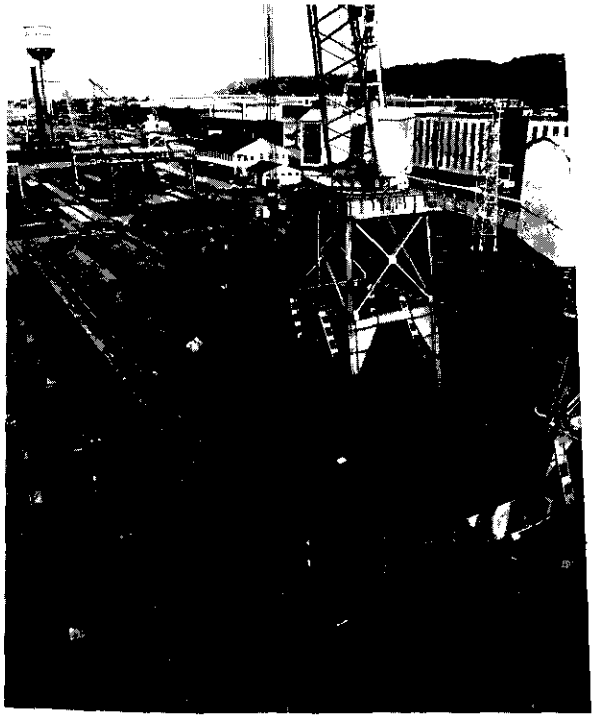

Fig. 1. Barge fitted with two long cylindrical tanks side by side

SSC-189 The Video Tape Recording of Ultrasonic Test Information proposed the use of video tape as a means of making a permanent record. While this procedure does not seem to be in general use at the present time, it represents a first step toward the solution of this problem.

Several studies have been made on the effects of various methods of straightening plates that have been deformed either by accidents or by attaching stiffeners or making other welded joints. In working with river equipment, straightening usually is done only for cosmetic purposes on the deckhouses of towboats or to remove significant dents and buckles from the deck or gunwale in the midships half length of a hopper barge. The reason for the latter repair is that very little consideration is normally given to the longitudinal bending stresses that are induced when a barge is loaded. A dense concentrated load located near midships in conjunction with a significant dent or buckle in the deck can easily lead to a buckled barge. Dents and local buckles in other parts of barge and towboat hulls are usually ignored unless they were severe enough to cause a fracture.

The results of research done on this subject provide information and procedures for straightening by both mechanical means and through the use of heat. The investigation has also included the effects on the material of the local yielding that occurs when mechanical means are employed and the changes in metallurgical properties that are caused by the heat applied when flame-straightening. The results of this investigation was reported in SSC-198 Flame Straightening and its Effect on Base Metal Properties and SSC-207 Effect of Flame and Mechanical Straightening on Material Properties of Weldment.

As noted earlier, the river business has had very little interest in the immense amount of work that has been done on the brittle fracture problem. We have not experienced catastrophic hull girder failures, although some local fractures that occurred gave every indication of being brittle failures. At the present time, there has not been any serious inquiries regarding the possibility of carrying either L.P.G. or L.N.G. at cryogenic temperatures in river-barges, due largely to the better economic situation associated with moving this material in pipelines at atmospheric temperatures.

The only applications that we have worked with are the carriage of anhydrous ammonia and vinyl chloride at, or close to, atmospheric pressure which results in temperatures that might possibly be as low as minus twenty or thirty degrees Fahrenheit. The work done on the brittle fracture problem was certainly of use when working with these applications, but the designs were completely within the state of the art.

The research and development work done on the brittle fracture problem did much to make designers and detailers aware of the importance of structural details. This awareness has been of great value to us in the river business, just as it has been to almost everyone else who is involved with designing and constructing steel structures.

One example of how easily designers can forget the importance of structural details is found in a series of semi-integrated double-skin tank barges that were built about ten years ago. The innerbottom of these barges, which formed the bottom of the cargo tank, was flat in order to simplify construction. This feature made it difficult to strip the cargo out of the tanks and since these barges were intended to carry various kinds of chemicals, which could be easily contaminated, a sump was provided at the forward end of each tank.

