TECHNICAL ABSTRACTS

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SHIP RESISTANCE AND FLUID MOTION

Friction Losses in Turbulent Pipe-Flow. Prosser, L. E., Worster, R. C., and Bonnington, S. T. *Proceeding, Institution of Mechanical Engineers, paper read* 9 Feb. 1951.

Significant developments in the theory of turbulent flow in smooth and rough pipes are reviewed to establish a rational basis for the commonly accepted logarithmic laws for pipe friction. The Prandtl smooth-pipe law agrees with measured results on smooth pipes up to Reynolds numbers of at least 3×10^6. With rough pipe walls and sufficiently high Reynolds numbers, viscosity (and hence Reynolds number) ceases to have any direct effect, and the friction coefficient depends on wall roughness and pipe size only. Almost all practical cases of water flow in commercial pipes lie between these two extremes of completely smooth and fully rough conditions, where the friction coefficient varies with both Reynolds number and roughness. A detailed study is made of published test data on wrought-iron and steel pipes which generally operate in the transition zone, and an exponential formula is derived that agrees with these results.

The relative merits of various exponential formulae, and of the Colebrook-White transition function, are discussed. The errors involved in the calculation of pipe friction in any practical case depend primarily on the accuracy and uniformity of the dimensions of the pipe, its roughness, joints and fittings, and the viscosity and density of the fluid. In a typical practical case there may be an uncertainty of ½% in the pipe diameter causing a variation in head loss of 2½% for a given flow. The variation in roughness may also cause an uncertainty in the head loss of 2½%, while the effects of joints and fittings may give a further 2½% error. Even if a perfect friction formula were used, the most probable error would be the root mean square of the individual errors, that is, 4.2%. This would be increased to only 6.6% if the formula itself were inaccurate to the extent of 5%. The additional errors introduced by the use of the simple exponential formulae are mostly within the above limit, so that under practical conditions of water flow there is little to be gained by using more complicated formulae, provided that the conditions lie wholly within the working range of the formula used.

There is a list of references.

Some Observations concerning Resistance and Propulsion. Ayre, Sir A. L. *Transactions, Institution of Naval Architects, paper read* 14 March 1951.

During the past few years, realization of the effect of laminar flow on the model experiment result has brought about a situation which, in itself, calls for a general reconsideration of the subject of resistance. This paper refers mainly to single-screw merchant ships. The Author suggests that it would be helpful if the different tanks would adopt a universal basis for the determination and the form of presentation of the data. At present, practice varies considerably and the results are only comparable after considerable basic modification. It is most desirable that there should be a generally accepted speed position for the comparison of one model with another. Up to the speed-length ratio of 1.0, long experience has shown the value of the Alexander formula in determining the speed beyond which the model and the ship become

" overdriven." The relationship of block and midship-area coefficients also calls for examination.

In reference to the angle of entrance, the various authorities appear to adopt different methods of determination. The adoption of a conventional method is suggested, possibly based on the area of a given proportion of the forward waterplane length resolved into a triangle from which the angle of entrance would be derived. There is no evidence available as to the efficacy, or otherwise, of the largely raked stem in regard to resistance ; and the modern practice of adopting a very largely rounded forefoot is also open to question. Attention is drawn to the considerable variation observed in e.h.p. results obtained by model experiments in the speed range $V/\sqrt{L}=0.75$ to $V/\sqrt{L}=0.90$. This variation is so wide that it is unlikely to be due to laminar flow.

The influence of the location of the propeller in the aperture on propulsive efficiency is considered. For vessels that have to make voyages in ballast condition with the propeller not fully immersed, it is not wise to reduce the after clearance to the full extent desirable from the sole point of view of propulsive efficiency. In cases where the propeller will always be immersed, however, the propeller should be located far aft in the aperture. The clearance of the propeller tips at the top of the aperture is another subject requiring investigation.

The relationship of the diameter of the propeller, relative to the breadth and the form of the hull which it is to drive, is discussed. The effect of the vessel being overdriven, i.e. beyond the Alexander speed, is referred to briefly. No generally accepted measure of the advantage resulting from the adoption of aerofoil sections for propeller blades appears to exist.

The Author considers that much can be learned from full-size trials when these have been carefully conducted during fine weather, with ample approach to the measured course, and avoiding the use of helm while on the course.

STABILITY, MANŒUVRABILITY, AND SEAWORTHINESS

Sperry Electric and Automatic Steering Control. *Shipbuilder and Marine Engine Builder*, **57** (1950), p. 757 (Dec.).

A system of steering is described that eliminates the need for telemotor equipment or other means of transmitting the movement of the wheel to the steering gear. Four alternative methods of steering are provided, namely hand-electric and automatic (as in the well-known two-unit installations), together with auxiliary means of control from the bridge and from a position aft. The change from one system to another can be effected promptly. The equipment comprises eight components, the bridge-control unit, power unit, after controller (for emergency use), motor-control panel (duplicated), D.C./A.C. converter (duplicated), and a control-panel change-over switch. The power unit contains a motor, rack and gearing, limit switches, and a Selsyn transmitter.

This type of electric and automatic steering control results in an efficient layout, allowing unobstructed passage athwartships.

PROPELLERS AND PROPULSION

On the Effects of Scale and Roughness on Free Running Propellers. LERBS, H. W. *Journal, American Society of Naval Engineers*, **63** (1951), p. 58 (Feb.).

Scale and roughness effects on propellers arise from variations of the lift and drag coefficients of the propeller sections. In the first part of this paper, a simple method is deduced from general propeller equations which enables the properties of the propeller to be determined from the properties of a certain profile of the blade. This method, known as the method of the equivalent profile or of the propeller polar curve, leads to very simple conclusions on scale and roughness effects if the lift coefficient is not affected by variations of Reynolds number or roughness. If both the lift and drag coefficient vary, which happens, for instance, when the characteristics of a full-scale propeller are to be determined on a basis of a partially or fully under-critical model, a different method must be applied. Since knowledge of the polar curves of the under-critical sections is required to apply this method as in the first case and such knowledge is lacking at present, the practical usefulness of the method is considered to be doubtful. Therefore, the practical possibilities of calculating scale and roughness effects on propellers are limited to cases where the influence of these effects on the lift coefficient of the sections is zero or can be neglected. This, at the same time, is the necessary assumption for calculating the influence on the drag coefficient with sufficient accuracy. In such cases, the integral method described in the second part of the paper is applied to investigate the influence of a non-uniformly distributed roughness, from which a relation follows between the loss of efficiency and the radial extent of roughness of an otherwise smooth blade.

