Replacement of nickel in electroplating processes and surface strengthening of aluminium by laser treatment

Nickel is a predominantly used metal in electroplating applications. It has an exceptionally good corrosion resistance besides possessing a pleasing appearance when plated with suitable brighteners. Nickel plate with or without an underlying coating of copper is one of the oldest protective–decorative electrodeposited metallic coatings for steel. Usually, this is followed by a chromium top coat which is remarkably good in protecting against corrosion of an assortment of materials ranging from automobile parts to household appliances. It is, therefore, as an intermediate coating that nickel finds very wide application. Since nickel can be easily applied and is relatively inexpensive besides being amenable to mechanical polishing and brightening, it has gained wide acceptance. What, however, tends to be overlooked is the fact that nickel compounds used in the electroplating industry are carcinogenic and nickel causes skin allergy. Nickel is used in various articles such as cutlery, watch straps, eye glasses, coins, costume jewellery, etc. The usage of these materials in everyday life has increased the risk of nickel cancer. This has resulted in the electroplating industry looking for an alternative metal or alloy for the intermediate-layer coating. However, in purely functional applications such as in anti-corrosion undercoat, nickel is still the best bet and may not find an effective replacement in the near future. Another important application is in gold plating, where nickel is used as a barrier coating to prevent the diffusion of copper and copper-based alloy materials needing gold plating. Nickel is also used as an alloying element in gold to improve the abrasion resistance. It is indeed difficult to find a suitable alternative to this versatile coating material. The paper on 'Alternatives for nickel in electroplating processes' by Simon[1] in the November 1994 issue of *Plating and Surface Finishing* addresses these issues and explores the possibility of utilizing several alternatives to nickel.

One of the alternatives suggested for nickel is bronze. This alloy of copper and tin in different proportions has remarkable properties which make it an attractive alternative to nickel. Firstly, bronze has good corrosion resistance properties, as shown by the salt spray test. It has a superior hardness *vis-à-vis* nickel (400–550 VHN as compared to 300 VHN for nickel). Besides, bronze does not cause skin allergy, a major drawback associated with nickel. It can be used in applications requiring better solderability, brightness and wear resistance and diamagnetic properties. It also has bactericidal properties, which may be advantageous when used in door handles in hospitals.

Bronze plating can be used on builders' hardware, locks and hinges. Good corrosion resistance of white bronze (containing higher – about 40% tin) makes it extremely suitable as an anti-corrosion coating. Bronze has also a superior throwing power compared to nickel during electrodeposition. This, however, is not without a price Bronze plating is carried out in cyanide baths and the problems associated with effluent treatment, etc., may have to be considered.

Palladium is considered as a potential alternative to nickel in costume jewellery for its bright and brilliant appearance. In fact, palladium is always cited as a replacement for costlier gold in the electronics industry. As a diffusion barrier coating for the final gold, an intermediate layer thickness of 0.3–0.7 μm of palladium is found to be sufficient. Palladium-chloride-based solution with suitable additives is recommended for electroplating

To sum up, bronze and palladium are effective alternatives for nickel. From the point of view of cost, however, the less expensive bronze scores over. As an underlayer for gold, palladium is superior.

Nickel-containing gold alloys usually contain 0.5–4% nickel. For decorative applications, nickel as an alloying element must be avoided. Nickel-free gold alloying processes are available such as gold with various metals such as indium, tin, silver, copper, cobalt and palladium. The colours depend on the alloying elements and their composition. Gold with iron as an alloying element has been suggested in this work Deposits of gold containing 1 4 and 1.7% iron have a good tarnish resistance and hardness. Deposits containing 1.4–1.7% iron are obtained by electrodeposition. Magnetic susceptibility measurements and X-ray emission spectroscopy showed homogeneous distribution of iron within the lattice. Corrosion test results showed that gold–iron alloy deposition is as good as gold–nickel–indium alloy deposition The deposit has a similar wear characteristic as that of gold–nickel–indium. The gold–iron alloy deposit can also replace nickel-containing gilding solutions without compromising on the colour quality Iron is also physiologically nonallergenic, unlike nickel

Another interesting paper[2] is on laser surface treatment of aluminium 6061 alloy with injection of SiC particles. The method is based on the surface strengthening of these alloys by melting using a high-powered laser. In this technique, carbide particles such as SiC, TiC, WC are used in combination with binding materials like Co, Al, Ni. In the injection technique the powdery material is carried through a nozzle with an inert carrier gas to a surface irradiated with a laser beam, which induces rapid cooling of the melted areas and consequent solidification. This forms a surface composite material comprising undissolved carbide dispersed in an alloy of aluminium and the dissolved carbide. After the laser surface treatment, the alloy is subjected to the usual hardening heat treatment. In this particular study carried out by the authors, the laser used was 3.4 kW continuous carbon dioxide laser. The injection material was SiC powder of average grain size 45 μm. This resulted in a laser-treated zone of about 400 μm, with the upper part strongly alloyed with SiC particles while in the lower portion the SiC showed only mechanical adhesion without dissolution. The upper part showed a fine microstructure with varied morphology. There is about tenfold

increase in surface microhardness and wear resistance after laser surface treatment. The technique is relatively recent and promises to possess a large number of applications.

