TECHNICAL ABSTRACTS

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STRUCTURAL DESIGN

Structural Failures of a Riveted Ship. MacCutcheon, E. M. *Welding Journal*, **27** (1948), p. 52 (January).

During a severe storm the bow of the 31-year-old riveted ship *Oakey L. Alexander* broke off, and the structural failure was afterwards examined and compared with structural failures of welded ships.

The fractures were found to have started at the square corners of the hatches. In addition to the main fractures which caused the ship to break in two, two minor fractures were found at other hatch covers, but they did not continue to spread. The fracture of the plates was of the " cleavage type," square to the plate surface. At the starboard deck seam and certain other positions, the fracture changed to the " shear " type at 45° to the plate surface. " Shear " fractures are rarely found in welded ships except at the termination of a fracture. In this case, the fracture seemed to have run from the hatch corners to the riveted seams, where a slight pause occurred and the type changed to " shear." The load on the riveted seams, however, was so great that it caused the ultimate failure of the entire hull.

All characteristics of welded steel ship failures were present, showing that the structural failures of the two types of ship are essentially the same. The presence of the riveted seams undoubtedly arrested the spread of cracks in numerous cases of riveted-ship failures, but this resistance is probably the only real difference between the two types of structures.

SEAWORTHINESS

Stability of Ships after Extensive Flooding. WRIGHT, C. L., JR. *Journal of American Society of Naval Engineers*, **59** (1947), p. 442 (November).

In connection with the conversion of merchant vessels and the improvement of combatant ships during the Second World War, the subdivision and stability of over a hundred classes of vessels were studied in detail. The methods previously in use for calculating and presenting the information necessary to determine the ability of vessels to survive damage were found to be far from adequate. New methods were developed and a series of model tests was conducted to check the applicability of the new methods to each special type of problem.

It is stated that, prior to World War II, metacentric heights rather than righting arms were used almost universally as the means of expressing stability after flooding, but it is now becoming generally agreed that righting-arm values are essential in presenting a complete indication of the stability characteristics of a vessel. For any specific case of damage in any specific condition of loading, the stability before and after flooding can be clearly represented by plotting the metacentric height and righting arms before and after damage as well as the heeling arms due to unsymmetrical flooding. The curves of statical stability and of heeling arms can then be drawn. From this the lost G.M. and the loss in righting arms due to flooding are clearly evident.

Consideration of all the different cases of flooding and of the probable conditions of loading in which the vessel may operate, indicates that certain conditions are less critical than others. Thus the flooding of wide compartments causes a greater loss in stability than the flooding of narrower ones; the flooding of a compartment with more impermeable material near the bottom than near the top, or near the centreline than near the shell, causes a greater loss in stability than the flooding of the same compartment when the impermeable material is more uniformly distributed ; and flooding occurring in the lightest condition of loading in which a vessel operates, or in the full-load condition, results in less stability than flooding occurring in any intermediate condition.

Examples are given of the methods of calculation, and it is stated that they have been applied and found satisfactory for all types of vessels from cargo ships to aircraft carriers and under all conditions of damage and loading.

SHIPBUILDING (GENERAL)

Aluminium Alloys in the Marine Field. WATKINS, G. L. R. *Syren and Shipping*, **206** (1948), p. 57 (7th January).

Steady progress is being made in the application of aluminium alloys to shipbuilding. Confidence in the material is being gradually built up as the corrosion-resistance properties of the different alloys under marine conditions are more widely appreciated. The existence of S.T.A.7 Services Schedule of Non-Ferrous Metals make it possible for the alloys to be ordered to an exact specification, comparable to the standards set up by the classification societies for steel.

Considerable use has already been made of aluminium alloys in the building and reconditioning of small craft. The Ministry of Transport recognise this material as conforming to their tests for lifeboats, and considerable interest has been aroused by the construction of a yacht. Aluminium alloy masts for dinghies have greater strength and rigidity than silver spruce masts on a basis of weight for weight, and the demand for them is increasing.

