The Uses of Lamination in Print Production for Consumer Packaging

Giancarlo Caimmi

Keywords: lamination, packaging, production, flexo

In our everyday life we are exposed, as consumers, continuously to laminated structures. It is about packaging in general, flexible packaging in particular and of course food packaging. Lamination for flexible substrates is about layering 2 or more webs, stabilizing the compound by means of an adhesive, in order to comply with a specific, end-use oriented, design.

Lamination has a specific social mission. Make package lighter and more consumer friendly. By formulating multiple webs compounds it is in fact possible to generate structures combining and perfecting the characteristics of alternative technologies such as rigid packaging. Once that is accomplished we have achieved a packaging that is not just lighter: it requires less energy to be produced, generates less pollution at production, has a better product to package ratio, accounts for less volume into landfill, it is more economical to transport, protects the product better, extends the shelf life, and more.

Nothing different from Mother Nature. Think to the way nature figured out to preserve fruits. The skin of water melons and bananas is way heavier and features a greater volume than some of the flexible packaging we are used to this days.

Therefore being packaging and its latest evolution “flexible packaging” being a great invention and innovation, one may think that people perception about the social role of packaging should be at very high and positive levels. It is not the case. Bad press and a misperceived sense of protecting the environment play against this technology. How many times you have been exposed by media to how bad is plastic for nature? And how negative is the impact of packaging on environment? How many times you have heard about the poor dolphin killed by a bunch of plastic floating on the ocean? It is not about plastic. It is not about packaging. It is more about the use people does with plastics and packaging at the end of the use. It is all about it.

Nordmeccanica s.p.a.

According to the EPA Americans generates around 250 million tons/year of municipal solid waste. Guess what category of waste plays the bigger role? Plastics? Packaging? Wrong answers: it is food. About 20% of the total.

Plastic is at the very bottom of the list, a mere 2%. Is this proportional to the media claims? Is this proportional to the real size of the problem?

No it is not, definitely it is not, but it makes for a better headline the dolphin tragedy that it makes to teach consumers and the industry that food waste is suitable to be reduced by means of a cleaver use of packaging; and to teach people how to dispose and recycle; and to teach and discuss about the most energy friendly and pollution friendly and waste volume friendly of the packaging technologies. There is no logic in media approach but it is what it is, and it is to us to try to disseminate knowledge and facts.

A first look at packaging options offers 4 large categories of packaging:

- Carton and corrugated carton. Mainly used for secondary packaging.
- Glass, and bottles in general.
- Aluminum cans.
- Flexible packaging.

Market share in volume for each category is presented in slide 3.

Each of those categories has a reason to exist, depends on the nature of the product inside, it depends on logistics associated to product distribution, it depends on cost, it depends a lot on consumer perception. Paper, glass and aluminum cans are in theory fully recyclable. In reality the volume of flexible packaging in urban solid waste is so low that even once considering recycling rates for the other options at 80% the volume of flexible packaging accounts for a small fraction of the others. Please refer to the chart presented in slide 6.

Surprised? Yes you should be in fact. And those last considerations only refers to urban solid waste. Are there other factors in favor of flexible packaging?

- Product to package ratio. It is a variable that depends on the volume/weight of the package referred to the total volume/weight of the product. Flexible Packaging defeats nature, let's alone other packaging technologies. On slide 7 I am offering a visual impacting idea of how many trucks will be needed to transport the same exact volume of product if that product is packed with alternative packaging technologies. See for yourselves. Less trucks means lower CO_2 emissions, lower energy consumption.

- Energy. Please refer to slide 8 to have an idea of the total amount of CO2 emissions and as a direct consequence, energy consumption, related to flexible packaging in the coffee brewing life cycle. That energy is a very little percentage of the total. A good supporter of global warming reduction should direct his or her attention to every factor with a level of priority directly related to the percentage that those factors have into the total. A similar ratio will be showed once comparing energy consumption associated to flexible packaging production cycle to the one of paper, glass and cans. A little, little, fraction.

- Emissions. VOCs generated through the production of flexible packaging are as well negligible compared to the production cycle of other packaging. Lamination in example features a VOCs emission ratio of zero if performed with the appropriate technologies.

