Title. Adhesive lamination: new technology in Solvent Less lamination.

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Short abstracts:

"A new development in solvent less lamination allows for: no need of a meter mixer dispenser; no pot-life concerns; quality check in 30 minutes; slitting in 90 minutes; delivery in 24 hours from lamination; while featuring the advantages typical of traditional solvent less lamination: low energy consumption and no emissions. Innovation required to implement a specific machine design and a new adhesive formulation. This paper will provide an overview of the technology from both the machine side and the adhesive side.

Extended Abstracts.

This is about the official presentation of a new technology developed in cooperation between Nordmeccanica and Dow Chemical. I am particularly proud to present the technology in deep detail, first time at a technical conference, at Aimcal. Nordmeccanica has always believed in the power of cooperation and Aimcal reflects most of the values we strongly believe in. I would like to thank the entire Coating and Web Handling committee as well as our session leaders.

Innovation in our industry, the industry of coating and lamination, comes under different definitions. The one definition that for sure marks the "real" innovation goes under the name of "industry changing" innovation. This is what we are talking about. A technology that allows to bring to converters real values at the cost of no additional complications.
Let's start from an industry overview. Talking about lamination of flexible substrates there are a few technologies that can be used. Choice of technologies going under a check list of advantages/disadvantages and check list of technology related requirements.

Dry-bond lamination.
Water based compounds. It is one of the oldest technologies in the industry. Allows for no VOCs emissions; requires a consistent amount of energy to be spent in order to dry the vehicle; in this case water; allows for low to medium performances of the laminated compound; allows for final optics quality of the laminated compound in the low range; allows for quick curing; shows limitations in lamination of metallic flexible substrates; shows limitations in production speed. It is favored in certain markets mainly involving paper because the extra cost of drying is compensated by paper absorbing part of the water and the low cost of those adhesives.
Solvent based compounds. It is the technology of choice in most of the high hand lamination application. Features VOCs emissions requiring the implementation of RTOs devices; requires a consistent amount of energy to be spent in order to remove the vehicle, in this case a solvent; allows for high performances of the laminated compound; allows for the best final optics quality of the laminated compound in lamination; allows for high sheer resistance at green and for quick curing; shows excellent performances in the lamination of metallic flexible substrates; allows definitely for production efficiencies always higher than with water compounds but may show limitations in production speed once associated to solvent retention limitations. It is favored in applications requiring top performances such as: optics and high temperature pouch treatments (sterilization; pasteurization; retort) for the great stability of the adhesive at temperature.

Extrusion lamination.

It is a technology very popular in North America and with limited applications world-wide due to the high equipment cost and the high job start-up scrap rate and overall production costs, limiting therefore the use to very long runs that are less and less frequent in the industry and to compounds requiring specific stiffness.

Energy cured adhesives.

Two main technologies here: UV cured adhesives; EB cured adhesives. The first category is limited by the weakness of the process influenced by the performances of a set of UV lamps with very limited applications in the industry. Same applies to the EB category, influenced by the investment associated to the EB curing unit and the cost of the adhesive itself.

I do not take your time and courtesy to debate about naiveties such as “thermal lamination” and “pre-coated webs” lamination. Defunct technologies resurrected at the Drupa show in May in the attempt to call for innovation.

Solvent Less lamination.

This is on a Global scale the fastest growing of all lamination technologies and the technology that attracts most resources in R&D because of the industry trend in favor of it. And this is the topic to be developed in this paper. It is about using the chemistry of the Isocyanates to generate the polymerization of an adhesive that requires no energy for drying or curing. The largest market share in the industry is justified by: the very low investment for the equipment; the small space requirement; the low investment on ancillaries; the low investment on utilities connections; the competitive cost of the adhesive that is 100% solid and requires no dilution into a vehicle therefore machine shows no drying system of sort; the overall smaller conversion cost; the easy handling of the process; the quality of the final laminated compound. This is just a partial list of the advantages featured by the technology. Disadvantages: time associated to the polymerization of the compound; difficult handling of the quality control within the first few hours after lamination; need of a curing room to allow the adhesive for proper curing under controlled conditions; time to market effected by the PAA decay requirements (food contact); pot life concerns associated to the adhesive aging at the coating head.

Now we can take a closer look to the technology in detail.

