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SOME NOTES ON THE WEAR AND
TEAR OF STEAMERS.

BY J. CHARLES McALLISTER.

It occurred to the writer that at the present juncture a few remarks on the deteriorating of steamers due to various causes might be interesting. There were many agencies other than the ravage of time that tended to wear a vessel out, among which might be mentioned quality of workmanship and material put into the ship when built. The particular trade in which she was engaged, personal attention of those in charge, regularity with which repairs are carried out, the quality of paint used, and the intelligence and regularity with which they were applied, immunity from grounding on flats or bars.

These agencies acting separately or collectively form an environment of circumstances that tended to a vessel's detriment or prolonged its useful existence as the case might be. Nearly every substance in nature was susceptible to change and had its favorite affinity in the form of another element or elements with which it sought to combine. Chemical affinities, when satisfied, rendered the resulting matter stable at certain temperatures for the time being.

Most of the metals were found in combination only. In isolated instances they were found free, but where this was the case it was generally the result of some ingenious action at some time more or less remote

in geological history. Iron was most frequently found in combination with oxygen

Magnetic Ore, $\text{Fe}_3 \text{O}_4$	Red Hematite, $\text{Fe}_2 \text{O}_3$	Clay Ironstone and Clay, $\text{Fe} \text{CO}_3$	2 Hydrated peroxide $(\text{Fe}_2 \text{O}_3) + 3 (\text{H}_2 \text{O})$
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and in such forms was reasonably stable but of no value as an engineering constructive material. When, however, it was freed by the agency of the smelting process from its affinities and appears as commercial pig iron, it is in a less stable though more useful form.

Nature's processes were never at rest where two elements with affinity for each other were in contact, and the efforts of iron and oxygen to re-combine were commenced immediately after processes of manufacture were complete. The re-combination proceeded with more or less rapidity according to surrounding circumstances of temperature, moisture, presence of corrosive agencies, galvanic action, and other causes, until the whole body of metal had re-assumed a stable form as hydrated peroxide of iron, $(\text{Fe}_2) (\text{H}_2\text{O}_6)$.

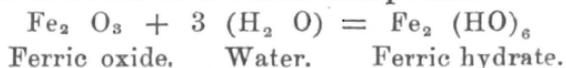
Having to construct our ships and engineering works of perishable material of this description, we found it necessary to use many precautions in order to prevent decay or rusting of the iron or steel. The absolute prevention of rust was practically impossible. It could merely be reduced to a certain minimum, which always depended on circumstances. The useful life of an iron or steel vessel was most largely influenced by three distinct factors, original thickness of scantlings, workmanship, and design, subsequent protection of the surfaces inside and out.

For ordinary commercial purposes, Lloyd's B.C. and B.V. rules for steamers' scantlings provided ample strength of material for say 25 years' wear with ordinary treatment. Of course, during that period

many parts had to be extensively repaired, or renewed, frequent cleanings, scrapings, and paintings resorted to in order to check decay. With the ordinary type of cargo steamer it seemed a prudent course to assume that the vessel would, if she existed, be obsolete in 25 years, and most steam companies provided for depreciation in excess of this allowance. It must be remembered that most cargo steamers carry small crews. The vessels themselves were expected to be constantly employed, and only the minimum time allowed in port for any purpose whatever. Periodical overhauls were curtailed as much as possible, and the interior of the hull might be perhaps as much as four or five years without a proper cleaning, or renewal of paint. In some climates and trades this did not appear to matter to any great extent, particularly if fine classes of goods only were stowed in the holds. In humid and hot climates, however, vessels that were painted black outside, were liable to very considerable deterioration of surfaces inside, chiefly owing to dampness, coupled with rather wide alternations of temperature.

When iron was exposed to the action of pure dry air at ordinary temperature rusting did not occur to any appreciable extent, but in moist air where C.O._2 was present, and temperatures alternated, say between 180 deg. F. and 60 deg., rusting was persistent and rapid; and in a very few years a comparatively thick plate of iron or steel would be reduced to hydrated peroxide of iron. During the progress of this chemical combination the metal increased in bulk about $2\frac{1}{2}$ times, became brittle and slightly heavier, and liable to fall into pieces on concussion. The theory of rusting was now well understood, and might be stated as follows: Moisture and C.O._2 were nearly always present in the air, and when iron was ex-

posed to its action, the O and CO₂ (contact being promoted by the moisture) began to act at once, forming a layer of carbonate of iron, Fe + O + CO₂ = FeCO₃. More O at once acted on the FeCO₃, converting it into Ferric Oxide (Fe₂O₃) with liberation of CO₂, which with more O from the air re-acted on the iron or steel. In the presence of moisture the hydrated peroxide of iron formed on the surface made a galvanic couple with the metal, and being electro negative to it a current was created at the expense of the iron, and corrosion rapidly proceeded, until all the metal was reduced to a stable compound.



