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STUDY OF BENDING PROPERTY OF DOME METAL STICKERS

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Abstract:
Modern customer demands unique printed products. Metal stickers is the prime choice in this context. Metal stickers are the allied branch of printing. These are used for branding of premium products like automobile, ornaments, electronics appliances etc. Due to the facts that, these types of metal stickers are of limited use on hard plane surface. The paper or like similar surface, these metal stickers are very rarely. Due to least flexibility of metal, it is avoided on paper like surface. This research work was carried out to explore the bending test on metal stickers and dome metal stickers for such applications. It has been found that dome material provides protection and enhance durability to the metal stickers.

Keywords: Electroplating, Metal stickers, domed metal sticker, folding endurance test, epoxy resin.

1. Introduction:

Printing is the process of reproducing text images, or any object typically using ink on paper, through various methods and technologies to create multiple copies of documents, publications, and other materials. This process may involve traditional methods like letterpress and offset printing or modern techniques such as digital for catering to diverse needs ranging from mass production to customised, on-demand print jobs.

Figure 1. Metal Stickers

Dome stickers and Metal stickers are unique applications of printing products. Metal stickers are strong, premium stickers made of either metal or materials like metal as shown in figure 1. These are sometimes referred to as metal labels or metal decals. The goal of these stickers is to provide a unique appearance. It gives a high-end surface to various products, a polished finish, and is utilised for branding, identifying, and ornamental purposes.

Metal stickers are produced using the electroplating technique (figure 2). In this process, electrolytic solution plays a very important role. The particle dissolved in the electrolytic solution gets concentrated to the cathode end and deposition of metal occurs. In this process, the following equipment's are needed like: Polyvinyl Chloride (PVC) Tank, Rectifier, Heater, Temperature Controller, Nickel Sulphate Sodium, Nickel Basket, and Water filter.

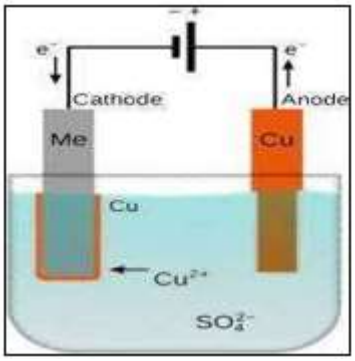


Figure 2. The basic concept of Electroplating

Dome stickers, also known as domed labels or domed decals, are a specific type of sticker that forms a clear, three-dimensional (3D) dome shape over a printed surface using polyurethane or epoxy resin coating. This dome gives the sticker a distinctive appearance and extra protection by producing a raised, glossy, bubble-like appearance (figure 3).

Figure 3. Dome Sticker

Dome stickers are commonly utilized in branding, logo design, vehicle emblems, dashboard decals, auto accessories, device labels, control panels, household appliances, retail, product packaging, and other related applications. Vinyl sheets are generally used to create dome stickers.
In this research, the application of dome was explored on metal stickers for its wide utility.

2. Review of Literature:

Luigi Brugnatelli, an Italian scientist, was the pioneer electroplater in 1805. The first law of electro deposition by Faraday amount of energy flowing through the plating bath directly correlates with the amount of chemical change caused by the current. The second law of electro deposition, by Faraday, different metals deposited or dissolved in the same amount of electricity have weights proportionate to their chemical equivalents (Nebiolo et al, 2022). Contemporary multi-layered nickel coatings can prevent corrosion on a long-term basis on steel, zinc, copper, aluminium, and many other materials when combined with micro discontinuous chromium (Di Bari et al., 2011).

An additional extremely popular galvanic procedure is nickel plating. Its glossy deposit makes it a popular choice for jewellery, accessories, finishing touches, and intermediate layers. An additional extremely popular galvanic procedure is nickel plating. Its glossy deposit makes it a popular choice for jewellery, accessories, finishing touches, and intermediate layers. (Giurlani et al., 2018). The thickness of copper and nickel depends on the electrolysis time. As the current density increases, the Cu and Ni thickness increases (Bazzaoui et al., 2012). The epoxy resin is a thermosetting polymer that is widely used in a variety of industrial applications due to its exceptional mechanical, chemical, adhesion, and electrical resistance (Yuan et al., 2024). The reaction products of bisphenol A and epichlorohydrin were the first epoxy resins to be marketed, and this is still the main method for making the majority of the resins produced today (Iverson & Dervan, 1993).

