No. 241
October 1981

AN OVERVIEW OF THE SHIPBUILDING INDUSTRY: TWO STUDENT RESEARCH REPORTS

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Edited by
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THE DEPARTMENT OF NAVAL ARCHITECTURE AND MARINE ENGINEERING

THE UNIVERSITY OF MICHIGAN

COLLEGE OF ENGINEERING

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Presented at the October 23, 1981
meeting of the Great Lakes and Great Rivers Section of the Society of Naval Architects and Marine Engineers held in conjunction with the centennial of naval architecture and marine engineering at The University of Michigan

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FOREWORD

In January 1981 The Department of Naval Architecture and Marine Engineering introduced into its curriculum a course specifically concerned with ship production and production planning. The course resulted from the growing realization that naval architecture students should develop a greater appreciation of the ship production process, and the relationship between that process and the design cycle.

One of the requirements of the ship production course was that the student prepare a research term paper. The students' topic selections covered a wide range of subjects -- some examples are welding technology, numerical control cutting, surface preparation, the Japanese management system, and aluminum construction technology. Each student worked independently on his topic and was required to submit his report in a format comparable to that demanded by a professional organization.

Two of the term papers have been selected for presentation at this meeting. Mr. Hagemeister's paper is a discussion of factors that impede productivity improvement in U.S. shipyards. Mr. Gupta's topic is a comparison of building practices in the various major shipbuilding nations. Both papers are typical in form to the majority of the term papers that were submitted. They were unique, however, in that they dealt with subject matter that went beyond the mere mechanisms of building the ship. They also related to the economic, social, and political arena of which the shipbuilding industry is so completely intertwined. For that reason these papers are presented for your professional consideration.

INSTITUTIONAL BARRIERS

TO IMPROVING PRODUCTIVITY IN

UNITED STATES SHIPYARDS

by

Kurt W. Hagemeister

SUMMARY

This paper identifies those areas of the American society and shipbuilding industry which present barriers to improving productivity in shipyards. Productivity has been defined on both a time and money basis so that any factor which affects shipbuilding costs or ship construction schedules can be related to productivity. The following seven areas were found to be the major obstacles to improving shipyard productivity in the U.S.:

1. shipyard work load characteristics;
2. relationship between shipyard and vendors;
3. government policies and legislation;
4. industrial relations characteristics;
5. social structure of U.S.;
6. effects of management strategy and decisions; and
7. adoption of shipbuilding industry standards.

In some cases, the barriers to improving productivity would be almost impossible to overcome. They would require major changes in business and society to be solved. Other problems are rooted mainly in tradition and would necessitate only time, hard work, and cooperation for change to occur.

INTRODUCTION

The U.S. shipbuilding industry was at one time in a dominant position in the world market. In the World War II period, the shipbuilding industry in this country reached an incredible peak of constructing 5,777 ships. At this time, there were 57 major private shipyards,[1] many of which were at the forefront in innovation and new technology. Such new concepts as multiple production of standardized designs (e.g. Victory, Liberty ships), welding in hull construction, and prefabrication of large sub-assemblies were developed in the U.S., and later adopted by foreign shipyards. This period was truly the apex of U.S. shipbuilding.

However, this situation changed dramatically at the conclusion of World War II. After the war ended, the volume of business dropped to a comparative trickle. The number of major shipyards decreased from 57 to a current level of 15. Employment has dropped a whopping 80 percent.[1] In addition, demand has fluctuated greatly from year to year. The industry has lost the technological and managerial edge it once had. Foreign shipyards, particularly the Japanese, are now the industry leaders in the area of ship production. U.S. shipyards are lagging seriously in productivity behind their foreign counterparts and have been in a poor competitive position in the world shipbuilding market for several decades. American shipping companies have for the most part purchased their ships from foreign shipyards where delivery time is less and costs are lower. Americans have seen the erosion of their world shipbuilding market share to 3.5 percent.[13]

It has been generally accepted that there are certain institutional advantages foreign shipbuilders possess that result in greater efficiency and which are difficult to apply in the U.S. The purpose of this paper is to identify U.S. institutional barriers to improving shipbuilding productivity. (Institutional barriers are meant to be those social, governmental, geographic, business, traditional, and market aspects of the industry which either directly or indirectly hinder the adoption of cost and time savings improvements.)

In this paper, productivity is defined in terms of both time and money, and their relation to an easily definable amount of shipyard output such as weight of steel. In other words, productivity, P, in an extremely broad sense can be found by these relations:

$$P = \frac{\text{TOTAL DELIVERY COST OF SHIP}}{\text{STEEL WEIGHT OF SHIP}} \quad \text{and}$$

$$P = \frac{\text{TIME FROM CONTRACT SIGNING TO DELIVERY}}{\text{STEEL WEIGHT OF SHIP}}$$

Thus, the productivity of one shipyard can be compared to another, on an absolute scale, by comparing costs and completion times of same ship types of reasonably equal steel weights. It should be remembered, though, that productivity is only a relative term in the sense that there is no absolute highest level.

This paper is not intended to be a rationalization of the lower productivity of U.S. shipyards relative to their foreign counterparts. Rather, it identifies those aspects of America which are counterproductive to the improvement of shipbuilding productivity. Several recommendations are included which will counter those barriers surmountable in the current social and political systems in the U.S.

The following discussion identifies those major barriers in the U.S. hindering productivity increases in American shipyards. Each of the seven major areas identified previously are briefly explained as well as reasons for their existence. At the end of the discussion, conclusions and some recommendations are offered which can help alleviate some of these barriers to improving productivity.

SHIPYARD WORK LOAD CHARACTERISTICS

In recent years, there have been basically two problems which have plagued the U.S. shipbuilding industry in the area of work load characteristics. They are: the effects of a varying market and the problems arising from a navy-commerical ship product mix.

A varying market has three basic aspects. First, there is the change in production levels as shown in Table 1. Even greater change has occurred in the nation's market share; it had dropped to 3.5 percent of world production by mid-1970. The implications of market share change can not be overemphasized. A large market share, such as is currently enjoyed by the Japanese, creates a comparative economies of scale benefit to such an extent that lower unit costs will tend to maintain that market share. Conversely, U.S. shipbuilders, with a low market share are faced with necessarily higher relative unit costs, and a subsequent continued low market scale. Instead, U.S. shipbuilders have resorted to risk aversion techniques to protect themselves. An example would be labor intensive production processes whereby a company decides to increase or decrease labor levels during fluctuations in work load rather than to invest in capital outlays. The expected result is lower productivity.

TABLE 1

Merchant Vessels Over 1000 Gross Tons

Ordered from U.S. Shipyards by Calendar Year[2]

Year	# of Ships	Gross Tons
1970	13	580,000
1971	24	617,000
1972	48	1,551,000
1973	43	2,013,000
1974	25	1,766,000
1975	14	635,000
1976	16	339,000
1977	30	399,000

Series ship contracts are becoming more and more rare in the domestic marketplace. Those that are awarded are usually for less than five ships. The result is that significant experience curve benefits and mass production techniques can not be achieved. This again lessens productivity by discouraging capital investment.

U.S. shipbuilders have found themselves with a larger variety of contract backlog than ever before. Whereas certain foreign shipyards have been able to specialize in similar ship types, American shipyards have found it necessary to take whatever is available in order to stay busy. The market has evolved into Navy, offshore, and merchant ships in which the latter has branched into a more specialized variety including tankers, container ships, bulk carriers, LNG/LPG ships, car carriers, drilling ships, OBO ships, and others. This contract variety creates problems through the constant changing from one design method and fabrication process to another. Again, this reduces experience curve benefits. Some shipyards eliminate this problem by specializing in one or two contract types.