There appeared to be no doubt whatever that steel was more subject to corrosion and rusting than was good malleable iron; but why this should be so seemed doubtful, and authorities were not agreed on the point; but it had been noticed that steels containing the greatest amounts of combined carbon suffered most from corrosion.

Some experiments bearing on this matter were carried out by Mr. Andrews, of the Wortley Iron Works, who found that in all the cases under observation where steel and iron plates were compared, the advantage was in favor of the wrought iron to the extent of about 25 per cent.

He also found that after a certain thickness of scale had been formed, galvanic action largely increased the rapidity of corrosion. The plates on which these experiments were carried out had been immersed in clear sea water. The effect of temperature on the rapidity with which oxidation progressed, appeared to have been neglected in Mr. Andrews' experiments.

In tropical or semi-tropical climates it was well known that any iron or steel work exposed fully to the

solar rays, unprotected by roofing or shade of any kind, deteriorated much more rapidly than would be the case if it were housed, this irrespective of paint protection.

The combination of efficiency in steamers with low working expenses was the aim of most shipowners, and except in a few instances where companies maintained a very high standard of excellence, the rank and file of owners were satisfied with vessels that were serviceable but not showy, and no efforts were made to make them so, either in finish, by the builder or by the owner in up-keep; in both cases from the same reasons. An owner who expected long and useful life from his vessel, should therefore commence by having scantlings as heavy as the limitations of his trade will permit. The sections should be of such shape that cleaning was not rendered difficult or impossible, as such work in obscure corners would nearly always slummed; and he should see that the best practice in shipbuilding was adopted by the firm he patronized. Two of the most important details in that regard were the fitting of the contact surfaces and quality of rivetting. Slop builders were not too particular as to the bevel of their frames, the flanges of which in many cases were left hollow, and with a quantity of furnace scale on the surfaces. These contact surfaces were left unpainted, and when steel plating was attached the junction at every bevelled frame was faulty, rusting progressed with ever-increasing rapidity in such places until at last the layer of oxide became so thick that the surfaces were forced apart and the rivets broken or drawn. It was an ordinary experience to observe whole lines of keelson and stringer angles that had assumed a corrugated form on their contact surfaces, which might have been obviated by, in the first instance a coat of paint. When, on the other hand,

the fitting had been properly done, contact-surfaces coated with zinc and oxide paint, and the rivetting as it should be, the joint maintained its integrity throughout the lifetime of the vessel.

In steam colliers the only guarantee of a reasonably long life was that the vessel should be built of heavy material with a wide margin of strength to provide against premature weakness, due to a decay which commenced with the first cargo the vessel carried. All the conditions for rapid corrosion were present in this case. A cargo that was entirely electro negative to the hull, and highly abrasive as regarded the destruction of any protective that be used, generally damp, and more or less charged with pyrites, which liberated under rise of temperature, moisture, and destructive sulphurous acids. It was possible to prevent decay in this case; it could only be delayed.

The action of coal on frames, stringers, reverse bars, ties, lower masts, and in fact all exposed iron or steel work was entirely destructive, and no successful attempts to combat it were known to the author. The shell plating was attached from inside, and frequent pitting occurs in addition to the flaky rusting. On the plates about the water line, notwithstanding the frequency with which they were cleaned and painted outside, the wasting was greatest and the danger limit was soonest reached. On the whole, in this class of vessel, wasting was greatest from inside. In any class of vessel, the bunkers, bars, floors and ties under or near the boilers, lower parts of bulkheads of machinery space, casings round stokehole and base of funnel, were always the first portions to require serious repair which could only be satisfactorily dealt with in their ultimate renewal. Patching was resorted to in the matter of bulkheads in the early stages of local corrosion; and in the case of bunkers they were generally pat-

ched all over in way of boilers before general renewal was required.

The bottom plating inside of the hull was generally protected from the action of bilge water and other corrosives by a coating of Portland cement, asphaltone, or one of the now recommended bituminous coverings. Portland cement mixed with an equal portion of sand, had established a hold on shipping people that pointed it out to be of great fitness for the purpose, where applied in a coating of sufficient thickness. It was not advisable to use thin coatings, as the protective is then liable to cracking, or abraision from coal or other solids rolling about among the bilge water. Sometimes, owing to the presence of too much sand, it was porous and permitted moisture to reach the plating, in which case local corrosion at once commenced. The gradually thickening film of oxide forced up the cement, and the pit gradually increased in area and depth until perforation was accomplished, unless the matter was discovered by examination and attended to.