Its lightness, ease of erection, dismantling and re-erection, and its resistance to bacterial infection and the corrosive effects of salt-water, ice, and slime, make aluminium alloy peculiarly suitable for fitting out trawlers. Fish holds are now being lined with panels of a sandwich formed by expanded rubber between two sheets of aluminium alloy instead of cork, which is hygroscopic. The resulting benefits have been immediately apparent, the fish arriving in port in much better condition. The difference in price obtained enabled the extra cost of fitting the panels to be covered within a short time. Many Scottish trawler owners are tending to use aluminium alloys for the construction of wheelhouse, deck house, and engine casing. The weight saved is of the order of 50% of the weight of the structure if built of steel.

From the navigational point of view, the use of light alloys instead of steel for the construction of the wheelhouses and navigating bridges of merchant ships is well worth while. Insulating holds are being lined with aluminium-alloy sheet, and the alloy can also be used with advantage for the construction of hatch covers, which should be made in large sections so that the holds may be opened more quickly. No serious attempt has yet been made, however, to use light alloys for stressed structures, although a considerable amount of preliminary investigation has been done. Abroad, particularly in America, Canada and Sweden, considerable progress is being made in the use of light alloys in the construction of merchant ships.

Special alloys are used for Diesel pistons, observation doors, condenser end-plates, turbine-gear covers, pump covers, etc., and the development of the gas turbine for ship propulsion opens further fields for the use of aluminium alloys in the engine room.

The aluminium industry aims at instituting programmes in which the normal shipyard operations will be employed with these alloys. The problem of welding thick plates is being investigated, and the distribution of stress in an alloy superstructure attached to a steel main hull is being carefully studied. Considerable progress has been made in developing suitable anti-fouling paints.

Plastic Boats. *Marine Journal*, **74** (1947), p. 24 (December).

Laminated plastics were used for building the hulls of the surf-landing boats used during the war at Attu in the South Pacific ; and tests carried out with several types of boat dropped from aircraft in rescue operations showed that only those built of laminated plastics could stand up to the severe test of drops from heights of from 100 to 500 ft above the sea. Boats built of this material are durable although they are light in weight. They have the added advantage that the material is repellant to marine life.

Outboard models and rowboats up to 14 ft are being built of this material, as well as 8-ft dinghies for yacht owners. Many layers of fabric, including fibre, glass and glass mats, are used in the building process. Each layer is impregnated with plastic resin and other chemicals, and shaped over a mould. The hull is then baked for two hours at a temperature above 200°, during which process the hull hardens. Coats of specially prepared filler and enamel are applied as a finish.

WELDING

Resistance Welding in Mass Production : Hot Riveting Principles and Applications. Hipperson, A. J., and Watson, T. *Welding*, **16** (1948), p. 30 (January).

Hot riveting may be defined as a process for hot-heading rivets by the passage of current through the rivet for a predetermined time, while the rivet is held under pressure between electrodes or dies. For many cases the use of riveting may be quicker and more economical than conventional riveting and can be applied to both ferrous and non-ferrous metals. Where single rivets are to be closed in each operation, hot riveting may be 50 to 100% faster in productivity than mechanical riveting, because metal can be forged at a more rapid rate when at suitable high temperatures.

The main groups into which the application of hot riveting fall, are : (*a*) plain studs to sheet, (*b*) screwed studs to sheet, (*c*) pillar nuts to sheet, (*d*) sheets to either end of spacing pillars, (*e*) tee joints, and (*f*) shaft and plate assemblies. Several examples are given illustrating these applications.

The three main rivet-head shapes, namely, snap-headed, cheese-headed and countersunk rivets are discussed and it is stated that the best all-round rivet-head shape for normal purposes is the cheese head.

The methods of keying rivets to prevent their rotation is also described.

The principles incorporated in the hot-riveting machines are fundamentally the same as in spot and projection welding machines except that the hot riveting involves lower temperatures, the duration of the current is longer, and the pressures are comparatively higher. The main respect in which a hot-riveting machine differs from a spot-welding machine is that a two-pressure cycle, preferably of infinitely-variable type, is essential for riveting if the best results are to be obtained.

MATERIALS

Stainless and Heat-Resisting Steels. *Mechanical World*, **123** (1948), p. 153 (6th February).