The sump, as originally designed, extended almost completely across the barge and only about one foot of the innerbottom remained intact at each side. To make matters worse, the cut in the innerbottom plating had square corners and the formed piece which was the bottom of the sump was attached to the innerbottom plating with a corner weld which required a high degree of accurate fit-up if the weld was to be sound.

The surprising thing is not that the sumps failed at the corners, which some of them did, but that not all of them failed and that the failures did not occur until the barges had been in service for many months. In those cases where failure occurred, and in later designs, the length of the sump was decreased significantly, leaving almost one half of the innerbottom intact, the shape of the cutout in the innerbottom was changed to an ellipse and the connection details were improved. On the barges where failure did not occur, the sumps were strengthened by installing radiused plates in the corners and, to the best of my knowledge, that detail has not given any further trouble.

There are two projects which are of great significance to the river industry that are not associated with structural problems in any way. Both of these studies were done for the U.S. Corps of Engineers. The first was carried out by the University of Pennsylvania and was a study of the Waterway Transportation System on the Mississippi River and all of its tributaries. This study was undertaken as a result of the Corps of Engineers noting that traffic congestion was beginning to occur at certain points along the river system. The purpose of the study was to determine if these problems of congestion could be solved by changes in procedures or perhaps through some system of traffic control; or if their solution could only be accomplished by an improvement in facilities such as increasing the size and number of locks at particular locations.

A mathematical model of the river system was made and a complete program was written to simulate the system. This work has provided the Corps with a valuable tool for assessing the effect all along the system of the many possible variables that affect the flow of traffic. It should at least provide some of the information needed in order to do the long range planning that is necessary if the industry is to continue to grow at its present rate.

The second study was related to ice breaking on the Upper Mississippi River. Normally this river closes due to ice sometime between mid-November and mid-December and doesn't open again until around the first of April. This particular study was made with industry cooperation and was aimed at determining if the navigation season could be extended by having the normal tows break ice. The experiment was generally successful, but the towboat used was damaged and it was clear that some extra protection and strengthening would have to be provided for towboats that were regularly engaged in this service. I have not read of any further work on this particular project.

The Coast Guard has done some work on methods for breaking ice on this section of the river, and I have included the reports on this work in the list of references, but I have not yet read them myself. It is my opinion that progress on this problem will be relatively slow until the need for year-round service becomes greater.

RESEARCH INDIRECTLY APPLICABLE

In beginning this discussion of research work that is indirectly applicable to the river industry, I return again to thermoelastic problems. The design of vessels to carry cargoes at cryogenic temperatures had lead to a need to have better procedures for determining temperatures at a number of points in ship structures when subjected to various environmental conditions, both steady-state and transient. This need has become particularly critical when attempting to satisfy the U. S. Coast Guard regulations for a secondary barrier.

To satisfy the above need, thermoelastic model studies were made under the sponsorship of the Ship Structures Committee and an analytical procedure for determining temperatures was developed based on two-dimensional theory. This work was reported in Ship Structures Committee Report SSC-241 Thermoelastic Model Studies of Cryogenic Tanker Structure.

At about the same time the above work was being done, the problem of moving asphalt was again raised. The barge equipped with cylindrical tanks, discussed earlier in this paper, was a technical success, but it cost too much to build to be profitable. Some way had to be found to design a barge that would handle asphalt whose cost would be closer to that of a normal, double-skin tank barge.

A study was made to determine where failures had usually occurred in standard, double-skin barges when used in asphalt service. It was found that nearly all of the failures had occurred in connections to the innerbottom, particularly at the ends of the barge and in way of transverse, watertight bulkheads. In order to make an estimate of maximum stresses due to thermal expansion, it was assumed that the temperature of the innerbottom was raised to 425° F, as would occur immediately after loading of the hot cargo began. A further assumption was made that steep thermal gradients existed on the structure attached to the innerbottom and that the temperature of the steel located only a short distance from the innerbottom was at the ambient temperature that existed before loading operations began.

This procedure furnished some idea of the order of magnitude of the thermal expansion and resulting thermal stresses that could be generated in the worst case. By installing radiused corners at the connection between the longitudinal bulkheads and the innerbottom and by breaking up the longitudinal continuity of the innerbottom through the use of expansion joints at the ends and at two of the transverse watertight bulkheads, it was possible to reduce the estimated stresses to levels which we believed would be acceptable. Needless to say, the innerbottom was not included in the calculation of section modulus after these changes were made. Figure 2 shows the general configuration of the expansion joints and their locations in a three hundred foot barge.