In Solvent Less lamination (100% solid adhesive lamination) it is about delivering to the converter adhesives in two components, using a simple definition: a resin and a hardener. Once the two components are separated they are inert. They become reactive and the polymerization process is activated, once the components are mixed in a proper ratio. It is at that time that the compound starts developing an increase in viscosity that will ultimately evolve in a solid adhesive. Therefore the lamination process starts at a meter mixer dispenser. In such equipment the two components are mixed together as close as possible to the coating head. There the adhesive will be milled between a sequence of rollers to be calibrated to the required coating weight. It is at this stage that the pot life concept kicks in. As I said once the two components are mixed the polymerization process is activated. We like to have a quick polymerization so to have our adhesive turning into solid quickly after lamination and the laminated compound ready as soon as possible; but we also need some time so that the adhesive will not solidify too early at the coating head. Pot life is the time required for the viscosity to grow from the initial value, just after mixing, to the double of the initial value. Once the adhesive has reached that viscosity, it is no longer safe to be handled and the coating head

requires immediate wash and a restart of the job with freshly mixed adhesive. Here is the point. We need quick curing, but not too quick, therefore the adhesive manufacturer business is to smartly "slow" down the polymerization so to allow for a reasonable pot life. Commercial pot lives will span in a gap between 15-20 minutes up to almost one hour. It is understood that the pot life extension will influence the final curing of the compound.
Once the compound has been laminated then we have other two technical time limits to consider: time needed to the adhesive to grow in viscosity to allow for the next conversion step (usually slitting) and time to the full PAA decay for food related applications.

The first limit, let's call it "time to slitter", will vary from several hours to a couple of days based on the specific adhesive chemistry. The second limit, time to safe food contact, will span from a couple of days to several days and up to a week.

All that I have mentioned in the previous paragraphs about limitations and disadvantages in handling solvent less lamination is properly taken care in good machinery design and smart adhesive formulation. All, but time. The know how developed will solve those inconveniences, the mentioned ones but as well: difficult web handling associated to a low sheer resistant adhesive; limitations in quick quality check; limited pot life and so on. Good design and good chemistry made in fact this technology the industry success that we currently know, but what about "time"? Time has been considered to date the necessary toll to be paid to have access to all the other benefits. A reasonable toll that will never be able to counter balance the very many advantages but primarily: no emissions process; the lowest energy consumption process; the overall lower production cost process.

What about if somebody has been able to work out a solution to that limit at the expenditure of no process complication?

That is what this paper will be all about.

The innovation we are presenting here has been developed thanks to the combined efforts of a machinery manufacturer and an adhesive manufacturer. A creative way to look into the process has evolved into a solid technology.

Step one. The new adhesive formulation is based on the same principles of the traditional solvent less formulation handled just in an innovative way. Machine design has evolved around solvent less lamination technology in an innovative way.

Step two. Innovation has evolved by taking an alternative approach to adhesive components mixing. What about if the adhesive is mixed after coating? Is it possible? Yes it is if we coat each components of the adhesive on one of the webs to be laminated. Therefore the machine lay out will be something different from what we have been used to, and the adhesive formulation will take care of the new set up. So machine has two coating heads, each head taking care of one of the components to be coated on one of the webs. So what we have at this point are the two webs, each one carrying one of the adhesive components travelling from the coating head to the lamination nip.

Step three. At the lamination nip the two components will see each other first and will touch each other soon after. The pressure at the lamination nip will generate the proper mix between the 2 components. So let's recap. We are at the lamination nip. Two webs arrived here each one carrying one of the two components. At the nip the two webs are laminated and consequently the two components are now touching each other.

Do we need to slow down the polymerization to allow for proper pot life? No we don't. Polymerization into the laminated compound can now proceed as quickly as possible and that is what the new technology is all about. We are talking here about patent pending technologies for both the laminator and the relevant adhesive. Machine name is **Duplex SL One Shot** ™ and the web diagram is shown into the slides. Adhesive is formulated by Dow Chemical and is named **Symbiex** ™ .

Machine lay out and webbing diagram is presented at the proper slide within the Power Point presentation. For Dow adhesive related features Dow personnel will be available at the conference to present technical details during Q&A.

At this point we will be able to discuss in deeper detail the complete list of the advantages featured by the new technology and that are not limited to "short time" to slitter and short time to food contact.

We have described a process where the two components of a 100% solid solvent less adhesive are handled at two different coating heads.