To create better surface coatings, Greenlee, who worked for Devoe and Raynolds, created resins that resembled those of Castan but had a little higher molecular weight. When compared to alkyd or phenolic

resins, the epoxy coatings created by Greenlee provided better adhesion, hardness, inertness, and temperature resistance (Iverson & Dervan, 1993). Theories of adhesion explains the phenomena of adhesion and four primary theories have been proposed namely mechanical interlocking; electrostatics; diffusion; and the adsorption theory (Iverson & Dervan, 1993). The epoxy resins within sub- nanometre distance from the surfaces with different chemistries exhibit distinct amine-to-epoxy ratios, cross-linked network structures, and adhesion energies (Miyata et al., 2024).

3. Research Problem:

Ink is usually transferred onto paper or other similar surfaces during printing. Printed products can be made by various printing process, such as pad printing, 3D printing, die cutting, direct transfer, domed stickers, etc. Domed sticker are the unique product of printing industry. Paper or vinyl are examples of materials that are combined with printed substances to make dome stickers. A distinctive touch is added by the dome material's modest exposure to metal. Experiments and research on metal sticker is the need of hour to increase the adoption in the ever-changing world of technology. For better output optimization, one of the key properties—the bending test of domed metal sticker's needs to be investigated.

4. Research Objective:

Generally, vinyl domed stickers are used in branding and other applications. Metal stickers are getting popular due to its attractive and premium appearance. Dome is rarely used with metal stickers. The objective of this study was to explore:

i. The feasibility of application of dome material on metal stickers.
ii. The bending test of domed metal stickers for optimization.

5. Research Methodology:

To execute this research, a text chart was prepared using CorelDraw software. The test chart contained horizontal strips of various thicknesses as shown in figure 4. The final test chart was developed by an electroplating process. This developed metal sticker was used for evaluating the bending test on domed metal stickers.

Figure 4. Test chart

5.1 Procedure: Plate Selection: A stainless steel plate was initially selected to execute this research work. Coating: A Ultra-Violet (UV) light sensitive material coating was applied to the plate, and it was baked at 120 degrees Celsius. Plate exposure: The exposure was provided by UV light that was powered by 2000V. The exposure time was given for eighty seconds and the vacuum pressure was set to eight hundred Pounds per Square Inch (PSI). Dimensions of the exposing machine was 20 x 25 inch. Developing the plate: in the first step, the plate was developed with Sodium Carbonate and then it was dipped into Sulphuric acid to stop the chemical reaction on the plate. After that, the plate was rinsed under running water.

Electroplating: for electroplating process, the prepared plate was submerged in a Nickel Sulphate tank. In step first, the plate was placed in the tank for 30 minutes at voltage of 2.50V and current of 25 amps. After thirty minutes, the voltage and current were changed. In the second step, flip the plate over and change

the voltage to 3.50V and current to 45 amps. Again, after thirty minutes, the voltage and current were changed to vary the depletion of metal layer. In the third step, turn the plate over and set the voltage at 4.50V and current to 65 amps. Again after 30 minutes, in the fourth step, the voltage and current were adjusted to 5.50V and 85 amps respectively. In step fifth, the plate was flipped in next 30 minutes over and adjust the voltage and current to 6.50V and 105 amps, respectively. The plates were removed from the tank after next 30 minutes.

5.2 Rinsing and Drying: Once the plates has been rinsed with distilled water, these were left to dry naturally in the air. The stickers were removed from the plate with the use of lifter tap once the plate had received sufficient drying time. On top of the sticker, the gum was applied. The following are the two categories of gum: (i) Pre-gumming and (ii) Screen gumming. The application of the screen gumming was accomplished with the assistance of a pressure spray cannon. Through the process of die-cutting, the shape of the sticker was achieved by laying the metal sticker on the gum sheet. This allowed the sticker to be cut out. Through the application of the dome material to the metal sticker, the shape of the dome was created.