The second major obstacle to improving shipbuilding productivity is the navy-commercial product mix. Problems arising from a navy-commercial product mix have caused subtle and negative effects in the productivity of some U.S. shipyards. One of these effects is the inherent differences involved in steel structure and fabrication for navy ships as compared to merchant ships. Weight is a critical factor in the design of many navy ships. This has resulted in a lighter, but more complicated steel structure, which is more difficult to fabricate. The impact of this on the shipyard is a reduced experience curve benefit derived from less repeated work on only one type of structure. Some foreign shipyards avoid this by building only similar ship types thereby enjoying maximum learning curve benefits.

Another effect of a navy-commercial product mix on some U.S. shipyards is the U.S. Navy procurement policy. In order to maintain an adequate mobilization base, it is necessary that the Navy spread contracts out among many shipyards. The Navy's objective is to procure similar ship classes from the same shipyards so that seasoned expertise brings better productivity. Unfortunately, in some cases, the limit of the yearly defense budget will cut short possible large series contracts into small quantities awarded on a "wait and see" basis from year to year. Thus, series ship benefits are reduced because of this staggered, indefinite method of ship procurement. It is recognized however, that this is necessary due to limitations in funding and constantly changing strategic needs.

These problems associated with the navy-commercial product mix are institutions which must be lived with unfortunately. Unless there is a massive positive change in the commercial shipbuilding market in the U.S., this situation will certainly continue. A review of current Navy steel design requirements may however produce more "workable" structures which will enhance productivity.

RELATIONSHIP BETWEEN SHIPYARD AND VENDORS

The relationship between shipyards and vendors in the United States is a major factor in the productivity disparity between American shipyards and their foreign counterparts. There are three main reasons for this disparity which are: lead times of major ship components, the absense of vertical integration in shipbuilding companies, and the relative size of shipbuilding in the U.S. economy. These three areas are all important and significantly affect productivity.

Long lead times for major ship components has long been a problem for American shipbuilders. The delays associated with these lead times will lengthen contract award to delivery times thereby lowering productivity. Table 2 shows a comparison of approximate lead times between Japan and the U.S. for major ship items.

TABLE 2

Typical Lead Times for Major Procurement Items - Japan vs. USA[12]

Item	Japanese shipyard (in months)	American shipyard (in months)
Main Trubines	10	16
Turbo-generator sets	9	13
Boilers	8.5	12
Propellers	5	7-9
Steering gear	10.5	12
Large pumps	6	8-12
Deck cranes	9	18
Deck machinery	6	15
Main diesel engine	9	15-20
Main valves	4	10-12
A-C equipment	4	12

For instance, the procurement time in Japan is 6 months shorter for main turbines and 6 to 11 months shorter for a main diesel engine. American shipbuilders would purchase foreign items for this reason if it were not for Title XI loan guarantee requirements and government source limitations on purchased items. Thus, the long lead times on major ship items drastically affects contract award to delivery times which in turn weakens the U.S. position in the world market.

The absense of vertical integration* in U.S. shipbuilding companies has several effects which inhibit increased productivity. The chief advantage of vertical integration is the reduction in lead times resulting from control over the production of major items. Some of the large shipbuilders in Japan and Europe have been able to achieve this profitably. However, American shipyards have been unable to realize this benefit due to the sheer economies of scale needed to attain it. The ship construction market dictates whether the shipyard will have a continued high volume of orders necessary to justify the expense of financing and maintaining such facilities. In addition, government competitive bidding regulations regarding purchased items for Navy ships will also discourage such vertical integration. A significant change from this situation is one of the only ways in which lead times will be improved.

The relative size of shipbuilding in the U.S. economy is another problem which hinders productivity. In the huge and diverse U.S. business market, shipbuilding represents a relatively small part of the total monetary output. This can be seen in Table 3, shipbuilding accounts for only about one percent of all steel produced.[9] There are several implications to this. Firstly, the relatively small volume of business does not provide the shipyards with the necessary coverage to acquire pre-made structural members and other sevices from steel mills. Typically, American shipyards must fabricate many shapes, which is inherently more inefficient. Secondly, the relatively small size of shipbuilding in American business results in a lower priority for orders placed with vendors. Vendors have a tendency to favor components going to more important customers. The result can be late delivery of ship-bound components, which will affect productivity.

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*By vertical integration, we mean the branching of the shipyard into the construction of other ship components which are usually purchased from outside sources. Examples would be boilers, main engines, pumps, steel, large castings, etc.)

TABLE 3

Distribution of Steel to Consuming U.S. Industries[9]
(in percent)

Industry	Volume
Automotive	23.6
Warehouses, service centers, etc.	16.8
Miscellaneous industries	13.3
Construction	8.2
Containers	7.4
Industrial equipment	6.1
Contractor's products	5.0
Oil and gas drilling	4.0
Rail transportation	3.6
Electrical equipment	2.9
Appliances, cutlery, etc.	2.3
Other home, commercial	2.0
Agriculture	1.8
Shipbuilding	1.0
Mining, lumbering	0.5
Ordnance, etc.	0.2
Aircraft	0.1
TOTAL DOMESTIC	98.8
EXPORT	1.2
TOTAL SHIPMENTS	100.0

In conclusion, the barriers imposed by long lead times, lack of vertical integration, and the relative size of shipbuilding in the economy are all barriers to improving productivity. The reduction in lead times will be essential to the substantial improvement in productivity for American shipbuilding. This is a critical problem which may be lessened by a more extensive industry-wide standards program, coupled with standard ship designs.

GOVERNMENT POLICIES AND LEGISLATION

Government policies and legislation have had the effect of creating a disparity between shipbuilding costs in the U.S. and in foreign countries. The result is a reduced level of productivity for American shipbuilders. The major governmental barriers are environmental legislation, the Occupational Safety and Health Act (OSHA), social legislation, and differences in government policies between the United States and major foreign shipbuilding countries.

Globally, the U.S. has introduced some of the most demanding and stringent environmental regulations. Pollution abatement regulations and standards have affected shipbuilders in the form of increased costs associated with their implementation. Overhead costs are therefore higher. In a 1973 survey by Todd Shipyards Corporation shipyards were asked about the extent to which costs were increased due to environmental legislation. Seventy-nine percent indicated that pollution abatement regulations alone increased their costs 5.4 percent.[10] Also, domestic steel makers are particularly hard hit by environmental legislation. This is especially important due to the large amount of steel required in constructing a ship. The difference in costs due to environmental legislation between the U.S. and foreign countries thus exists as a barrier to increasing productivity in American shipyards.

The Occupational Safety and Health Act of 1970 (OSHA) has contributed to reducing productivity in the U.S. shipbuilding industry through the increased costs associated with its stipulated standards, compliance, and record keeping requirements. Since similar policies are largely non-existent in foreign countries, the increased costs due to OSHA are especially burdensome to American shipbuilders. In the same Todd Shipyards survey mention previously, shipbuilders indicated a 5 percent increase in labor costs due to the operating burdens imposed by OSHA.[10] Since ship construction is very labor intensive, this higher cost will be reflected in lower productivity.

Social legislation such as workman's compensation, social security, equal opportunity employment, and unemployment insurance have all contributed to increased overhead costs for U.S. shipbuilders. For instance, workman's compensation has increased significantly due primarily to the encompassing rules and escalated benefits resulting from the 1972 amendments to the Longshoremen and Harbor Workers Compensation Act. For this, insurance carriers increased rates for the new ship construction and ship repair segments of the industry by 3.2 percent.[10] In addition, social security contributions have added on another .3 percent according to the Todd Shipyards survey. Thus, social legislation has contributed to increased overhead costs for U.S. shipbuilders with a corresponding disadvantage in the global marketplace.

