FABRICATION OF FLEXIBLE FOIL LAMINATES FOR EMI SHIELDING APPLICATIONS

As flexible laminates incorporating metallic foils gain acceptance as a viable method to control electromagnetic interference (EMI), fabrication of these laminates becomes an important factor in the application. The design engineer should become familiar with the fabrication techniques available to yield a finished part ready for assembly into the device on the production line.

Flexible laminated shielding materials are composed of a metal foil, such as aluminum or copper foil, combined with a reinforcing substrate, such as plastic films or specialty papers. The thin metal foil, usually about .050 mm thick, provides the conductive surface necessary for attenuation of EMI, while the substrate provides mechanical reinforcement and an electrical insulating layer. Flexible laminates can provide excellent attenuation on a cost effective basis on many applications. (See Table 1.)

Because of their flexibility and ease of fabrication, laminated shielding materials can be designed to meet a wide variety of configurations to shield EMI sources of various sizes, from shielding an individual component to enclosing the total circuitry. In general, flexible foil laminates offer the design engineer the freedom to control EMI at the source, thus requiring less area coverage than other shielding methods. To effectively utilize foil laminates, it is important that the design engineer understand what can be done in terms of fabrication in order to develop an effective EMI shielding part.

Flexible foil laminates from .125 mm to .80 mm thick are produced in continuous roll form up to 915 mm wide or in flat sheets up to 915 mm by 1120 mm (36″ × 48″). In order to be effectively used in a shielding application, the laminate must be cut to shape, usually with tabs or holes for attachment and/or grounding purposes, and often must have slots or other shaped openings for input/output (I/O) lines or ventilation. Usually the part must then be folded or formed into boxes or more complicated shapes to form an enclosure. The following fabrication techniques may be used to accomplish these steps on flexible foil laminates.

STEEL RULE DIES

Steel rule dies are a low cost method to punch, score, crease and slit parts out of materials up to .80 mm thick. A typical steel rule die will cost from $100 to $350, depending on size and complexity. They are used for short-run applications, up to 10,000 pieces, but can be re-steeled for additional use. Standard tolerances are ± .40 mm, although solid punches may be used for holes to provide hole-to-hole and diameter tolerances of ± .125 mm.

The outer periphery of the steel rule die will effectively punch out an overall shape while internal dies will punch out holes, slots, or other shapes at the same time. Additional rules may be added to score or crease the part as an aid to subsequent forming operations. A score is a cut half-way through the material; it is usually used on thicker paper and board materials to affect a sharp 90° bend. A crease is a rounded indentation in the material requiring male and female forms; it is also used to aid in forming bends. When forming scored or creased parts, the old fabricator's axiom applies: "Fold away from a score, fold into a crease."

Two other operations that may be accomplished in a steel rule die are slitting and stamping. A slit is a partial cut into the part to allow for a separation or compound bend. It is recommended for use only on thinner materials. For identification purposes, letters and/or numbers may be stamped onto parts thicker than .50 mm. See Figure 1, which depicts some of the fabrication operations that may be found in a typical punched part, such as an EMI shield for a keyboard. One of the materials used in this type of application is .05 mm aluminum foil bonded to .64 mm flame retardant kraft paper. In the example shown, the aluminum foil would face up: dotted lines represent creases; light solid lines represent score cuts on the paper side. Other features of note are:

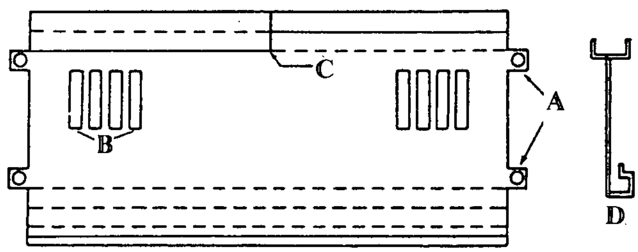

Figure 1. Fabrication Operations of a Typical Punched Part.