The basis of all highly corrosion-resistant steels is chromium, but there are two basic types which are different in composition. These are the high chromium ferritic type, and the high nickel-chromium austenitic type. The former are magnetic and are susceptible to heat-treatment. They are, in fact, usually finished in the hardened and tempered condition, when their corrosion resistance is a maximum. Their mechanical properties are similar to those of the ordinary structural low-alloy or carbon steels. The austenitic type, however, are non-magnetic, and are practically unaffected by heat treatment. They have a lower value of Young's modulus than the ferritic steels, and a low and ill-defined yield point.

The carbon content of these alloys controls their properties to a great extent ; but since chromium readily forms a carbide, which contributes to the hardness of the steel but renders the chromium inoperative for corrosion resistance, it is necessary to control the carbon content to suit the purpose for which the steel is required.

An alloy containing 20% of chromium and 2% carbon has excellent corrosion resistance when operating under the severe conditions of turbine blades and impeller blades handling salt water. The addition of about 2% of nickel restores the heat-treatment properties of the steel, the maximum corrosion resistance of the resulting steel being obtained by hardening and tempering. Silicon acts in a similar way to chromium, and raises the transformation temperature. Together with their resistance to scaling at high temperatures, this property makes them very suitable for the construction of internal combustion engine exhaust valves. Comparatively small amounts of silicon have quite a big effect.

With the austenitic types, nickel is added in substantial amounts to prevent any transformation. These steels are therefore non-magnetic, relatively soft and extremely ductile, exhibiting all the properties of a homogeneous solid solution. The high chromium content ensures good corrosion resistance, which is improved, where certain chemical reagents are concerned by the nickel. The commercial steels harden rapidly with cold working, because of crystal distortion ; but the hardness may be removed by annealing at a high temperature and quenching under certain conditions, such as those arising during welding. Intergranular corrosion can be prevented by the addition of small quantities of molybdenum or titanium.

The selection of a stainless or rust-resisting steel for a specific purpose usually involves a compromise, the various requirements being of such a conflicting nature. Both a knowledge of the physical properties of the material and of the method of fabrication to be adopted are essential. This is illustrated by a discussion of the choice of a steel for steam-turbine blades.

Mechanical Properties of Metals. *Nature*, **160** (1947), p. 696 (22nd November).

Some of the salient points are summarised from the lectures and papers read at the summer school and conference on the mechanical properties of metals held at the University of Bristol between the 2nd and 9th of July.

The subject was the theory of the mechanical properties of metals, especially dislocations, plastic flow, and precipitation.

From the experimental point of view, a clear distinction was made by nearly all the speakers between " transient " and " viscous " creep. Transient creep occurs when a metal, either a single crystal or a polycrystalline specimen, is stressed beyond the elastic limit. Viscous creep is the term given to the ultimate steady rate of creep which is obtained in certain cases.

According to Andrade, in the early stages of creep there is rotation of the crystallites, accompanied by glide on crystal planes, but the final stages of true viscous creep in polycrystalline materials take place in a narrow zone surrounding the crystal boundaries in the form of grain boundary slip.

For transient creep, the elements of the theory are beginning to appear, based on the concept of dislocations, and this is discussed in some detail.

A New Chromium-Diffusion Process. *Oil Engine*, **15** (1947), p. 265 (December).

A new process has been developed for " chromizing " iron and steel articles, in which the chromium penetrates into the article, forming an alloy with the underlying metal without alteration of the dimensions of the article. The depth of the layer can be controlled from 0.0005 in. to a maximum of 0.025 in., the average chromium content of the layer being 30%.

The layer provides an excellent corrosion-resisting and hard-wearing surface, which compares very favourably with normal stainless steel for resistance to atmospheric and nitric-acid corrosion. It is very resistant to thermal oxidation, *i.e.*, to scaling, when exposed to temperatures up to 900° C. The physical properties vary considerably according to the steel of which the article has been made. On steels of carbon content from 0.1 to 0.4% the layer is very ductile, reasonably soft, and can easily be cold worked. On steels with higher carbon content the layer is somewhat thinner, less ductile, but very hard and highly resistant to abrasion. It has a low coefficient of friction.

The new process has many applications for components where corrosion resistance, heat resistance, or resistance to wear are important.

MARINE POWER INSTALLATIONS

Oil Engines and Steam Engines for Marine Propulsion. Jones, P. L. *Proceedings of the Institution of Mechanical Engineers*, **157** (1947), p. 171 (*War Emergency Issue No.* 29).