It is already a lot to give an idea of the very many advantages of Flexible Packaging in general and of Flexible Packaging as a substitute of other packaging technologies in particular. And as a matter of fact, despite the bad press, flexible packaging is a constantly growing industry. Through the years of the global crisis Flexible Packaging kept a constant growth rate and on average is featuring a yearly 5% growth, again on a global scale. Consequently flexible packaging is one of the best possible choices once considering investments in new technologies. In slide 9 I am presenting some market data sourced through the FPA, the Flexible packaging Association (www.flexpack.org).

Let me touch briefly the tasks accomplished by Flexible Packaging, or what a Flexible Packaging made container (pouch, bag) can take care of:

- Marketing. Flexible packaging offers a large printable area. All the packaging surface can in fact be printed. This characteristics offers an excellent marketing vehicle for the brand owner, It is obviously accomplished through print and through those coating process enhancing the print (gloss coatings; matt-gloss effects; etc).

- Consumer information. The container itself is the vehicle of information to the consumer. Ingredients; nutritional facts; warnings; promotions, can be printed directly on the container in very high definition as allowed by modern Flexography, Rotogravure and Offset Printing. In order the 3 most used printing technologies in packaging in North America.

- Brand recognition/protection. The large printable area of a flexible packaging container allows for the expressions of the best creativity for graphic developers. This implies a formidable communication vehicle, a very high level of personalization of the packaging and consequently a promotion of the band and a protection against attempts of counterfeits and improper use of brands.

- Product protection. This function is accomplished through a proper selection of the several layers composing a flexible packaging structure. Therefore is primarily through the lamination of those substrates and the implementation of specific coatings that the product protection, intended as: mechanical protection; gas barrier and light protection is ultimately taken care. We will go through this in better detail later. Please refer to slide 11.

- Technological functions. Think for one second to those pouches you have been using and that allows for easy opening; reclosing through a zipper. Those technological accomplishments are developed by the creative use of lamination and bag making, the steps during which the final package in developed and formed. It is a matter of listening and understanding the consumer needs and to use the versatility of flexible packaging. It is a territory that will still allow for a great innovation rate in the years to come.

Now is time to pay some attention to how flexible packaging is made. The entire conversion flow path is presented in slide 23.

It all start by determining the graphic set up as needed to properly "present" the product and brand to consumers and ultimately how to vehicle consumer info; then to select the mix of webs that will allow to properly protect the product. Therefore we will need possibly a white web to be used as print substrate, or we can print a white back ground behind a reverse print on a transparent web or we can reverse print a transparent web to be then laminated to a white substrate and more. Nature of the product to be packed and the required shelf life (product expiration date), will influence the mix of webs to be laminated together. This is a matter of packaging science. Exposure to gasses, mainly oxygen and light (the UV component of light) will influence product life. A more sophisticated packaging compound will extend life but will cost more. Once the proper recipe has been identified we can look into the process in details.

Webs or substrates. There are a variety of substrates playing in flexible packaging. Some will have very good gas barrier characteristics and will therefore influence heavily shelf life, others will play a great role in shielding light, and others will have mechanical strength or puncture resistance or temperature resistance as main feature. The science here is to formulate the best mix to take care of the final task while allowing for easy conversion and cost reduction. Most of the structures used in flexible packaging are 2 or 3 layers, occasionally 4 and, rarely, 5. List of webs includes: plastic films; aluminum foil; paper; foams.

First conversion step will cover the print. The web selected to be printed will be processed on a press and in North America as mentioned, the large portion of this is covered by Flexo; Roto and Offset. Some EB print is emerging while digital print, now an irrelevant portion of the total, is destined to gain ground as the web width and the conversion speed of those presses, will grow to more industry competitive levels. The flexibility of digital printing is emerging currently primarily in the territory of narrow webs and short, very short, runs.

Once we have a printed reel the next thing is to laminate that reel to a second web. Print protection during the logistics cycle of a pouch justifies for a large portion of lamination. We are talking the case of trapping the print between two layers to avoid scratches and damages to the printed layers during transportation and shelf life. So if the packed product does not require any specific protection a two layers compound of basic inexpensive films will make for the recipe. The two layers compound introduces the next step through the conversion process: lamination.

Lamination for flexible substrates is a technology that has evolved parallel to rotary presses. Lamination and print are really sharing a lot. Not just on the web handling side, but mainly on the coating technology. The vast majority of coating technologies have been developed in fact around the same design of one of the printing technologies: Rotogravure and Flexo for low viscosity coating; Offset for high viscosity.

