

New finishes for zinc alloys

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SINCE 1958, the International Lead Zinc Research Organisation (ILZRO) has pursued a number of projects which have resulted in new methods of polishing and finishing of zinc alloys. Of these developments, some have already been adopted commercially while others have led to the establishment of information that is being used by the zinc die casting industry to upgrade the quality and durability of zinc die castings. Above all, the developments that have taken place are expected to reduce industrial finishing costs. This paper surveys the six important developments which have arisen as a result of ILZRO research in the finishing field.

Elimination of buffing by a new finishing and plating cycle

New methods for cleaning and copper plating were studied with the aim of reducing the preparation cost for plating with nickel and chromium. The current practice of copper plating on zinc die castings usually includes a 2 or 3 - minute copper strike in a cyanide solution containing 20 to 25 g/l copper cyanide and a 10 to 15 - minute bright copper plate in a cyanide solution having 60 to 80 g/l of copper cyanide. In this procedure, all the die castings must be buffed before plating to arrive at a finish that matches quality appearance standards for copper, nickel and chromium plated hardware. A lot of blistering also occurs during processing and storage after plating. To avoid this problem, ILZRO sponsored research projects which resulted in a new copper plating process. The following steps are recommended to bring down cost and to eliminate buffing while, at the same time, improving quality :

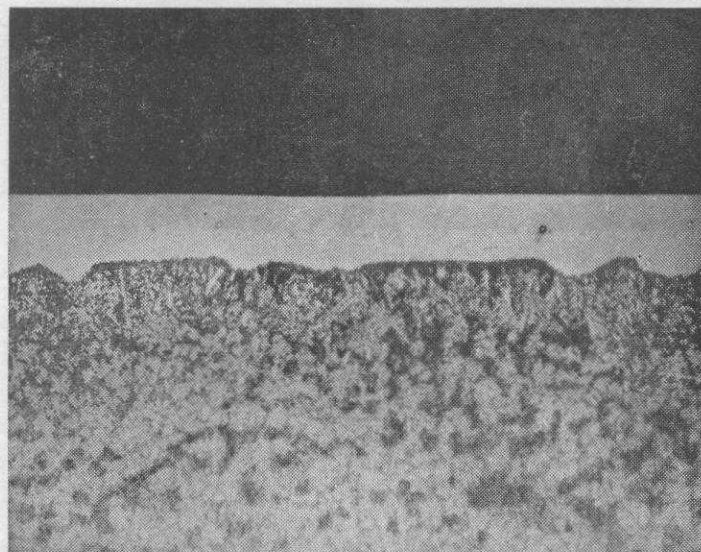
1. Surfaces which are rough or have fissures or skin blisters should be finished in a vibratory mill, spin polished or mechanically polished on abrasive-coated belts to eliminate the defects and produce a finish which has a maximum roughness of 0.2 to 0.3 μm . Normally, surface layer defects have a depth of less than 40 μm ; so they can be rapidly removed by polishing.

SYNOPSIS

A number of new finishes for zinc alloys have been developed in recent years as a result of research carried out under the sponsorship of the International Lead Zinc Research Organisation, Inc., New York. The paper describes some of the developments which have already been adopted commercially or are in the final stages of development. Among the latest plating developments is the elimination of buffing through the use of new finishing and plating cycle that includes bright, levelling copper plated in copper sulphate sulphuric acid solutions. This has resulted in the saving of cost by as much as 40 per cent. New nickel-chromium plating systems have been described that improve durability as much as 500 per cent. The use of auxiliary anodes for improving the thickness uniformity of nickel and chromium has been discussed; this has been widely adopted in some countries for conserving nickel and upgrading the durability of complex shapes. Research on alternative finishes to chromium plating, which has resulted in the development of abrasion and corrosion resistant anodised finishes for zinc is described. The development of clear organic finishes on highly polished zinc surfaces, which may act as a substitute to chromium plating is also highlighted.

2. Buffing should be eliminated. A good levelling copper plating bath in conjunction with vibratory finishing on spot polished parts can produce a mirror like finish which is obtained by buffing. The cost of this step would also be lower.
3. Following conventional cleaning, electro-polishing in alkaline solution will smoothen polishing scratches and dissolve metal at the peripheries of any pores or crevices that persist after mechanical polishing.
4. The copper cyanide strike generally used in the initial plating step should have a composition enabling it to deposit a pore-free dense copper layer with a thickness of 2.5 to 3.5 μm .
5. A bright copper deposit of 12 μm should be obtained with addition agents capable of providing good levelling power.

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Duplex Nickel

Copper

Zinc Alloy

1 Zinc die casting copper plated in an acid copper sulphate bath $\times 250$

With these modifications, reduction in cost can be achieved, heat blistering can be eliminated and corrosion resistance can be enhanced. These conclusions were drawn after evaluating the new copper plating procedure for a large number of commercial complex shapes, such as automobile window frames, door handles, tail lamps, etc. The new procedure is recommended both for Alloy 1 of IS : 713-1966 and ILZRO 12, and also for zinc extrusions containing about 0.1 per cent titanium.

In the case of some castings, cleaning and copper plating can be done directly after the parting lines are smoothed, whereas in other cases the castings should be polished to remove surface layer defects. The usual belt operation for smoothing parting lines can be extended to polish any defective areas. Generally belts coated with a 300-grit abrasive are suggested to avoid deep polishing scratches that might require more than the recommended 12 μm of bright levelling copper. For small castings, spin polishing and vibratory finishing can be used instead of belt polishing for cutting off defective surface layers. Smoothing is done by spinning in ground corn cobs or nut shells by attaching castings to spindles rotated with a peripheral speed of about 2000 ft/min. A finish of 0.125 to 0.2 μm can be obtained after 5 to 10 minutes of polishing. Vibrating tubs loaded with plastic chips such as polyurethane impregnated with an abrasive-like aluminium oxide smoothen the surfaces of zinc die castings within 3 to 4 hours when frequencies ranging between 700 and 2100 cycles/min. and amplitudes of about 5.5 μm are employed.