1) First noticeable evolution is that we do not need a meter mixing dispenser unit any more.
2) Second advantage is that we have the two components sitting separately in separate coating station. Being components not mixed there will be no aging and viscosity increase at the coating head: quicker job change over, lower scrap, lower down time due to unplanned station washings.
3) Selective coating. The ability to decide the chemistry of the components that will better fit the contact with the printed layer at the coating head is giving countless advantages such as the impressive reduction of ink smearing.
4) The ability to use two coating stations widens the range of useful coating weights.
5) A temperature controlled curing room is no longer needed to allow for proper polymerization under controlled conditions. Actually a curing room is not needed at all: Laminated roll can go from the laminator to the slitter.
6) No telescoping issues due to the immediately very high sheer resistance of the adhesive after the lamination nip.
7) Immediate quality check. The quick rise in viscosity of the compound allows for quality check, as quickly as in a few minutes after lamination.

The above listed bullets are some of the advantages allowed by the new technology and directly related to the technology set up. There is then a list of "indirect" advantages, things that have not been targeted in the R&D process but that have been accounted for as test and practical use of the new technology developed. At a first level of importance the list can be limited to the following bullets:

a) No misty. The specific process set up allows for this achievement that in solvent less lamination is quite a result.
b) Higher production speed. Wetting of the webs has improved, therefore the combined efforts of high quality optics on difficult substrates (meaning foils and metallized webs) combined with the previous bullet allowed to rise process performances up by 25 to 30%.
c) Optics improvements. The final level of quality of the optics is measurable minutes after lamination and the general level for difficult webs shows results in the territory of quality of solvent based adhesive lamination.
d) An unprecedented reduction of the number of washings required through a production run.

Into the Power Point presentation a number of slides are provided to support with graphs and test results what above. But just to list out a few data allowed by gen.1 of the new adhesive and the new machine design:

i) Time to slitter: 90 minutes.
ii) 25 to 30% higher production speed.
iii) Quality check available in 30 minutes.
iv) Form-feel-seal machine in about 6 hours.
v) PAA decay and food contact in 24 hours.

In other words the converter involved in food packaging will be able to deliver the product to his customer in a day. The converter involved in non-food packaging will be able to deliver in as short as 12 hours.

I would like now to touch in deeper detail the process on the machine side.

Slide 9 shows the webbing diagram of the innovative laminator. A part my previous debating on that issue it is evident on the drawing that machine has two coating heads now. Two coating heads: and the relevant costs. Apparently there is a little bit of extra steel into it. But at an overall cost analysis such extra component does not account for a significant machine price increase. Investment will be in the range of the one considered for a traditional laminator and the reason is primarily in the fact that a meter mixer dispenser and some of the devices associated to handle the traditional process are no longer needed.

Overall process cost: once we have combined the machine price, the adhesive price, the general process cost drop, the significant scrap reduction, the up time increase and the higher productivity, the overall process cost is significantly lower once compared to traditional two components solvent less lamination.

Process set up time: two coating heads implies double the set up time! Right? Fortunately this is another: no. A new patent pending technology has been implemented in fact in the machine design. A solution that allows not only for a very quick job set up but as well for unprecedented accuracy in the coating weight set. Both coating stations have been completely remote controlled in the gap setting stage. This allows for numerical control of the dosing gap and the automatic replica of set up of the coating weight related variables on the second station. As it is well known into the industry Nordmeccanica patented the 5 rollers coating technology for Solvent less in the early 80s. Now, the inventor of the 5 rollers system has taken the design to the next level. This innovation is in fact bringing additional accuracy to the process and, once paired with the nearly 1 to 1 mixing ration of the new adhesive, in a process set up time in the same range of time of the one related to the traditional process. Once the set up stage is completed by the analysis of the reduced number of washings allowed by the new technology and the extended and virtually unlimited pot-life, the overall set up time of the new technology is way inferior to the one of a traditional laminator.

To conclude the description of the new machine design and the relevant advantages, a last but not least kind of thing: we have to point the fact that, Duplex SL One Shot, once using traditionally mixed two components adhesives in association to a Meter Mixing Dispenser unit, allows for unprecedented short job set up even once working in traditional mode.

In conclusion, this is, as anticipated, an industry changing technology. Now solvent less lamination is looking into an even brighter future than predicted. The ability to check immediately lamination

quality, the ability to eliminate curing inventory, the scrap reduction and the overall process cost reduction, the quality improvements in optics and bond, the simplification of the process. All of the things that in the past have been addressed as the negative side of the most energy and environment friendly of all converting technologies have been taken care by the innovation presented in this paper.