There is a bibliography.

WELDING AND OTHER METHODS OF CONSTRUCTION

An Explanation of Hot-Cracking of Mild Steel Welds. ROLLASON, E. C., and ROBERTS, D. F. T. *Welding Research*, **4** (1950), p. 129r (Dec.).

Hot cracks in mild-steel welds are intercrystalline tears occurring at an elevated temperature, and the surfaces of the cracks are " blued " by oxidation. After reviewing previous work on the subject, which has shown that carbon and sulphur cause hot-tearing and hot-shortness of iron and steel, the Authors put forward a theory to account for hot-cracking. The effect of sulphur and manganese, pre-heating, and high welding currents are discussed. It is shown that silicon and phosphorus adversely affect hot-cracking, and that the ductility of steel falls rapidly as the carbon content rises from 0 to 0.1 %. This fall in ductility is associated with a rapid development of strength that will increase the self-imposed restraint on the weld metal as its carbon content rises. Nickel in amounts as low as 0.5 % in a weld can materially increase hot-cracking. It appears that, for a given sulphur content in a weld, nickel is instrumental in increasing the amount of grain boundary sulphide and consequent cracking.

There is a list of references.

Deposit Welding and the Carburising Welding Method (German). SCHROEDER, A. *Die Technik*, **5** (1950), p. 587 (Dec.).

One of the first applications of welding was to repair components which had become too worn to be of further use. This process has been developed to build up wear-resistant deposits on such components as valve seatings and bearing surfaces, alloy filler rods being used which result in a hard surface. The constituents of these filler rods are however difficult to obtain (in Eastern Germany), so that the process becomes expensive, while the weldability of these highly alloyed rods is also low. In this article, a process is described whereby a hard, wear-resistant deposit can be obtained by semi-skilled welders using normal filler rods.

The difficulties inherent in welding with rods of high carbon content are avoided by increasing the carbon content of the deposited metal during the actual welding process. This is achieved by fitting further nozzles to the welding torch, which direct a stream of gas with a high carbon content, such as acetylene, so that it impinges on the molten weld metal as this is cooling down. The weld metal then absorbs carbon from this gas, and its carbon content may be increased from the 0.1% of the filler rod to 1.0% or more, which corresponds to an unalloyed, high-carbon, tool-steel. The weld deposit can then be hardened by any heat-treatment method, and Rockwell hardness numbers of 65 can be obtained without difficulty. The increase in the carbon content may be regulated by adjusting the flow of gas through the subsidiary nozzles. By depositing the weld metal in a number of layers, and increasing the gas flow with each succeeding layer, it is possible to arrange for the carbon content to increase continuously from the base metal to the surface.

The Author states that welds deposited in this manner may readily be forged, without cracks developing or the deposit becoming separated from the base metal, if the correct forging temperature is maintained. A number of examples of the production of hardened components by deposit welding and subsequent forging are given.

Hard-Facing by Spray Welding. HOLTGREN, L. A., and PARKER, R. E. *Welding*, **18** (1950), p. 523 (Dec.).

Hard-facing has for many years helped considerably to increase the life of machine parts subject to wear, corrosion, or erosion. For all degrees of corrosive service it has become standard practice in recent years to apply hard-facing to one of the 18-8 austenitic steels. While this base metal is satisfactory in many respects, some problems have arisen due to inter-granular corrosion, strain checks or cracks occurring during processing or in service, a tendency to flow under heavy pressure, and galling when close fits are involved. Because of unfavourable experiences with hard-faced 18-8 parts, some users have employed 11-13% chrome martensitic stainless steels, heat-treated to give the best resistance to wear and corrosion.

Until recently, however, these materials have not been used as base metals for hard facing, since it has been considered impossible to obtain a sound deposit free from cracks and checks. The Author outlines a procedure which has proved satisfactory for hard-facing martensitic stainless steels. The process consists of hard-facing with powder applied by a metallising gun ; but it should not be confused with metallising, since the deposit is fused to the base metal and produces a molecular bond. The part is first sprayed with the hard-facing powder, and then heated to fusing temperature (1,900° F.) with a large multi-flame oxy-acetylene torch. Immediately after fusing, the part is placed in a furnace at approximately 1,800° F. and allowed to cool at a rate between 50° and 150° F. per hour. The resulting layer of hard-facing is a homogeneous mass without porosity. Important factors in the success of the method are that the part is uniformly heated over the whole weld area, comparatively low heat is required, application is simple, distortion is small, and subsequent tooling and grinding are reduced. For many applications the as-deposited metal is sufficiently smooth, and no finishing operation is required.

SHIPBUILDING (GENERAL)

The Engineering of a 30,000-Ton Super Tanker—The First Ship using 1020 Deg. F. Steam. GOLDSMITH, L. M. *Marine Engineer and Naval Architect*, **74** (1951), p. 26 (Jan.).

This vessel, the *Atlantic Seaman*, has a deadweight capacity of 30,155 tons. The block and prismatic coefficients are about 0.74 and 0.75 respectively, while the midship section coefficient is 0.982. Many recent large tankers have been built with no rise of floor, since for a given displacement it is then possible to obtain finer ends ; but the Author feels that a moderate rise is very desirable, since it enables the tanks to be drained without listing the ship from one side to the other, as well as improving the seakindliness in rough weather. The hull lines were drawn with a moderate bulb at the fore-foot, as it was considered that the proposed speed of 17 knots lies within the region where a bulb is of assistance in reducing wave-making resistance. The hull lines were studied with reference both to ballast as well as full-load conditions. In consequence, this vessel uses approximately 350 h.p. less at the same speed than other recently designed super-tankers, although she is 3,000 tons heavier in full-load condition and 825 tons heavier in ballast.

It was intended that the entire hull fabrication should be by arc welding, but the American Bureau of Shipping and the U.S. Coast Guard required crack-arresters to be provided. As a result, eight riveted longitudinal seams were provided extending over the amidship three-fifths of the vessel's length. These add 45 tons to the ship's weight.

