TECHNICAL ABSTRACTS

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SHIPBUILDING (GENERAL)

First All-Plastic Sandwich Construction for Commercial Craft. *Ship and Boat Builder,* **9** (1956), p. 71 (Mar.).

J. Samuel White & Co., Cowes, have developed an all-plastic sandwich method of construction suitable for marine craft up to 100 ft in length. The advantage is greater rigidity with considerable saving in weight. The skins are of fibre-glass reinforced plastic, and between them there is a foamed core which weighs 5 lb/cu ft. Although neither the skins nor the core are stiff in themselves, when they are securely bonded together they exhibit extreme rigidity. This process was first used in a plastic 16-ft standard Admiralty motor launch, of which the frames and engine bearers were of sandwich construction. The launch was also used as a prototype for developing a method of fabrication which would dispense with the need for expensive moulds, and which would be suitable for the construction of fair-sized vessels.

The sandwich construction is a simple operation. The fibre-glass used is supplied in matts, fabrics, and woven rovings. The polyester resins employed are of the usual types and are impregnated with the requisite colour. A hull constructed of these materials is virtually unsinkable, and there are no buoyancy problems such as can occur with the normal fibre-glass construction. A second 16-ft launch has been constructed entirely of the sandwich material. Like the first vessel, this is to undergo extensive tests.

NUCLEAR POWER

Nuclear Power Reactor Controls. STONE, J., JNR. *Battelle Technical Review* 5 (1956), p. 7 (Jan.).

A power reactor should operate in such a manner that the rate of heat generation is equal to the rate of consumption of this heat by the attached load. The trend is away from auxiliary control devices and towards the development of systems with 'self-control' properties. For such systems a negative temperature coefficient of reactivity is desirable. The Author discusses the influence on reactivity of changes in temperature and pressure of moderator and circulating fissionable material. Many factors affect the kinetic behaviours of a nuclear reactor and will influence methods of control. It is in principle feasible to control a power reactor solely by regulating temperatures. No control rods would be required, and the system would automatically adjust itself to the load by maintaining the temperatures at the proper levels. As an example, the case of a pressurized-water reactor is discussed. The main difficulty arises from theromodynamic oscillation due to transport lag. Methods of overcoming this are suggested. Reactor-control systems must provide for starting and abnormal conditions, but even here control rods may in future be dispensed with.

MACHINE PARTS

Rotary Magnetic Seals. *Shipp. World,* **134** (1956), p. 363 (11 Apr.).

The J.C. Rotary Magnetic Seal Co. Ltd., Bath, have developed a new type of mechanical gland seal for rotary pumps, in which stuffing boxes and packing materials are dispensed with. The seal is formed by a carbon ring located between two magnets, one on the fixed flange and the other on a carrier attached to the shaft, which are attracted towards each other. No coolant is required, as the small amount of heat generated is dissipated through the magnets direct to the shaft and pump body. The seal can therefore be safely used in pumps handling petroleum products. No static electricity is generated. The only part subject to wear is the carbon ring, and this should only need renewal at very long intervals. Tests carried out on screw pumps handling petroleum spirit showed that after two years the wear on the carbon ring amounted to only 0·014 in. None of the other components of the seal showed signs of wear or fatigue.

Seals can be supplied for shaft diameters from ½ in to 7 in. The minimum overall length of the smallest seal is about 2½ in. The seals can be fitted to existing pumps without alteration of the pump unit and are suitable for any form of liquid. They can be used on pumps with pressures up to 250 lb/sq in, or vacua up to 26 in. of mercury. The almost complete absence of friction while the seal is working has improved the performance of many pumps. In one type of pump the use of rotary magnetic seals in place of gland packing is said to have increased the output from 20,000 to 25,000 gallons per hour, while the power consumption dropped considerably. Rotary magnetic seals are fitted to cargo pumps in the Union Lighterage Co's. tankers, and also in the new coastal tankers *B.P. Haulier* and *B.P. Miller*. They are not restricted to pumps, but can be used on any rotating shaft protruding from a liquid-filled casing.