The net effect of all environmental and social legislation is substantial. In 1978, the Shipbuilders Council of America made an industry survey of five shipyards to determine an estimate of the increased costs associated with federal government regulations. As a base, the estimators used a hypothetical 56,000 DWT tanker with a cost of $45 million. The survey results showed an estimated increase in costs for U.S. shipyards of 14 percent.[11] These costs would be even higher if a naval vessel was used in the survey. Although foreign shipyards must deal with similiar types of legislation, they are far less stringent than in the U.S..

Disparities between government policies of foreign countries and the U.S. have indirectly resulted in lower productivity in American shipyards. The differences lay in the inherent characteristics of each political system. In Japan for example, the government has created a situation whereby the shipbuilding industry is closely intertwined and domestic competition is significantly reduced. The government offers credits to shipbuilders, offers attractive financing for ship owners, and does not have anti-trust concerns. The result is a much better position in the world marketplace, which has greatly reduced the level of business in American shipyards. Another factor on the world market is that countries such as Korea and Spain have been operating outside economic community constraints on subsidies and credits. This has reduced their shipbuilding costs and thereby increased their market share. For the reasons stated above, American shipbuilding productivity will be effectively reduced.

In conclusion, the differences in government policies and legislation between the U.S. and foreign countries has reduced the competitive position of the U.S. shipbuilding industry. Although foreign shipbuilders are burdened to some degree with the same types of regulations, they are not nearly as stringent. Until the U.S. and foreign countries can compete in the world shipbuilding free market on equal footing, these barriers to productivity will exist.

INDUSTRIAL RELATIONS CHARACTERISTICS

The current industrial relations structure in the U.S. is deeply rooted in tradition and will be difficult to modify. There are three areas which act as barriers to improving productivity. They are the company/worker relationship, effects of labor unions, and personnel development. The effects on productivity here are difficult to estimate, but nevertheless, are real.

The management of labor in this country has long been one of conflict rather than cooperation. The adverse relationship between management and labor unions has resulted in nearly all expenditures for personnel welfare being disputed over in company/union contract negotiations. Seldom, are these expenditures voluntarily undertaken by the company. The American system thus breeds worker discontent because of the adversary confrontations over working conditions, and the extent of worker participation in management. There is general distrust of the company. The direct result of this adverse relationship is that many workers will tend to identify with a union rather than the company. The worker will, thus, believe his job security is vested in the strength of the union, rather than the benevolence of the company. This becomes more valid if one considers the risk aversion techniques shipyards often use involving labor levels (described previously). The ultimate result will be generally lower worker morale, which causes lower productivity.

The existence of labor unions in American shipyards has created problems in the allocation of manpower resources. The unions are organized by trade (see Appendix A-2), and it is not uncommon to find seven different craft unions in a shipyard. In Japan workers all belong to one union. Thus, the production planning function is simplified since workers can be given any of a group of jobs to do without concern as to whether his union will allow him to do it. The critical difference is that zone outfitting will be more inefficient in the U.S. because of the difficulty arising from multi-craft work going on in a small space. Another problem which has confronted U.S. shipbuilders is the unrest associated with union fragmentation. The usual cause of this is one union breaking into two smaller ones with the resulting disagreeement and disruption. This ultimately lowers productivity. Thus, labor unions have subtle, but real effects on productivity in American shipyards relative to their foreign counterparts.

American shipyards (and most U.S. corporations) have maintained a rigid, vertical organizational structure which has resulted in personnel having a fairly narrow view of shipyard operations. By contract in Japan most middle managers go through extensive career development programs whereby they spend time in all areas of the shipyard operations. In addition, there are more extensive training programs for labor, which result in a greater skill level than in the U.S..

The industrial relations policies of most U.S. shipbuilding companies must be changed in order to improve attrition rates, absenteeism, worker morale, skill levels of employees, and ultimately, productivity.

SOCIAL STRUCTURE IN AMERICA

The current social structure in America has in itself created a barrier in shipbuilding productivity relative to the world industry leaders. The structure of society in the U.S. is heterogeneous as opposed to homogeneous. The American society is a huge melting pot of people which encompasses many nationalities, cultures, morals, ideas, and goals.[6] This situation, plus a relatively loose family structure, has resulted in a society where people tend to be individually rather than group oriented. Sociologists have described the present American society as the "Me-Generation." This has several results which are subtle, but nevertheless hinder higher productivity in U.S. shipyards.

Group orientation is a phenomenon which exists in some societies and lends itself well to productive work. Perhaps the classic example is Japanese society. Japan is an almost purely homogeneous society in which people who grow up together often end up working in the same shipyard.[5] Group orientation is instilled in children at an early age and is carried on through life by way of a tight family structure and close peer relationships. The result is that there is a large degree of camaraderie on the job; much more so than in the U.S. This system is well suited to increased productivity through the efficient cooperation among workers. In America for the most part, this situation is not the case.

Another implication of a close-knit society is that the effects of peer pressure are in general, much stronger. In Japan, the emphasis on hard work and pride in workmanship has resulted in shame and derision to those who do not meet these ethics. The result is higher productivity. In America, where there is a much looser social fabric and greater individualism, peer pressure to perform is not nearly as intense. This can create a more passive attitude toward work. The obvious effect of this is a less efficient worker thereby lowering shipyard productivity.

One other problem associated with the individual orientation of American society is increased job mobility. In general, the social structure in the U.S. has resulted in weaker family ties, less affinity with fellow workers, less loyalty to the company, and a stronger desire to better one's self by changing jobs. The result is that shibuilding in the U.S. suffers a high rate of employee turnover.[7] The impact of this on U.S. shipyards is reduced efficiency due to the time and resources spent training new workers.

EFFECTS OF MANAGEMENT STRAGEGY AND DECISIONS

One of the very biggest impacts on the productivity of a shipyard is the management strategy and decisions carried out at that shipyard. Although American management used to be greatly respected on a world scale, serious questions have been raised in recent years regarding the strategies pursued in the U.S. There are several problems in this regard which face the shipbuilding industry in particular. They are, the financial policies followed by most American corporations and the extent of cooperation among domestic shipbuilders.

The most major impact by management in many American industries, including shipbuilding, has been the adherence to financial strategies which emphasize immediate profits and return on investment at the expense of long-term investment in capital facilities. American corporations have ownership by many individuals whose major desire is a "handsome" quarterly dividend. The direct result is that most American shipyards have suffered from capital shortages at the very time when they are most needed. Foreign shipyards have forged ahead with substantial capital improvement programs which have greatly elevated their competitive positions. Meanwhile, the U.S. has resorted to more labor intensive production techniques which are inherently more inefficient. The predictable bottom line is that increased ship costs and therefore lower productivity, have reduced the world market share of American shipbuilding. This management strategy is deeply rooted in both the economic structure of American society and the thinking of many executives. This situation must be reversed through the reevaluation of current thinking and the spurring of investment through various government actions. The latter has partly come about as a result of recent legislation accelerating depreciation write-offs on capital assets.

Another area where potential productivity gains are stymied is in the sharing of technical data between shipyards. This is an area where foreign shipbuilding industries, particularly the Japanese, have implemented extensive programs of cooperation. The sharing of statistical data, marketing research, computer programs, design studies, etc. has been found quite advantageous from an efficiency standpoint in these countries.[8] The principal barriers to applying ideas of cooperation in the U.S. industry have been an intensely free market system, tradition, and anti-trust legislation. It is of interest to note, though, that the Maritime Administration has established a program of cooperation for the U.S. shipbuilding industry.