All longitudinal frames and stiffeners are provided with a serrated or scalloped welding edge. This is due to the Author's belief that continuously welded longitudinals act as integral parts of the shell plate, and if the plate fractures will fail with it.

The boilers are of the single-drum, water-tube, sectional-header type, and are located on a flat aft of and above the propulsion unit in order to obtain the most compact possible arrangement. Each boiler is rated at 65,000 lb. per hour at 650 lb/sq in. and 1020° F.

The electrical generators consist of two sets of turbine-driven 750-kW 450-volt A.C. generators, and a 700-kW 450-volt A.C. generator driven off the intermediate shaft of the reduction gear. Three single-stage motor-driven centrifugal pumps are located in a pump room just forward of the engine room, while the three 500-h.p. motors are in the engine room and drive the pumps by means of jack shafts through stuffing boxes in the bulkheads. It is these motors that are the cause of the unusually large auxiliary generators on the ship. It was, however, found that this system, in addition to eliminating the complications of the steam and condensate system, would be cheaper than the more usual turbine-driven pumps with their attendant condensers, water sprays, etc.

Planning and Scheduling a CV33 Class Aircraft Carrier at a Naval Shipyard. STONE, G. P. *Journal, American Society of Naval Engineers*, **63** (1951), p. 11 (Feb.).

The planning and scheduling procedures for a naval vessel discussed in this paper are illustrated by applications to the CV33, U.S.S. *Kearsarge*. This vessel is a modified CV9-class aircraft carrier of improved design, with a stronger flight deck and a more thorough internal subdivision. The displacement is 27,100 tons, and 33,000 tons at full load. The major factors are considered under the headings of organization, facilities, manpower, plans, and material.

When a contract is awarded to construct an aircraft carrier, the information generally available consists of a set of contract plans, and general and detail specifications. From these the necessary time-tables must be prepared. These fall into three phases, overall, master, and detail. The overall scheduling phase consists of setting the cardinal dates, establishing a control calendar, determining the logical erection groups, and preparing the overall structural, outfitting, and completion time-table, and should be completed during the pre-keel period. Master scheduling is begun in the pre-keel period and should be completed prior to launching. It covers plans, material, shop fabrication, structure, piping, machinery, electrical, ventilation, outfitting, testing and painting. Detail scheduling is completed during the outfitting period, and consists of preliminary and final compartment completion schedules, a plan cross index, a hull-structure schedule, area scheduling, weekly summary lists, special spot schedules, and electrical wiring diagrams and procedure.

Production, cost, and progress control are discussed briefly, and a recommended procedure for planning and scheduling is described. A detailed statistical analysis is made of the relation between time, man-hours, and number of vessels. Operational analysis is applied to the escort carrier, destroyer escort, and Liberty ship programmes, and it is shown that the effect of an increase in the number of ships built leads to a decrease both in manpower and time. Allowance must be made for this reduction when carrying out the necessary planning and scheduling for succeeding vessels. Analyses are also made of the manpower expenditures by shops for various CV33-class aircraft carriers and suggestions for improvement are given.

The philosophy underlying planning and scheduling is outlined, and suggestions for future study are made.

There is an extensive bibliography.

SHIPYARDS AND DOCKS

Electrification of Shipyards. McCulloch, J. S. *Transactions, North-East Coast Institution of Engineers and Shipbuilders, paper read* 9 Feb. 1951.

An explanation is given of the causes of the increasing cost of electricity and the reasons for load shedding of the public supply, and the installation of stand-by plant is considered.

Alternating current is used to supply most of the shipbuilding yards in the country. Advantages of an A.C. system of distribution include lower conversion losses and reduced cost of distribution and equipment. The question of distribution is discussed, and the use of more than one sub-station is recommended in a large yard. An inter-connected distribution system suitable for welding on building berths is outlined. The standard A.C. voltage of 415 volts is considered to be a dangerous voltage for distribution by temporary wiring to provide power and lighting on board ship during construction. A device is described for disconnecting the A.C. voltage immediately should a dangerous potential difference arise between the framework of an automatic welding machine and the ship. The importance of adequate earthing of all non-current-carrying metal is stressed.

Results are given of some tests to find the load and power factor of a group of welders on a distribution system ; and a vector diagram is developed to simplify estimation of loading conditions when designing a welding distribution system. The effect of welding on power factor, and the correction of power factor by fitting condensers to multi-operator welding transformers are discussed.

The lighting of shipyards is reviewed under two headings : the internal lighting of the shops and offices, and the external lighting of the yard. In general, the service value of average illumination for internal lighting should not be less than 8 lumens per sq. ft. In designing an internal lighting installation it must be remembered that it is the reflected light from the surfaces that determines the effectiveness of the installation. The cost of fluorescent lighting is compared with standard incandescent lighting. With an electricity tariff of £5 5s. per kVA and 0.65d. per unit, and allowing for the capital charges to be written off at the rate of 12% per annum, tubular fluorescent lighting is cheaper than the ordinary incandescent lighting, provided that the equipment is used for more than about 1,800 hours per annum. A description is given of a large outside-lighting installation in a shipyard.

MATERIALS : STRENGTH, TESTING, AND USE

Hard Facing of Steam Valve Seats and Disks. SWENSON, O. E. *Welding Journal*, **29** (1950), p. 1053 (Dec.).

A general outline is given of the welding procedure adopted at the U.S. Naval Engineering Experimental Station for hard-facing the valve seats and disks of high-temperature, high-pressure steam valves. The testing devices used for determining the hot-hardness, hot-impact values, and steam tightness of hard-facing alloys are described.

Welding is carried out with an oxy-acetylene flame and with non-ferrous hard-facing alloys composed of copper-chromium-tungsten, chromium-nickel-boron, or chromium-cobalt-nickel-molybdenum. It is shown that all these overlay compositions may be interchanged if the composition of the flame and the deposition conditions are controlled.

Flame Hardening applied to Diesel Engine Parts. *Motor Ship*, **31** (1951), p. 315 (Jan.).

The Shorter process of flame hardening is being applied to a number of important components of marine Diesel engines, in addition to its adaptation to ordinary industrial requirements. In this process the temperature of the part to be treated is raised by the application of an oxy-acetylene flame and is localized. The flame is traversed by mechanically operated blow-pipes and is followed by a quenching spray. The result is that the maximum hardness is obtained on a surface layer, leaving the bulk of the part in its original condition, so that there is very little tendency for distortion. This method of hardening can be located within close limits and terminated when required, so that long portions of shafting can have a number of journals treated, leaving the remainder of the shaft untreated.