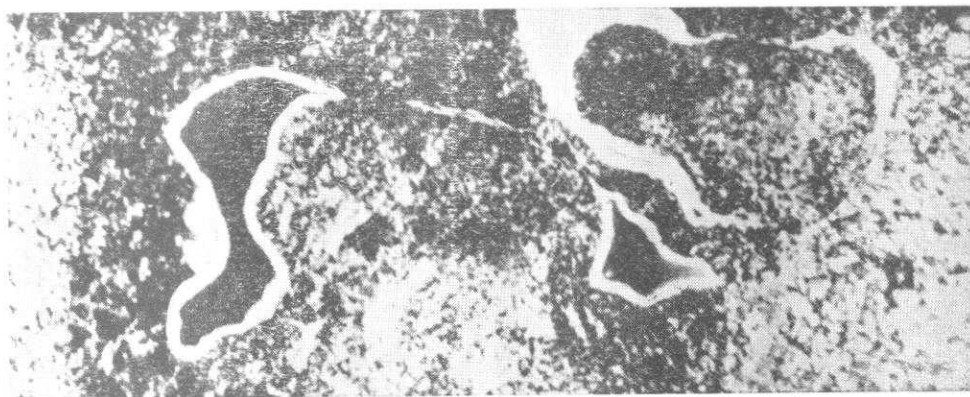
In place of electrolytic alkaline cleaning, electropolishing is recommended a 2 to 4-minute cycle with an anode current density of 20 amp/sq. dm will remove 1.0 to 3.0 μm of zinc alloy. The temperature is maintained between 27° and 32°C and specific gravity

TABLE I An improved copper cyanide strike plating bath for zinc alloys

<i>Bath formulation</i>			
Copper cyanide, g/l	30	to	40
Sodium cyanide, g/l	45	to	80
Free sodium cyanide, g/l	12	to	14
Sodium carbonate, g/l	15	to	75
<i>Operating conditions</i>			
Solution temperature, °C	52	to	55
Cathode current density, amp/sq. dm	3.2	to	6.4
Ultrasonic agitation, watts/l (20 or >20 kc/sec)	2	to	3.3
Plating time, min.	5	or	6
Copper thickness, μm	2.5	to	4

between 1.53 and 1.55.¹ After electropolishing and rinsing, articles should be dipped in 0.5 per cent sulphuric acid solution for 20 to 40 seconds. Ultrasonic agitation of the solution helps in the removal of any oxide smut which may sometimes form on zinc alloy surfaces.

Table I gives the copper strike plating bath which is recommended for complex shapes. The plating rate



2 Copper-filled crevice in the surface layer of a zinc die casting

of the copper cyanide strike is increased by means of ultrasonic agitation which also helps to increase the cathode efficiency from 30 to 60%. Air which is entrapped in deep blind holes is dispersed and porosity is reduced, particularly at low current density areas. The plating time for a satisfactory copper strike must be between 8 and 10 minutes in case ultrasonic agitation is not adopted.

After the copper strike, bright acid copper is recommended for zinc alloys to level polishing scratches, fill any exposed surface pores or cold shuts, eliminate blistering, and round off inside corners in the grooves and other recessed areas with sharp radii which are popular for styling many zinc die castings and extrusions. Brighteners are available for solutions containing about 225 g/l of copper sulphate, 50 g/l sulphuric acid and 80 ppm of chloride ions. These brighteners have good micro-throwing power and are effective. A 12 μm coating can be deposited in 15 to 20 minutes in air-agitated solutions with a cathode current density of 4.3 to 6.5 amp/sq. dm. Fig. 1 shows the levelling obtained with bright acid copper over a rough-polished zinc surface.

Commercial die castings plated with 12 μm of bright acid copper, bright or duplex nickel and chromium hardly ever show blisters after heating to 150°C whereas a lot of blisters appear on castings plated with bright cyanide copper, nickel and chromium. A number of blisters ranging from 10 to 25 appeared on small or medium-sized castings plated with bright cyanide copper. Similar castings plated with bright acid copper showed none or, at the most, 1 or 2 blisters after heating for 30 to 45 minutes at 150 to 175°C.² Bright cyanide copper bridges fissures and pores, but the difficulty is that the solution entrapped in the pores dissolves zinc and produces hydrogen which causes blistering. In the case of bright acid copper, nearly all pores and fissures are filled. Fig. 2 shows the pore filling power of the bright acid copper.