ADOPTION OF SHIPBUILDING INDUSTRY STANDARDS

In most industries the one way to achieve higher productivity is through the adoption and use of industry-wide standards. To define standard here, Y. Ichinose of Ishikawa-Harima Heavy Industries describes: "A basic element, component, or unit used for hardware, or a basic rule or criterion used for software, that should not be changed, irrespective of the system they belong to."[14] To be more specific, standards can be of either engineering or material types. The basic advantage of industry standards is that standardization of raw material specifications, basic ship fittings, machinery specifications, test costs for various components, and electrical and navigational equipment will reduce design, procurement, and production time. This will therefore increase productivity. An example of this comes from a study done by the Maritime Administration which determined that the economic benefits of applying standards to the steam plant alone could save 15 percent of propulsion acquisition and installation costs.[3]

The U.S. shipbuilding industry has been unable to adopt an extensive set of shipbuilding standards. The problems in adopting industry standards are several. First, the large number of organizations involved in the adoption of industry standards has necessarily slowed the development of them. Input must come from bodies such as three committees within SNAME, the Coast Guard, the American Bureau of Shipping, various manufacturers, shipowners, and of course, shipyards. The level of cooperation, time, and expense involved in developing and approving these shipbuilding standards is itself a barrier to improving productivity. Second, shipowners buying ships from American shipyards generally desire them to be more "tailored" to their own needs and specifications. This discourages the development of standard ship designs which also discourages industry-wide standards. Thus, the benefits accrued from repeated work will be lessened. Finally, as previously discussed, the current shipbuilding market has evolved into a situation where at least for the short term, standard ships are realistically not possible. Standardization is a concept which by nature is suited for mass production-type industries. Therefore, extensive industry-wide standards will be more difficult to achieve.

In conclusion, the barriers to adopting extensive national shipbuilding standards is difficult to overcome, but not impossible. Improved cooperation and attitudes will help to bring greater standardization to the American shipbuilding industry. Industry standards coupled with shipyard standards will significantly improve productivity.

CONCLUSIONS

This paper has identified those aspects of American society and business which act as barriers to improving productivity in shipyards. Here, productivity has been defined so that all major factors inhibiting any part of the ship procurement process will become important. To justify the identification of certain institutions as being barriers to shipbuilding productivity, comparisons have been made against a standard. This standard represents the highest existing level of shipbuilding productivity on a world scale, and most often represents the Japanese shipbuilding industry. The six areas which appear to have the greatest impact on the American shipbuilding industry productivity are:

* The American's small market share of the world shipbuilding market is a barrier itself to acquiring a larger share. The Japanese are able to sustain their huge market share due to economies of scale.

* The long lead times of principal ship components in America has significantly lengthened contract award to delivery times.

* The U.S. does not operate on the same footing as foreign shipbuilders do, due to the effects of government policies. Domestic shipbuilders are faced with more extensive social legislation, and environmental regulations and, foreign government policies generally provide greater assistance and incentives to its shipbuilders and shipowners than does the U.S.

* The mutual hostility, distrust, and disrespect currently existing in the company/worker relationship in most American shipyards is very adverse to high worker productivity.

* The social structure of the U.S. has evolved into a generation which emphasizes the fulfillment of ones personal desires and goals often at the expense of communities, family, and peer relationships. This, combined with a loose family structure has resulted in a very high worker turnover rate, diminished worker interaction, and a generally passive, less loyal job attitude than other major shipbuilding nations.

* The adherence to financial strategies which emphasize short-term profits and return on investment has caused U.S. shipyards to remain labor intensive rather than becoming relatively capital intensive. Most foreign shipyards have a more modern and efficient plant, which results in productivity benefits.

These six areas constitute the major barriers to improving productivity in American shipyards and are intended to reflect the overall condition of the industry rather than applying specifically to any individual shipyard. For significant change to be implemented, a national commitment to the maritime industry will be needed. Only through substantial government cooperation and assistance will the U.S. be able to boost shipyard productivity to an extent which will allow us to compete on a world scale.

RECOMMENDATIONS

The overall low state of American shipyard productivity must be significantly improved in order for the Americans to regain a large world market share. In some areas improvement will be realistically impossible in the current social and political system. However, other areas can be changed with a reasonable amount of time and effort. Here are some possible ideas to create higher productivity:

- An extensive industry standards program must be pursued virgorously in the next decade with input from shipyards, shipowners, vendors, SNAME, MARAD, the Navy, ABS, the Coast Guard, and other interested organizations.

- Owners must receive increased incentives to have their ships constructed in the U.S. through accelerated depreciation rates, and more attractive financing conditions.

- A reversal of the current company/worker relationship is essential. Increased worker involvement in the firm, greater job satisfaction, and improvement in production methods can be attained through quality of work life programs. Incentives and profit sharing plans will help cause workers to take a more active role in increasing productivity.

- Corporate executives must place more priority on long-term capital investments in such areas as computerization, standardization, facilities, and equipment.

- More government support is necessary to decrease regulation, spur capital investments through faster depreciation, assist in implementing standards, and coordinate a national effort in the revitalization of the U.S. maritime fleet.

The improvement of productivity on a large scale will be no easy task and will necessitate a great deal of time, effort, and cooperation to attain. Management and labor must work closely together to solve the myriad of obstacles to boosting efficiency. Only with a commitment from everyone involved will the American shipbuilding industry regain the prominence it once possessed.

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APPENDIX A-1

Percent of Orders Placed in Major Shipbuilding Countries, 1980
(World Market Shares)

Country	Share
Japan	52.7
South Korea	9.0
Spain	5.2
China Taiwan	3.7
*USA	3.4
United Kingdom	2.7
West Germany	2.2
Denmark	2.1
Yugoslavia	1.7
France	1.7
Norway	1.7
Italy	1.6
Finland	1.5
Sweden	1.5
Romania	1.3
Netherlands	1.2
Rest of world	6.8
TOTAL	100.0

source: Blenkey, Nicholas, "World Shipbuilding Report," Marine Engineering/Log, p. 78, June 15, 1981.

APPENDIX A-2

Unions

BPAT - Brotherhood of Painters and Allied Trades, AFL-CIO

BPDPHA - Brotherhood of Painters, Decorators and Paper Hangers of America, AFL-CIO

IABSOI - International Association of Bridge, Structural and Ornamental Ironworkers, AFL-CIO

IAMAW - International Association of Machinists and Aerospace Workers, AFL-CIO

IBB - International Brotherhood of Boilermakers, Iron Shipbuilders, Blacksmiths, Forgers, and Helpers, AFL-CIO

IBEW - International Brotherhood of Electrical Workers, AFL-CIO

IBFO - International Brotherhood of Firemen and Oilers, AFL-CIO

IBT - Truck Drivers and Helpers local, affiliated with the International Brotherhood of Teamsters, Chauffeurs, Warehousemen and Helpers of America

IUMSWA - Industrial Union of Marine and Shipbuilding Workers of America, AFL-CIO

IUOE - International Union of Operating Engineers, AFL-CIO

MA/MTD - Master Agreement with Metal Trades Department of the AFL-CIO, Pacific Coast Metal Trades District Council, and local Metal Trades Council

MTC - Local Metal Trades Council, AFL-CIO

PSA - Peninsula Shipbuilders Association

SIU - United Industrial Workers, affiliated with Seafarers International Union of North America (Atlantic, Gulf, Lakes and Inland Waters District), AFL-CIO

SMWIA - Sheet Metal Workers International Association, AFL-CIO

USA - United Steelworkers of America, AFL-CIO

UAJAPPI - United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry of the United States and Canada, AFL-CIO

UBCJA - United Brotherhood of Carpenters and Joiners of America, AFL-CIO

Source: Personnel Requirements For an Advanced Shipyard Technology, National Academy of Sciences, Washington, D.C., 1980.