Process evolves around coating an adhesive on one of the two webs, and combining a second web to the coated one in a lamination nip. The elementary process is presented in slide 18 while the schematic of a laminating machine is offered at slide 17.

Unwind 1 will provide to deliver the primary web (usually the printed one) to the coating head. There a print like coating station, available in a variety of technologies as influenced by the nature of the adhesive in use, will provide to dose the right amount of glue onto the substrate. A second unwind (unwind 2) will handle the web to be laminated, a combining nip made by a set of cylinders, alternatively chromed and rubber-covered ones, will dose pressure so to allow a proper wetting between the laminated webs and to trigger the adhesion between them that will be completed as the adhesive will finally evolve into a solid, fully cured compound, between the layers.

Technology offers a variety of chemistry for the adhesives and it is not the matter of this paper to present them all. Let just say that a family of those adhesive is very “ink like”. It is the family of the “dry-bond” adhesives. The resin that plays the real adhesion role is diluted into a "vehicle": water or solvent. The vehicle, same as in print, needs to be removed into a drying oven. The "dry" resin will then face the secondary web at the lamination nip.

In this family of adhesives viscosity of the compound is at such levels to allow for the use of print station like coating units. See the left side of slide 21. There a rotogravure coating station is schematized. In every detail similar to a rotogravure printing station. Main difference is that the rotogravure roller here is uniformly engraved with cells sized to the target coating weight.

In state of the art applications solvent based adhesives are prevailing nowadays versus water based ones. Reason being: performances, energy consumption, final optics characteristics of the laminated compound, overall quality and overall production costs. VOCs emissions advantages that is in favor of water based adhesives not sufficient to compensate the other factors.

A new technology in adhesive chemistry is gaining market share on a global base. "Solvent less adhesives" or better: 100% solid adhesives. It is an adhesive technology based on chemistry of the isocyanate compounds. Adhesive is delivered in two separate components, resin and hardener. The two components are mixed only at time of coating and a chemical reaction will be triggered to provide the mixed compound to grow in viscosity rapidly until solid, or fully cured. This technology requires no dryers for vehicle removal, featuring no emissions and a process energy consumption very low. Up to 80% smaller compared to the one needed to process water based adhesives. This family of adhesives features a viscosity at coating in the range of 1000 centipoise and up (a honey like viscosity territory in practical terms). This requires the use of specifically developed coating stations (right side of slide 21). Something similar to an offset press printing station. Multiple rollers, turning at a controlled increased speed, provide to dose the adhesive reducing to thickness of the layer down to really small values as imposed by typical coating weights used in the industry.

Characteristics of this last family of adhesive is to feature a very low shear resistance (or bond) at lamination. Adhesive curing will develop with time but at the beginning is so low to be unmeasurable. It will take hours before some consistence bond builds up. It is the side effect associated to the very friendly environmental impact of this technology. An important effect of this initial low bond is that it is quite difficult on the laminator to handle the web after the lamination nip and through the rewind. Imagine two layers of webs, featuring different mechanical characteristics (elastic module mainly and rate of elongation under tension) laminated with an adhesive with no initial adhesion, webbed through multiple supporting rollers and machine devices: a really tricky task to take care of. Ingenuity and technology advancements luckily come to rescue. On modern equipment such tasks are taken care really effectively with great ease and really good quality of the final product.

Now we have a nice roll made of two laminated webs, curing in a temperature controlled room waiting for the next step. It may possibly happen that we need to run that web again through the laminator to add a third web. It is understood that proper design laminators for 3-ply lamination in one pass are available and definitely suggested in use to produce multiple layers compound with consistent quality.

Lamination is a very technical conversion process. It may transpire from this initial approach to the technology I took you through. It is all about measurable variables and recipes, hardware plays a key role. Coating weight for adhesives are consistently higher that the ones used in print to layer inks. This involves some considerations about the quality of the coating or the uniformity of the coated layer. The more adhesive I use the thicker will be the layer between the print on the printed web and the second web: the print protective layer. That will influence the appearance of the print. An excess of adhesive will therefore impact print quality perception. Intuitively an accurate coating station will allow to deposit the lower amount of adhesive imposed by bond requirements, supported by the reliability of the stability of the coating weight. Cost of adhesive will be reduced, final quality of the compound will be higher.

