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NICKEL DEPOSITS ON WORN OR NEW MACHINE PARTS.

It has for many years been possible to build upon the surface of one metal a very thin layer of a different one, but, owing to the tendency of such films to flake or peel off, these processes have been almost solely applied to work of an ornamental character. Modern developments in this field, especially as regards the deposition of nickel, have enabled the very exacting requirements of engineering processes to be met, and it is now possible to build up films of appreciable thickness, their adhesion to the body of the material being all that can be desired. There is therefore an increasing tendency to employ deposition either as a repair measure or as a standard production operation, and it may be of interest to briefly recount some of the directions in which the system has been applied.

Method of Deposition.—There are in existence various methods of applying metal coatings, but that which is best known in this country is an electrical process, which has the advantage that no heat is required, while there appears to be no reasonable limit to the depth of skin that can be applied.

The articles to be treated are initially placed in a tank containing a waxing solution. The wax is then carefully removed from the parts on which the deposit is to be made. All particles of foreign matter, traces of oxide, etc., are then effectually removed by immersion in an electrolytic cleaning bath. This is most necessary, as not only might such matter prevent the coating from adhering, but also the bath might be fouled by floating specks, which might subsequently be included in the coating. The work is then thoroughly washed with water, and finally transported to the deposition bath, in which it remains till the desired depth of coating is attained, all measurements being made while the part is still in the bath. The time allowed depends upon the thickness of coating, and, together with the composition of the bath and the current density, is regulated to suit the job in hand.

Plant exists in Great Britain which will deal with parts weighing as much as 2 tons, the vats being capable of taking work up to 48 inch diameter. The maximum superficial area that can be dealt with at one operation is, however, limited by technical considerations, but there seems no reason to doubt that such limits will gradually be extended.

After the deposition is completed the work is removed from the bath, cleaned off, stripped of wax and finally machined.

Adhesion of the Coating.—Tests have been carried out at the N.P.L. on a specimen consisting of a plain steel bar upon which a nickel deposit $\frac{5}{64}$ in. thick had been built up. Screw threads were cut in the deposit and also on the test piece and

these were screwed into steel holders carried in a tensile test machine. The threads of the steel holder carrying the deposit stripped when sufficient load was applied, the nickel thread, however, remaining intact. Arrangements were then made to apply a test load directly on the end face of the nickel deposit, and by this means the ring of nickel was pushed off the steel test piece, being broken in one place. Examination of the inner skin of the ring showed amalgamation of the steel and the nickel, the skin of the former having actually sheared; in other words, the relative strengths of the materials and not the adhesion determined the point of failure. Microphotographs indicate that the crystals of the two materials actually interlock, giving the closest possible union.

An excellent test of adhesion was made in a practical case of a splined shaft belonging to a road motor. The splines at one end had been badly worn on service, and it was decided as a severe test to grind the shaft true, removing all traces of the original splines. A nickel deposit of sufficient thickness was then built up on the shaft, and new keyways were cut in the nickel, the final cut of the milling operation being deep enough to remove all traces of the deposit at the root of the splines. The resulting part in effect consisted of six nickel keys deposited on a plain steel shaft, the adhesion of each spline being thus required to withstand the proper share of the load, and receiving no assistance from any connecting band of nickel between them. Reports extending over a number of years' service are stated to indicate that little wear, no deformation and no evidence of loosening of the deposit has been observed.

Deposition is being somewhat frequently used for building up parts which have worn oval, and in many such cases the subsequent machining operation has produced feather edges of infinitesimal thickness where the nickel and the steel blend into each other. Even in such cases it is stated that the nickel will not lift or strip.

Nickel.—Nickel is now obtainable in a state of great chemical purity and, owing to its hardness (300 Brinell—5 m.m. ball and 750 R g load) and its toughness (30 in Herbert pendulum testing machine), a coating of this material gives an excellent degree of resistance to wear. The coating naturally cannot be expected to withstand the same conditions as case-hardened steel, although it very frequently is an improvement on many imperfectly hardened surfaces.

Pure nickel is an excellent metal for resisting corrosion, but owing to its expense only small parts are made from the solid material. The use of nickel coatings for this purpose appears to have many advantages, as not only is the cost less than the use of parts made of solid materials chosen with this aspect in view, but also the advantage of resistance to wear is conferred. This latter point is often of great importance in connection with long life, as corrosion products not infrequently form excellent abrasives which may cause very rapid wear.

Nickel coatings to be resistant to corrosion must, of course, be homogeneous, and perfectly united to the underlying material, but, although very great advances have been made in this respect, it is not possible by any ordinary means of inspection to be certain that this ideal has been attained.

Few organic acids have any effect upon nickel, although it is slightly attacked by nitric acid, and somewhat more so by aqua regia; alkaline solutions do not affect the material, which is thus very suitable for use in ammonia refrigerating plant.

Applications of deposited Nickel coating.

New Work.—Expansion sleeves for steam pipes carrying superheated steam. Valve seats and spindles similarly protected against superheat. Turbine blades and nozzle plates. Nickel can be deposited on steel of varying qualities, including case-hardened and tempered steel, spring steel and stainless steels.

Cast and malleable irons, together with phosphor or manganese bronzes and gunmetal, have also been employed as foundations for nickel coatings, but it is essential that these materials should be free from sand inclusions or blow holes. The subsequent machining of the nickel coatings on these latter metals has, however, presented some difficulties. The tough nickel coating rapidly dulls the cutting edges of the tools, and when this occurs the strain is apt to become greater than the basic metal can withstand. This results in portions of the deposit being detached, *with the base metal adhering to it*; that is, the adhesion is satisfactory but the underlying metal fails under the machining stresses.

Machine work, with tools that are not allowed to become dull, has, however, proved to be possible provided that the cut is kept small, but it is preferred to substitute grinding operations for machining in such cases whenever possible.

It is advocated by specialists in this work that non-ferrous materials should preferably be replaced by mild steel, which is then given a coating of nickel to protect it from the corrosion, the prevention of which is the usual reason for employing the former metals.

Satisfactory results are also reported from coatings on aluminium. Some difficulty appears to have been encountered in obtaining a satisfactory finish in cases where nickel is deposited on two meeting surfaces which are mutually at right angles.

In such cases the junction of the two surfaces nearly always presents a jagged and rough appearance after machining of either or both.

Repair Work.—The use of nickel coatings for building up worn parts is undoubtedly extending, and by means of this process very considerable economies should be effected, especially, as is often the case, when the coating provides a longer life than that of a new part.

Worn journals, rollers, articles spoilt in machinery, corroded shafts, damaged keys or keyways, &c., may readily be repaired by such means. A record exists of one case where eroded turbine nozzle plates were coated, in this instance the nickel being carried over the junction between each plate and the diaphragm casting, thus giving protection at a point which is usually somewhat vulnerable.

The great advantage of deposition over building up by welding lies in the fact that overheating of the body of the material is avoided, and thus not only is there no chance of damaging the metal but also unknown stresses due to unequal heating cannot occur.

A very special technique has been evolved in the course of prolonged experimental work in connection with the right types of solution, the current density and the methods of ensuring chemical cleanliness of the surfaces. This store of information is naturally the stock in trade of the few specialist firms who deal with this class of work, and extensive facilities do not yet exist for its employment. There is, however, little doubt that, even in the present state of the art, methods of this description will be adopted to an increasing degree and should prove very valuable " tools " in any engineering establishment.