The parts to which the process is applied include pistons, in which the piston-ring grooves are hardened ; sprockets, in which both the flanks and bottoms of the teeth are treated, while the tips remain unhardened, the maximum depth of hardness occurring at the pitch line ; and crankpins, hardened at the bearing surface, leaving untreated the ends which are to be shrunk into the crank webs. The gudgeon pins of engine cross-heads are also hardened by this process, leaving the remainder of the block untreated.

The Measurement of Surface Finish and its application to Problems in the Steel Industry. HOPKINS, M. R. *British Iron and Steel Research Association, Mechanical Working Division, Coatings Committee*, Jan. 1950.

Certain methods of recording and measuring the irregularities in the profile of a metal surface make use of the stylus instrument. A description of the principles and application of one of these, the Talysurf, is given. A fine point is drawn lightly across the material so as to follow the detailed contour of the surface. The motion of the point is highly magnified and recorded on a paper chart to provide a picture of the irregularities in the surface. The method is also quantitative ; it gives a numerical value for the average roughness of the surface, which makes it possible to compare different finishes with ease and rapidity. Some articles are too big or too inaccessible to be examined in the normal manner, and replicas of the surface are made on perspex blocks. The replica technique can also be used for microscopic examination of metal surfaces.

A photometric method of assessing surface finish by the criterion of how much of the light falling on it is reflected and how much is scattered is also described. This instrument, the Guild Smoothness Meter, is particularly suitable for the routine control of the surface quality of highly finished rolled sheets.

Several references are given.

The Titanium Programme at the U.S. Naval Experiment Station. WILLIAMS, W. L. *Journal, American Society of Naval Engineers*, **62** (1950), p. 855 (Nov.).

Titanium and its alloys are becoming important structural materials because of their unique combination of properties : titanium is plentiful, light in weight, strong, and corrosion resistant. The Author presents experimental data obtained on this metal at the U.S. Naval Engineering Experiment Station. Starting from the sponge metal, which is obtained when the ore is refined, titanium ingots can be produced by a number of methods, all of which fall into two main classes : powder metallurgy processes and melting processes.

Fatigue tests show that melted titanium is the only known structural metal with an endurance limit consistently in excess of 50% of the tensile strength ; titanium produced by powder metallurgy on the other hand has a lower endurance limit. Titanium is also very responsive to understressing. This consists of the application of cyclic stresses just below the endurance limit, as a result of which there is a noticeable increase in fatigue resistance. By this means it is possible to raise the endurance limit to some 80% of the tensile strength.

Flame Hardening of Large Surfaces. BARRY, J. J. *Welding Journal*, **30** (1951), p. 111 (Feb.).

One of the most satisfactory methods for obtaining a part with a tough core and a wear-resistant surface is by flame-hardening the component. This process does not require bulky or expensive equipment, and will handle a variety of work with an economy, flexibility, and speed that are not attained by any other method. In recent years, this process has been applied to large surfaces and to parts of great size. While much of this work has been done quite successfully by manifolding equipment of relatively small capacity, capable of passing 250 cu. ft. of acetylene per hour, the scope of the process has been considerably extended by the development of torches with a capacity up to 2,250 cu. ft. per hour.

The Author describes and illustrates the application of these torches for flame-hardening such items as large flat surfaces, large boring bars, the interiors of cylinder liners, and bars up to 20-ft. long and 20-in. diameter.

The Development of Low-Carbon N-155 Alloy for Gas-Turbine Construction. BINDER, W. O. *Journal, Iron and Steel Institute*, **167** (1951), p. 121 (Feb.).

The composition of N-155 alloy is 0.12% carbon, 20% nickel, 20% chromium, 20% cobalt, 2% tungsten, 1% niobium, 3% molybdenum, remainder iron.

Tests made on this alloy show that it is particularly suited for highly stressed parts for operation in the temperature range of 1,200°-1,800° F. It has a high degree of hot-workability and can be produced in the form of bars, forgings, plates, sheet, and strips. Although it is strong and stiff, it can be formed by bending, spinning, stamping, and drawing. It possesses useful creep, breaking-strength, and impact strength properties at elevated temperature. Its high chromium content should render it resistant to oxidising atmospheres. The properties of the alloy can be markedly influenced by appropriate heat treatments to make it suitable for particular conditions of service.

There is an extensive bibliography.

Refractory Materials (French). RENIGER, V. *Technique Moderne*, **43** (1951), p. 7 (Jan.).

Future developments in the field of refractory materials will probably take place in three directions : (1) alloys based on chromium, tungsten, or molybdenum : (2) pressed or sintered mixtures of metals and refractory oxides, borides, nitrides, or carbides ; and (3) ceramic materials. The Author surveys the properties of these materials from the point of view of their use in high-temperature equipment, such as turbine blades, combustion chambers, heat exchangers, exhaust valves, etc.

It is now possible to employ alloys of chromium at temperatures up to 1,600° F. Further research is in progress to obtain alloys suitable for use at temperatures up to 1,800° F.

Composite materials of type (2) often have better properties than either of their constituents. They combine the high heat resistance of ceramics with the high resistance to thermal shock of the metal. As an example, the Author quotes a mixture of 80% titanium carbide and 20% cobalt, which is suitable for gas-turbine blades. Other composite turbine blade materials are mixtures of chromium boride with Inconel, Hastelloy B, or Vitallium ; and mixtures of alumina and iron. The Author describes the results of several tests carried out on these materials. Particularly good results were obtained with a mixture of alumina and 30% iron.

The Author summarises test results obtained in Germany on a few ceramic materials, based on alumina, clay, silicon carbide, and talc. Good results were obtained with turbine blades of silicon carbide.

The Author then considers the use of refractory coatings which have been deposited either from the vapourised material or in powder form. Among the former type, carbides, nitrides, and borides of refractory metals have been found particularly suitable because of their high resistance to erosion. Among the latter type, tests by the Ferro Enamel Corp. are quoted on the material Ferro No. L625-2056, a mixture of alumina, black and red clay, boron oxide, and citric acid. Good results were obtained when using it in exhaust tubes, exhaust valves, and heat exchangers, as a coating for mild steels, Inconel, and stainless steels.