The Author summarizes the present position regarding oil engines and steam engines for ship propulsion, and speculates on the trend in the near future.

Oil Engines.—More than half of the ocean-going ships now being built or on order throughout the world will be driven by oil engines, whose low fuel consumption is its most attractive characteristic. For medium and large powers, three main types of engines are used, namely : (1) opposed-piston, (2) four-stroke single-acting either supercharged or non-supercharged, and (3) two-stroke, single-acting and double-acting. Of these, the opposed-piston oil engines of the Doxford type are being built for the majority of ocean-going ships in the United Kingdom. The types mentioned are briefly described and some details, such as mean indicated pressure and range of power, are quoted. For propelling ships of smaller power, non-supercharged, two-stroke, single-acting, trunk-type engines are the most popular in merchant practice. They are built in sizes ranging from 50 b.h.p. per cylinder at about 600 r.p.m. to 400 b.h.p. per cylinder at 250 r.p.m.

Gearing for oil engines has been adopted for a large number of ships, principally for foreign owners, the chief attractions being the reduction in weight and headroom. The power is usually transmitted to the gear pinions through special couplings of the Vulcan hydraulic or magnetic types. At the present time, the cost of geared oil engines is considerably higher than of direct-drive. Diesel-electric drive has found more favour abroad than in this country ; its principal advantages, in addition to reduced weight and headroom, are the excellent manoeuvring and the elimination of reversing of the engines. The initial cost is, however, much higher, and the fuel consumption is at least 10% higher compared with direct-drive.

Important developments are now pending, and it is probable that supercharged, two-stroke, single-acting engines of conventional design, developing 400 b.h.p. per cylinder at 400 r.p.m., will soon be in production.

Reference is also made to the combination of the reciprocating oil engine and exhaust-gas turbine. The efficiency of this process is extremely high.

The already strong position of the marine oil engine would be greatly enhanced if the use of heavier and cheaper grades of fuel could be adopted instead of the more expensive Diesel oil. Recent advances have shown that this may be possible. Welding has had an enormous influence on oil-engine development, and has made possible important reductions in weight and dimensions : in the opposed-piston engine, the reduction in weight due to fabrication amounts to about 30%.

Steam Engines.—Although reciprocating steam engines are comparatively uneconomical they are still widely used, and for special ships, such as cable-laying ships, may represent the best economic proposition. An important advantage is their excellent manoeuvrability.

Some of the engines now under construction are of the double-compound type, but the majority are triple-expansion. The Uniflow principle is adopted to some extent, and most designs involve special features in valve construction, the cam-operated poppet valve being very much in favour.

The chief application of the reciprocating steam engine to-day is with the exhaust low-pressure turbine, which results in machinery of great reliability, low first cost, and very good economy.

Reference is made to reheat reciprocating engines, and also to units operating with pressures up to 800 lb/sq. in. and temperatures of about 1,000°F. developed in Germany before the recent war ; both designs are described in some detail.

The prospects of the reciprocating steam engine will largely depend on the supply of engineering personnel, and if this is difficult to obtain for up-to-date machinery, the steam engine and exhaust turbine will remain in use.

STEAM PROPELLING MACHINERY

Steam Condensers with Rolled-in Tubes. DUNKLEY, W. H. *Engineering*, **164** (1947), p. 592 (19th December).

The older method of fixing tubes in condensers, by which at least one end was left free to slide in a gland, has been the cause of considerable trouble due to leakage, which can be eliminated if the tubes are " rolled-in " at each end.

Provision for expansion can be made either by fixing the tube plates and bowing the tubes, or by fitting an expansion joint in the shell. Tests carried out showed that it would be inadvisable to roll-in over 4,000 $\frac{3}{4}$-in. diameter tubes, in a tube plate $8\frac{1}{2}$ ft in diameter without an expansion joint. The Author has found the incorporation of a Roses' patent expansion ring in each condenser shell to be satisfactory. In view of the large force required to compress the tubes axially, no stays are needed between the tube plates. The only holes through the tube plates should be the tube holes, a simple rubber seal being used to seal the water-head diaphragm against the tube plate on the inlet-outlet end of a two-pass condenser. It has not been possible for systematic research to be carried out on vibration effects, but the Author does not consider that these should cause trouble.