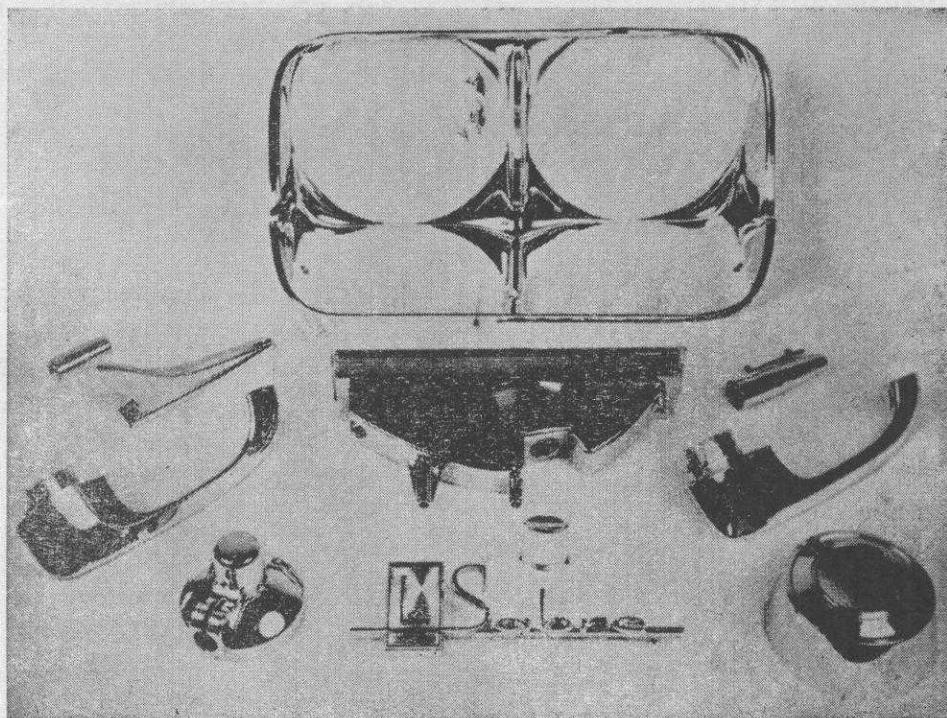
The present day cyanide copper striking procedures present many difficulties.³ The roughness which is started in the strike is magnified with a succeeding cyanide or acid copper plate. The usual free cyanide concentration represents a compromise between a high

TABLE II Composition of the pyrophosphate solution and operating conditions for striking complex shapes

Solution composition	
Tetrapotassium pyrophosphate $\text{K}_4\text{P}_2\text{O}_7 \cdot 3\text{H}_2\text{O}$	254 g/l (34 oz/gal)
Copper pyrophosphate $\text{CuP}_2\text{O}_7 \cdot 3\text{H}_2\text{O}$	28 g/l (3.75 oz/gal)
Potassium citrate $\text{K}_3\text{C}_6\text{H}_5\text{O}_7 \cdot 2\text{H}_2\text{O}$	23 g/l (3 oz/gal)
pH (adjusted with polyphosphoric acid)	8.0 to 8.3
Operating conditions	
Solution temperature	22° to 30°C
Voltage (a)	2 to 3.5 V
Cathode current density	3.2 to 4.3 amp/dm ²
Anode current density	6.0 to 9.5 amp/dm ²
Anodes	High-purity, OFHC copper, bagged
Ultrasonic agitation	3.3 W/l, 20 to 100 kc/sec.
Power input to transducers	25 to 250 W/dm ² of cathode surface
Position of transducers	On opposite sides adjacent to the anodes (b)
Continuous filtration	300 to 550 litres/hr.
Tank and filter material	Type 304 stainless steel
Plating time	3 or 4 min.
Copper thickness	1.2 to 4 μm (0.05 to 0.16 mil)
Cathode efficiency	100 per cent at 3.2 amp/dm ² (94 per cent at 4.3 amp/dm ²)
Anode efficiency	100 per cent at 6 amp/dm ²

(a) Each rack load of die castings was connected to the cathode bar before immersion in the strike solution, while the voltage was adjusted to about 2 V. After immersion, the voltage was raised to about 3.5 V, to adjust the cathode current density to 3.2 or 4.3 amp/dm².

(b) An 800 W transducer (25 cm wide $\times$ 40 cm long) was used on one side of the tank and a 200 W transducer (20 cm wide $\times$ 30 cm long) was used on the other.



3 Vibratory-finished die castings plated with 0.5 mil of levelling acid copper, 1.2 mils of duplex nickel and 0.01 mil of chromium.

level that is helpful for avoiding blistering and roughness and a low level that favours a satisfactory cathode efficiency and plating rate. The anode efficiency is difficult to maintain at a satisfactory level unless the high free cyanide concentration is maintained. Moreover, the use of cyanide solutions requires costly cyanide-decomposition equipment for treating rinse waters and contaminated solutions. In order to overcome these disadvantages, further investigation into new copper striking processes was carried out which led to the development of copper pyrophosphate strike baths. Table II gives typical composition and operating conditions of a pyrophosphate bath which is faster and more effective than copper cyanide strike baths for filling fissures and pores. Anode and cathode efficiencies are approximately 100 per cent when the solution is ultrasonically agitated. Furthermore, the bath exhibits better stability than cyanide strikes. Figs. 3 and 4 illustrate high quality strikes which were deposited using the new plating cycle.