Finally, the Author refers to investigations of the heat resistance of mixtures of zirconia with thoria, chromic oxide (Cr_2O_3), strontium oxide, barium oxide, calcium oxide, and magnesium oxide, at temperatures between 4,200° F. and 4,400° F. Best results were obtained with the equimolecular mixtures zirconia-magnesia and zirconia-thoria.

There is a bibliography.

Report on Welding and Fabricating of High Temperature High Pressure Piping. MCNUTT, L. C. *Society of Naval Architects and Marine Engineers (Philadelphia Section), and American Welding Society of Philadelphia, paper read at joint meeting,* 15 Jan. 1951.

The Author summarises the methods he has found useful for welding and fabricating different types of alloy steels to form high-temperature high-pressure piping. In particular, he points out how the presence of different amounts of chromium in the steel affects its air-hardening properties and its tendency to carbon precipitation and brittleness, and how the welding and fabricating procedures have to be modified accordingly. He divides the steels into six groups, i.e. four types of martensitic steel containing less than 14% Cr, ferritic steel with more than 14% Cr, and austenitic steel, and gives the suitable range of service temperature for each type of steel, as based on recommendations of the U.S. Steel Co.

A description is given of a grain-refining heat treatment for preventing carbon precipitation during the welding of carbon, molybdenum, and chromium steels containing less than 1% chromium.

Among the austenitic steels, the 18/8, 25/12, and 25/20 chrome-nickel steels are considered. The most suitable method for preventing crack formation in welds was found to be continuous water-cooling of the base metal during welding.

BOILERS AND STEAM DISTRIBUTION

Sealing of High-Pressure Steam Safety Valves. ADAMS, R. E., and CORCORAN, J. L. *Transactions, American Society of Mechanical Engineers,* **72** (1950), p. 1137 (Nov.).

A fundamental investigation of sealing in high-pressure steam safety valves (1,500 lb/sq in.) has shown that poor sealing is a result of self-induced growth of minute initial leaks. Expansion of the leaking steam cools local areas of the valve seat, causing contraction of the seating surfaces in a manner that increases the size of the leak. A new design of valve seat has been developed, incorporating thin flexible seating surfaces. With such a design, the cooling effect of the leaking steam is counteracted by the hot steam on the back of the thin elements. The new design has resulted in considerable improvement in sealing ; and service tests, carried out at 1,200 lb/sq in. over a period of three weeks, gave excellent results.

Combustion Guide for Oil-Fired Boilers. *Shipping World and Shipbuilding and Marine Engineering News,* **124** (1951), p. 124 (24 Jan.).

One of the most common losses in the operation of boilers is that due to incorrect fuel-air ratio. A new form of combustion guide to assist operators of oil-fired boilers in maintaining the correct relation between these quantities has been developed by Bailey Meters and Controls, Ltd. This consists essentially of a stainless-steel bellows for the measurement of oil flow and a diaphragm to measure air flow. Each meter operates a recording-pen which marks a chart. The instrument is adjusted so that for all values of oil flow the percentage of total air will be as low as possible, when the two records are coincident. When the traces diverge the air supply is incorrect for the oil supplied, and by adjusting the relative quantities until the records again lie one on the other the operator is able to maintain smokeless conditions continuously.

New Babcock Marine Boiler Design. *Shipping World and Shipbuilding and Marine Engineering News,* **124** (1951), p. 250 (7 March).

The latest Babcock and Wilcox marine boiler is the two-drum " Integral Furnace " unit, a simplified version of the Babcock double-furnace controlled-superheat boiler. Two of these units have been installed in the *Punta Medanos,* a tanker of 8,500-tons deadweight built for the Argentine Navy by Swan, Hunter and Wigham Richardson, Ltd.

Basically, the new design of boiler consists of a single bank of tubes inclined at 15 degrees to the vertical, with an upper steam/water drum and a lower water drum. The furnace side wall is of water-tube construction, while the back wall can be either plain refractory or water-cooled, according to the furnace rating. The front section of the furnace-wall tubes is completely covered with chrome ore, while the rear section is exposed to flame, with chrome ore used as the sealing medium between tubes. In this way, the furnace temperature in the section nearest the burners is maintained high enough to promote good combustion at low ratings with the lower grades of fuel oil. The furnace wall has a steam/water circuit quite distinct from that of the main tube bank.

An outstanding feature of the design is the circulatory system. The lower part of the upper drum is divided to form an annular space, and the mixed steam and water from the evaporating tubes is discharged into this space and thence into cyclone separators. The steam released from the top of the cyclones passes into the dry pipe, while the water passes downwards into the main body of the drum. The absence of steam bubbles passing through the main mass of water in the upper drum prevents wide variations in water level when rapid manœuvring takes place, as there is no general collapse of water level when the oil burners are shut off, nor any appreciable rise in level when they are all lit up again.

Quick Steam Raising with Automatic Boiler Equipment (Dutch). *Polytechnisch Tijdschrift*, **6** (1951), p. 197a (20 March).

If steam is required only occasionally or intermittently, the expenses of keeping a boiler steaming may cause the cost of the steam actually used to reach a high level. The Clayton Manufacturing Co. of California have developed automatic boiler sets which are manufactured in a range of capacities from 10 to 100 h.p. and deliver steam less than 2% wet within five minutes of flashing up. These boilers are said to have a thermal efficiency of between 75% and 80% at a steam pressure of 150 lb/sq in.

The fuel supply is controlled by a thermostat which protects the water tubes from overheating, and by a pressure-controlled valve which keeps the steam at the working pressure, so that the boiler, once started, is completely automatic in operation.

GAS TURBINES

Combustion Problems of the Gas Turbine. LUBBOCK, I. *Transactions, North-East Coast Institution of Engineers and Shipbuilders, paper read* 12 Jan. 1951.

Some of the problems associated with the combustion of oil fuel in industrial, marine, and aircraft gas turbines, and their effect on the design of combustion chambers and gas burners are discussed. Existing designs are used for illustration. The problems dealt with include the burning of heavy fuel, atomisation of the fuel, production of stable flames by controlling the distribution and flow pattern of the combustion air, and production of high combustion efficiency by controlling the intermixing of the fuel and air.

