EUROPEAN EXPERIENCES WITH WATERBASED INLINE COATING (WBC)

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Abstract:

Inline coating with waterbased dispersion coatings becomes more and more widespread in sheetfed offset. The opinions about the physical properties of the wet coating during its application differ. Various methods for drying assist of WBC's are offered by several manufacturers of drying equipment. It is investigated whether a trend is noticeable towards an effective method which assists drying of WBC's without putting too much stress on the printing substrate.

An increasing number of tailor made coatings is offered to obtain specific properties of the dried coating film. It is well known that the gloss obtainable with WBC's has a certain limit. What can be done if it is not high enough? Similar to UV-coatings or foil lamination (cellophaning), waterbased primer-coatings can help produce very high gloss, while displaying a very high process reliability at the same time.

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1. Methods of inline application

Basically we differentiate between two methods of application. One is called the indirect method where the water-based coating is applied from a coating pan to a number of rollers, to a plate cylinder and from there via a blanket cylinder to the printing stock. The direct application method uses rollers to meter the WBC onto a forme cylinder which is very often covered with a blanket and transfers the coating directly to the printing stock. The experience in industrial practice shows that the direct application method allows to transfer higher amounts of coating than the indirect method.

The indirect application method evolved from using existing damping units, preferably of the continous type. Direct applicators are designed only for this very purpose - coating - and can exclusively be used to put on coatings. The advantage of a convertible indirectly working applicator can also turn into a disadvantage when it comes to handling time, especially cleaning time when changing from coating to damping. In general, there is a distinct trend noticeable towards the direct coating method. Most of the coating applications recently presented by machine manufacturers worldwide use the direct method. Even retrofittable coating applicators seem to follow this trend.

If you look at the printing methods from the standpoint of their basic machinery design, you will notice that gravure and flexo are the two designs having the "shortest" possible inking units in combination with a low viscosity type of ink, thus avoiding a number of detrimental effects connected with pasty inks.

So why not make use of this feature with the low viscosity WBC's (or UV-coatings) as well? And here the question is not only, how to bring the medium to the substrate by the shortest possible route but also how long it takes for the coating material not being used - either because of a smaller than maximum formate or because of uncoated areas - to return to the container.

Applicators that are designed without taking this into consideration, produce a build-up of coating and need additional blades, rollers, water dripping systems and so on to counteract this phenomenon.

In order to keep the viscosity of air drying WBC's con-

stant, also with respect to the returning coating, these applicators should be equipped with a circulating system.

As already mentioned, blankets are generally used to lay down the coating on top of the freshly printed ink. This is normally the case where the indirect method is used. Therefore, also hard letterpress plates like Nyloprint, Dycril or similar plates can be used on the plate cylinder to keep certain areas (for instance glue flaps) free from coating.

However, these hard-surface plates used in the direct process on the forme cylinder can cause the orange peel effect, especially when heavier coatings are put on. Therefore, new plates are being introduced using soft photopolymers which, after exposure and a washout process, achieve a surface hardness comparable to that of a blanket. To facilitate the use of these plates with blanket clamps, the base is a Mylar foil instead of metal.

It is important that besides the mechanical characteristics, the chemical surface properties are clearly defined as water receptive and not ink receptive. Nevertheless, most of them do accept ink. Quite a number of experiments with these plates therefore result in a lot of ink mostly in places where a multiple layer of ink is preprinted. The accumulation of this greasy medium partly blocks the transfer of WBC's and results frequently in low or no gloss. Because of the wear and tear, the water receptivity of flexible coatings should not only be achieved by a surface treatment.

Blankets used for application of WBC's should be of uniform and constant thickness to ensure that the coating can be rolled on with the lowest possible pressure to avoid a build-up on the trailing edge as long as possible and to avoid spitting of the coating. Conventional blankets sometimes seem to have an advantage over compressible ones. The latter can show a tendency to collecting board coating; this phenomenon occurs much later with non compressible blankets. When coating full size formats the underpacking is slightly smaller than the sheet to be coated. The minimum difference between coated and non-coated areas in this case should be 0.6 mm.

For instance if glue flaps are to be kept free from coating, the top rubber layer of the blanket is cut and peeled off. In this case the minimum difference should be 0,4 mm.

Consequently the second important property of a blanket which is used for inline coating should be: not too much resistance when peeling off the top layer. To make these recesses, a knife should be used on which the point can be set to cut the top layer only without injuring the layers underneath.