New durable nickel/chromium plating systems for zinc alloys

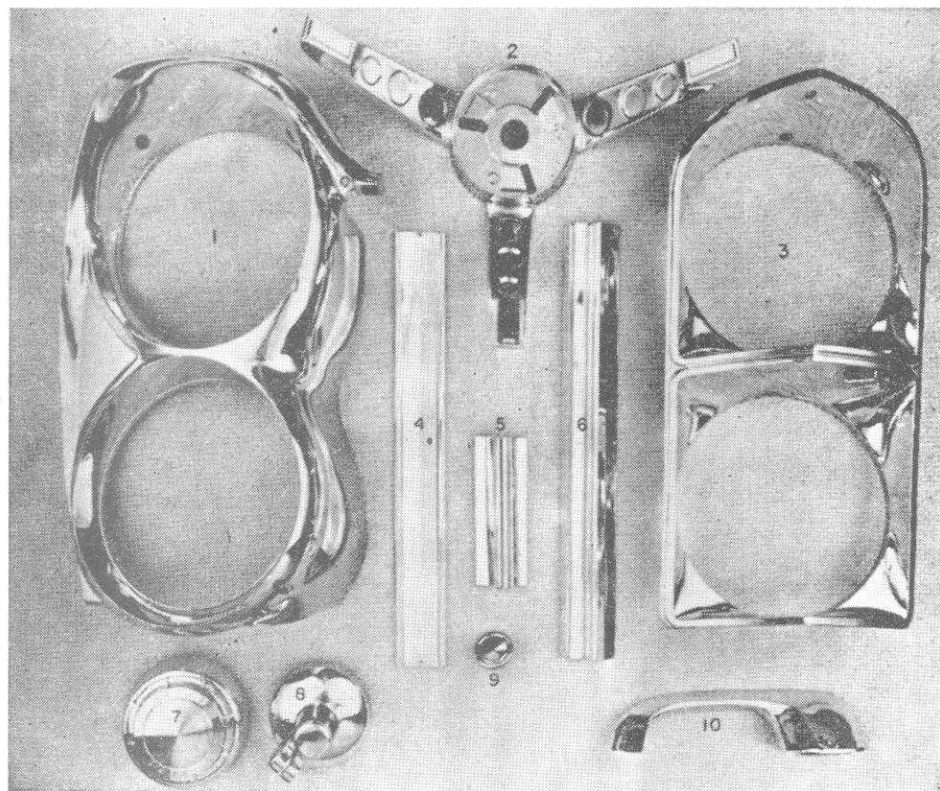
In each of the five exposure programmes initiated by ILZRO at 12 or 18 months intervals since 1962, it has been shown that zinc die castings plated with bright or duplex nickel and microcracked chromium exhibit good resistance to corrosion. Systems incorporating microcracked chromium always proved better than those systems which included duplex nickel and crack-

free, microporous or conventional chromium. Figs. 5 and 6 show the appearance of representative die castings after an exposure for 30 months on a New York Harbour tugboat and a Youngstown, Ohio, truck.

The comparative corrosion endurance at five exposure sites for die castings plated with 15, 22 or 30 μm of duplex nickel and microcracked chromium was studied. The composite including only 15 μm of duplex nickel and microcracked chromium supplied greater protection than one containing 30 μm of duplex nickel and conventional 0.1 mil chromium. The microcracked chromium contained 400 to 800 cracks per linear centimetre in a uniform closed network. Thickness was 0.75 μm . It was plated in two layers in chromic-sulphuric-fluosilicic acid solutions. Selenic acid was added to the second bath.⁴ Chromium containing a large number of microscopic pores coinciding with dispersed insoluble particles integrated in the final layer of bright nickel delayed basis metal corrosion on die castings plated with 2 or 4 layers of nickel. Fine pitting and staining led to dulling of the microporous chromium surfaces. Microcracked chromium resisted pitting and staining for longer periods and was more effective in delaying basis metal corrosion.

On die castings plated with 30 μm of duplex nickel and 0.25 μm of conventional chromium, invisible cathodically precipitated films of hydrated chromium oxide delayed nickel-corrosion pitting and basis metal corrosion. It was noted that such films exhibit an impedance value of 80 to 90 ohm. sq. cm after drying.⁵

Electroplated die castings of over 250 motor cars



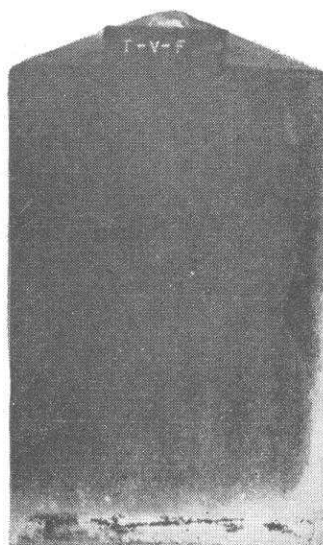
4 Unbuffed die castings and extrusions plated with a copper-pyrophosphate strike, bright acid copper, bright or duplex nickel and chromium, free of blisters after heating 0.5 hour at 150°C



0.01-Mil
Conventional
Chromium

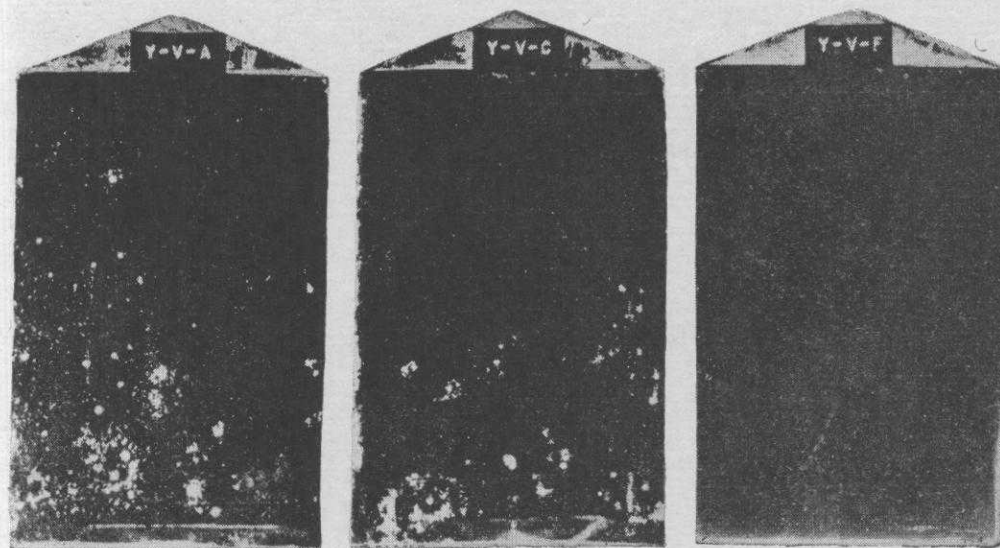


0.01-Mil
Microporous
Chromium



0.03-mil
Microcracked
Chromium

5 Die castings plated with 0.4 mil of copper, 1.2 mils of duplex nickel and chromium after 30 months' exposure on a New York tugboat



