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TECHNICAL PAPER

II

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FC84-1001

Some Samples of Radiation Curing in the Paper, Film and Foil Converting Industry

abstract

Hotmelt PS coatings can be improved by radiation curing. Possible machine lay-outs for in-line coating and curing of radiation curing silicones and radiation curing PS hotmelts are discussed. New developments in radiation curing hotmelt laminations are explored.

author

WOLFRAM AURIN
President
Pacon Machines Corporation
Madison, Connecticut

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RADCURE '84
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index terms

Coating Processes
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CONTENT

Introduction

Today, 100% solids and hotmelt coatings and laminations are widely used in the paper, film and foil converting industry. In most cases they have replaced solvent based systems because of these advantages:

- No air pollution problems,
- Lower energy consumption,
- Less floor space, because no drying tunnels required,
- No fire hazard.

For some products like high gloss decorating papers or laminations for detergent boxes, hotmelts work perfectly, and the processes are not in great need of improvement.

Radiation Curing in the Pressure Sensitive Adhesive Industry

However, another large area of hotmelt application, namely

pressure sensitive adhesive hotmelt coating

is, in spite of great progress, still in need of further improvements and innovation.

One of the unsolved problems in the coating of pressure sensitive adhesive hotmelts is the instability of the adhesive after chilling, rewinding and die-cutting. This problem is the more difficult to solve, the heavier the coating weight and the higher the pressure applied to the finished coated product. This lack of stability has haunted the converters.

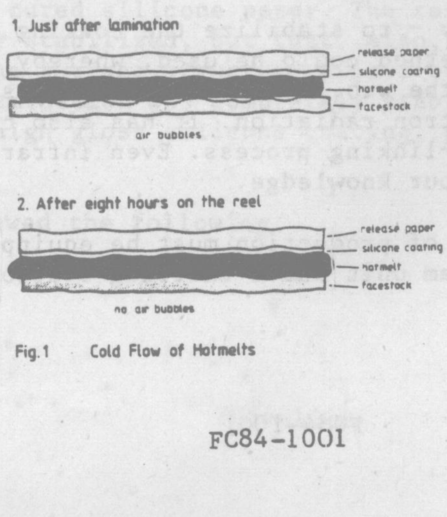

Fig.1 Cold Flow of Hotmelts

To overcome this difficulty, high molecular additives as stabilizers were blended with the hotmelt adhesive. These stabilizers, however, increased the viscosity, which made it more difficult, to coat the adhesive uniformly and smoothly under constant conditions. The higher the working temperature and the higher the pressure in the coating heads and the laminating stations, the more difficult it was to keep close tolerances and the more stress was put on the coating machines. This lead, in some cases, to a certain resistance against hotmelts, and there was a danger, that the whole hotmelt coating process would loose much of the ground it had gained over the last few years, in favor of aqueous systems. In fact, some companies are today thinking of switching from hotmelt coatings to aqueous coatings, even though these systems require much higher investments and more energy for the evaporation of the water.

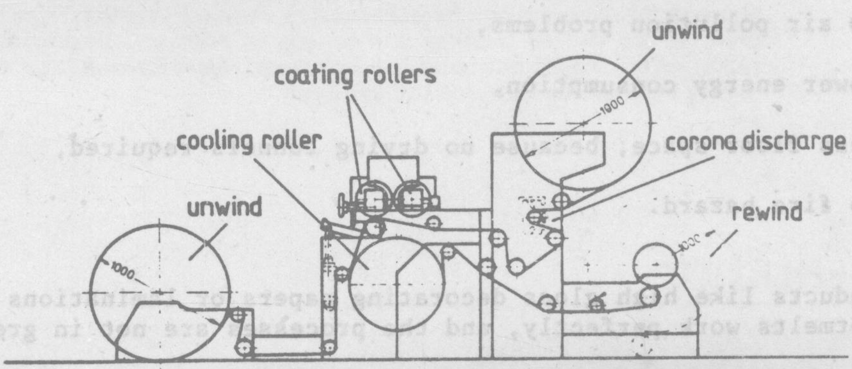

Fig.2 special pressure sensitive hotmelt coater and laminator

This tendency can be reversed by the introduction of cross linking hotmelts, which offer the possibility to start the stabilization of the coating after its application to the web. The stabilization can be effected by different means. It usually requires additives, which must not be destroyed during the melting or the application process. Apparently, acrylic polymeres are especially well suited for this purpose, as they can be polymerized by electron radiation.