COMPARISON OF U.S. AND FOREIGN SHIPBUILDING PRACTICES

by

Sudhir K. Gupta

"Only America can surpass Japan in shipbuilding - but we do not have to worry as America does not have enough college-educated people in middle management."

Dr. H. Shinto
October 1979

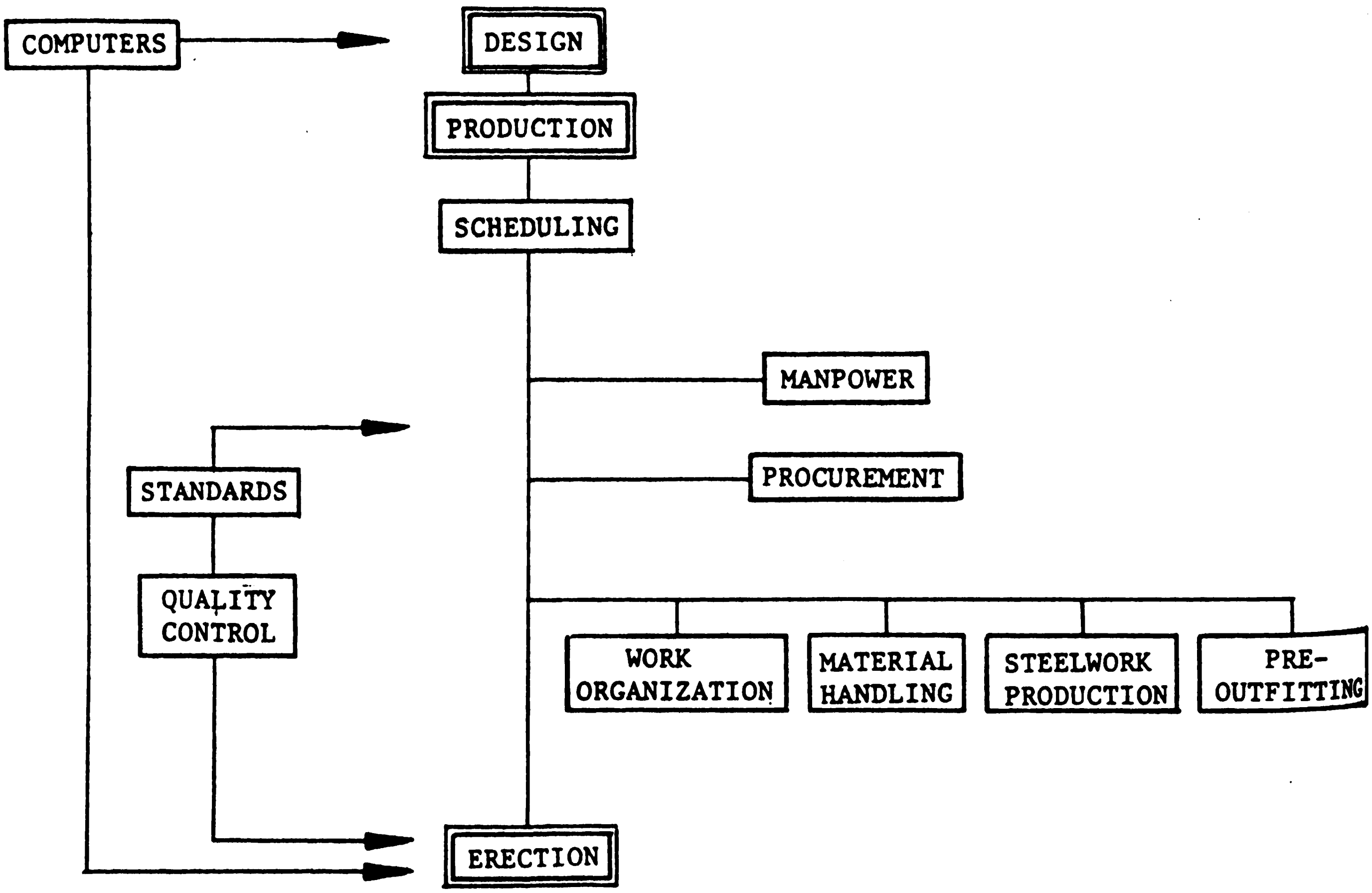
INTRODUCTION

While comparing U.S. shipyards with European and Japanese shipyards, some characteristic similarities stand out, e.g.:

- Most of the yards have a long shipbuilding history dating back to at least World War II or earlier.

- Most of the "efficient" yards have made large capital investments in land and/or facilities with good returns, or are newly constructed.

Over the last 10 to 15 years the Japanese shipbuilders have dominated the world market, at the expense of U.S. and European shipyards, due to low selling costs. This affected the American yards, but the various subsidies to the U.S. shipowners and shipbuilders helped them to survive. Unfortunately, however, the support tended to de-emphasize the need to implement modern shipbuilding practices. This paper compares some of the areas where a large difference exists. It is hoped that the various aspects covered may assist in determining where the changes are most urgent or may be most fruitful.



Areas of Comparison

SUMMARY

The cost of a new ship is a question of design, planning administration, manufacturing, and follow up. The objective is to utilize the existing resources in the best possible way, i.e., a combination of management and facilities. Some of these aspects are:

a. Designing

Designing is a primary area of difference between the U.S. and foreign shipyards. The U.S. method of using independent design agents who are totally uninvolved in the production has been detrimental in application of modern production.

b. Scheduling

Different levels of importance by U.S. and foreign shipyards are placed on scheduling. U.S. yards use PERT/CPM methods for scheduling where as Japanese find them too inflexible in the short shipbuilding period.

c. Manpower

As the range of wages in U.S. between skilled, semi-skilled, and unskilled workers is quite narrow, it may be more cost effective for the American yards to pursue a policy of high wages, high skills, high productivity, accompanied by interchaneability between skilled workers.

d. Procurement

Because the U.S. yards are not major consumers of materials and are being widely dispersed, they are a low priority item industry as far as suppliers are concerned. By contrast, IHI of Japan has consolidated a group of exclusive and technically specialized subcontractors for the production of components for zone control.

e. Work Organization

Utilization of manpower and resources are the two main aspects of work organization. Over three hours per working period is nonproductive as an average as per a study by British shipbuilders. A savings of 1-1/2 hours daily is equivalent to a savings in ship cost of over 10 percent.

f. Material Handling

Although Japanese have very small stockyards, they have still made large capital investments in the stockyards. A neglect of advance in handling and storage methods may lead to 60 percent of total manhours being spent in material handling and locating.

g. Steelwork Production

The shops in the U.S. yards lack organization and the equipment is of poor standards. The yard layouts and material flow patterns are inferior to most European and Japanese yards.

h. Preoutfitting

The U.S. yards have no generally accepted methods for preoutfitting. This has been primarily due to their inability to measure the impact on costs and benefits of preoutfitting.

i. Erection Methods

The American yards have generally stayed with inefficient slipways, while the Europeans have rearranged their yards, and added graving docks; the Japanese have constructed big building docks.

j. Standards

Use of standards has provided the Japanese shipyards with a formalized way of documenting their experience. Standards also establish common understanding between the parties as to the tolerance in quality and accuracy.

k. Quality Control

Once preoutfitting and hull block construction methods are employed, increases in quality control are necessary. This must start at design stage and not be relegated to an after-the-fact process as is presently done in many yards.