0.01-Mil
Conventional
Chromium

0.01-Mil
Microporous
Chromium

0.03-Mil
Microcracked
Chromium

6 Die castings plated with 0.4 mil of copper, 1.2 mils of duplex nickel and chromium after 30 months' exposure on a Youngstown (Ohio) truck

have been inspected each year in Youngstown, Ohio, to check the durability of complex shapes. Data indicated that microcracked chromium over bright nickel with a thickness of 20 μm was much better than conventional chromium over 30 μm of duplex nickel for preserving a satisfactory appearance in the local environment. The door handles were judged satisfactory if their condition corresponded to an ASTM rating number of 7. A lower rating was considered unsatisfactory. It was noted that door handles plated with conventional chromium were more durable on 1961 model cars in comparison with the recent models and this is attributed to:

1. an increasing amount of salt being used for de-icing roads, and
2. an increasing amount of industrial pollution.

However, these factors have little influence on the durability of door handles plated with microcracked chromium.

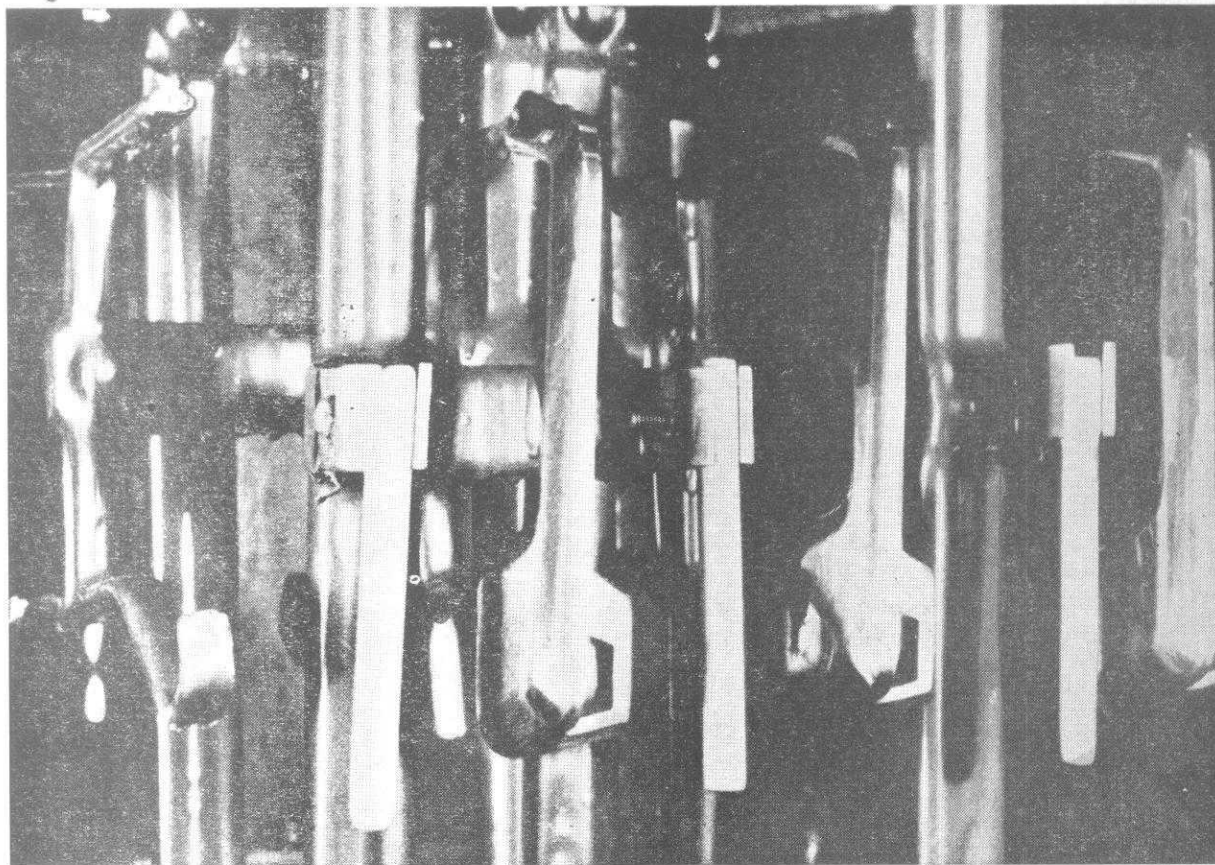
Auxiliary anodes for nickel and chromium plating

A number of practical difficulties are encountered while plating complex die castings with nickel and chromium using the conventional process. Firstly, the thickness of the nickel and chromium coatings varies considerably and secondly, it is seen that recessed areas corrode faster than other areas that receive a greater share of the current. In this context, ILZRO examined the feasibility of using auxiliary anodes at recessed areas and checked the effectiveness of this method by compar-

ing thickness distribution patterns with and without the auxiliaries.⁶ It was seen that on castings such as automobile headlamp housings, the use of auxiliaries inside each lens opening increased the thickness by nearly 300%. Therefore, the plating time was shortened to adjust the minimum thickness to the specified requirements and then the amount of nickel deposited with auxiliaries was compared to that deposited without them. The use of auxiliaries brought about a reduction of 60% in nickel consumption for door handles. The plating time was shortened by 30% and nickel consumption was reduced by 40% with auxiliaries placed near the push-button aperture. A proportionate decrease was obtained in the chromium plating time.