In order to avoid spitting, that is accumulations of coating on the impression cylinder, the coated area should always be slightly smaller than the sheet.

2. Properties of waterbased dispersion coatings in wet condition

It is recommended to have a data sheet furnished with every type of WBC. It should not only specify what the properties of the dried coating films are intended to be (see also chapter 7), instead it should also specify the viscosity at which the coating is delivered and the working viscosity according to the methods of application, for instance for use on a varnishing machine where it is applied wet on dry ink. It also should be explicitely mentioned where the coating is designed for application wet on wet with oil based offset inks.

In Europe the viscosity is very often measured with a DIN 4 mm-cup. Not just because this is a metric metering instrument, but rather than using the metering principles of Ford or a Zahn-cup - which meter through a hole in a tin - the DIN-cup meters through a short pipe of defined length and bore. The fact that there the coating has to run through a pipe seems to produce readings which better fit the actual demand under production conditions.

Metering the viscosity with a cup results in a reading which one might call a measurement of the (more or less) static viscosity. What happens in the metering gap of a coater, however, occurs under dynamic conditions.

This might explain why different brands of WBC's may produce identical gloss meter readings despite different viscosities. Pragmatic coating experts sometimes refer to this variation in behaviour as "different soul of the coating". The data sheet should clearly mention if water and/or alcohol is to be used to adjust the viscosity of a coating. In case a mixture is to be used it should clearly prescribe the mixing proportions. Above all it should give the maximum figure (preferably percentagewise) for the

dilution that must not be exceeded.

The ideas about the ideal viscosity of WBC's differ. Some manufacturers tend towards higher viscosities. This tendency stems from the experiences with varnishing machines, but offset presses nowadays run at a high speed; therefore the coatings have to have a very short drying time in order to avoid problems in the pile.

For coatings in the higher viscosity range, possibly in connection with a higher wet film weight, there sometimes seems to be unsufficient spreading time before the drying starts. This produces a texture primarily in circumferential direction. In such case, a slight reduction of the viscosity in combination with a slight reduction of the weight of the coating applied per sheet usually improves the situation, frequently leading to even higher figures for reflection.

The latest development in this direction are WBC's - mainly intended to produce high gloss - with about 40 to 44% solid content at viscosities starting from 20 to 24 seconds measured with a DIN 4mm-cup.
The data sheet should also clearly mention the shelf-life. It should provide hints what to do when coating is delivered in a frozen condition and should list the content of film forming ingredients (solids). During storage those WBC ingredients which are especially responsible for the properties of the dried coating film mostly gloss - can accumulate at the bottom of the coating container. Therefore the stereotyped advice "Stir well before use" should be repeated on the container also.

3. Drying assist

On principle, the waterbased dispersion coatings, as they are used in Europe for inline application on sheetfed offset machines, are air drying. A few years ago it seemed that on the part of the users of the coating as well as on that of the manufacturers of drying equipment there was a preference to use IR only to assist the drying process. Meanwhile due to practical experience that opinion has changed. Increasingly, the drying equipment offered on the market uses warm air without or only with a limited amount of radiated heat, i.e. IR. Instead, a lot of warm air is directed against the direction of the travel of the sheet in order to "peel" off the layer of water-saturated air and to increase the evaporation rate. This is mostly

accomplished by using several (about 4 - 5) airknives. In order to impart a flow direction to the saturated air and to increase the efficiency at the same time, a suction device is also installed. Air flowing over the wet, coated surface has a cooling effect, - consequently some heat is necessary to keep the temperature from dropping below MFT (minimum film forming temperature).

It has been observed that too much IR-radiation increases the tendency to blocking and/or setting off. There are now dryers being offered where the heat is generated outside the machine; they dry only by convection; the results are good.

Some dryers use a limited amount of IR-radiation to create some heat. The capacity required of an IR-dryer - or rather a drying accelerator - is determined mainly by the following factors: Type and thickness of stock, ink coverage, receptivity factor of the IR-ink, machine speed.

If the same job was to be printed instead of IR-inks and no inline coating with conventional inks and coated inline with WBC's, then the IR-dryer should be used only up to abt. 20% of capacity plus a lot of air should be applied as described above. It turned out that an air-cushion drum after the application of WBC's is also a good starter for drying.