LAYOUT AND INSTALLATION

The Alignment of Main Propulsion Shaft Bearings in Ships. KOSIBA, R. E., LT., U.S.N., FRANCIS, J. J. and WOOLLACOTT, R. A., *Soc. N.A.M.E.* (New England Section), Paper read January, 1956.

The Authors discuss various causes of difficulty in shafting alignment, such as hull movement, bearing movement relative to the hull, distribution of mass, and dynamic loads. They also describe the measurement technique in use at the Boston Naval Shipyard, in which the continuous-beam theory is applied to the shafting system as a whole including attached propulsion components such as reduction gears and main engines. Investigations carried out on ships are described to illustrate some of the effects which can be produced on the shafting systems ; these include the effects of thermal expansion of reduction gear casings, and bearing wear for particular arrangements of the bearings and associated components.

The Authors conclude that studies made early in the design of new shafting arrangements would be helpful in ensuring that the bearing positions and wear tolerances in the system were acceptable. They consider that a number of points merit further investigation ; these include the significance of the various bearing movements on the shaft system ; a re-examination of the advantages of the familiar stern-tube bearing arrangement common in ship design ; and the development of a more economical and accurate technique for measuring bearing positions or loading. A method of direct measurement by jacking is being developed to meet this latter requirement.

AUXILIARY EQUIPMENT AND MACHINERY

Development of Glandless Pumps. ALLARD, J. R. *Nuclear Engng*, **1** (1956) p. 28 (Apr.).

In the liquid circulation systems for nuclear power plant leakage must be eliminated, and so suitable glandless pumps have been developed. Absolute reliability is of major importance in a circulating pump in nuclear plant, and to achieve a life of several years without maintenance, the main problems to be solved were those of finding suitable insulation for the motor windings and the development of water-lubricated bearings capable of taking high loads. For pumps in cooling circuits using light water not exposed to radiation, PVC is considered to be the most suitable insulation for the motor windings. It softens only gradually over a wide range of temperature and so can withstand overheating for short periods without failure. The load on the bearings can be reduced by shortening the overhang of the impeller, and self-aligning plain journal bearings made of very hard materials have proved satisfactory. Another solution is to achieve full fluid-film lubrication by means of a ring of tilting pads. The use of hydrostatic bearings has been proposed.

For circulation of water through a reactor, the motor must be made of radiation-resistant materials. Polythene insulation is used. The pump unit must not contain materials which can go into solution and get into the reactor circuit. Aluminium rotor bars are preferable to copper ones, since the latter must be isolated from the water by a sheath round the rotor. The pump must also be able to withstand the corrosion-erosion of hot high-pressure water containing radiolytic oxygen, and the pump and impeller are therefore generally made of stainless steel. A 14 per cent chromium iron is normally used for the motor laminations.

For handling radio-active acid solutions of uranium, isolating the stator in a thin sheath may be desirable, in spite of the lower efficiency. This construction may involve the use of noble metals.

When slurries of uranium and thorium are being pumped, special wear and erosion problems are encountered. Pump components in high-velocity areas should be made of titanium. The water circulating through the motor must be kept as free from particles as possible.

For large glandless pumps impeller specific speeds less than 3,000, and for smaller ones less then 2,500, are desirable. Very low specific speeds should be avoided.

CORROSION, FOULING AND PREVENTION

The Corrosion of Cargo Ships and its Prevention. ADAMS, H. J. and HUDSON, J. C. *Inst. Mar. E.*, paper to be published with written discussion.

It has been found that the corrosion of ship plate when immersed in sea water is not materially affected by the composition of the steel. Consequently, corrosion under these conditions cannot be prevented by alterations in the steel itself, and other measures must be adopted. The two basic methods are protective coatings and cathodic protection. Research has shown that when steel immersed in sea water begins to rust, sodium hydroxide is formed at the cathodes of the corrosion cells, which like other alkalis, destroys paint media by a process known as saponification. For this reason, a high resistance to saponification is probably the most important single factor determining the successful performance of an anti-corrosive composition. Straight linseed-oil paints, however pigmented, are prone to saponification, and are therefore not to be recommended for ships bottoms. Within the last twenty years, various paints on synthetic resins have been developed with extremely good resistance to saponification, and these are very successful as marine paints. In the United States paints based on vinyl resins are regarded as particularly promising, but in Great Britain extensive research by the B.I.S.R.A. has led to successful formulations known as No. 173, No. 185, and No. 655 in which the medium is a modified phenolformaldehyde stand-oil varnish and the main constituent of the pigment is basic lead sulphate. The Admiralty has adopted No. 173, and No. 185 is used on ships of the Cunard Company. The Authors emphasize the importance of mill-scale removal before the application of any anti-corrosive composition.

