The Moulding of ABS (acrylonitrile butadiene styrene) terpolymer and its blend with Polycarbonate prior to Electroless and Electroplating

Styrene is a thermoplastic which has an acrylonitrile-styrene matrix with butadiene rubber uniformly distributed in this matrix making it unique for plating operations,
Plating plastics involves the following steps:

Moulding
Pretreatment
Electroplating

Moulding

There are a number of design requirements for successful moulding

- Integral parts should be used to avoid welded or glued joints.
- Gates should be put in non-appearance areas.
- Ribs and Bosses should be designed to eliminate 'sink' marks.
- Texturing can be used to break up large flat surfaces and hide any defects such as scratches.
- Draft angles should be at least 1° for easy removal from mould.
- Parting lines should be put in non-significant areas if possible.
- "Close tolerance fits" must include the final plate thickness in the part design.
- Wall thickness should be as thick as possible for rigidity.
- Plate uniformity-which is a result of high and low current densities must be considered in the initial design. The design should exclude
    - V grooves,
    - 90° angles
    - Letters should be kept close to surface and
    - Angles should be as large as possible
    - Large flat planes should be crowned.

Consideration should also be given to drainage holes, rack contact areas and rigidity

Hot runner systems are best, otherwise runner systems should be fully round, polished, max radii where possible with generous gates.

Moulding Operational Parameters

Proper drying of resin - moisture in the resin can cause "splay" or de-lamination on the part that may result in a blister.

Drying times for plastic powders; ABS and ABS/PC
Certain plastic materials in a finely divided form, i.e. prior to moulding, attract substantial amounts of water from the atmosphere. If this absorbed moisture is allowed to enter the moulding machine, it will form gas (steam) voids in the molten plastic and subsequently in the components produced. On plating, any voids near to the surface will produce blisters or other serious visual defects.
ABS is particularly subject to water absorption and should be dried for The recommended minimum drying time for ABS plastic is 4 hours at 190°F to 200°F (90° to 95°C)
PC/ABS - The recommended minimum drying time for PC/ABS plastic is 4 hours at 200°F to 220°F (95° to 105 °C) and then transferred to the moulding machine.

The feed hopper on the machine should be covered and preferably also fitted with a warm air dryer to ensure that the material remains dry as moulding continues.

Injection rate
The slower the rate of injection, the better will be the adhesion and general performance of the plated deposit.
Actual injection times of five seconds for smaller components, and up to twenty-five seconds for larger components produce the best results.

Injection pressure
The lowest injection pressure that will fill the mould without producing faults such as 'short shot', 'sinkage', 'weld lines', etc. should be used.
Although the injection pressure and secondary pressure do not have as pronounced an effect as melt temperature and injection time, they should be kept as low as possible to minimise residual stress in the moulding.

Tool temperature (mould temperature)
In order to produce consistent results, it is necessary to control the temperature of the moulding tool. This should be maintained preferably as high as possible or at least within the range of 65-80°C.

Inter-relation of moulding parameters
If one moulding parameter, such as injection rate, is varied then a direct or indirect change will occur in all the parameters as each is related in some way to the other.
It is important, therefore, to establish a workable set of conditions for a particular component and then to adhere strictly to these conditions for every production run, otherwise quite substantial changes in plating performance can result from batch to batch.
Due to the design of the components or to certain tool features, compromises on the recommended conditions may be necessary in order to produce dimensionally acceptable mouldings, and, although acceptable performance may still be achieved after plating, there will be a detraction from the ultimate performance. Many of these compromises can be avoided, however, by good design of tools and components in the first instance.

Care of the moulding tool
Moulds should be kept highly polished for the best decorative finish.
Mould release agents, particularly of the silicone types, should not be used, as they cause plating defects.

Care of moulded components
Dry Storage conditions are essential
Due to the relative ease with which the high gloss finish of unplated plastics can be damaged, components should be handled with soft gloves and carefully packed with individual wrappings where possible.
Gloves should be used for all handling operations prior to etching in order to minimise soiling and finger printing of the surface that is particularly likely to occur during the racking operation.

Quality Control of Mouldings
It cannot be over emphasised that the success of plating on plastics depends to a large extent on the quality of the mouldings presented for plating; some defects may be quite obvious, such as gross surface imperfections, lack of gloss, warpage, stringing etc. However, many defects are not obvious; moulded in strain, entrapped in water and micro-pits are some of the more troublesome, less obvious, defects. A number of tests have been devised which give some idea of moulding quality prior to plating, but by far the most satisfactory way is to plate a pre-production batch of samples produced under the proposed conditions. Any defects arising at this stage will be readily attributable to a particular cause.
The following tests may give an indication of faults in mouldings prior to plating.

Proper mould temperature - a too cold a mould will cause the plastic to "skin", that is, the first material to hit the mould wall hardens and the hot material under it flows creating surface skin effect that may cause de-lamination.

Proper melt temperature - too cold a melting temperature causes internal stress to increase and become incorporated in the part leading to uneven etch and thermal cycling test failure A too hot a melt may cause the material to degrade and thus give poor adhesion
Melt Temperature should be maintained at 1-2 deg C below heat degradation temperature

Proper fill speed - too short a fill speed can overpack a mould thus making it harder to etch and leading to **poor adhesion**. The best results are obtained using a slow fill speed.

Highly polished mould - poor mould surfaces can cause defects in the moulded part, such as pits. These show up in the final plate and cause rejects.

