TECHNICAL ABSTRACTS

The following abstracts are reproduced from the 'Journal of the British Shipbuilding Research Association', Vol. 9, Nos. 6, 7, 8.

MATERIALS: STRENGTH, TESTING AND USE

A Review of Ship Steel Research and Recommendations for Future Studies. BARRETT, C. S., and MAHIN, W. E. *U.S. National Research Council, Committee on Ship Steel, Serial No. SSC*–70, 15 Feb. 1954.

This report constitutes a review of the progress made in recent years in research into the metallurgical aspects of brittle fracture in ship steel, with a view to assisting the Committee on Ship Steel to make recommendations to the Ship Structure Committee for further research programmes.

The chief problem is to find means for reducing the probability of catastrophic failure of welded steel ships by improving the notch toughness of steel plate. Since most failures in ships have started at or near defective welds or at points of stress concentration where weld metal is present, some investigators consider that the greatest field for improvement lies in the weld. The Authors are of the opinion that improvement of primary welding cannot provide a complete cure for brittle failure, and that the greatest ultimate gain in ship performance will come through improvement in the notch toughness of ship plate which, if of 'crack-stopping' quality at service temperatures, would make it possible to eliminate serious brittle failures completely.

Among metallurgical variables in plate steels, grain size has attracted particular interest, but it has not been established that grain size is a primary controlling variable. A more critical review is needed of data previously obtained on grain size and related variables, together with careful research into the effects of austenite and ferrite grain size, grain-coarsening temperature, austenizing temperature, cooling rate and deoxidation practice (which may be more fundamental variables upon which grain size is dependent), the effect of the degree of reduction during rolling, the part played by subcritical heat treatment, and the reason for variations in transition temperature shown by plates of different thicknesses.

Since these variables are closely interrelated and affect the properties of the finished plate by controlling its structure, the effects of the variables on the macro, micro, sub-micro, and atomic structures, and the relations between notch toughness and a particular structure, require to be elucidated.

There seems little need for further research into the effects of chemical composition on transition temperature ; and since the fabrication of laminated plates (which are known to give desirable transition temperatures) is not economically feasible at present, little further work on them need be carried out. Contrary to expectation, catastrophic failure of ships rarely follows the heat-affected zones (where transition temperature is increased) of welds running normal to the most severe applied stresses.. Various hypotheses have been advanced, but thorough understanding of the mechanism of brittle failure at or near welds is needed to confirm that low-temperature stress relief is invariably desirable.

Available notch-sensitivity tests are adequate for normal purposes, but more should be learned about the stresses necessary to initiate and propagate a rapidly spreading crack ; and the drop-weight test, in which a hard-surfacing weld deposit is made to start a crack which is then made to run through a flame-cut full-thickness sample of plate, needs to be developed.

Statistical investigation is suggested into a number of factors, including the most suitable test method for mill inspection of notch toughness, the average and maximum values of transition temperature required for each plate thickness, the number of notch-test specimens required for adequate representation of heats of steel plates, the possible advantage of some reduction in tensile strength by reduction in carbon content, and the possibility of utilizing controlled rolling to provide grain refinement at less cost than present normalizing treatments.

The long-term fundamental research which is most likely to contribute to a solution of the ship steel problem is surveyed. Topics of interest comprise the mechanical properties of high-purity alloys, embrittlement by oxygen, intergranular and transgranular fracture, chemical composition and its relation to transformation temperature, metallurgical structure and its relation to notch toughness, mechanics of crack initiation and propagation, the phenomenon of delayed yielding, plastic-wave propagation, micro strains, the size effect in brittle fracture, the metallography of fractures, and strain ageing.

A number of references are given.

BOILERS AND STEAM DISTRIBUTION

Steam in Seconds with New Boiler. *Marine Engineering*, **59**, No. 4 (1954), p. 63 (Apr.).

Packaged steam generators, of the same automatic type as those installed on Diesel locomotives for heating passenger coaches, are employed for a variety of purposes in the Royal Canadian Navy's Dockyard in Halifax, Nova Scotia, whenever steam up to 5,000 lb/hr and at 75–300 lb/sq in is required. They can develop 200 lb of steam pressure from cold water in two minutes, during which time compressed air is used to atomize the fuel oil. Thereafter, a small amount of steam is used to atomize the fuel oil. Once the boiler has been started up, the automatic controls take over and cycle on and off, making steam as required.