1. Computers

Computers are assuming a greater expanded role in all shipyards. It is believed each yard should insist on computer planning to be directed at the overall development of the yard.

Designing

"... the design consultant system so familiar in the U.S.A. is not very understandable. The existence of a shipbuilder with no such care for the development of basic technical progress is entirely beyond our comprehension." These are Dr. H. Shinto's words [6] and are echoed by all foreign shipbuilders, and is, in the author's opinion, one of the primary reasons the U.S. shipbuilding industry has not increased productivity as fast as it could and should have.

Dr. Shinto feels that as both production process and the design stage are continuously having new innovations, both basic design and the production system should advance in a mutual relationship. He further suggests that even when a design consultant is employed, his activity should be confined to basic design which decides the performance and the capability of the ship. All production design should be done in the yard and the consultant may check these as the owner's representative [5].

The Japanese divide the design effort in four stages:

- Basic design: done at the head office.
- Functional design: includes key drawings such as general arrangements, system diagrams, and structural scantlings.
- Detail design: conversion of functional design into zone or area oriented structural and outfit working drawings.
- Work instruction design: develops in detail fabrication sketches required to fabricate or purchase small subassemblies.

The basic contract design done at the head office is more complete than the drawings in the U.S. The functional, detail, and working drawings are done at the yard as per a schedule drawn in the beginning. The use of Composite Outfit Arrangement (COA) drawing is a key element in reducing working plan development time in Japan as compared to U.S. These COA drawings are not very sophisticated drawings but include elevations, sections, and details, and are coded to indicate on-unit/on-block/on-board stage.

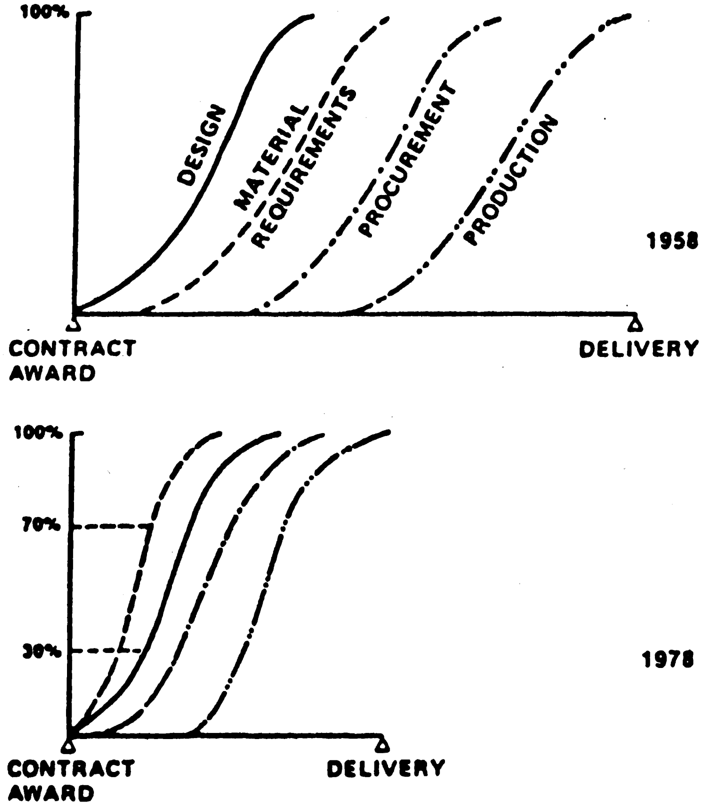
At IHI's Kure yard the design department is split up into nine different design groups including the business administration group. Some of the groups, e.g., hull structure design group and engine fitting design groups, are further split up into a key plan group and a working plan group. Each group has its own work clearly defined and works to meet specified schedules [10].

In the U.S., the shipyards have, unfortunately, very few long term goals and contracts. The merchant shipbuilding has lost most of its trade to Japan and Korea and the naval shipbuilding industry's improvement and expansion programs are solely dependent on the administration's decision to build; and "what, where, and when" vary each year.

The U.S. shipyards need design contractors to avoid having to employ designers during low peak periods, but must involve the design contractors more and more in their ship production methods. Large design contractors must be asked to get more involved in the production stage to enable the entire system to progress.

Scheduling

In most of the U.S. yards, the management only does the key event schedule, as their primary concern is meeting contractual and milestone deadlines and not individual work package schedules [11]. Over the past few years the major yards have tended to organize production planning by paying attention to smaller details in scheduling.



Note: Due to overlap of design, material definition, procurement, and production, competitive shipbuilders have 70 percent of required material defined when only 30 percent of design has been completed [24].

In the Japanese yards, the shipbuilding period has become so short they have found it necessary to parallel the design, material procurement, and production phases. Although most of the U.S. yards still use PERT/CPM, the Japanese have abandoned them as being too inflexible, in favor of Gnatt charts or simple lists. Their schedules are simpler and have less detail, but they maintain excellent control due to their previous experience [2].

The scheduling and control of front end and production phases are simplified by the common zone or area orientation of the design, planning, schedule, labor, and material control and production. The sequencing of work and the scheduling by process enables them to plan for buffer storage where blocks can be stored if not immediately required.

The Japanese shipyards do scheduling at different levels of the management heirarchy. This enables the nesting of each series of schedules within another. They have saved manhours and money by doing crane scheduling and including remnant control in their scheduling [3]. The crane scheduling helps them to check and ensure that all schedules are being met.

In the U.S., most shipyards have great difficulty in meeting their delivery schedule. Maybe all that is required is more buffer time initially which can be gradually reduced as production methods continue to be improved.

Manpower

Most of the world's shipyards now realize that high levels of productivity can only be achieved by good long term employee relationships. In the U.S. the unions are organized by craft, and management has to deal with each union; the unions have traditionally been antagonistic to the management aims [4]. In the U.K. the negotiations are held between the British shipbuilders, the Shipbuilding Negotiation Committee, and the Confederation of Shipbuilding and Engineering Union [5]. All U.K. shipyards have Joint Action Committees, consisting of management and union, to protect the delivery dates and maintain targets. They have specialist working parties and sector working parties which are sent in to bring items back on schedule [1].

The Japanese shipyards have house unions and not craft unions; these house unions belong to the Japan Confederation of Shipbuilding and Engineering Workers Union. The unions have a basic policy of giving precedence to productivity increases in all matters. The union management cooperation to increase productivity is maintained, provided the management can maintain employment and improve working conditions regularly [6].

The U.S. yards are far behind in providing good working conditions. The amenities provided are of a very low standard as compared to Japanese and European yards. Most of the "efficient" yards have paid considerable attention to working conditions, thereby enhancing the morale of the workers and effectively reducing the turnover [7].

The Japanese worker is, in comparison to the U.S. worker, highly educated, trained, and when working for a large company, likely to work on a long term basis. The entire workforce being ethnically uniform reduces problems [4]. The Japanese working force is committed to group aims, whereas the Americans are more committed to individual goals [8]. In most of the Western countries, there is a stigma attached to people who work in shifts and until this is gradually eroded, it will be difficult for a different class of worker to move into the yards.

U.S. shipyards are very low in productivity per employee [4]. Sweden is the highest and Japan rates only 4th, in compensated gross tons produced per employee. This is due as much to low productivity as to overmanning [1]. The Japanese direct labor manhour costs, and construction schedules are one-half when compared to U.S. practices [3].

In the Western world, the deskilling of tasks does not result in reduced costs as the range of wages paid to the skilled, semi-skilled, and unskilled worker is quite narrow. Hence, it may be more cost effective for the American yards to pursue a policy of high wages, high skills, high productivity, accompanied by interchangeability between skilled workers [9].