General Moulding Faults & Causes

Internal Stress/poor adhesion

Incorrect moulding practice can cause high internal stress, which can seriously affect the moulded component during plating causing poor adhesion or absence of coating.
Most plastics can be checked for the presence of internal stress prior to plating.
ABS, for example, can be checked for moulding defects by immersion in Glacial Acetic Acid for 1 to 2 min, (ABS/PC 3-5 min) rinsed and dried.
Peeling of the plastic surface indicates, "skinning" or de-lamination, whereas a bright area will indicate a stressed area that will etch differently than the rest of the part leading to adhesion and thermal cycle test failures. Cracks or actual breakage indicate a highly stressed material Plastics in this condition should not be processed
Tool design itself is as critical as the process temperature; the 'A' face of the part needs to be as stress free as possible. Use as large a 'gate' as possible, which combined with the higher tool temperature, allows the plastic to flow freer. **Avoid** high holding pressure and long holding times; it should be enough to fill but not to over pack the tool creating a hard skin.

Flow / Knit lines; to reduce or eliminate flow / knit lines the process temperature generally needs to be in the region of 140° to 190°F (60 – 90° C)

Mica / micro / splash / silvering / fish eyes; The most common cause of this is moisture (see drying times above) but other characteristics that can create this are; lack of back pressure, too long a 'residence' time in the barrel, 'cold spots' in the barrel and runner design [not too many changes of direction (bends / corners) or too small an orifice], 'suck back' can introduce air into the moulding, this too can cause mica/silvering.

Material change over; Ensure that all residues of other materials are fully purged from the barrel, screw, hopper etc. as this too can cause Mica or stress

Hard spots; can be caused by **'gate debris'**, residue materials, **'gas trappage'** (especially on polished faces where no **venting** is adjacent to the area). A tool-cleaning programme may relieve some of these problems; which may necessitate disposing of the first few shots after cleaning.

Flash; Though sometimes acceptable, on mouldings not intended for plating, flash is to be avoided as the plating process will turn the flash into a razor sharp shard or edge or propagate nickel burn, sharp corners should be avoided for the same reasons.

Sink marks; However slight they may appear in the virgin moulding are magnified many fold by the shine of the Chromed surface finish, avoid sudden changes in material thickness or thick walled bosses on the 'back face' or long ribs.

Mould Release & Fillers

Silicone- type mould releases should not be used. These compounds are extremely difficult to remove and usually lead to adhesion failures (blisters) or skip plate
Silicones interfere with the function of the etching process (Moulders of plastics for plating do not generally use mould release chemicals). If it is necessary to use a mould release, then a stearate or soap type material should be used sparingly.
In some cases, fillers are added to plastics for increasing strength (glass), making the material fire retardant (Sb_2O_3, Organic Phosphates) or to impart colour (carbon black, TiO_2).
These can cause problems in plating.
For example, glass will usually give a rough surface to the finished part.
Some fire retardants can diffuse to the surface during etching leaving a film that is difficult to wash off and cause adhesion failures. If this non-adherent layer can be removed after etching, good results can be obtained.
Other fillers used, such as Talc (Mg SiO2) are added for promoting adhesion in difficult plastics.
These fillers are preferentially etched out of the surface to create the bonding sites required for good adhesion. Large particles create poor surface appearance.
Usually in a situation of this type, a happy medium is achieved where adhesion is adequate and the part looks acceptable.

The adoption of correct moulding conditions is one of the most important steps towards ensuring satisfactory performance of plastic components after plating.
This is particularly true when the plastic material is ABS and the following information relates specifically to this particular polymer, although the general principles hold for most other plastic materials, e.g. polypropylene.

Selection of moulding machine and moulding conditions for plated parts

The type and size of moulding machine used will determine whether the required moulding parameters can be achieved and maintained.
Only pre-plasticising machines, such as the screw types, should be used and the single screw injector generally gives excellent results.

This is largely due to the more rapid plasticising and mixing action that ensures that the molten material is homogeneous and that excessive external heating is avoided.
The size of machine, i.e. its total shot weight, also has a large influence on the quality of the mouldings produced for plating purposes.

The total shot capacity should be no greater than three times the weight of the moulding (with runners) being produced. The optimum ratio of total shot capacity to actual shot weight is 1.5:1.
When the above ratios are achieved the maximum control can be exercised over the moulding conditions, and the retention time of the molten plastic in the barrel of the machine is kept to a minimum. This ensures that the minimum of degradation of the polymer occurs during moulding.
When the component has a large projected area in relation to its weight, e.g. thin flat plates, the higher clamping pressures required may exclude the use of smaller machines, or the tool size may be physically very large and a larger machine would be required.
In cases of this type a smaller barrel should be fitted to the machine to restore the proper ratio of shot capacity to actual shot weight.

Stock temperature (melt temperature)
Adhesion between a plated deposit and ABS increases with increase in stock temperature.
When the stock temperature at the nozzle area of the machine is between 250°C and 270°C mouldings of lower residual stress and superior plating performance are produced.
Melt Temperature should be maintained at 1-2 deg C below heat degradation temperature

Tests for Moulded Parts

Acetic acid test (for stress)

Sometimes an immersion of the component into glacial acetic acid is an indicative test. The part is immersed for 1-3 min (ABS/PC may require longer) at room temperature. The part is fully dried and examined. Areas of greatest stress show as a shiny surface (i.e. not etched). This gives a guide to flow marks and the distribution of stress in the moulding. This is only used as a guide.

Some plateable grades of ABS & ABS/PC

Recommended materials;

ABS materials:
Chi Mai Polylac© PA 727
GE Cycolac© S705,
Bayer Novadur© P2MC in plating grade ABS

PC/ABS materials:
Where the Polycarbonate is not greater than 45%
Bayer Bayblend© T45 **[Not T65 or T85]**