These steam generators are used on ships or are employed as portable units for such purposes as operating steam cranes, pile-drivers, and testing sea-water evaporators and other equipment. The units are carried about the docks by means of fork-lift trucks.

DIESEL AND OTHER I.C. ENGINES

The Use of Boiler Fuels in Medium Speed Diesel Engines. THORN, J. D. *Combustion Engineering*, **8** (1954), p. 111 (April).

The results of experimental work on the use of boiler fuel in a Ruston & Hornby VEB non-pressure-charged engine are summarized. Preliminary tests with 1,000-sec fuel heated to 180°F, at a supply pressure of 30 lb per sq in, with an increase in the size of the injection-pump elements (to ensure satisfactory atomization) and an advance of the injection timing, proved promising. Tests of a total duration of 934 hours were therefore undertaken to simulate the operating conditions of a marine auxiliary generator set, at sea and in port, with a load cycle of 60 hr at $\frac{5}{8}$ load ; and 10 hr at $\frac{1}{4}$ and full load, alternate hours. The fuel contained 3·3 per cent of sulphur and 0·045 per cent of ash, and had a Conradson carbon residue of 8·65 per cent, a viscosity of 971 sec Redwood 1 at 100°F, and a flash point of 225°F.

Inspection of the engine at the end of the test showed liner wear of about 0·0025 in, but otherwise wear rates were not much greater than would be expected when using gas oil. Thick hard carbon deposits had formed around the top of the liner, above the ring travel, and on the top piston land, but the valve ports and exhaust pipe were comparatively free. Carbon trumpets were found on the injector nozzles, but the valves were in surprisingly good condition, probably because double purifying of the fuel oil, which reduced the ash content from 0·045 to 0·024 per cent, had removed most of the sodium.

Tests with a fuel of 3,000 sec viscosity, at slightly higher fuel temperatures, resulted in wear rates about double those obtained with 1,000 sec fuel and gave appreciably greater deposits. The Author concludes that, under suitable conditions, VEB, VGB, and VLB engines (with outputs of 240 to 1,500 b.h.p.) would run satisfactorily enough on fuels of up to 1,500 sec viscosity and show an economic advantage. Residual fuels frequently vary widely and the variation increases as the viscosity of the fuel increases. The additional difficulties and risks inherent in the use of fuels with viscosities greater than 1,500 sec would not be justified by the slight extra saving in the cost of the fuel. In deciding whether a particular marine duty is suitable for boiler fuel, consideration must be given to the average load and the utilization factor (both of which should be reasonably high) ; the wide variations in quality and cost of low-grade fuels in different ports throughout the world ; the seriousness of an unintended shut-down, should one occur, since the likelihood of this happening is much greater with high viscosity fuels ; and the need of more frequent shut-downs for general maintenance.

Combustion and Performance in Diesel Engines. FOX, G. B. *Gas and Oil Power*, **49** (1954), p. 44 (Feb.), p. 60 (March), p. 81 (April), and p. 114 (May).

The Author first reviews the essentials of good combustion in open-chamber engines. The main factors affecting combustion are the amount of oxygen available for combustion and the distribution of fuel into that oxygen. In connection with the first point, sources of error in given optimum valve settings are mentioned, and attention is drawn to the fact that the term volumetric efficiency does not strictly define the amount of air drawn in and available for combustion, as this gas is not necessarily all air, but may be partly composed of exhaust gas drawn in during the overlap ; the term volumetric efficiency really applies to the gas induced expressed as a percentage of the theoretical cylinder swept volume. An example is quoted where change of valve setting increased the amount of air trapped in the overlap period, with consequent increase in the efficiency of the engine.

When considering fuel distribution, the Author mentions that although it may be easy to break down the fuel into a state where it is most acceptable to the air, the equal concentration of particles throughout the combustion chamber is more difficult to achieve. Some of the features of design involving departures from the open combustion chamber that are used to overcome the distribution problem are mentioned.