These barges were quite successful both technically and economically. The work done for the Ships Structure Committee on estimating temperature distributions had not been completed at the time the barges were designed. Had it been available, it would have

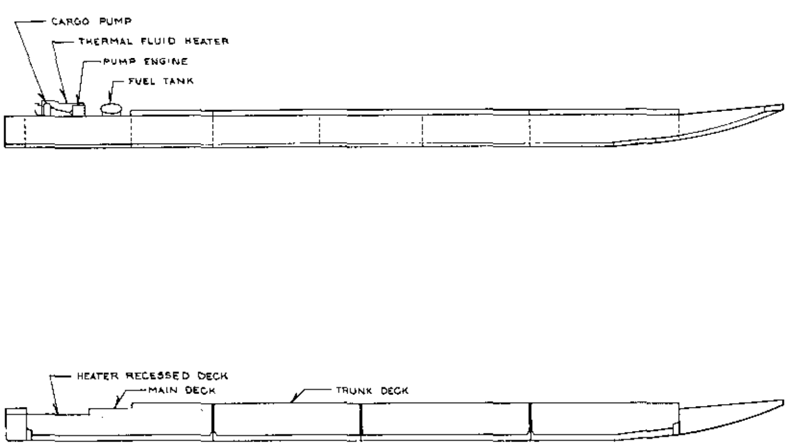

Fig. 2. General configuration of expansion joints in a 300-ft barge

been very useful and should have removed some of the risk that was taken in going ahead with the design. This type of problem, however, is one that recurs frequently in a variety of forms and I feel certain that there will be an opportunity to use this work at some future time.

With increasing power in both ships and towboats, vibration is becoming more and more of a problem. Although the principles involved are the same for both types of craft, the specific problems are quite different. Designers and operators of ocean-going ships are usually concerned about unacceptable levels of vibration that occur when the vessel is going ahead at or near it's normal cruising speed. High levels of vibration when backing or maneuvering are not usually thought to be a problem because of the transient nature of these conditions. With towboats, we are concerned with vibration that occurs over a much wider range of operating conditions. Towboats will operate at almost any ahead speed from idling to full power for extended periods of time depending on the river conditions. These boats will also go full astern for extended periods of time. Excessive vibration can not be tolerated under any of these conditions.

One of the most important steps in solving any vibration problem is to determine the frequency and amplitude of the motion. In order to do this, it is absolutely essential to have equipment that will measure low-frequency signals accurately. It is also highly desirable to have some means of making a permanent record of the measurements that are made. There is absolutely no point in attempting to analyze a problem when the only information available is the degree to which an individual's toes tingled when that person was standing in a particular location.

Both the Society of Naval Architects and Marine Engineers and the Maritime Administration have published information on various kinds of vibration instrumentation. The SNAME information is contained in Technical and Research Bulletin 2-10 entitled Code For Shipboard Hull Vibration Measurements. The instrumentation described herein covers the required frequency range and provides a permanent record of the measurements. The equipment is only semi-portable but has the advantage that measurements can be taken at many different locations without the necessity of moving the pickups or the instrumentation. It is particularly useful in analyzing hull girder vibrations where a steady-state condition can be maintained for a relatively long period of time. The equipment requires a relatively large crew to set up and dismantle it and it is relatively difficult to transport from one location to another.

The instrumentation used by the Maritime Administration also has good frequency response and provides a permanent record. Only two pickups can be used at the same time and the cord length is limited. Hence, if a number of readings are to be made along the length of a ship, the instrumentation must be moved several times. The instrumentation is easy to set up and is sufficiently portable to be carried as hand luggage on airplanes.

One last point with regard to vibration is the various criterion for acceptability that have been published. These standards have been very helpful and the three references listed below have been found to be particularly useful:

F. Everett Reed, Acceptable Levels of Vibration on Ships, published in April 1973 issue of Marine Technology.

David Taylor Model Basin Report, Criteria for Human Reaction to Environmental Vibration on Naval Ships, DTMB 1635.