A—mounting tabs with holes for screws or rivets,

B—slots for ventilation,

C—slit cut so that one flap may be folded up, the other folded down.

D—side view of formed part.

Most steel rule dies affect a compound operation, i.e., the periphery, holes, scores and creases are all done at once in a single station operation—one punch, one piece.

SOLID DIE SETS

A solid die, or hard tooling as it is also known, is a matched set of male and female components that can

Laminate Description	Shielding Effectiveness, dB				
	300 kHz	3 MHz	27 MHz	100 MHz	1 GHz
.05mm aluminum foil/ .64mm KR kraft paper	>80	>70	>60	57	59
.05mm aluminum foil/ .125mm polyester film	>80	>70	>60	53	56
1 oz copper foil/ .075mm polyester film	>80	>70	>60	58	60
.10mm aluminum foil/ .05mm type 410 Nomex Aramid paper	>80	>70	>60	52	57
.125mm aluminum foil/ .38mm kraft paper	>80	>70	>60	54	56

Table 1. Shielding Effectiveness of Flexible Laminantes.

perform all of the functions of a steel rule die, at closer tolerances, as well as additional operations. Solid dies can hold tolerances down to ± .075 mm on stock thicknesses up to 4.0 mm, and will typically yield a cleaner edge cut than a steel rule die.

Solid dies can perform compound operations, or they can be designed for progressive fabrication operations. A progressive die has two or more stations within the die set to perform separate fabrication functions on the same part as it is indexed through the punch press. Depending on the complexity of the die, hard tooling will typically cost from $1,000 to $5,000 for a specific application. However, they have a much longer life than a steel rule die—1,000,000 or more pieces per die cavity is common. Although the dies must be sharpened periodically, depending on the material being punched, production runs of 50,000 pieces without sharpening is normal for close tolerances. Because of their costs, solid dies are usually specified for large quantity, high volume runs.

In addition to the standard functions of punching, scoring, creasing, slitting and stamping, solid dies may also be used to form, smooth-shave, and print. The male and female die set may be designed to form or shape flexible stock into mild contours such as a shallow bend or curve. The design must allow for springback in the material formed of 20% to 30%; that is, the material must be over-formed and then allowed to relax to the intended configuration.

Smooth-shaving is done in a tandem smooth-shave die to give polished edges on thicker materials. The part is punched slightly oversize and then forced through a smaller die of the same shape to shave the edges of the part into a smooth surface. It is also possible to white leaf print directly onto the surface of the part on materials that will accept ink.

Solid dies may be used to stamp unusual composites, such as a rigid board backed with rubber. They may also be designed to fabricate very small parts and/or holes and slots in the part. Slots as small as .40 mm by .80 mm can be punched in parts only 3.175 mm by 11.10 mm. Materials that are .125 mm thick will require die sets with clearances down to .0125 mm (.0005″).

SUMMARY

There are many details inherent in the design of a part that the fabrication engineer must take into consideration when building a die. These include hole placement and sizing which are of special importance in EMI shielding applications, whether to crease or score (never score the aluminum foil side of EMI shielding laminates), and layout of the die to obtain maximum material utilization in production.

There is one detail that must not be overlooked; special attention must be given to establishing a continuous, effective ground. The advantages of having a continuous metal foil shield must not be negated by failing to effect a properly grounded enclosure. The edges and corners of formed parts must have metal-to-metal seams if the opening would otherwise be long enough to allow EMI emissions. The design engineer must also provide for metal-to-metal joints where the shield meets the groundplane; this can often be accomplished by metal mechanical fasteners such as screws or rivets.

In general, flexible laminates incorporating metal foils provide a cost-effective means of controlling EMI. But in order to be utilized, they must first be fabricated into a properly designed part. The design engineer must work hand-in-hand with the mechanical engineer to develop an effective configuration that may be economically fabricated and processed.

This article was written for ITEM 85 *by R. William Simpson, Jr., Spaulding Fibre Company, North Rochester, NH.*