The problem of pressure drop in a combustion chamber is then examined. The Author states that no law has yet been fully established for relating the pressure drop to the rate of combustion. A good working rule is that the pressure drop increases with the rate of combustion to the power of 1.5.

Standard design procedures, such as dimensioning and calculating the heat flow for the combustion zone, are summarised.

Problems introduced by special conditions, such as combustion under pressure, " running-up " periods, and passing from full load to light load, are discussed.

Finally, fuel and ash problems are discussed, and present approaches towards their solution are described. In order to prevent the high-temperature corrosive attack of ash constituents such as vanadium and sodium on the turbine blades, special blade materials are being developed. Simple nickel plating and steels with high cobalt content have given promising results in laboratory tests. It has been established that high-nickel alloys generally, and to some extent the 18/8 nickel-chromium steels, are resistant to the high-temperature corrosion, while molybdenum steels fail fairly rapidly.

There is a bibliography.

Operating Experience with a 750-kW. Gas Turbine. FEILDEN, G. B. R. *Diesel Engine Users' Association, paper read* 15 Mar. 1951.

The Author discusses practical aspects of the operation of gas turbines on the basis of experience gained during the first twelve months of endurance running of the Ruston and Hornsby 750-kW. gas turbine. This plant is the first prototype of a production industrial gas turbine to be tested in Great Britain. A brief description is given of the leading design features of the set, which incorporates two-stage overhung-disk turbine rotors both for the compressor turbine and the output turbine, together with a sectional-arrangement drawing of the complete turbine installation.

The overall performance of the turbine, when operating with its heat exchanger, was determined by testing the plant up to full power on a water brake. A fuel consumption of 0.59 lb. per b.h.p. per hour was measured when the plant was operating at full power, the equivalent thermal efficiency being 23.4%.

Details are given of the performance of the various components of the gas turbine, based on the experience obtained during the first 1,100 hours of running. These components include the air-inlet filter, compressor, heat exchanger, combustion system, turbines, reduction gear, bearings, and lubrication system. Brief notes are also given on some of the accessories, such as fuel pump, ignition equipment, and governor.

Throughout the tests it was noticeable that breakdowns were due to relatively minor items rather than failures of major components. By far the most frequent cause of lost running time were the fuel atomisers, but the introduction of Shell fuel-cooled atomisers completely cured this trouble. Next in order after fuel atomisers as causes of lost running time were the combustion system proper and the reduction gear, though the latter resulted in only a relatively small loss in possible running time. As a result of this initial operating experience with distillate fuels, there is substantial evidence for believing that little trouble is to be expected from the compressor and the high-temperature turbines.

There are two appendices, one dealing with an examination of lubricating oil during the endurance test, and the other with a spectrographic analysis of deposits from components of the plant on completion of the endurance test.

DIESEL AND OTHER I.C. ENGINES

Light Diesel Engine for High Output (Swedish). HÖJLUND, R. W. *Teknisk Tidskrift*, **81** (1951), p. 132 (17 Feb.).

A description is given of the " Multiplex " light Diesel engine for high output, invented and developed by G. Hamel in conjunction with J. R. Retel, and described in more detail in *Le Génie Civil* of Oct., 1947. With the object of obtaining a light, compact, and practically vibrationless engine, the design provides for the use of a large number of small cylinders of standard size, based on the simplest form of two-stroke, single-acting, opposed-piston Diesel cylinder. The cylinders are arranged in " rings " of six cylinders each, forming the sides of a regular hexagon, with a crankshaft at each corner, all six crankshafts driving a central main shaft through gearing. Up to six such rings can be combined in a " block " having gearing to the main shaft at one or both ends only, the six crankshafts being continuous through all rings. With a standard cylinder size of 130-mm. bore and 2×150-mm. stroke, the output is about 70 h.p. per cylinder, and the piston speed only 20 ft./sec. —a factor making for long life of the engine. The total output of each cylinder " ring " is 400-450 h.p., and by combining up to four six-ring blocks as described above, powers up to 10,000 h.p. are possible. In addition to the low piston speed already mentioned, it is stated that the engine is fully balanced, and that the main shaft is consequently free from all but torsional vibration. Examples given include a 9,000-h.p. marine installation to replace a 8,400-h.p. standard four-stroke unit. The weight of the new unit is said to be 30 tons, as against 450 tons ; the total cylinder volume is reduced from 4,800 to 576 litres and the piston speed from 30 ft/sec. to 20 ft/sec.

Control of the Wear of Running Engines by Spectrographic Analysis of the Ash of the Lubricating Oils (French). WELLARD, R., and DELMAS, R. *Revue Génerale de Mécanique*, **35** (1951), p. 52 (Feb.).

Wear in internal-combustion engines shows itself by an increase in the metallic impurities contained in the lubricating oil, and is due to two main causes : chemical attack on the metal parts of the engine by the oil itself when it contains acids, and abrasion by friction. The Authors give a brief résumé of the general theory of wear, and consider the impurities due to each of the above causes. The wear that takes place in an engine can be determined from a qualitative and quantitative analysis of the metals and metallic salts present in the lubricating oil. If this is to take place while the engine is running, the measurement must be carried out on a sample of the oil, and may best be performed by determining by spectrographic means the quantities of metallic oxides present in the ash of the oil.

The Authors describe the manner in which the sample should be drawn and burnt, and the ashes treated and compressed to a form suitable for analysis ; they also give brief indications of the method of carrying out the analysis itself. The time required at present to perform an analysis is of the order of four hours from the receipt of the oil sample, most of which is spent in preparing the specimen. Efforts are being made to reduce this time. The results of tests carried out on a number of engines are given.

Wear of Fuel Injection Equipment and Filtration of Fuel for Compression-Ignition Engines. AUSTEN, A. E. W., and GOODRIDGE, B.E. *Proceedings, Institution of Mechanical Engineers, paper read* 13 Feb. 1951.

A means of evaluating the performance of various fuel filters used or contemplated for use on compression-ignition engines, and of specifying adequate filters for such use, has been devised. The dependence of the wear of fuel-injection equipment on abrasive-particle size has been determined using closely graded abrasive prepared by air elutriation. A mechanism of wear is proposed that accounts quantitatively for the wear observed.

The particle-transmission properties of filters in common use and of possible alternative filter materials have been measured, using the same preparations of particles. Some information on the nature and particle sizes of solids in fuels is given. Estimates of the effect of various filters in reducing abrasive wear are made for a particular particle-size distribution of abrasive. These estimates are compared with the results of a review of service experience in Great Britain with current filters, gauze, cloth, and felt.