1 Franz Simon, *Plating and Surface Finishing*, November 1994, p 16
2 Pantelis, D, Giannetaki, E, Chryssoulakis, Y and Ponthiaux, P, *Plating and Surface Finishing*, November 1994, p 52

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OPINION

Dynamics of the psychology of the Ph D students and the question of what to do with them

V. Sitaramam

We have a reasonably sized work-force of research scholars in the country, who spend anywhere from 4–8 years in search of a doctorate. Nearly all the research in the country, good, bad or indifferent, is carried out by them. Many go abroad while some remain behind or even return These are the main takers of whatever jobs that are available. Since the time span they spend on an average is nearly the same or more than a professional student does, the suggestion is that we impart some breadth into their programmes This requires a critical view of what is currently going wrong. Useful statistics are hard to come by, though much is known by experience. This note is a plea that we should understand this species, the doctoral student and his/her dynamics (more of the lack of it). Since the overall scenario of science in the country is far less than satisfactory, if not dismal, we need to do something about this critical group of captive students, in our own interest of jobs that need to be managed. Can we actually use it in a more efficient manner? *We have to shift our focus in planning to our average performer rather than to the desirable performer, if our plans and the reality have anything to do with each other*

What to do with higher education and research in India is a point of considerable discussion these days. Is it possible to reduce the problems of higher education to a simpler theme and keep hammering at it in the hope that something useful happens? The Ph D student is the pivot, the focal point, the basic workhorse, the cannon fodder..., or whatever, of the research life in India as elsewhere. The entire higher learning has this milestone, the doctoral degree,

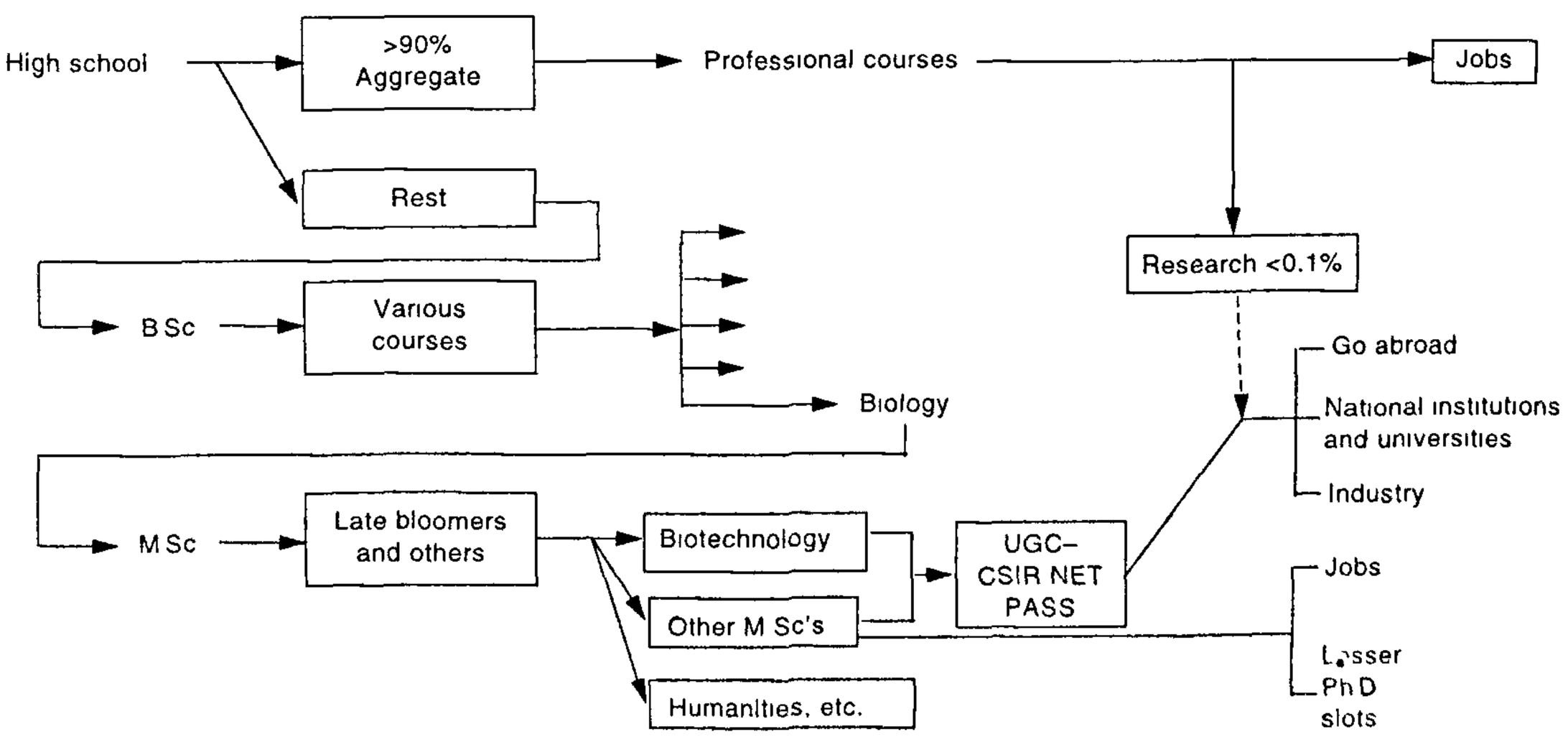

Figure 1. Flowchart of students.