Up to now, microwaves cannot be utilized for drying in sheetfed presses. The metal gripper bars running through a drying channel would cause short cuts. Drying the sheets by running them on a non-metallic belt through the microwave channel reduces the machine speed considerably.

Paper weighing less than 100 g/m^2 needs a decurler after coating to counteract the effect of the big amount of water applied to one side of the thin substrate. If a printing stock curls under the load of the applied coating, the reverse side cannot be printed inline since the decurler would smear the perfected sheet.

Gloss needs time to develop. In order to avoid adverse effects in areas of high ink coverage, the drying process should not be accelerated too much (cracking of the coating).

Leading European folding box manufacturers try not to exceed - if possible - an ink coverage of about 280%. UCR is

used to get close to that figure.

Accelerated drying is mostly used in case of a stock with a low absorption rate or in humid climate. It should not be used to make a coating work that dries too slowly. With respect to coating weight also see chapter 5. If it is necessary or unavoidable to use spray powder, then only untreated starch - and only very little at that - should be used. The starch grain absorbes water, grows bigger in diameter and carries the following sheet very nicely. The drying of the starch grain takes more time than that of the WBC. Siliconed starch as spray powder should not be used at all.

4. The three important parameters for inline coating and their interaction

By far the most important parameter for good results in inline coating on a sheet-fed offset press is the top surface of the printing stock itself. This refers not only to gloss but also to the various properties which nowadays can be built into WBC's. To name only a few: High rub resistance, deep freeze properties, waterbased blister coatings or coatings with defined slip properties a.s.o.

On the average, the coating we buy with a coated printing stock consists of abt. 85 to 90% kaolin, talkum, chalk, lime clay and pigments and binding agents as remainder. Consequently the gaps between the particles of the substrate are not completely filled with binder. The binder acts like an adhesive, glueing the different particles of the substrate only partly together. This then results in a poreous, sponge-type structure of the board- respectively paper coating with smaller and wider pores.

On the average, board for normal folding boxes has pores from abt. 4 to 12 µm in size, in some cases they are as big as 30 to 40 µm. Pores of cast coated calandered stock usually are 3 to 4 µm and even smaller.

These pores have to act as a sort of filter for the (mineral-) oil of the ink and for the water of the WBC as well. Because of this double filter action the amount of ink should be limited - if at all possible - to the 280% mentioned above if the sheet is to be inline coated. This prevents that all pores are filled completely with the oil of the ink and have no more further capacity free to absorb the water of the WBC.

For the WBC-process the smaller pores are more desirable since most of the small resin particles are then kept on top of the board, forming the dry glossy film there. If too many pores of big diamter are present, then too many resin particles can disappear in the pores. This results in a reduced gloss as test coatings easily demonstrate. The best way to determine the suitablity of board is to mix different brands of identical size and thickness in one pile and print and coat it at the same time. A gloss meter (reflectometer), preferable with 60° geometry, will give you the relevant percentage of reflection (gloss-points).

Board suitable for coating or not suited for coating is not synonymous with expensive or cheap board. So the most important parameter for inline coating is determined by the structure of the pores on the top surface of the printing stock.

Consequently a number of European board manufacturers have changed the application method of their clay coating from "airknife-coating" to blade-coating. This method increases the gloss attainable with inline WBC considerably.

Number two of the most important parameters of inline coating is the WBC itself. The waterbased dispersion coating itself can be adapted to a certain degree to the type of stock to be coated. This requires pretesting with a wire bar. Mostly the 4 micron (or 6 micron) bar is used.

The importance of the parameter number two is somewhat lesser than that of number one. It is a fact that a high gloss WBC on an unsuitable board will render only poor results. A WBC not specially designed for high gloss gives a good result in combination with a suitable board. An excellent result of course requires a suitable board plus a high-gloss-coating.

What applies to the result as far as gloss is concerned also applies to the other properties of the dried ink film. The board properties are of top importance when the board is to be coated with waterbased blister coatings. The more of the coating remains on the surface of the board, the better the sealing effect between board and plastic top. Consequentially the weight of the product to be blistered is in direct relation to the amount of coating available for the sealing effect.

Number three of the most important parameters for inline coating is the ink. Practice shows that the inks used in combination with the WBC applied wet on wet should only have a low content of wax, silicone or similar components in order to accept a good layer of coating. European WBC's are generally designed to have a surface tension of < 35 m/Nm, i.e. lower than that of the ink. Unsufficient wetting properties result in what is called "orange-peel-effect" which can be seen already when pulling a sheet from the delivery of the running machine.