The choking properties of filter materials have been compared using a waxy sludge obtained from marine Diesel fuel, and a hypothesis of the choking mechanism is proposed that makes it possible to predict choking behaviour from initial resistance and thickness, and to assess filter materials of different particle-transmission properties and thicknesses.

For some services improved filtration is necessary. Papers transmit fewer particles than cloth or felt but choke more readily, necessitating the use of a large filter area ; but provided the paper and free volumes on the clean and dirty sides are suitably chosen, a paper filter appears to be practicable, giving a greatly improved pump-element life with adequate filter-element life and reasonable bulk.

There is a list of references.

MACHINE PARTS

Diesel Engine Bearing Development. CRANKSHAW, E., and ARNOLD, R. *Diesel Power*, **29** (1951), p. 46 (Jan.).

The development of the Diesel engine towards more horsepower, higher speeds, and lighter weight has necessitated corresponding developments in the design of bearings and the use of bearing materials.

Nominal analysis of representative bearing alloys are given, and the Author lists these bearing materials in their relative order, under the headings of surface behaviour, fatigue resistance, and corrosion resistance. In a more detailed comparison, the load-carrying capacities of the various materials and the relation between fatigue life and thickness of the bearing surface layer are shown graphically. Developments in manufacturing methods and assembly are also mentioned.

MARINE POWER INSTALLATIONS (GENERAL)

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The Performance and Design of Machinery for the 26,800-Ton Esso Super-Tankers built by the Newport News Shipbuilding and Drydock Co. IRELAND, M. L., JR., WHEELER, M. D., and SPENCER, L. E. *Society of Naval Architects and Marine Engineers (Chesapeake Section), paper read* 30 Nov. 1950.

Eleven similar vessels have been built ; this paper mainly describes the performance and design of their machinery, although a brief description of the chief hull features is given. For fire protection, a portable deck-sprinkler system is provided to spread a film of water over the upper deck and thus reduce the vapour tension of petroleum products carried in the cargo-oil tanks while the vessel is traversing the Panama Canal ; carbon-dioxide fire extinguishing equipment is provided for the machinery spaces.

Tables showing design data for the hull and propeller are given, as are performance curves. From these curves it is seen that the speed-power results of the trials on the vessel itself lie appreciably below the model-tank self-propulsion test values. This difference is attributed to scale effect on propeller efficiency and skin friction. The manner in which the trials were conducted is described, and the results of manœuvring tests and stopping tests are given.

The method by which the shaft was calibrated for power measurements is illustrated and described.

The general features of the propulsion plant are described and illustrated with the aid of basic cycle diagrams, general-arrangement drawings, and heat-balance charts. The propulsion machinery consists of cross-compound double-reduction geared turbines driving a single shaft at a normal rating of 12,500 s.h.p. at 112 r.p.m. Steam is supplied by two Babcock and Wilcox two-drum type boilers at 850 lb/sq. in. gauge and 850° F. at the superheater outlet. A major feature of the plant cycle is the use of four stages of extraction feed heating to a final temperature of about 400° F., since the full value of the advanced steam condition can be realised only through the use of the greatest practical amount of regenerative feed heating. Auxiliary power is supplied by A.C. generators driven by high-speed turbines. Alternating current has the advantage over direct current that the motors are tougher and have very low maintenance costs, while there are no brushes and commutators to spark, wear, or get dirty.

There is a list of references.

Combined Turbine Installation (German). *Hansa*, **88** (1951), p. 247 (3 Feb.).

A projected 18,000-ton Swedish tanker is intended to be fitted with a combined gas- and steam-turbine installation. The plant comprises a high-pressure gas turbine driving a two-stage compressor with inter-cooler. From the high-pressure turbine the gases pass through a second combustion chamber into a low-pressure turbine which drives the propeller shaft through a double-reduction gear. The exhaust gases heat a boiler fitted with economiser and superheater. The steam generated drives a two-stage steam turbine, in the low-pressure portion of which an astern turbine is fitted. These steam turbines also drive the propeller shaft through a double-reduction gear. The fuel consumption is estimated at 0.418 lb/b.h.p. hr.

AUXILIARY EQUIPMENT AND MACHINERY

Intake Tunnel Design for Condenser Circulating Pumps. PONOMAREFF, A. I. *American Society of Mechanical Engineers, Paper No.* 50–*A*–138, *read at Annual Meeting, New York*, 26 Nov.-1 Dec. 1950.

High-speed vertical pumps of the propeller and mixed-flow type are simple in design, compact, and occupy little floor space. They are suitable for condenser circulating-water applications requiring large quantities of water at relatively low heads, and their high operating speeds result in high motor efficiencies and power factors. The satisfactory performance of these pumps depends on uniform flow to the suction and, in consequence, the correct design of the intake tunnel is important.

The Author discusses the basic requirements for the design of intake tunnels, and the limitations of high-speed pumps. The use of small-scale models has been found extremely helpful in evaluating the hydraulic characteristics of intake tunnels. Although they cannot be used for cavitation tests, flow patterns existing under simulated pump operating conditions can be studied.

There is a bibliography.

Rubber Impeller Pumps for Marine Service. PUGH, M. D. *Motorship*, **36** (1951), p. 34 (March).

In recent years, the pump with the single rubber impeller of the concentric type has come into extensive use for marine applications. The Author reviews the principles of operation of this type of pump, which has a cam or offset plate between the inlet and the outlet ports to create displacement. Advantages are that it is simple and economical, instantly self-priming, water lubricated, and that it withstands abrasion and gives long life. Many of these pumps have been in steady use for as long as 5 and even 10 years before being replaced. They are well suited to the pumping of small volumes of liquid.

INSTRUMENTS AND CONTROL DEVICES

Electronics in Naval Architecture : Some Applications to Research Problems. BURRILL, L. C., and BOGGIS, A. G. *Transactions, North-East Coast Institution of Engineers and Shipbuilders, paper read* 26 Jan. 1951.

The Authors discuss the development and use of electronic instruments for recording displacements, accelerations, and strains in ships. These instruments have been used mainly in investigations of vibration problems, such as the vibration of the main hull itself and local or panel vibration, the analysis of propeller vibrations, and the measurement of noise.