This stabilization does not necessarily have to start immediately after the application, as this would stop the cold flow and thus the flowing-out and smoothening of the coating, which is pressed against the high-gloss silicone paper. It should also be possible, to use the same radiation not only for the curing of the hotmelt, but also for the curing of the silicone coating, if the finished combination of silicone paper, hotmelt adhesive and face stock is exposed to electron radiation.

With this new technology - to stabilize the coating after its application - the simple, direct coating method could be used, whereby the molten material is applied in the usual way to the web, is smoothened and is then - under favorable conditions - exposed to electron radiation. It has also been suggested, to use UV or gamma rays for this cross-linking process. Even infrared has been tried out, although unsuccessfully, to our knowledge.

A machine for this type of production must be equipped with an unwind, a coating head, an electron beam unit and a chilling station, followed by a rewind station.

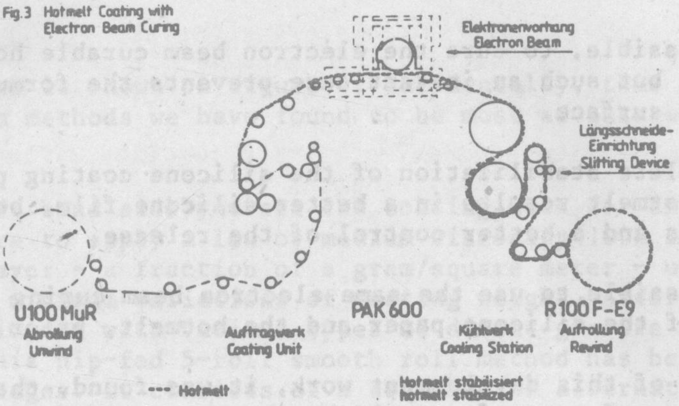

Fig.3 Hotmelt Coating with Electron Beam Curing

For laminating or for transfer coating, the machine can be equipped with an additional unwind and high-pressure laminating station.

Some suppliers of silicones offer electron beam curing silicone systems. This lead to the suggestion, to use the same electron beam station for the hotmelt coating and the silicone coating. It was tried out, for example, to coat a silicone base paper with a radiation curing silicone and, simultaneously, the face paper with a curable hotmelt. After both webs were laminated together, they were fed through the electron beam unit, to have the silicone and the hotmelt cured simultaneously. This would have made it possible, to produce the finished label stock in one single pass without intermediate storage; starting with the two base papers all the way to the finished product. An additional advantage would have been, that the paper would not have lost its moisture and flexibility. Unfortunately, the results of these trial runs were not very encouraging, as some uncured silicone transferred to the adhesive and was cured there together with the hotmelt. Therefore, the properties of the label stock produced this way did not meet the requirements of the roll label industry.

Based on this experience, another test was designed, whereby the web had to pass twice through the electron beam unit. This test proceeded as follows:

The silicone base paper was coated in a 5-roll coating head with a solvent-free, radiation curable silicone and fed through the electron beam unit immediately after coating. From there, the web ran directly into the laminating station. The second web (the face stock) was coated with pressure sensitive adhesive hotmelt, ran through the chilling station and then through the same electron beam curing unit. The cured and stabilized hotmelt was then laminated in the laminating station to the previously cured silicone paper. The result of this test showed, that the hotmelt had fully stabilized, but that, also, the hotmelt did not have enough time to flow out the surface structure caused by the application. As the hotmelt at the point of lamination was completely stabilized, the hotmelt could not be smoothened by the high gloss silicone coating, producing the desired glossy adhesive surface.

This test clearly showed the following:

1. It is possible, to cure the electron beam curable hotmelt immediately after coating, but such an instant cure prevents the formulation of a high gloss adhesive surface.

2. The complete stabilization of the silicone coating prior to the lamination to the hotmelt results in a better silicone film, better surface characteristics and a better control of the release.

3. It is possible, to use the same electron beam curing unit for the separate curing of the silicone paper and the hotmelt, prior to lamination.

As a result of this development work, it was found, that, quite probably, the following sequence of operation would be the most advantageous for the manufacturing of label stock with electron beam curing silicone as well as electron beam curing hotmelt:

1. The silicone base paper is coated with an electron beam curable silicone in a special coating head for solventfree silicones and then fed as fast as possible into the electron beam curing unit. Surface structure and release properties are determined by the conditions in the coating head and the mixture of the silicone.

2. The completely cured silicone paper then runs into the hotmelt coating station, where the electron beam curable hotmelt is coated on top of the silicone.