Such encouraging observations on the effectiveness of auxiliary anodes have led to their increasing industrial use. In fact, in the US nearly all suppliers of electroplated automotive die castings have adopted auxiliary nickel anodes for increasing thickness uniformity and production and reducing the consumption of nickel. Some are using them for every shape that is being electroplated. Fig. 7 shows part of a plating rack fitted with auxiliary anodes for upgrading the quality of plated exterior door handles.

The recommended material for these anodes is nickel rod containing about 0.2% carbon and 0.2% silicon. It is the most popular material for auxiliary anodes in use today. Electrolytic deskinning is important for avoiding loose particles that cause shelf roughness. By maintaining the pH of the plating bath between 3.2 and 3.5 and the current between 2.5 and 3.5 amp/sq. dm., the tendency for the formation of loose particles can be reduced. The current directed to the auxiliary ranges



7 Section of a plating rack showing how auxiliary nickel anodes are used for increasing thickness and corrosion resistance in recessed areas near push-button apertures of exterior automotive door handles

from 30 to 40% of the total D.C. power. In another ILZRO research programme conducted sometime ago, the use of lead alloy auxiliary anodes for chloride-free nickel plating baths and chromium solutions appeared feasible. These lead alloy anodes would also be satisfactory for bright acid copper. Nickel that contains sulphur would have to be used for the anodes arranged in rows on the sides of the tanks in order to ensure good corrosion of the regular, soluble anodes in the chloride-free solutions.

Adherence of decorative paint on chromium-plated zinc

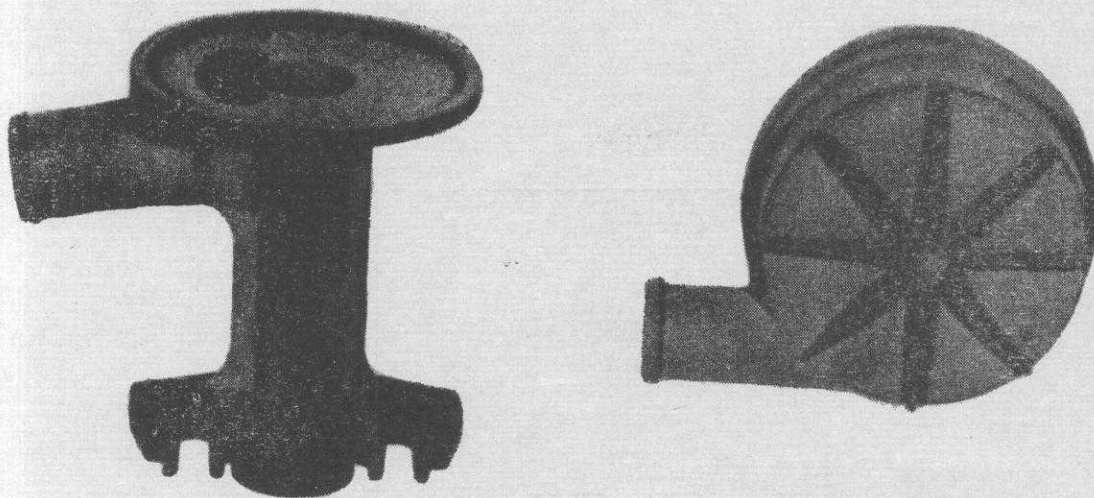
There is poor adherence of paint on chromium surfaces which are contaminated with grease, oil, minerals, alkaline residues and other foreign materials. Another cause for the poor adherence of paint is the rinsing after chromium plating of the die-castings with deionized water containing 20 ppm of dissolved minerals which leave residues. It is, therefore, recommended that rinsing be done with water containing less than 5 ppm of dissolved minerals.⁷ Field work has indicated that these ILZRO recommendations are effective and have produced good results in several plants painting selected areas of chromium plated zinc die-castings for decorative

effects. Surfaces affected by dirt films which are deposited before painting can be cleaned by immersion in hot solution (70° to 75°C) of chromic acid (0.25 to 0.5 g/l). However, it is imperative that greasy dirt films should be cleaned first with hot alkaline solution.

The chromic oxide films precipitated cathodically in sodium dichromate solutions form an excellent base for subsequent paint coatings. The contrast in adherence of an alkyd-base paint on filmed and unfiled, contaminated surfaces after exposure to 75°C detergent solution is illustrated in Fig. 8. It is seen that chromium-plated die-castings, which are filmed before painting, show no trace of poor paint adherence even after 4 years or more of outdoor weathering. The adherence of paint produced by filming in sodium dichromate solutions was better than the adherence obtained by any other method.⁸ The filming cycle can be cut down to mere 20 seconds by increasing the current density to 0.9 amp/sq.dm. in solutions prepared with 50 g/l of sodium dichromate and 1 g/l of chromic sulphate.

Zinc anodizing

The anodizing process brings about a dramatic improve.



8 Anodised zinc die cast pump components for a washing machine; the anodised coating provides added corrosion and abrasion resistance

ment in the corrosion resistance of zinc. However, anodizing should not be thought of as competing with the cheaper chromate conversion coatings which are adequate for many applications. The new technique was developed by the Consolidated Mining and Smelting Co. of Canada Ltd. (Cominco) in a programme sponsored by ILZRO. A family of four anodized finishes now provides zinc with inexpensive quality coatings which exhibit high corrosion resistance and have the added advantage of increased aesthetic appeal. The four colours available are brown, green, grey and dark grey. Anodizing can be applied to wrought or die-cast zinc parts, galvanized zinc or even sprayed zinc. Corrosion resistance under neutral salt spray is excellent. For instance, tests on one of the coatings designated APCF showed an index number of 100, signifying no corrosion after 8 days of exposure to the ASTM 5% NaCl salt fog test.