Apart from the corrosion of the plates, the corrosion of rivets in the underwater portion of the hull may entail very serious expense. Rivets corrode mainly because of electro-chemical differences between the rivet material and the surrounding plate. Thorough removal of the mill scale from the plating would lessen the likelihood of such corrosion ; another possible expedient would be to use a ' nobler ' material for the rivets than for the plating. It is not yet known whether this latter method would be practicable.

In discussing cathodic protection of ships hulls, the Author points out two factors which complicate the application of the method. The first is that since the whole submerged hull is the cathode of the corrosion cell, the conditions in the immediate vicinity of the plates become alkaline and tend to break down the paint by saponification. The second is that the development of alkalinity at the cathodes also reduces the solubility of calcium and magnesium solution and precipitate on top of the anti-fouling composition of the hull and impair its efficacy. Experience with ships of the Royal Canadian Navy has shown that cathodic protection is of great value for ships out of commission.

Serious corrosion of the superstructure is rare because all accessible parts are usually repainted at frequent intervals for the sake of appearance. The conditions for obtaining a good protective paint layer for the superstructure are correct surface preparation, application of one or preferably two coats of suitable priming paint, building up a system of undercoats and finishing coats to dry-film thickness of about 0·005 in and careful conduct of the painting and cleaning operations. A mixed red lead and white lead in linseed oil is as good a priming medium as any of the alternatives. Until fairly recently, the best paints for use as finishing coats were made with media of the stand-oil type, but synthetic-resin media are favoured in modern practice. The range of available pigments has been extended, notably by the development of inert titanium pigments. Leafing pigments, such as graphite, aluminium and micaceous iron ore are also commonly used in underwater and finishing coats.

The protective measures to be adopted for preventing internal corrosion inside ships are, in general, similar to those used to protect the superstructure. In addition, cement washes, concrete coatings, and bitumen coatings are valuable means of protection. Coatings consisting essentially of zinc dust in sodium silicate (waterglass), which are cured after application by heating or by chemical treatment, are said to be useful for protecting steel plates that are likely to be grazed by cargo.

An appendix to the paper gives extracts from Lloyd's Rules relating to corrosion, and in another appendix some cases of corrosion, reported by Lloyd's surveyors, are described.

A bibliography is given.

Pitting Corrosion of Ships' Shell Plating and of Tank Interiors in Tankers (German). DETERMANN, H. *Schiff u. Hafen*, **8** (1956), p. 210 (Mar.).

Pitting corrosion of shell plating is caused primarily by local gaps in the oxide scale normally covering the surface of the plates. The scale-covered area is more ' noble ' and becomes the cathode, whereas the patches of bare steel act as small anodes and are corroded when an electrolyte (sea water) is present. Cold forming may damage the oxide layer, which is brittle, and may therefore break its continuity ; this may happen, for example, on a rivet head, particularly at the edges, when a small anodic area is thus created. It is found, in fact, that pitting corrosion often starts there, and therefore anti-corrosion paint should be applied with particular care over rivet heads.

Pitting can also be caused during the fitting-out period by stray currents flowing between the hull and the earth. Numerous electric cables, particularly those feeding the welding machines, usually run from ship to shore at this time, and in the absence of perfect insulation, stray currents may occur. The current density will be greater at rivet heads than at the flat surfaces, and so the heads again become the weak parts as far as corrosion is concerned. Corrosion initiated in this way during the fitting-out period is likely to continue later in service.

Pitting corrosion of shell plating can be eliminated to a large extent by descaling the plates and immediately applying anti-corrosive paint.