Johnson, Ayling & Coachmon, On the Vibration Amplitude of Ship Hulls, The Institution of Engineers and Shipbuilders in Scotland, 1962.

The degree of control that must be maintained over a river fleet is much greater than that which must be maintained over a ship, due to the physical limitations of the river environment. The physical factors influencing the fleet, however, are identical to those that would influence a ship in a similar circumstances, so much can be learned from research done on controlling ships in shallow and restricted waterways. The Society of Naval Architects Technical and Research Bulletin No. 1-27 entitled Notes on Ship Controllability has an interesting section on the subject and also has a number of good references.

The significance of this information is that it provides a better understanding of what is happening in many of the tight maneuvering situations that seem to be so common on the rivers. Today we still rely on the expertise of the captains and pilots whose ability is based on years of operating experience. They may not know why something is happening or how the physical forces involved are interacting, but they know what is happening and they know how to deal with it. As traffic increases, however, and as our need for trained people tends to outrun our ability to train them in the traditional way, a better knowledge of the theoretical situation may help us to deal with a wide variety of problems that are already on the horizon.

The use of production line

techniques in shipbuilding were being applied in river shipyards long before they were generally applied to the construction of ocean-going vessels. As with any other advances in technology, however, once the ocean-going yards became interested in the concept of automated shipyards, ideas were developed that were of value to the river yards.

One example of this is the fabrication and outfitting of deckhouses. Towboat superstructures had always been erected panel by panel in place after the steel hull was completed. This meant that the outfitting work could not begin until almost all of the steel work had been completed. The result was that the construction period of the vessel was extended and the outfitting and finish work was done in a great rush with inefficient use of manpower.

Assembling the deckhouse complete with erection beginning at about the same time the keel is laid, allows the outfitting of the upper levels to proceed while the hull is being assembled. By the time the hull is ready for the deckhouse, outfitting of the upper levels is nearly complete and the unit is placed on the hull in a single lift.

One final project that should be of great value in the long run was edited by Prof. J. Harvey Evans and was recently published by the Ship Structures Committee. The title of the publication is "Ship Structural Design Concepts" and it contains both computer programs for the solution of particular problems and the concepts and design procedures upon which the programs are based. While the programs may be of limited usefulness in dealing with river equipment, due to the differences in the problems involved, the design information will be invaluable.

DEVELOPMENTS WITHIN THE INDUSTRY

As discussed in the first section, the nature of the river industry is such that a number of significant technical developments have been generated within the industry. One of the most important of these is the Kort nozzle. This device is simply a shroud with an airfoil cross-section surrounding the propeller. The Kort nozzle provides a major increase in propulsive efficiency for heavily-loaded propellers moving relatively low speed vessels.

It is the author's understanding that this device was originally intended to reduce bank erosion in the narrow canals and channels in Europe. While it had only limited success in accomplishing its intended function, it produced a marked increase in speed in the low-powered, low-speed vessels that are common on Europe's waterways.

The nozzle was introduced in this country under a license agreement and was first installed on the towboat PIONEER in 1937. Since that first installation, the nozzle has been developed both hydrodynamically and structurally into the highly effective propulsive and maneuvering system that is installed on virtually every new river towboat of any size that is built today.

The hydrodynamic development has been a combination of model tests and full-scale experimentation. The cross-sectional shape, the length of the nozzle, the propeller location and design, the arrangement, cross-sectional shape and location of the strut and the arrangement and size of the steering and backing-rudders all affect the performance of the system which has continued to improve over the years. Figure 3 shows a typical modern Kort nozzle system with rudders and vertical shaft strut.

The structural design of nozzles has progressed primarily on a trial and error basis. Both the internal structure of the nozzle and the connections to the hull have had to improve as the power of the towboats has increased. As is the tendency with many problems, however, the industry has overreacted and many vessels are being built today with nozzle structures that are excessively heavy and that bear little relation to the technical requirements.

Steering systems are an excellent example of a design that developed completely within the industry. For some reason, the traditional builders of steering systems never attempted to design and market a complete, integrated steering system for river towboats. One possible reason for this is that at any one time in history, there may never have appeared to be a sufficient market to justify the development cost.