It must be emphasized that anodizing of zinc is different from anodizing of aluminium. Zinc anodizing produces a film of the barrier layer type, a porous structure overlying the initial barrier-layer.⁹ This is in contrast with the simple oxide layer formed during the anodizing of aluminium. In zinc anodizing, a complex fritted compound of fused particles is formed by anodic spark discharging beginning at about 65 to 70 volts. The coating is hard, porous, absorbent and has excellent masking properties. It is thicker, harder and more corrosion resistant than zinc chromate or phosphate conversion coatings. Because of the porous nature of the coating, the anodized film is very receptive to paint, enamels, lacquers, protective oils and waxes. Generally, however, further treatments are not necessary because anodizing restricts moisture penetration and prevents under-film corrosion.

A brief description of the various aspects of the anodizing process is given below :

Electrolyte

100 gallons (US) of the electrolyte contains the following :

24.5 gallons of 28% NH_4OH
50 lbs CrO_3
6.8 gallons (96 lbs) of 85% H_3PO_4
15.3 lbs NH_4F
plus distilled or deionized water

Some applications may require fluorine added as HF. Bath elements are depleted during continued operation and must be replenished periodically. Ammonia is used up at a more rapid rate than the other elements as it is consumed and vaporized during coating formation. The pH value serves as a guide to ammonia content and must be kept in a range of 6.8 to 7 by adding NH_4OH as it evaporates.

Power requirements

The power source must be capable of supplying the required amperage over a 0 to 200 volt range (AC or DC). A practical anodic current density is 10.8–13.4 amp/sq. dm. A typical cell might handle 93–186 sq. dm. and require 100–200 KVA. During anodizing, the current must be kept constant over the entire voltage range applied.

The anodizing cell

The cell tank can be of steel, stainless steel or any other material commonly used in plating. A neoprene liner is recommended in a small tank. As anodizing occurs at elevated temperatures and generates ammonia and water vapours, ducts should be installed to remove these fumes

from the tank. Racks can be made from aluminium alloys. Any aluminium immersed in the bath is coated, but it can be easily removed to provide electrical contact for subsequent cycles. Provision should be made for heating and cooling the electrolyte to maintain a temperature of 65°-90°C in the bath.

Operating procedure

1. Clean the work pieces of dirt, grease and oil. Trim parting line flash from the die castings and remove chips from drilling or tapping operations. Buffing and polishing are not necessary.
2. With power off, mount the work pieces on cell racks and ensure that gas which is formed during anodizing can flow easily out of the recesses.
3. Start process with electrolyte in the 65-80°C range.
4. Apply constant current until the voltage rises to the desired terminal value.
5. Shut off current and rinse parts in distilled or deionized water to remove the electrolyte.
6. Rinse again in tap water, paying particular attention to holes and crevices.
7. Allow parts to dry. Unrack.

During these operations, a grey-green precipitate of ZnNH_4PO_4 is formed which settles to the bottom of the tank. This precipitate should be removed by filtration or by sucking sludge from the tank during down time. Table III gives the operating parameters for producing coatings in the four different colours :

TABLE III Operating parameters for zinc anodizing

	Green (APCF)	Light grey (SSC)	Dark grey (SSCV)	Brown (SSC Mn)
Voltage, V	200	105	90	105
Current, amp/ sq. dm.	13.4-16.1	13.4-16.1	13.4-16.1	13.4-16.1
Temperature, °C	60	60	80	70
Processing time, min.	7	9	10	8
Coating thick- ness, mil	1.25	1.6	1.6	1.5

ILZRO has conducted a number of field trials to study the various properties of the anodized coatings and has come up with the following observations.

Corrosion resistance

The corrosion resistance is very good for neutral solutions and where acids or alkalies may be anticipated, the coating can be effectively sealed either by means

of a hot sodium silicate solution or with paints. Anodized coatings applied on zinc die-castings by ILZRO-developed procedures provided excellent corrosion protection during 30 or 48 months of exposure at all the six sites adopted for Battelle's Exposure Programme VI. The SCC and APCF anodized coatings afforded better corrosion endurance than that of electroplated systems. There was no significant change in the appearance of anodized specimens exposed on a Detroit roof top and Wilmington, North Carolina, trucks. Slight outer surface pitting and spalling were noted on some of the APCF and SSC-system panels exposed on Detroit and Youngstown trucks. Tugboat specimens indicated some pitting, pinpoint corrosion and basis-metal stain after 30 months of exposure. On the tugboats, the SSC coating provided greater protection than the APCF coating.

Impact resistance

Impact resistance is good, provided that the deformation of the basis metal is not too severe. A 1" dia. steel ball weighing 65 g. dropped from a height of 6' does not cause flaking of the coating if the basis metal is not so thin as to deform drastically. Tests, including road testing under the front bumper by one of the leading automobile manufacturers, have shown outstanding resistance of anodized coatings to gravel damage and to road salt.

Wear resistance

Development work has been carried out on the use of anodized zinc for automobile generator pulleys. It was observed that while hard chromium plated zinc pulleys ran 10 000 miles, anodized pulleys ran 40 000 miles before any significant wear became evident. The two surfaces showed essentially the same co-efficient of friction.