An increased use of industrial engineers may also be found beneficial. Presently, the Japanese are using twice as many industrial engineers as any of the European yards [7]. The middle management in the U.S. yards normally work their way up from the trades and often have difficulty accepting and adapting to new ideas and procedures. The educational institutions should expand their curriculum to include production and planning concepts appropriate for use in shipyards. The middle management people should be encouraged to broaden their viewpoints by attending seminars and classes.

Procurement

The low relative demand for material by the shipbuilding industry places them low on the suppliers priority ladder. A lack of standards among the yards also discourages the suppliers from concentrating on the production of standard equipment. Dr. Shinto mentions that IHI, as the first step in procuring consolidates a group of exclusive and technically specialized subcontractors [6] for producing outfitting components on time and in the configurations required for zone control.

This foresight has enabled the Japanese yards to need only very small plate and shape storage yards because the material is delivered one to three days prior to fabrication. They realized that a close scrutiny of the choice of materials is important and are willing to use slightly more expensive materials which may subsequently reduce the labor handling costs.

In Japan, the ordering is done in progressive stages and throughout the functional design, detail design, and work instruction design phases to suite the material lead times. Long lead materials, e.g., main engines and cranes, are even ordered at the basic design stage [2].

In the U.S. yards, there are presently two tendencies:

- Subcontracting most of the manufactured equipment previously made in shipyards to endeavor to reduce the overhead costs and have minimal capital investment [12].
- Reduction in the outside source of supply as well as lack of improved product lines offered by marine equipment industry [13].

The National Shipbuilding Standards Program will go a long way in revitalizing the marine equipment industry and inviting the nonmarine industry to pay more attention to the demands of the shipyards.

The Japanese subcontractors are largely people who used to work for the yard and have either retired or decided to go into business themselves. The yards here could also use the same technique and encourage the exceptionally qualified people who retire every year to become subcontractors (even on a very small scale initially).

Work Organization

There are two aspects to work organization: utilization of manpower, and utilization of resources. The British Shipbuilders did a study [1] of the average nonproductive time per employee:

- Morning and afternoon breaks	-	23 minutes
- Late start, early finish	-	47 minutes
- Idle time	-	21 minutes
- Adverse weather conditions	-	17 minutes
- Correction of errors	-	12 minutes
- Others	-	8 minutes
	Total	185 minutes

Over 3 hours of working period is nonproductive. This loss can be greatly reduced by taking the work to the workers instead of taking the workers to the work and maintaining a steady flow of material and information to the work place. A saving of 1-1/2 hours daily is equivalent to a 30-percent productivity improvement or a saving in ship cost of over 10 percent.

The Japanese divide the work into small work packages limited to the assembly work 1 to 3 people can do in a week. This enables a quick check on the productivity of each group.

Organization of a typical Japanese design or outfitting production division is product or zone oriented. The work packages are zone or area oriented to simplify scheduling and control of labor and material. IHI even has well laid-out guidelines to assist in defining pallet breakdowns [2].

All outfit parts other than piping are, in some Japanese yards, subcontracted locally. This greatly simplifies the internal control on material and labor, but makes the yards dependent on organizations over which they have no direct control. This can be a reason for avoiding this in U.S. yards, so that a strike in one or more small contractors' firms does not delay or hinder production.

Material Handling

Even though the Japanese have very small stockyards, compared to their American or European counterparts, they have made large capital investments in the stockyards. Extensive use of remotely operated overhead traveling cranes are made. Television cameras scan the steel plates for identification, enabling accurate disposal of each plate [14].

A neglect in advances in handling and storage methods may lead to 60 percent of total manhours being spent in material handling, searching for, moving, positioning, handling steel and materials of outfit, components, and subassemblies. These can be very labor intensive if not mechanized and automated [15].

Crane capacity has a large influence on the block sizes and vice-versa. Dr. Shinto, IHI, suggests that the crane capacity should be limited to the size of steel blocks that can be built in shops. Hitachi finds it more convenient to join large blocks (approximately 300 tons) into grand blocks outside the building dock and then lift the grand block (700 tons) into the building docks [14].

Steelwork Production

The block breakdown is defined very early in the Japanese yards. The Japanese have a great advantage as compared to U.S. yards in respect to storage yards. Their storage yards are very small and the steel is delivered only one to four days prior to being used. At Hitachi's Ariake Shipyard, steel plates and shapes are taken by conveyors to the subassembly shops, where after sorting and gas cutting they are welded into large panels of up to 100 feet by 100 feet prior to welding the egg-box of stiffeners and webs. Hitachi has developed an automatic welding system claimed to save 40 percent of the welding time in construction of the egg-box [14].

At IHI, too, the steel fabrication and assembly areas are large and well laid out. The subassemblies of small floors and web frames are typically done on a moving conveyor system [3]. The American yards are using advanced plate cutting technology but have neglected the stiffener cutting method. The overall level of technology is quite low in the U.S. in the steel work production area. The welding processes are continuously being improved and it is suggested that the shipyards consider the advantages of using robots for welding.

An introduction of new hydraulic and mechanical fairing systems is taking place in the U.S., but the Japanese only use heat line fairing to correct weld distortions [2].

The shops in the U.S. yards lack organization and equipment to produce standard items. The layout of most yards is poor with nonexistent material flow patterns. The material handling methods too need renovation. All this requires capital investment, and with the anticipated shipping boom, now is the right time for all yards to invest in equipment and other facilities [7].

The steelwork production needs to be defined earlier to assist the production people in defining blocks earlier. Unfortunately, many designers are not familiar with different welding techniques. And many designs have been found to be uneconomical at production stage. All naval architects and marine engineers should be encouraged to learn welding and cutting techniques to ensure that the designs are compatible with production.

Preoutfitting

If there is any area where the U.S. shipyards are very significantly behind as compared to foreign, especially Japanese yards, it is in the outfitting area. All major U.S. shipyards initiated hull block construction methods a long time ago, but most have still not started on-unit outfitting. In the U.S. yards, there are no generally accepted methods for preoutfitting; however the U.S. yards are actively engaged in developing an advanced methodology for preoutfitting [11].

IHI initiated the on-unit and on-block type of outfitting. The outfit manhours on a typical tanker are distributed as follows:

- 30 percent on-unit
- 50 percent on-block
- 20 percent on-board [8]

The preoutfitting starts in the planning and design stage. The design and drawings are adjusted for the system, and an earlier knowledge of equipment to be installed is absolutely necessary. The U.S. yards doing naval construction may find this difficult to meet, due to the consistency of large change orders.

The large number of change orders can be easily reduced or at least their effect on production can be minimized by using the modular concept as originated at Blohm and Voss yards. This would also prevent the Navy vessels from becoming obsolete in terms of advanced equipment and armament. This would require large planning and detail work by U.S. yards.

Preoutfitting increases the amount of work area required and all equipment will usually need an earlier delivery date [17]. This again may require additional planning in the U.S. due to the low priority placed on U.S. shipbuilders by the suppliers.

Zone outfitting recognizes that significant subassemblies can be produced away from the hull erection site. Outfitting is thus accomplished simultaneously with hull construction and, subsequently, considerably reduces the construction period. The working conditions in the shops are, comparatively, ideal and it also helps in reducing the interface between the outfitting and structural activities [3]. Mitsui tries to shift as much work as possible to ground, and carries out a continuous inspection during the progress of outfit work [18].