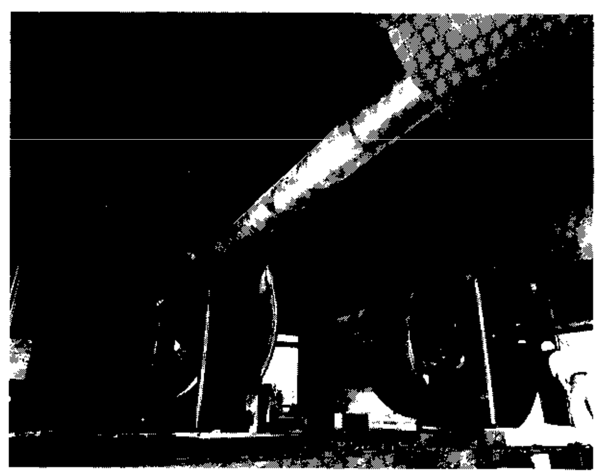

Fig. 3. Typical modern Kort nozzle system with rudders and vertical shaft strut

In any event, since there was no source for an integrated system, each of the shipyards developed their own. In earlier times, the great majority of the components, with the exception of pumps and electrical equipment, were manufactured by the individual yards. Today there is a trend to purchase standard components such as hydraulic cylinders, valves, etc. and to modify them as required. Tillers, links, cylinder supports and control linkage are still generally manufactured by the shipyards.

The linkage connecting the backing rudders together can be quite complicated since this linkage, on most larger towboats, provides a means for having the two backing rudders in front of each nozzle toe out at the leading edge when the rudders are midships and become parallel again when the rudders are hard over. This approach reduces the losses from the backing rudders when the boat is going ahead without reducing their effectiveness when maneuvering. Figure 4 is a photograph of a typical steering engine. Most of the steering engines in use today are electro-hydraulic with the normal system pressure not in excess of one thousand pounds per square inch (1,000 psi). Much higher pressures are regularly used in hydraulic systems, but the requirements for a flow control valve that gives smooth, reliable control in a relatively simple system has not been conducive to moving to higher pressures. In addition, pressure-compensated, variable-volume pumps are commonly used and the life of these pumps is significantly reduced at operating pressures much greater than 1,000 psi.

Mechanical push rods are still generally used to connect the steering controls in the pilothouse with the steering engine. The boats are short enough to make this a practical system and it has very high reliability. Cost studies have shown that this approach is also the most economical way of solving this problem. The only alternate system that even approaches the cost of the mechanical system is the use of spring-loaded air actuators with pressure regulators and this system is much less reliable. Intuitively one would expect an electrical control system to be more economical, but such is not the case due probably to the fact that most of the standard components that are available are intended for the salt-water atmosphere associated with ocean-going service and are of a higher quality than is required for river service.

The use of bow thrusters was first begun on either Great Lakes or ocean-going vessels. The benefits associated with this innovation were very interesting to river operators, but the equipment used could not be applied directly for a number of reasons. The fixed tunnel-type thrusters generally are ineffective at speeds in excess of two or three miles per hour and are unsuitable for the limited draft of river craft.

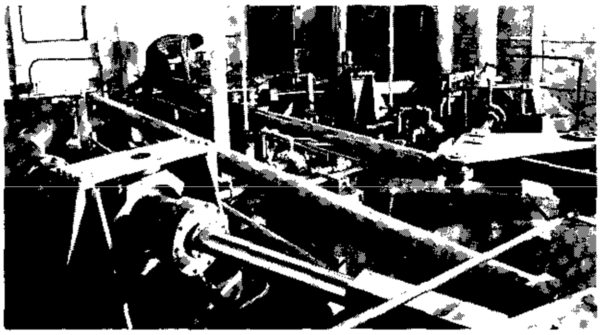

Fig. 4. Steering engine of a river towboat

The first units developed specifically for river service were propeller-type units which could be rotated through three hundred and sixty degrees (360°) and raised and lowered from a point where the centerline of the propeller was about three feet below the baseline of the barge to a point where the propeller was fully retracted. The rotational capability made the units effective at all speeds which made them useful not only in approaching locks and piers but also in steering around tight bends where, without the thruster, considerable delay would have been experienced in maneuvering around the bend in the more traditional way. Figure 5 shows a typical propeller-type thruster unit mounted on a river barge.