The third section of the paper deals with starting troubles, and such defects as lacquering and corrosion of the injection-nozzle orifices which may impair efficiency.

Finally, the Author deals with the performance that may be expected from the use of various kinds of fuel. The calorific values of British Standard Class A and Class B fuels differ very little from each other, or from that of boiler fuel oil. The difficulties that arise from the use of low-grade fuel are not therefore a matter of obtaining the power, but rather the formation of deposits on the cylinder head, injector tip, valves, and piston rings. Ignition quality is discussed, and three methods of reducing delay in ignition are suggested.

LUBRICANTS AND LUBRICATION

Turbine Oils and Lubricating Oil Systems; Cleaning Turbine Oil Systems. CLARK, G. H. *Scientific Lubrication*, **6**, No. 3 (1954), p. 14 (Mar.).

Oil systems in new machines should be cleaned by flushing, preferably with a fully-inhibited turbine oil of the same viscosity as the final charge, rather than with a special flushing oil of much lower viscosity, the last traces of which cannot easily be removed and remain to contaminate the final turbine oil. The oil should be heated during flushing to about 160°F, to loosen scale and rust, and the bearings should be by-passed by temporary ' jumper ' pipes to prevent damage by foreign matter. A centrifuge or other efficient filter should be used throughout the flushing period, which should last for at least three days for large machines. After removal of the flushing charge and careful draining of oil from all the low points in the system, the final charge is put in immediately to prevent rusting.

In old machines, where the oil has been in use for several years, the old oil is washed with hot water at 160–180°F in conjunction with an efficient centrifuge operated at half its rated capacity.

Most of the oxidation products of the oil are water-soluble and are removed by water washing with the old oil. The water also assists in coagulating finely-divided dust, fly-ash, and metal oxides, so that they are more readily removed by the centrifuge.

If hot-water washing with the old oil leaves the system still dirty, then more drastic methods must be employed, such as washing with low-pressure steam or hot distilled water at 180°F or treatment with proprietary alkali degreasing compounds (which should be kept from the governor system by blanking off) or solvent degreasers, e.g. trichlorethylene, carbon tetrachloride (both of which are toxic, and dangerous to handle in enclosed spaces such as oil tanks), or tetrahydronaphthalene (' Tetralin '). Great care must be taken to remove all traces of alkali (otherwise troublesome emulsions will be produced when the turbine is returned to service) or organic solvent. If possible, the cleaned parts should be blown through with clean dry air and coated with oil as soon as possible.

Efficient cleaning equipment should be provided with all turbines to maintain the oil in good condition. The oil purifiers usually installed are centrifuges of the Sharples long-bowl or De Laval multiple-disk types, both of which are described in detail.

Rust Removal and Protection Against Corrosion. *Syren and Shipping* (*Ship-Repairing, Reconditioning and Survey Number*), **231** (1954), p. 57 (28 April).

Some experience has now been obtained of the effectiveness of the two fluids known as Formula A and Formula B introduced by the Plus Gas Co., Ltd. a year or two ago (see Abstract No. 5590, Dec. 1951) for rust removal (Formula A) and protection against corrosion (Formula B).

Formula A dissolves rust by removing the water content, leaving it in the form of an oxide ; its penetrating power is high and only a small quantity of fluid is necessary. Some examples of its successful use are described. These include the freeing of bilge pumps where the internal thread had corroded, and the corroded hydraulic heads of the rams of cranes. Aluminium-piston heads can be cleansed of carbon deposits, and valve and cylinder heads may be derusted. The fluid need not be cleaned off after use as it has no chemical action on metal itself.

Formula B is a resin-based fluid, which may be easily applied by brushing, spraying, or dipping and has a coverage of approximately 1,200 sq ft to the gallon. It has no effect on lubricating oil and can be applied over oil-bound or lead-based paint to give it longer life. The coating created is so thin that only rarely in the case of the most delicate machinery is it necessary to remove it when the equipment is operated ; but if necessary the covering is easily removed by a little white spirit. Formula B is particularly suitable for equipment subject to extreme variations of temperature, as the elasticity of the covering enables it to expand and contract with the metal it protects. It has been used with success to protect the running gear of the television mast at Sutton Coldfield, which had previously given considerable trouble from corrosion.