3. Thereafter, the face stock is laminated to the soft, plyable hotmelt in the laminating station.

4. The laminated web is run through the lower level of the same electron beam unit, so that the hotmelt is cross linked.

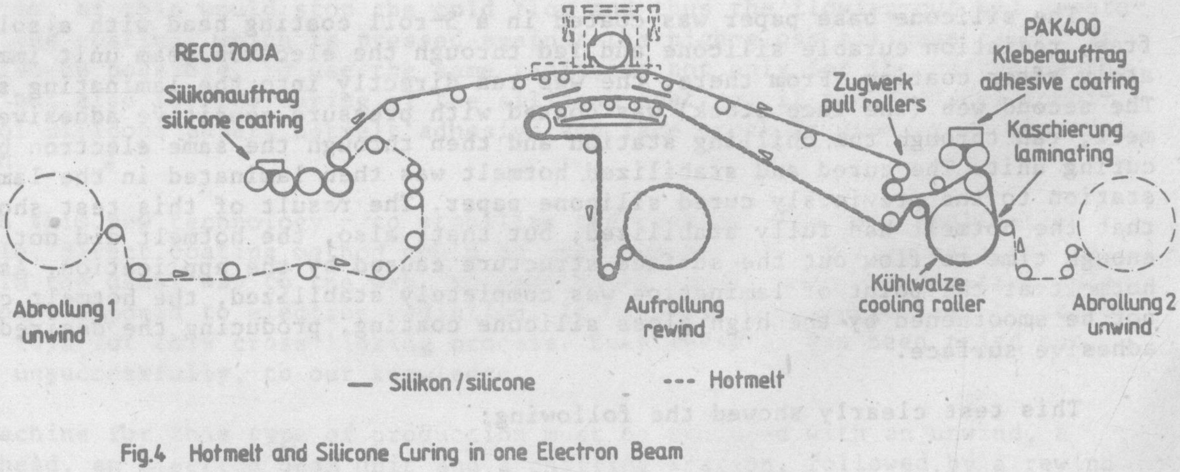

Fig.4 Hotmelt and Silicone Curing in one Electron Beam

This system is shown on figure 4. Incidentally, this picture also illustrates the application methods we have found to be most advantageous for this type of coating:

On the left hand side you see the coating head for the silicone coating. The requirements are to apply a low or medium viscosity 100% solids liquid in an extremely thin layer - a fraction of a gram/square meter - uniformly, without pinholes and with minimum variations of coating weight. After years of development work and experiments with various types of direct gravure and offset gravure pan fed systems, this nip-fed 5-roll smooth roll method has been found to offer the greatest advantages. It consists of a sequence of alternating rubber and steel rolls. The increases in circumferential speed from roll to roll, together with nip pressures, reduce the coating film to its final thickness at which it is applied to the web. The advantages of this system are:

No coating pan, therefore no danger of foaming or splashing,

No gravure rolls, therefore no danger of clogged cells,

Horizontal arrangement, therefore exactly definable nip pressure (no accummulation of roll weight as in a vertical arrangement),

All roll temperatures controlled to maintain uniform coating conditions.

The right hand side shows the coating head for the hotmelt. Its task is quite different: To apply a high viscosity 100% solids molten material at a temperature of 175°- 200°C with a coating weight of 15 to 70 g/m2 with variations in coating weight of ± .5 g/m2 or less. The roll coating application shown here seems to be the most suitable for this kind of application, because the problem of heat expansion, especially for wide webs, can be handled more efficiently with a system of rolls than with a slot die, which is sometimes used for hotmelt coatings. Therefore the coating weight accuracy is usually better on this type of roll coater, and there is no danger of streaks caused by lumps or coagulations caught in the slot. The hotmelt is pumped directly from a drum unloader into the coating nip (which can be blanketed with inert gas) without any intermediate holding tank. This eliminates any danger of deterioration caused by oxydation or long exposure to high temperatures.

Both these application systems have been in commercial use for quite some time. However, this particular machine layout shown on figure 4 has not yet been test run, as this entire development program is currently under way, therefore results can not yet be reported. It seems, however, that this double-pass curing method could substantially reduce the investment required for a combined silicone and hotmelt in-line coating installation. Such a machine layout would be of interest primarily to those companies that run the same, unchanged product for longer periods. Companies that are producing special high quality products with frequently changing specifications are usually better served by two separate lines, one for silicone coating and one for hotmelt coating. The separate curing of the silicone coating and the laminated finished product allows more flexibility in the production. It is also easier to make certain corrections during production, so that the waste rate, especially for short runs, can be kept lower. Finally, such a separated production allows smaller companies with a limited investment budget to start coating electron beam curable hotmelts without the additional expense of setting up a silicone coating line, because silicone paper, either heat cured or radiation cured, can be purchased easily from the outside.