This internal pitting was usually local, and of small area, from say 1 sq. inch to 10 sq. inches, but when discovered, it was generally well to remove more cement, here and there, for examination of plating.

In passenger steamers it was now considered a mistake to line with wood any more of the ship than was absolutely necessary for the decorative plan; and in way of ports, the lining was made protable so that any rust or wasting due to leakage might be attended to. The old practice of fitting mouldings and carvings of wood on stem and stern was being discontinued. This was always productive of rusting and corrosion, the plate being generally eaten through before the matter was noticed. The protection of the outside of hulls by means of anti-corrosive and anti-fouling paints was

the subject of endless patents, but the best first coating within the knowledge of the writer was oxide of Zinc. Red or white lead was not a good first coating for the outside of a ship. When the oil in which these pigments was ground had been perished by sea water, chlorides of lead was formed, which were rapidly acted on by the iron, forming chlorides of iron, with deposition of metallic lead, which in turn carried on the corrosion of the iron by galvanic action.

The most approved anti-corrosives for ships bottom now consisted principally of Oxide of Zinc, and finely divided zinc, the peroxide of iron being used as coloring matter, the whole mixed with certain varnishes and spirit driers. Various shades of red appeared to be the favorite color for this class of protective paint, on account of its more or less effectually hiding any rusting that might be going on. These protectives were, generally, effective and in most cases reliable, and we seldom heard of much external corrosion in vessels the bottoms of which were not subject to abrasion through being engaged in deep water trades.

The class of anti-fouling compos poisoned with salts of copper effective enough in their particular function, had fallen into complete disfavor for use on iron or steel ships, on account of their destructive action on the metal, should the protective covering become abraded. In actual practice, the plates along the water line of a steamer were probably subject to more than twice as much wasting, as well under or above that locality. The constant abrasion and destruction to which the protectives were subjected by esbes, clinker, and other waste constantly being thrown over-board.

Shallow draft vessels that were frequently aground on bars, or shallows, were usually scoured

clean on the bottoms, and suffered more or less acutely from pitting. There was no remedy known in this case, to the writer, excepting frequent docking and renewals of defective plating. Sheathing and shoeing was also frequently fitted on the parts most subject to this scouring action, which when worn through might be again renewed.

With respect to the wear and tear of boilers and machinery, which, in these days of evaporators, anti-friction metals, compound oils, etc., should be very moderate even with hard and constant duty, we found that a great deal depended on the personal factor, which was generally a somewhat uncertain quantity. With careful brainy attendants who were vigilant and interested in their duties, cleanly, orderly in their habits, the life of machinery was indefinitely prolonged; where with careless treatment, the owners were called upon to pay enormous bills for so-called "wear and tear".

It was the writer's experience, that the greatest proportion of tear and wear was due to inferior system, or want of system, of lubrication, which was frequently neglected even by good builders. Small flimsy oil cups that invariably became loose and leaky were supplied, do duty on trial trips and for a few weeks longer, were frequently then discarded by the engineer in favor of an oil hole. The engineer who studied the subject of intelligent lubrication studied his own comfort as well as the interest of the shipowner, it was well to know that the purely mineral oils seldom alone gave satisfaction on fast running brass bearings; but with the admixture of a very small proportion of olive or cotton-seed oil with an occasional drop of fresh soft water, an emulsion was formed that answered every purpose, and kept wear at a minimum.

Deck machinery, such as steam winches, windlass, steam steering gear, etc., was seldom treated too well in respect of lubrication, owing to the fact that the attendants were seldom skilled in anything more than working the handles, they allowed oil holes to become filled with coal or grain dust; and although the machine generally was greasy enough for any purpose the bearings were stinted. It was not unusual on a hard worked coasting steamer to have £15. per annum spent on each winch, which was about four times as much as should be the case were they treated decently.