A description is given of the technique which has been developed in America for making reliable rolled-in joints quickly. It is claimed that no change in the reliability of the push-out strength of the joints was found when a new inexperienced operator took over the work.

If sufficient attention is paid to details of design, the all-rolled design should cost less than the older types of condenser.

DIESEL AND OTHER I.C. ENGINES

The Burning of Boiler Fuels in Marine Diesel Engines. LAMB, J. *Transactions Institute of Marine Engineers*, paper read 9th December, 1947.

This paper gives a detailed account of the experimental burning of boiler fuel, first in the specially built experimental single-cylinder Werkspoor engine, and then in a 4,000-i.h.p. engine of the same make installed in the 12,250-tons D.W. tanker *Auricula*.

Various stages of these experiments, both in the workshop and at sea, are fully described and details are given of the fuels used, their treatment prior to admission to the cylinders of the engine, and the effect of these fuels on various parts of the engine.

In the final stages of the experiments with the *Auricula*, which lasted a year, heavy fuel was used both for full and reduced power operation, and also for manoeuvring on entering and leaving port. The engine was of standard make, and no special parts were used except slightly modified fuel valves.

The only really objectionable constituent in boiler fuels, when used for Diesel engines, was found to be ash, which is composed of silica, iron oxide, vanadium oxide, and other abrasive matter ; and this was extracted by a special centrifugal separator—the clarifier. The latter was installed in addition to the ordinary separator—the purifier—usually employed for extracting water and suspended matter. The temperature of the fuel was raised to 180° F. before the purification process was started.

As a result of these experiments, the Author states that it has been conclusively proved that, with practically no alterations, a standard four-cycle Diesel engine will operate indefinitely under normal sea conditions on boiler fuel up to 1,500 seconds if treated in the manner described. The conditions set up by heavy weather, involving constant and wide variation in engine speed, had no detrimental effect upon any part of the engine when operating on heavy fuel. To obviate the formation of deposits and to ensure satisfactory operation on heavy fuel at slow speeds, a fuel temperature of 175° F. should be maintained at the engine fuel pump.

The consumption of the heavy fuel shows about 2.5% increase as compared with the Diesel fuel but, if compared on a cost basis, the saving is over £200 for each Atlantic crossing with a 4,000 i.h.p. engine. It is estimated that the cost of converting an existing ship of this power for the burning of heavy oil should not exceed £5,000, which is approximately the saving effected during one year's operation.

Porous Chrome Hardening of Diesel Engine Cylinders. WILLIAMS, C. D. B. *Diesel Engine Users' Association*, paper read 15th January, 1948.

The lack of success of earlier attempts to reduce cylinder-bore wear in internal-combustion engines by depositing chromium on the bore has been attributed by H. Van der Horst to poor lubrication caused by the inability of chromium to retain oil. He therefore evolved a process whereby a hard chromium surface could be produced which at the same time would be covered with pits and depressions suitable for retaining the lubricant. This type of surface was immediately successful. Despite a considerable amount of research aimed at superseding Van der Horst's methods, they are still, in the Author's opinion, the most satisfactory.

The types of porosity obtained by this process are described and the depth and percentage of porosity for the best results are considered. In the Author's opinion the percentage of porosity should be as great as possible as long as the load-carrying region is of sufficient strength and area to carry the load. In no case should the depth of the pores be greater than the depth of the chromium layer. The adhesion of electrolytically deposited chromium is also discussed.

The general layout of the plating plant and the sequence of operations for plating a cylinder are described.

As some indications of the results obtained the following examples are quoted by the Author ; they are taken at random from performance records :—

(*a*) Medium sized Diesel-engine liner, 13.8 in. bore, 0.0002 in. wear per 1,000 hours.

(*b*) Commercial vehicle Diesel-engine cylinder block, 0.002 in. wear in 100,000 miles.

(*c*) Small marine auxiliary engine. Plated liners run in direct comparison with unplated ones ; at the end of the test, unplated liners showed 0.020 in. and the plated ones 0.002 in. wear.

A great deal of work has been done towards the perfection of the process and improvements are continually being made.