The general problems of instrumentation and the relative merits of various types of transducers, amplifiers, and recorders are discussed.

Finally, some applications are described in which simple measurements are facilitated by the use of electronic instruments. These include the measurement of the polar moment of inertia of a propeller using wire resistance strain gauges ; and an instrument for measuring the angle of heel of a vessel, which can be calibrated to indicate the metacentric height and can be used for the quick routine determination of the metacentric height of a ship before sailing or on arrival. It includes a very light pendulum the deflections of which are measured by a photocell.

Sample records of some of the measurements are given, and there is a list of references.

Measurement of Temperatures in High-Velocity Steam. MURDOCK, J. W., and FIOCK, E. F. *Transactions, American Society of Mechanical Engineers,* **72** (1950), p. 1155 (Nov.).

In the measurement of the temperature of high-velocity steam, the impact of the steam on the instrument tends to produce erroneous readings. At the high velocities prevailing in modern steam power plants, these errors are too high to be neglected.

This paper describes the development of thermometer wells which are so constructed that the velocity of the steam is reduced practically to zero before it reaches the temperature-sensitive element. The instrument therefore measures a temperature corresponding to the total heat of the steam at rest, which in this paper is called the " total temperature," and the instruments are called total-temperature type wells. Their development is based on thermodynamic considerations.

OPERATION AND MAINTENANCE

The Application of Statistical Methods to the Analysis of Service Performance Data. BONEBAKKER, J. W. *Transactions, North-East Coast Institution of Engineers and Shipbuilders, paper read* 9 March 1951.

Before a ship is built, her model will have been tested in order to get the best combination of ship's lines and propeller design. These experiments give the relation between power and revolutions over a certain range of speeds, but at one draught only and under ideal conditions. The tank tests are subsequently checked by carrying out progressive measured-mile trials. These, however, have nothing to do with the ship's service performance.

Endurance trials can be carried out under favourable conditions while the ship is in service, but in order to obtain the correct relation between power, revolutions, speed, and apparent slip for any set of specific external conditions likely to be met in service a large amount of basic information would have to be collected over a number of trials. The Author suggests that modern statistical methods applied to less numerous performance data will give more reliable and accurate results. The set of curves of the generalized power diagram can be reduced to a single straight line, even if more factors are included, such as ship's draught.

Service-performance data of three actual ships, a single-screw turbine steamer, and two twin-screw motorships, are analysed to illustrate the suggestions, and sample calculations are given.

In Appendix A, brief reference is made to some aspects of the theory of screw-propulsion theory. First principals of mathematical statistics are treated in Appendix B.

Comments on Ship Performance. MEIGS, C. H., Cmdr., U.S.N. *Journal, American Society of Naval Engineers,* **62** (1950), p. 779 (Nov.).

The purpose of this paper is to correlate as simply as possible the principal factors that influence ship performance ; it is intended primarily for the operating engineer rather than the designer. The two relationships that are of fundamental importance are those between speed and r.p.m. and between speed and fuel consumption. Both are considered and shown to be representative of true relationships only under one unique set of circumstances, which it is impossible to duplicate at will. Since trials are usually run under favourable weather conditions, and often with specially trained crews, the results obtained tend to be representative of optimum, and even abnormal, operating conditions. When comparing the performance of individual ships the conditions under which the data were obtained must be considered.

MISCELLANEOUS

The Testing of Motive Power Machinery. BROWN, T. W. F. *Greenock Philosophical Society, Watt Anniversary Lecture for* 1951, *read* 19 *Jan.* 1951.

In order to study the developments that have taken place in the full-scale testing of motive-power machinery, some typical tests at intervals of about 50 years are considered, starting with the year 1800. The first practical Diesel engine was produced in 1897. At this period, the reciprocating engine was the usual means of propulsion of ships of all types. A brief account is given of a number of sea trials carried out about this time.

The developments between 1900 and 1950 are summarized briefly. Apart from hydraulic dynamometers, which have been greatly increased in sensitivity by controlling power absorption at the water outlet from the dynamometer, the chief development in power measurement has been the use of eddy-current dynamometers, which are now used for high-power and high-speed applications. Many attempts have also been made to develop reliable and accurate torsionmeters. Strain-gauge equipment for the measurement of static and transient stresses, including vibrational stresses, in machinery parts is now common. The means of fastening such gauges to the parts of machinery has now been so perfected that strain-gauge equipment can be used for temperatures up to 1,200° F. Control instruments consisting of capacitance gauges enable rotor movements and the shuttling of gear elements to be determined. The measurement of axial and torsional vibration is now performed electronically by suitable pick-ups and cathode-ray oscillographs. Noise-level meters and analysers are available to measure machinery vibration and noise.

In marine work, a new feature has been instituted, namely shore testing of propulsion machinery. The Admiralty Engineering Laboratory tests Diesel machinery for Naval use ; a Naval Wing is being constructed at the National Gas Turbine Establishment to test gas-turbine propulsion machinery developing powers up to 10,000 h.p. At the Pametrada Research Station full-scale tests can be carried out on machinery with powers up to 60,000 h.p. per shaft. A description is given of full-scale machinery trials carried out under the supervision of the Admiralty. These trials included the accurate measurement of fuel, main condensate, auxiliary condensate, brake load, and revolutions per minute, and the recording of all steam pressures and temperatures at entry to and in the various stages of the turbine.

A brief reference is made to a new type of test on gearing by means of back-to-back tests at increasing torques until destruction of the gearing is effected.

A list of references and numerous illustrations are given.

The F.C.M./Valensi Funnel. *Shipbuilding and Shipping Record*, **76** (1950), p. 606 (14 Dec.).

The F.C.M./Valensi funnel has been designed to prevent the descent of smoke on to a ship's deck. The cross-section of the casing is shaped like a symmetrical aerofoil with maximum thickness 20% of the chord. In side elevation the funnel resembles a short half-wing of an aeroplane with a rounded tip forming the funnel top. The smoke emerges in the locality from which the trailing wing-tip vortex springs and is carried downstream. Provided the funnel is of sufficient height to penetrate the turbulence boundary the smoke is carried well clear of the deck. The vortex ceases to be produced when the angle of the relative wind exceeds 25 degrees on the bow, but it is stated that the use of slots and deflectors makes it possible to increase that angle.