The propeller-type units had the disadvantage that, even though the units could be raised and lowered, there were times, when the barges were fully-loaded, that they couldn't be used at all due to the depth limitation of the channel. Quite often, those were times when the unit was needed most. As a result of this, development was begun on a jet-type unit which would utilize the thrust from a direct water jet and which could be installed with the entire unit permanently mounted above the baseline. This approach has met with some success and development work is continuing.

Another problem which has made the use of bow thrusters difficult in some situations is the result of the way in which some of the barge fleets are operated. A fully-integrated unit tow is one in which all of the barges in the fleet remain together with the same towboat and generally operate in some sort of dedicated service such as moving petroleum products or chemicals. In this situation there is no problem because the bow thruster unit is mounted in one of the lead barges, the controls for it are in the pilothouse of the towboat and the two always operate together.

The other type of tow is the so-called common-carrier tow. These tows constitute the great majority of the fleets operating on the river system and very seldom, if ever, operate with the same barges. Barges are picked up and dropped off at various landings and fleeting areas along the river as they are loaded and unloaded. In this situation there is no way of mounting the thruster unit in one of the barges since there is no way of knowing which

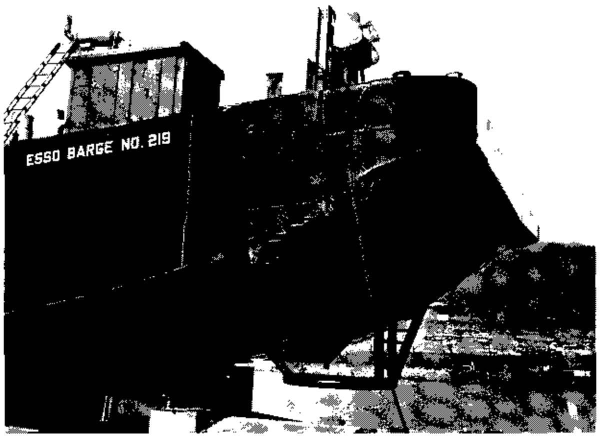

Fig. 5. Propeller-type thruster unit mounted on a river barge

boat will be towing it or if it will be used for floating storage etc. One solution to this problem was to mount the thruster unit in a small, separate barge that could be lashed on at the head of a fleet and which would remain with the towboat regardless of what happened to the fleet in between. These barges are generally referred to as bow boats and have been used with only very limited success due to a number of reasons which are primarily non-technical.

The last subject to be discussed in this section is that of barge covers. Those hopper barges which have covers are fitted with either rolling covers or lift-off covers. Both types of covers are fitted with labyrinth-type weather seals and are considered to be weather-tight and not water-tight.

Lift-off covers are fitted with eleven or twelve sections per barge with each section weighing about two and one half tons. Grain, which is the product most often carried in barges having covers of this type, is loaded and unloaded through grain doors located in each cover section. If the barge is to carry coal or ore or some other product which requires an open hopper, the covers are lifted off and stored or stacked on the ends of the barge.

A few years ago a small fiberglass manufacturer began to experiment with making lift-off covers out of fiberglass. A very successful design was developed which was lighter than the steel covers and less expensive. There is some question with regard to the durability of these covers, but there has not been enough service experience with them to make a definitive judgement.

As the fiberglass covers began to cut into the sale of steel lift-off covers, the manufacturers of steel covers took a hard look at their designs. It was found that the designs were complex, heavy and difficult to manufacture due to the large number of separate pieces involved. Through a careful redesign of the cover, it was possible to reduce the weight by about 25% without reducing the stiffness of the cover and the number of pieces was cut almost in half. A series of full-scale tests units were loaded to destruction in order to test the new design.

SUMMARY

This paper has been a resume of how research and development work, particularly that sponsored by the Ship Structures Committee, has affected the river industry. Despite the fact that none of this work was done specifically for the river business, it is clear that much of it has been applicable, both directly and indirectly. It is also interesting to see how the characteristics of the industry have made it possible to make great technological strides within the industry without any outside help. Improved coordination between the river industry and those organizations responsible for carrying out marine research and development programs for the entire marine business should lead to greater and more rapid technical advances in the future.

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