In opposition hereto "cracking" appears about half a minute or longer after the sheet has left the running machine. This phenomenon can appear when WBC's are applied wet on wet on top of a high ink coverage of > 280% or if the drying assist has been exaggerated, usually by using too much IR-radiation. The appearance then is comparable to that of the glaze of antique porcelain.

So its preferable in inline coating to use a normal ink with a high pigment concentration which dries by oxydation. A few types of pigments for example alkali blue, some fanal pigments and milori blue can show a discolouration in combination wth WBC's. According to the information some ink manufacturer gave me, it is suspected that this is due to a low level of resistance to amines. However, since this shows up immediately, this trouble can be detected before the OK-sheet is signed. Providing your order for inks with the additional note "suitable for inline coating with WBC" will help your ink manufacturer to supply the proper type.

5. Coating weight in relation to the desired effect

Many years ago, inline coating with WBC was mainly used to cut down the use of spray powder or elimninate it altogether, to run full piles and to increase the rub resistance. For this purpose, wet weights of 2.5 to 3 g/m^2 were sufficient. The demand grew with time. Due to various properties that could be "built into" the coatings, the demand grew from a mere protective coating to a type of special finish (see also chapter 6). At the same time the layers of coating became thicker and thicker. And since it is not easy to measure the coating film thickness exactly, it appeared that some printing plants really did not know exactly how much coating respectively money they put on the sheet. The only reliable metering is done by measuring the consumption in relation to the number of printed

sheets. All measuring procedures (mechanic, magnetic, inductive, a.s.o.) are indirect measurements which include the board thickness. And the tolerance in stock thickness itself is frequently higher than the difference between uncoated and coated stock. Using a piece of aluminium foil taped to the board results in a reading which is usually too low due to the missing absorption.

Figures out of practical work with direct application indicate that for a finish coating 4.5, 5, 5.5 or maybe 6 g/m^2 wet weight should be sufficient. This is what is sometimes called an "economic optimum". Please note that this does not apply to waterbased blister coatings (see chapter 4). For primers a thin layer of abt. 3 g/m^2 wet weight should be sufficient. Putting on a layer which is thinner yet creates the risk that the coating surface is not completely covered especially if the viscosity is high.

Of course varnishing machines like the ones made by Billhöfer or Steinemann or similar machines can apply a much heavier layer of coating for special purposes but consider the speeds at which this is done!

Machines running at top speed require - if a board with a lower absorption rate is coated - a drying assist as described in chapter 3. You might consider the dryer somehow as your "insurance" for these cases. It should not be used to dry uneconomically thick layers of coating. Again: blister coating is the exception.

6. Properties of the dried coating film

In the early days of inline coating, the properties of a dried coating film could be described as protection against rub and a slight increase in gloss. Then the demand for gloss increased. Compared to gloss meter readings from about 8 years ago, there is considerable progress.

Using a high-gloss WBC on cast coated stock and medium drying speed, reflection figures can be achieved that are already close to UV. Note: This is in combination with conventional ink and at a much lower price.

Compared with OP's (overprint varnishes) the price for a WBC coating at an "economic optimum" is somewhat higher if you consider just the coating material. But all the advantages mentioned earlier, like shortened handling time for

a job and the absence of a yellowing effect should also be included in the consideration. Due to the fact that these coatings are odourless after drying, they are widely used for packages for odour-sensitive products. German manufacturers of pharmaceutical packages for instance demand WBC.

The family of WBC grew considerably. Besides good "universal coatings" which have quite a number of desirable properties, but never reach the maximum in all respects, there are now WBC's available with various special characteristics: High gloss, extreme rub resistance, matte in all degrees, slip coatings, anti slip coatings (coating against coating or coating against metal), blister coatings a.s.o. More are under development.

A good WBC designed for gloss should not display a big difference in gloss meter readings whether the measurements are taken with or without ink underneath. These coatings display a good balance between the components which are most responsible for the gloss in the respective areas (dispersions/hydrosoles).

7. Coating and simultaneous perfecting

The next step for an inline production beyond inline coating seems to be perfecting. This is either done in a first printing unit with or without turning the sheet according to the position of the respective printing unit. But the use of turning devices is limited where the weight of the stock to be printed increases. If a sheet is printed on the reverse side in a unit, so to speak from "underneath", this perfected side travels from impression cylinder to impression cylinder while the ink is still wet. In a coating unit, however, both procedures are combined. The sheet is coated from the top and the impression cylinder, working in combination with the blanket covered forme cylinder which serves at the same time as blanket cylinder for a plate cylinder which carries the plate for perfecting. Coating and perfecting occurs in one nip. The sheet then travels directly on to the delivery pile.