In case of pressure sensitive adhesive hotmelt coatings without release liner (self wound tapes), the EB stabilizing can be done directly in-line with the hotmelt coating, which means that the material can be wound up immediately and moved to the following converting operations. Again, this operation will have the effect that the surface of the hotmelt can not flow out and produce a high gloss, as the surface structure caused by the coating head is immediately "frozen". This might or might not be a disadvantage, depending on the use of the finished product.

In Europe the UV curing silicones have created considerable interest, and it seems quite possible, that they, in the long run, will replace some of the thermal curing systems. Unfortunately, EB curing silicones are hindered in Europe by very restrictive laws, which require extensive protection and shielding, making the EB curing method very expensive.

Radiation Curing in the Flexible Packaging Industry

Besides silicone coatings and pressure sensitive adhesive hotmelts, as used in the production of pressure sensitive adhesive labels, tapes and medical products, there is another converting field, into which radiation curing has made inroads: the laminating of food packaging materials with electron beam curing hotmelts.

The development of radiation curable hotmelt adhesives has taken place somewhat in the shadow of the solventfree catalyst curing dry-bond lamination system using, for example, polyurethane adhesives.

The electron beam curable hotmelt laminations typically combine two films or one film and one foil with a layer of approximately 4 g/m2 (2.5 lbs/ream) electron beam curable hotmelt. This method of laminating two transparent films together produce a film combination of excellent transparency. The crystallization of the hotmelt and its film forming and binding properties allow a very smooth and uniform coating, which is further smoothened by the high pressure in the laminating station, so that a very solid bond between the two webs is achieved, without bubbles or patterns and with excellent clarity. The rapid shock cooling after lamination improves these properties even further, so that a micro crystalline layer forms. The electron beam curing can take place immediately after the chilling station, prior to the rewind.

Such an electron beam curing of a hotmelt lamination is always required, if the finished product has to be heat resistant, for example for heat sealing or for the packing of hot food, like freshly baked bread. Simple hotmelt laminations without electron beam curing are always in danger of delaminating under such conditions. The electron beam curing of such a hotmelt lamination prevents the reactivation of the hotmelt after the lamination process has been finished.

In all these described applications of electron beam curable hotmelts, the curing itself is achieved by additional stabilizers, while the hotmelt itself is basically not changed. This could be best described in a picture:

> The additive, after electron beam induced cross linking, forms a skeleton, which provides a firm structure and support for the original hotmelt. Heat can not destroy this skeleton, which prevents the hotmelt from flowing out.

Such a combination of hotmelt with cross linking additives has the advantage of a rather low price. The acrylic acid additives usually cost 5 to 6 times as much as the basic hotmelt. Obviously, such a combination can be lower in price than a catalyst curing solventfree polyurethane adhesive, which consists 100% of expensive pre-polymeres.

Conclusion

Cross linking or stabilizing coatings other than radiation curing systems have been known for quite some time. Thermal curing silicones, for example, have gone through a long development phase. Obviously, the new UV and EB curing silicones still have to go a long way, until they reach the flexibility and reliability of the thermal curing systems. As these radiation curing coatings are still very young, it can not be expected, that they can match all the properties of the thermal curing systems accquired over many years, but rapid progress is being made.

TECHNICAL PAPER

FC84-1002

An Evalutation of UV & EB Clear Coating Cured on Polyboard

abstract

A comparison is presented of UV and EB curing for a selected clear coating. Although the formulations are similar, it was necessary to add photoinitiator for the UV curable coating. Polyboard stock was used because it is nonabsorbent and is of interest to the packaging field. This evaluation could help an end user decide on the application of UV or EB for their specific needs.

author

JOSEPH V. PASCALE
Group Leader
Sun Chemical Corporation
Carlstadt, New Jersey

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ABSTRACT

The objective of this technical report is to compare U.V. & E.B. curing for a selected clear coating. Although the formulations are similar it was necessary to add photoinitiator for the U.V. curable coating.

Polyboard stock was used because it is non-absorbent and is of interest to the packaging field.

The parameters for evaluating the cured coating are as follows:

1. Infrared Spectra
2. Solvent Extraction
3. Sutherland Rub Test
4. Film Properties
   - A. Flexibility
   - B. Scotch Tape Adhesion
   - C. Glass Measurement

In conclusion, this evaluation could help an end user decide on the application of U.V. or E.B. for their specific needs.

INTRODUCTION

In recent years much has been written about U.V. & E.B. technology.[1-3] Fortunately, a good deal of this published information has concentrated on the application of U.V. & E.B.[4-5]

The close connection between radiation technology and application was highlighted by the Radcure VI conference theme: "Performance + Productivity = Profits".