Zinc anodizing should be considered wherever the use of zinc castings is not recommended because of corrosion problems, and in those cases where an improvement in the corrosion resistance is sought. Some of the common items which are ideal for anodizing are pump housings, carburettor components, parts for door mechanism and wind shield wipers. Fig. 8 shows some anodized washing machine pump components.

Clear, colourless coatings for zinc alloys

Freshly polished zinc die castings have a pleasing appearance with high lustre, but with the passage of time atmospheric oxidation causes tarnishing. The die-castings finally take on a matt-grey colour which is unsuitable for decorative applications. It is, therefore, normal practice to plate zinc die-castings used in decorative applications with bright nickel and chromium. Recently, however, research has led to the development of clear lacquers which help preserve the lustre of polished zinc and thereby eliminate the plating operation. Research was conducted by DeBell and

Richardson, Inc. under the sponsorship of ILZRO, which led to the development of clear colourless lacquers that help preserve the lustre of polished zinc. The objective of the ILZRO programme was to provide clear castings for polished zinc die castings to permit a five-year life in automotive use. An initial exploratory test in 1963 screened ten primers and 23 topcoats by accelerated ultraviolet, salt and humid aging, and showed maximum promises for a system composed of soyabean oil-modified epoxy resin ester primer covered by a thermosetting acrylic topcoat containing 2% benzotriazole ultraviolet light absorber to protect the epoxy resin underneath and this coating system compared very favourably in appearance with the chromium-plated panels employed as controls. In this series of tests, however, none of the coatings was able to match the high reflectivity of the chromium-plated samples. A more extended study was undertaken in 1964 to improve the reflectivity and explore the full range of useful epoxy primers, acrylic topcoats and ultraviolet light absorbers. These coatings were also subjected to a greater range of aging conditions up to long term normal outdoor weathering.

The results of the second study indicated that a thermoplastic acrylic resin solution, applied over the same primer as used in the first test and employing the same or similar ultraviolet light absorbers, performed at least as well and perhaps slightly better than the thermosetting acrylic coatings which produced the best results in the first study. However, there was one difficulty in the second series of coatings developed. Accelerated aging caused slightly greater loss of reflectivity in the coated panels than in the plated panels with the exception of one chromium plated control part, when exposed to salt water. The results of the second study show that in an optimum cleaning procedure zinc products should be polished with a water-based spray buffing compound, cleaned in boiling 1:1:1 trichloroethane vapour and dried for 5 minutes at 120°C.

Based on the various studies carried out in the field of clear, colourless coatings for zinc alloys, ILZRO has come up with a new product known as ILZROLAC 1540 (clear coating for polished brushed zinc). This is a clear thermosetting acrylic finish for the protection of polished or brushed zinc surfaces for exterior and interior applications with the following features.

1. It protects polished or brushed surfaces against abrasion and corrosive chemicals and gases.
2. It enhances the appearance of the component.
3. It is good for both exterior and interior use.
4. It is inexpensive and easy to apply.

The product specifications are :

Type	Thermosetting acrylic
Solids	30%
Viscosity	17 to 20 sec. No. 2 Zahn Cup
Spray reduction	Stanley 79X-392 thinner as required
Film thickness	0.6 to 0.7 mils per coat
Optimum curing	20 minutes at 162°C
Clean up thinner	Xylol, toluol, ketones or lacquer thinner

The technical characteristics of ILZROLAC 1540 are :

Pencil hardness	4H
Impact (direct)	No failure at 28 in-lbs
Taber abrasion	19.8 (mg. weight loss)
Colour	Waterwhite
Reflections	0.471

ILZROLAC 1540 and its electrostatic spray counterpart ILZROLAC 1640 are being marketed by Stanley Chemical, a Division of The Stanley Work, East Berlin, Connecticut 06023.

Conclusion

The preceding paragraphs have surveyed the major landmarks in ILZRO research in the field of finishes for zinc alloys. Some of the processes described have already been adopted industrially for reducing costs and/or improving quality and others will soon follow suit. Of course, further research is being continued and newer and better processes will be available in due course. Improvements in the finishing of zinc alloys have been effected at a faster pace in recent years in comparison with the developments announced for competitive materials. With this fast rate of development, it can be fairly well expected that zinc alloys will be put to increasing usage.

References

1. Bride, J. E. : U. S. Patent 3 202 589, August 24, 1965, to Diamond Alkali Company.
2. Safranek, W. H. : Preparation of Zinc Die Castings for Plating, Soc. Die Casting Engineers, Paper No. 605, November, 1966.
3. Safranek, W. H. and Miller, H. R. : Copper Plating on Zinc Die Castings, *Plating*, **55**, 233-37, March, 1968.
4. Safranek, W. H. and Miller, H. R. : Advances in Electroplating Decorative, Microcracked Chromium, *Plating*, **51**, 543-50, June, 1964.
5. Safranek, W. H. and Miller, H. R. : The Durability of Chromium Plated Zinc Die Castings and Supplementary Surface Films, *Plating*, **52**, 873-8, September, 1965.
6. Safranek, W. H. : Research Developments on Electroplating Zinc Die Castings, Soc. Die Casting Engineers, Paper No. 43, November, 1964.
7. Safranek, W. H. : Adherence of Paint on Chromium Plated Zinc Die Castings, Soc. Automotive Engineers, Paper No. 668C, March, 1963.
8. Garwood, W. S. : Paint Adhesion to Decorative Trim, *Plating*, **53**, 1923-30, November, 1966.
9. Radtke, S. F. : New Anodized Coating for Zinc, *Precision Metal Moulding*, **23**, 45-53, April, 1965.