The descaling can be done by blasting with abrasive, burning with a flame torch, or applying etching compounds. The latter process is much used in the U.S.A., but in Germany satisfactory ways of eliminating the resulting residuary acid have not yet been developed. Other precautions to be taken against pitting corrosion are keeping a check on stray currents during fitting by recording the electric potential between ship and earth (this is strongly recommended), applying cathodic protection during fitting out, and dry-docking the ship at least twice within the first year of service, so that any areas showing a tendency to pitting corrosion can be dealt with.

Pitting of tanks that are used both for ballast and for oil cargoes is an even more serious problem than pitting of shell plates. In this case the most likely sources of the corrosive currents are potential differences between scale-covered and scale-free surfaces, potential differences between dry and wet rusted surfaces, and potential differences between oily and oil-free surfaces. Factors likely to initiate corrosion are, again, small gaps in the oxide scale ; cold-formed or stressed elements of the metal surface (for example in pipes) ; water drops (both where they are suspended and where they fall on the metal surface) ; and the jets of Butterworth tank cleaning apparatus hitting the metal surfaces. An effective method for reducing pitting corrosion in tanks is the installation of cathodic protection. This will protect the tank and, in time, will also loosen the oxide scale on the plating, so that it can be easily removed. Cold-worked and highly-stressed areas in the metal surface can be reduced by careful design, but they cannot be entirely eliminated. The formation of water drops can be prevented by installing the Cargocaire air-conditioning system in the tanks. Butterworth cleaning is regarded as the most serious cause of corrosion and it should therefore be carried out only when absolutely necessary ; also, a cleaned tank should not be used for sea water ballast before it has carried a cargo of oil, so that a new oil film can be formed over the metal surfaces. The correct sequence of cleaning, load carrying, and ballasting should therefore be worked out for all tanks.

On the Corrosion of Sea-Water Pipes on Board Ship (German). WALLBAUM, H. J. *Hansa*, **93** (1956), p. 547 (24 Mar.).

In recent years, severe pitting corrosion has been encountered in copper sea water pipes. A discussion of the chemical and electro-chemical processes occurring in the corrosion of copper and copper alloys leads to the conclusion that the highly refined copper now used is an unsuitable pipe material. The copper formerly used contained up to 0·1 per cent arsenic, and it has been found that a small arsenic content gives considerably greater resistance to erosion and pitting corrosion.

The corrosion is greater in flowing than in standing sea water, since the flow prevents the formation of a uniformly effective shielding layer. Turbulence produced by bends or surface irregularities, and concentrations of air bubbles, are especially dangerous. Critical flow velocities, above which local erosion-corrosion is likely to occur, are given for various materials. These show the beneficial effect of 0·3–0·5 per cent arsenic, and also the superior corrosion resistance of copper-nickel alloys, especially those containing iron.

The general surface corrosion is somewhat greater for copper containing arsenic than for pure copper. In England and the U.S.A., copper-nickel alloys have been tried. Very satisfactory results have been obtained with an alloy known as Cu Ni 5 Fe (93·3 per cent copper, 5 per cent nickel, 1·2 per cent iron, 0·5 per cent manganese). Its superior strength and corrosion resistance permits a reduction in wall thickness which partially compensates for the higher price. This alloy may be hot-worked to 600 degrees C. (1,100 degrees F.). Pipe connexions are made by brazing or by argon-arc welding. The corrosion resistance of Cu Ni 5 Fe is inadequate for condenser tubes, for which an alloy containing 10 per cent nickel is to be preferred.

Comparative tests on the materials described and on other materials are to be carried out in order to establish German specifications.

Erosion-corrosion may be counteracted either by choosing a suitable material, or by eliminating turbulence and air bubbles. The installation of deaeration pipes at suitable points of the system has given good results. The sea water intake should not be situated at a point where the water contains many bubbles, e.g. immediately under the bilge keels.

On the Nature and Causes of the Internal Corrosion of Tankers Carrying Crude Oils. HURLEN, T. *Paper read at a Meeting of the Schiffbautechnische Gesellschaft, Hamburg*, 12–13 Apr., 1956.