The corrosion of boilers was still a problem which was not altogether solved, although of recent years the causes and remedies were better understood. Wasting in its earlier stages was seldom sufficiently guarded against, and for a year or two with new boilers we seldom used sufficient precaution until one day on examination some local pitting was discovered. With regular fresh distilled water feed there was seldom any trouble with corrosive agencies, provided the water was kept alkaline in order to neutralize any acidity that may be present. In marine practice, however, it was hardly possible to keep the feed universally fresh, chiefly due to slight weeps or leaks from the condenser; and although the quantity of salt water supplied might be small, or look small when the leak was discovered, yet acting over several days or weeks a good deal of harm was done. At the high temperatures now in use the sulphate of lime scale was deposited almost at once, and with feed water in which salt could not be tasted a very considerable thickness of crust might be formed in a few weeks. It was generally prudent to test the feed water with nitrate of silver. A few drops of the solution of nitrate of silver let fall into a small quantity of the water to be tested, and the mixture exposed to the action of

light, would indicate the merest trace of salt present, by turning the water cloudy or dark, as the case may be.

The scale from salt water gathered thickest at the necks of combustion chamber stays or other surfaces which were subject to greatest heat. There was often a good deal of difficulty in removing the scale as the positions were often somewhat inaccessible; and although the plane surfaces in the vicinity might be well cleaned during over-haul, the scale still remained at the junction of the plate and stay, forming a cravat of uncertain thickness.

These parts protected from contact with the water, naturally attained higher temperatures than would be the case if the iron were perfectly clean, and the consequence of this was that the moisture under the scale was decomposed, forming black magnetic oxide with the liberation of Hydrogen. This oxide being electro negative to the boiler formed a galvanic couple with the iron if any salt be present in the water and rapid corrosion ensued until latterly the stay was found to be leaky. With regard to stays in un-get-at-able corners of a boiler the first intimation we had of this class of corrosion was usually leakage, and when repairs were being effected, it was found that the stay was thin at the neck and the plates worn to a knife edge. In this case it was usual to fit a larger stay, or fit on a small circular patch into which the stay was screwed.

Since the introduction of the petroleum products for Cylinder lubrication, it was seldom that much pitting occurred along the water-line of a boiler, but its action was equally or more detrimental in another direction where it found its way in any quantity into the boiler and adhered to the heating surfaces. Its flashpoint was so high, and its integrity as oil so perfect,

its temporary function as a non-conductor so effective that the plates become overheated and bulged more or less. The introduction of filters did not altogether prevent an occasional recurrence of these accidents though of recent days the number was minimized.

The makers of engines had conservative notions about slide valves that were incomprehensible to us who used them; probably the cost of production was less in the case of the slide valve, and he will not alter his pattern unless paid extra; possibly the matter was overlooked, or the shipowner was not well advised:— in any case the only radical cure known to the writer for the oil-in-boilers nuisance was not to use any through the cylinders, but to so construct the parts that the saturated steam would be sufficient lubricant. Slide valves very seldom gave satisfaction when working at pressures over 90 lb. unless they were properly balanced. The balance gear in most marine engines slide valves was unreliable, the wear and tear was great, and the best way out of the difficulty was to fit piston valves.

The failure of shafting contributed largely to the list of break-downs; and it depended on circumstances and the ingenuity of those in charge as to whether or not the break-down was total. The breakage of stern shafting was usually the most hopeless type of accident, although in three instances it had been overcome patiently and hardily. In one instance by tilting the ship (filling fore-hole with water) and fitting spare shaft and propeller; in the other two by cutting away the stern pipe and fitting a coupling. The cause of breakage were various, among which might be noted inherent flaws, want of rigidity in the ship, grooving or wasting of stern lengths, racing in heavy weather, in which the transformation from full load to no load occupied only a few seconds, shafting being out of

line. The last was probably the most frequent cause of breakage, as the constant flexure, though within the elastic limits, gradually developed cracks which ultimately caused failure.

The function of the Board of Trade with respect to Steam ships was in general to provide a comprehensive specification and standard factors of safety for all propelling machinery and boilers, and by means of their inspectors to see that the proper standards of workmanship and materials were adhered to during construction, and that wear and tear was sufficiently provided against afterwards.

The periodic inspection to which passenger vessels were subjected in New South Wales, ensured to the traveller a reasonably wide margin of safety; but the act was incomplete inasmuch as it did not provide for the survey of all vessels within the colony.

The majority of owners maintained good working efficiency in their ships, but these days of competition there was little margin for luxury excepting in vessels of the highest class.

It was necessary, in effecting repairs to old or mature vessels, to be consistent. It was sometimes difficult to see just where to begin or end extensive work, which when finished, only brought the rest of the ship into unfavorable contrast. It appeared to the Author that the ideal way was to so regulate repairs that the margin of safety might be approached from various directions. And here the Government surveyor came in and gave the matter his veto, if he believed the margin of safety to be less than we assumed it to be.