IHI has, by unit-outfitting, reduced the preoutfit time of engine room lower level blocks in half, using extensive preassembly of piping, grating, etc. IHI on-unit outfitting incorporates 80 percent of all piping, compared to 55 percent at Bath [2]. The British shipbuilders, in developing the Tyne ship yards, found that using a new steelwork breakdown for a 250,000-ton tanker, reduced the total number of steelwork units from 700 to 380, which has reduced the berth work content by 35 percent when measured in terms of welded joint lengths. This length has been transferred to the fabrication shop where it is performed much more efficiently and economically in controlled working conditions [22].

Erection Methods

With the advent of large vessels, most of the ship's elements such as plates and sections grew bigger, panels and weldments heavier, and the increase in ship's heights created many problems. All this necessitated a change in the existing yards. Whereas the American and European yards decided to rearrange existing yards, the Japanese preferred to construct big building docks [17]. Because of their "rearrangement" decision, quite a few of the U.S. yards are still using sloped slipways in spite of the problems associated with erection on slipways, especially at times of joining grand blocks.

Some European yards, like A.G. Weser in West Germany, build 300,000-dwt ships on a slipway, but the Japanese prefer to construct graving docks, in spite of that being the most costly single facility in a large shipyard. There are many different block joining methods employed around the world, each one is specially designed and adapted to the geographical location of the yard and the shipbuilding concept of the yard [14].

The U.S. yards should seriously consider investing into one of the systems described below [17] instead of using slipways and side launching presently favored in the U.S.:

- Platform to graving dock: Setenave, Portugal
- In dock with side pocket: Mitsubishi Koyagi, Japan
- In double ended dock: Namura, Imari, Japan

A few decades back all countries were building on slipways. The Japanese have practically totally converted to graving dock construction and the European yards have constructed graving docks while retaining their original slipways. The U.S. yards have remained with the slipways and need to invest large sums to build graving docks or build the kind of system Litton has at Ingalls. The Ingalls' system works very well for a series of ships but for single ships a graving dock may have been more economical and efficient.

Standards

The first move towards the formulation of shipbuilding standards is believed to have been the presentation of a paper to the NEC Institute (U.K.) in

1917 by Mr. Waldie Cairns, advocating standardization in relation to deck equipment. In 1919, the British Standards Association took up the matter and set up an extensive structure of committees to undertake the work of standardization. Unfortunately, in spite of this early start, until 1968 the U.K. had less than 25 standards in comparison with France's 450 hull outfit standard [23].

Whereas the U.S. yards limited their lists of standards to various types and sizes available, the Japanese went ahead and developed a list of standards which covered all major aspects on production, including which types of joints to be used and size of flanges, with respect to pipe diameter, and the length of welding beads.

Use of standards has provided the Japanese shipyards a formalized way of documenting their experience. They use extensive standards for use in functional design, detail design, planning, production, and quality control. Design and material standards start at the level of individual components and pieces of raw material and include progressive tiers to the level of standard machinery arrangements and system diagrams for various standard ship and various sizes of standard power plants [2].

Using the design standards, the designer can select from different alternatives to create the functional and working drawings for a new ship. These design manuals and checklists provide substantial guidance to the design and ensure reduced costs and problems in production and guarantee. These standards have been developed to reflect the highest quality based on new requirements and past experience. As all Japanese yards do their own designing, they can sell the use of standards to owners, during technical negotiation prior to contract award, based on the principles of proven service experience, reduced delivery time, and reduced costs [2].

Standards also establish common understanding between the parties as to the tolerance in quality and accuracy for hull structures and outfitting works avoiding any trouble or disputes [3].

The National Shipbuilding Standards Program sponsored by MARAD/SNAME presently involves 15 major shipyards in addition to Navy (NAVSEA) and MARAD, and hopes to coordinate the industry's approach to a disciplined standards technology, helping to reduce costs, shortening schedule durations, and improving productivity [18].

Quality Control

No machinery or people can produce items which are perfect each and every time. The purpose of quality control is to ensure that products produced are acceptable the first time and are as cheap as possible while still satisfying the customer's requirements [1].

In Japan, quality control is an integral part of the skill of every worker, whereas in the U.S., it is a separate entity within the company. At IHI, dimension control is maintained by monitoring and control of each fabrication, subassembly and assembly operation, based on worker and supervisory quality control inspection and documentation. Having an extensive list of standards based on experience and statistical projection of cumulative errors reduces the rework to a minimum [3].

A number of U.S. yards have initiated quality control and are quite often using similar check sheets to those developed in Japan. It is not yet integrated in the system, and that will only occur when the U.S. shipyards involve quality control from the drawing stage. The U.S. yards still consider it an expensive, contractually necessary nuisance, and often it is an after-the-fact process [19].

The mobile work force in the U.S. has been a great frustrating force in implementing quality control. At IHI quality control, besides setting requirements, educates and trains the worker at all levels to uphold standards. This decreases the work done by the quality control department and only about 5 percent of the items produced are check by them.

The check sheet at IHI is used at each production stage for each individual unit. Each individual signs his work and is graded. All grades are made public even though there is no official action taken for low grades. They feel that poor quality results from unsafe working conditions and unhappy workers, and take measures to avoid these [20]. Overall, the production costs is reduced to one-half of the U.S. yards' costs.

Use of Computers

Computers can have a significant effect on productivity by making information handling more efficient and providing information to each user in a convenient format. Each large shipyard needs to develop its own system and each manager and supervisor can assist in making a critical review of his own information needs by asking:

a. What is the information I need?

b. Where does it come from?

c. To whom do I supply data?

d. Can I benefit from on-line interactive access to the information I require?

In the U.S., the shipyards have tended to buy computer system packages originally developed for another shipyard. The management appears too short-sighted at the onset of the planning process by not insisting that computer planning should also be directed at the overall development of the yard, as well as the individual ship. The planning "to suit production" has largely been replaced by "to suit the computer" [21].

In Japan, extensive use of computers is made in all aspects of design and construction. Specific use of computers is done in material control and outfit schedule, procurement and palletizing of material, piping design and production systems, and use of standards for dimension control [3].

In the U.S., many of the planning and scheduling details such as material procurement and testing schedules are overlooked in favor of feeding steel sequence and major outfitting plans to some piece of computer software. The necessary support schedules for shop work is often ignored due in part to the fact that such detailed information would require an overly complex set of data to be inputted, and eventually extracted, from the computer [21].

U.S. shipyards must realize that the general purpose computer programs cannot sufficiently accommodate their specific needs, except in terms of data summarization and problem isolation by exception reporting. With the increased speed and storage capabilities of most large scale computers, planning and scheduling can be done at the yard level as well as the individual ship level. Total integration of ship, shop, engineering, and material requirements can be accommodated, even considering the increased complexity of the resultant schedules [21].

Computer aid is available to the management of IHI and Mitsui at all stages of production from sales, design, to plate control and NC pipe shops. IHI's aim in computerization is this rationalization: the quality of the work involved is improved by the process of job review undertaken in applying computers. IHI and Mitsui have developed computer applications in areas where the return on investment is greatest [24].

CONCLUSION

A number of factors have affected the U.S. shipbuilding industry's decline over the past three decades. Some of them which stand out are: 1) insulation from competition due to federal subsidies; 2) lack of capital investment in the yards; and 3) lack of bright young educated people in the yards. None of these is too difficult to overcome, but to compete with the foreign shipbuilding industry U.S. shipbuilders need to use shipbuilding practices as advanced as any other country around the world.

The product/zone oriented methods, characteristics of Japanese shipyards, originated in the U.S. and only America can once again surpass Japan in shipbuilding. Most U.S. yards have initiated, and some have already implemented, large changes in their production methods, but there is still a long hard way to go.

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