On solvent based adhesives, in function of the high quantity of adhesive deposited, consistently high will be the amount of solvent to be removed. This is critical especially for food packaging. An excess of solvent residual left into the compound after lamination may infringe law regulated limits. A good efficiency in the drying system is paramount to handle quality lamination.

A question may surface. Why use solvent based adhesives if a more friendly technology such as the one of 100% solid adhesives is available? The answer is in the final use of the compound. 100% solid adhesives feature some weakness if the final pouch is exposed to very high temperatures: 300 F and above. Not rare cases. It is in fact what happens in "cook in the bag" products (soups in example or microwavable products) or applications requiring the final product to be sterilized or pasteurized at the proper temperatures. Think dairy products and pharmaceutical here. In the lamination of substrates related to those application the use of solvent based, dry-bond adhesives, is state of the art.

100% solid adhesive remains the fastest growing technology in North America covering around 35 to 40% of the total business of lamination for flexible packaging. Another territory of use for solvent based adhesive is the multi-layer compound laminated in one single pass. Because here the webbing through the machine is quite long after the first two webs have been laminated, for a matter of shear resistance it is imperative the first two layers are stable after the lamination nip. Such result is achievable easily with solvent based adhesives and therefore multi-layer lamination is usually made in dry-bond.

Another topic frequently discussed within the industry is about in line or off line lamination. In line being a set-up of laminator connected to the printing press. This is a machine set up used a lot in the past once production runs used to be exceptionally long: no longer the case these days. Today laminators may run up to two times faster than a printing press and, most importantly, laminators features an up time way higher than the one of a press. Consequently a good laminator can easily serve two presses and more, giving as well access to a more consistent process reliability and overall productivity.

I took you through an initial exposure to lamination technology. The intention of this paper is to help being exposed to the most important aspects of the technology. Nevertheless there is more to it. And it is a fascinating "more" made out of: technology, chemistry, mechanics, polymers science and packaging science, graphic design. I wish this paper will trigger your curiosity to go deeper because it is definitely worth. And is worth in every case: should you be an investor looking for new opportunity; a printer interested to open up to the horizons for future developments of your business; a student interested in selecting a field on which to invest for the future.

Nevertheless we are still missing some few details about the completion of the journey to the production of flexible packaging.

We are now ready with the laminated material, made out of the proper number of layers, laminated using the most appropriate adhesive on state of the art equipment. What's next?

Adhesive at the coating head is layered between webs about a quarter of an inch narrower on each side of the webs. Reason being you do not want adhesive to escape the laminated compound at the lamination nip. At the lamination nip, in fact, the web-adhesive-web structure goes into a pressure nip and should the adhesive layer be too close to the edges of the webs then the final result can be adhesive accumulated on the sides of the rewound roll with the effect to block the entire roll. Real disaster.

Consequently the two webs are not laminated all the way across but, as said, about one quarter of an inch inside on each side. The production step that follows lamination is the one that allows to remove those two edges. And in most cases to slit a larger roller into multiple narrower ones, should the print set up been developed to allow for multiple prints across the web width. Machine that is involved is a "slitter rewinder". Please refer to slide 26. Those machines are faster than a laminator and usually suitable to serve 2 to 3 laminators each.

After the slitter the process may take two distinct directions. The converter will sell the final rollers out of the slitter as they are: in that case the packaging user will use what is called a "form-fill-seal" machine. Slide 28. On that machine their product (potato chips in example) will fill a pouch formed on that same machine.

Alternatively the converter can manufacture pouches on a machine similar to the one shown at slide 26th. Those are usually pouches way more complex in shape and features than the ones manufactured on a form-fill-seal machine. Think to stand up pouches versus potato chips bags. Think zipper bags. Pouches will be sold to brand owners and product will go into the pouch on a machine similar to the one shown at slide 28, a pouch fill machine.

Now we reached the end of the road, possibly while enjoying some nice snack, properly packed into flexible packaging.

Again my intention was not to release a final work, sort of: "all you should know about flexible packaging and lamination", but to trigger your curiosity. Should you be interested to learn more then I will welcome every question will be delivered to me and I will be happy to direct to the proper source or institution. The internet may be of help, mainly through OEM web sites and institutions such TAGA and more specifically for lamination and flexible packaging the Flexible Packaging Association and AIMCAL. Thank you for your perseverance and determination to follow me to this point.