With this unit there are a few things, however, which should be mentioned. For example, if the forme cylinder keeps glue flaps free from coating, then there is no perfecting possible in this area due to the missing backpressure. It is also to be noted that the gripper edge on the perfected side is slightly larger than that on the upper side.

8. Considerations and experiences with the application of low viscosity UV-coating

It is understandable that very often printers want to make use of all the experience they have with conventional inks which dry by oxydation and all their experience collected over decades with colour separation, dot gain and so on. And to top it all of, it would be marvellous to enhance the wonderful printed result and to protect it by coating it inline with a UV-coating.

But there are interactions between this ink type and the UV-coating which make it very difficult to achieve a satisfying and repeatable result. In most cases a considerable "draw-back" occurs within the first 24 hours after printing and inline coating and a clear gloss difference becomes noticeable between preprinted and unprinted areas on the single package.

The gloss meter readings on the UV-coated areas that were preprinted are very often below those of a WBC used in combination with a suitable board. And even if the gloss should show hardly any draw-back effect, there still is often a reduced bond between ink and coating. Lack of tape resistance also turned out as a severe defect in some European countries causing the customer to start heated arguments about price reduction and even rejection of a job.

I am very glad that a few companies do tests in this direction or even plan their production in this way. It is a good way to learn more about this phenomenon. Where ever it is done - and this is true for most of the cases I know of - the printer is more or less his own customer.

To judge by what you can observe in testing, it seems as if this phenomenon is no problem of surface tension or the like, rather it is my personal point of view that we are dealing here with a volume problem. Therefore it is somewhat hard to resolve it satisfactorily and reliably.

9. Outlooks for the future

The question that is most frequently asked by printers in relation to inline coating is: Will the future be WBC or UV? I personally believe that the future will see both types of coating.

On one side there will be a lot of WBC for every day products, especially for packagings which are sold in self-service-stores, since WBC represents a relatively cheap and uncomplicated method to increase rub protection and create a finish with a good gloss level. Compared with what was possible eight or ten years ago, there is considerable progress due to the much further developed and diversified coatings.

More and more the substrate surfaces are adapted to suit the inline printing and coating demands. Dryer manufacturers now build equipment that fits exactly the needs to effectively improve the evaporation rate, to increase the speed and quality also on stock having a reduced absorption rate.

The use of WBC's is in the trend of the time: Free of solvents, no skin irritation, no environmental pollution but good protection at a gloss level which does not lower the readibility; a very important factor for self selling products. Every progress, especially in increasing the gloss, improves the situation in favour of WBC's.

There will also be an increase in use of UV-coatings. High quality packaging products like cosmetics a.s.o. will more and more make use of the inline process. At the moment extremely high gloss meter readings are achieved by either using UV-inks inline with a low viscosity UV-coating or in a two step production: Conventional ink coated inline with a waterbased primer and in a second step applying the UV-coating. Printing UV-inks at high speed can cause ink-misting.

However, it is done and customers ask for it frequently: Printing with conventional inks and coating inline with primer and then with a UV-coating - all in one pass.

This production method prevents adverse effects between ink and UV-coating but it cannot solve the volume problem in a satisfactory manner. If tests in this direction are intended it is recommended to use a continuous type dampening system for the application of the primer and the coating unit for the application of the UV-coating.

This method was used by a well-known English printer who also tested this sequence. When he dropped these tests he then had at least an additional damping- respectively

printing unit he could put to work; if he had purchased two coating units, one would now be useless.

There is plenty of room for further development in ink- and/or coating laboratories: for instance a high gloss UV-coating to top off conventional ink with no or only low draw-back, good tape resistance and enough flexibility to prevent cracking problems.

The criterion when selecting a coating applicator should be its ability to coat either WBC or UV. The delivery section of the offset press should be prepared to accept a UV-curing unit in case the above described type of UV-coating will be available at some later time.

Meanwhile we should try to differentiate: what properties of the dried coating are we aiming at and what type of coating offers us a chance to achieve this goal in an economic relation to costs, thus maintaining a good profit margin for the printing process.