In order to prepare the material for the dome, two different kinds of components were combined. The selection was begun with the softer resin (polystyrene), and then move on to the hardener (triethylenetetramine). It was common practice to combine these in a ratio of 8:2. In addition to the conventional mixture of the material of polystyrene and triethylenetetramine, 01ml of ethanol was added to lower the viscosity. After the mixture has been mixed, set it aside for five minutes so that any bubbles that may have formed during the mixing process can be eliminated. When applying the dome mixture on the metal sticker, the funnel was utilised for the application. The dome material was spread out in a gentle manner so that it would not be able to spread the surface of the metal. For a period of sixteen to eighteen hours, the dome metal stickers were allowed to dry at room temperature.

6. Data Collection & Analysis:

The bending test of any product is crucial when it comes to the durability. The folding endurance test is generally used to evaluate the bending test. The folding endurance testing device as shown in figure 3 was used to measure the bending frequency. The bending of sample was made at 90° angle.

Figure 3. Folding Endurance Machine

The technical specification of folding endurance testing device is mentioned below:

Sr. No.	Particular	Unit
1	Specimen	15x150mm
2	Counter	999 - 0000
3	Angle of Folding	135±0.5°, 90±0.5°
4	Speed	175 +/- 10 cpm
5	The folding head's width	19±1 mm.
6	Folding head arc radius	0.25±0.02, 0.38±0.02, and 3.5±0.02 mm

7	Folding head clamping thickness	0.25, 0.5, 0.75, 1.0, 1.25 mm
8	Measurement (WxD)	390 x 450 mm
9	Height	520 mm
10	Weight	22 kg

With the help of folding endurance device, the data was collected of bending test for metal sticker only as shown in Table 1 below. The data for each strip of variable width were taken into account. The average of measurement was taken in the last column. The three test samples were taken into consideration.

Table 1. Folding Endurance of Metals strips.

Sr. No.	Strips size in (Points size)	Bending Frequency			Average value of all sheets
		Sheet (1)	Sheet (2)	Sheet (3)	
1	0.12	2	2	2	2
2	0.25	2	2	2	2
3	0.50	2	2	2	2
4	0.75	2	2	2	2
5	1.00	2	2	2	2
6	1.25	2	2	2	2
7	1.50	2	2	2	2
8	1.75	2	2	2	2
9	2.00	2	2	2	2
10	2.25	2	2	2	2
11	2.50	2	2	2	2
12	2.75	2	2	2	2
13	3.00	2	2	2	2

The table 2 shows the data collection of bending tests for dome metal stickers. Three different samples were prepared. With the help of folding endurance test, the data was collected for bending test.

Table 2. Folding endurance of combination of Dome & Metals strips.

Sr. No.	Strips size in (Points size)	Sheet (1)	Sheet (2)	Sheet (3)
1	0.12	3	3	3
2	0.25	3	3	3
3	0.50	3	3	3
4	0.75	3	3	3
5	1.00	3	3	3
6	1.25	3	3	3
7	1.50	3	3	3
8	1.75	3	3	3
9	2.00	3	3	3
10	2.25	3	3	3
11	2.50	3	3	3
12	2.75	3	3	3
13	3.00	3	3	3

The table 3 shows the comparative analysis of average values of bending test for metal sticker and the dome metal stickers.

Table 3. Comparative average values of bending frequency for metal and dome metal strips

Sr. No.	Strips size in (Points size)	Metal strips	Domed metal strips
1	0.12	2	3
2	0.25	2	3
3	0.50	2	3
4	0.75	2	3
5	1.00	2	3
6	1.25	2	3
7	1.50	2	3
8	1.75	2	3
9	2.00	2	3
10	2.25	2	3
11	2.50	2	3
12	2.75	2	3
13	3.00	2	3

The average value of bending test for metal sticker was found 2 whereas; for domed metal sticker was 3. In this case bending test, the reading was taken into an account till the metal was broken. The figure 4 is showing the graphical representation of analysis of bending test for metal stickers and metal sticker with dome.