This paper describes work done under a programme of research into tanker corrosion initiated by the Ship Research Institute of Norway. A broad comparison is given between corrosion in oil tankers engaged in the 'clean' trade and tankers engaged in the 'dirty' trade, but the main part of the paper is concerned with the severe pitting specially prominent in tankers transporting Middle East crude oils. A survey of Norwegian tankers engaged in this trade has shown that pitting is very heavy in ballast tanks, but is only slight in non-ballast tanks.

The discussion of the causes of pitting is divided into three sections which consider the effect of cargo (which contains a certain amount of water), the effect of wash and ballast water, and the combined effect of cargo and ballast water. It is concluded that the typical pitting by crudes seems to be caused by two effects called the scale effect and the oil-film effect, in the occurrence of which separate water phases in the cargo play a part. The scale effect arises from the fact that the cargo may react with the steel and form corrosion products on the surface which cause electro-chemical action when the tank is filled with ballast water. For example, iron sulphides may be formed on the tank walls, either by direct reaction between sulphur compounds in the oil, or by an exchange of oxygen in iron oxides with sulphur from the oils. Iron sulphides have been proved to give relatively high cathodic potentials to iron in salt water. The effect of separate water phases in the cargo may prevent the formation of iron sulphide scale in certain areas, and so cause anodic patches on the steel when the electrolyte (ballast water) is present. A mill scale on the steel surface will behave in a similar way as the scale produced through reaction of oil and steel; water phases in the cargo may cause local dissolution of this scale and again cause anodic patches of bare steel.

The oil-film effect occurs if some parts of the steel are covered by an oil film and some are not when the tank is filled with ballast water. The oil film will partly prevent cathodic reactions at the covered areas, but will also alter the distribution of anodic reactions so as to concentrate their occurrence on uncovered areas.

The upper side of the heating coils and of the various structures in the lower part of the tank are locations most exposed to the oil-removing effect of the Butterworth cleaning equipment, and practical experience shows that they are usually the most pitted.

Attention is also drawn to the effect of sulphate-reducing bacteria which seem to be of greater importance in tanker corrosion than previously assumed.

Extensive laboratory experiments have been made in the course of this investigation, and some results are quoted.

References are given.

The Flame Cleaning Process. *Syren and Shipping* (*Ship-Repairing, Reconditioning and Survey Number*),—(1956), p. 55 (16 May).

The British Oxygen Company's flame-cleaning process is now used in shipyards in Britain, Germany, France and Holland. Briefly, the process consists of the passage of a very hot flame over the steel in a series of short forward and backward movements. The loosely bonded mill scale is removed by differential thermal expansion and at the same time the heat dehydrates the rust, leaving it dry and powdery and easily removed by wire brushing. The anti-corrosive paint is applied while the plates are still warm.

A direct comparison of the effectiveness of flame cleaning with that of scraping followed by wire brushing was obtained on a ship on which the one cleaning process was applied to the port side and the other process to the starboard side. After three years service, many plates on the scraped and brushed side had to be chipped to base steel and repainted, but no descaling was found necessary on the flame-cleaned side. The difference between the effectiveness of the processes was most marked at the boot topping and top-sides. Paint consumption for maintenance was three times greater for the scraped and brushed side than the flame-cleaned side.

Experiments have also shown that cleaning by flame produced by oxygen and propane is much less effective than with oxygen and acetylene. To date, over 100 ships belonging to 33 owners have been flame cleaned, including the liner *Bergensfjord*.

A table is given showing the consumption of oxygen and acetylene in flame cleaning nine tankers owned by Shell Tankers Ltd. The figures give an average consumption per sq yd cleaned as 10 cu ft of oxygen and 10·3 cu ft of acetylene. For three of the ships, the make-up of the cost of flame cleaning has been calculated as follows : oxygen, 6 per cent ; acetylene, 27 per cent ; labour, 20 per cent ; supervision, etc., 47 per cent.

Flame cleaning is work of a specialized nature, and it has been found that where the results were not up to standard, the failure was due to insufficient experience by the operators and lack of proper supervision.