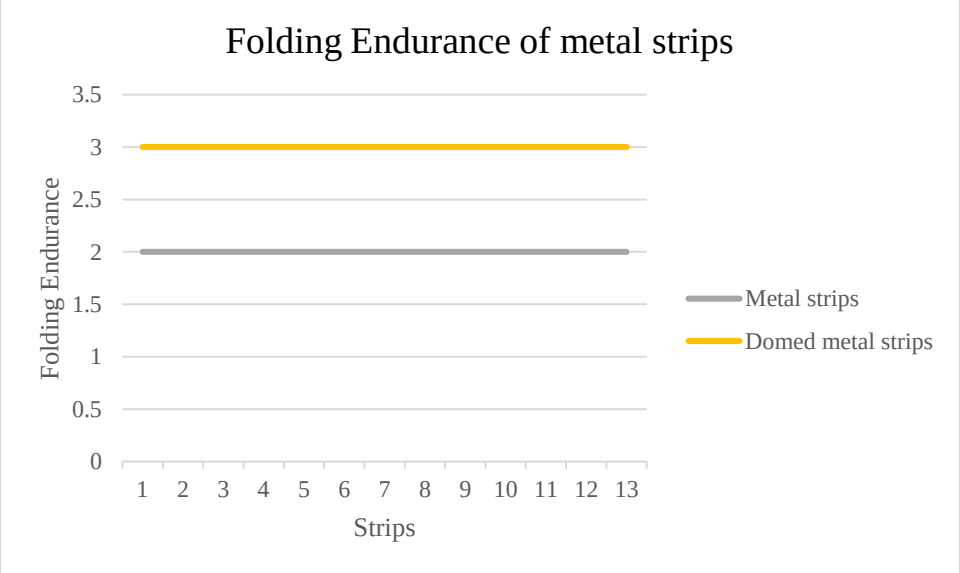


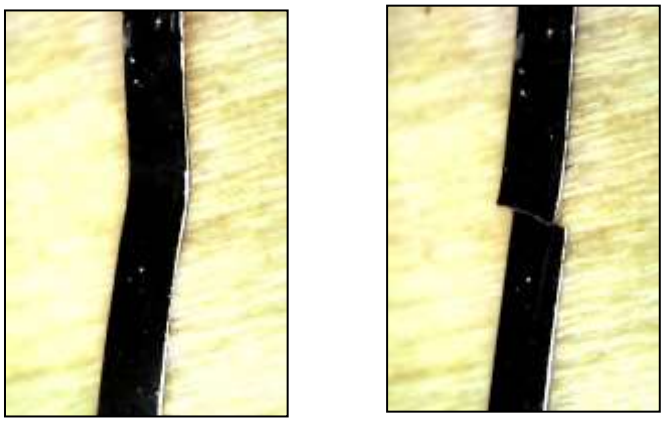
Figure 5. Folding Endurance of strips

The figure 4 has shown that the value of bending test of different samples lies below the dome metal stickers. The value of bending test for metal sticker measured as 2 whereas for dome metal stickers was measured as 3.

7. Results and Discussion:

The bending test for metal stickers were explored metal stickers and dome metal stickers. According to the figure 6, all metal strips have the same bending strength which shows that there is no co-relation between the width of metal strips and bending strength. All metal strips were equally performed in the case of the bending test. The metal in the dome gets broken. When the metal strip was folded for the first

time, as shown in figure 6(a), the bending effect was evident. No crack was found but leaving the bending effect on the metal strip, though. Figure 6 (b). The metal strip broke when folded for the second time.



(a) (b)

Figure 6. Metal Strips

In the case of dome metal strips, the bending strength increased to 3. In this category, all samples were having same performance. But due to dome it stayed inside the dome which ultimately increases its durability.

Figure 7. Domed Metal Strip

In case of domed metal strip as shown in figure 7, when two folds were made on the dome metal strip, it gave bending evidence to the metal strip. When the third fold was done, the metal strip on the inside of the dome got broken but the metal strip at one place fixed this due to the dome material. Following numerous tests, it was discovered that the dome material increased both the resilience and longevity of the metal stickers.

8. Conclusion:

This research work was executed to explore the bending test on metal stickers and domed metal stickers. The results concluded that the metal stickers had a bending strength of two folds. Whereas; the dome metal stickers have a higher bending strength due to dome property. It has the bending strength of threefold which provides more durability in comparison to metal stickers. Therefore, the dome stickers enhance and protect the metal in the case of bending strength as well as the rub resistance of the surface.

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