HOT MELT LAMINATING WITH HOT ROLL LAMINATORS

PRESENTED BY YOUR PAPER PRINTER
AND AACC

HOT MELT LAMINATING
WITH HOT ROLL LAMINATORS

The factors of

TEMPERATURE-PRESSURE-DWELL TIME/SPEED

all coming together.

The process of hotmelt panel lamination is accomplished by heating and softening a pre-applied hotmelt adhesive to a point between the melt point of the adhesive and the point where the adhesive becomes fluid. While the adhesive is in this semi-molten state, pressure is applied as it passes through the nip rolls on the laminator and the initial bond to the substrate is completed as soon as the panel begins to cool to below the softening point of the adhesive. The lamination will continue to build bond strength as the adhesive returns to its crystalline state. Assuming that all of the laminating conditions of temperature, pressure and dwell time are correct for the paper, adhesive and the panel, the process should be quick, simple and easy.

The laminating conditions of the process are variable and these variables if not correct can lead to poor bonding quality and durability.

LAMINATING TEMPERATURE

Laminating temperature is probably the most critical factor in the process of lamination. The correct temperature for American Adhesive Coatings Company (AACC) adhesives is approximately 275^{o}F to 325^{o}F roll temperature at 30 to 70 FPM. Adjustments in the roll surface temperature need to be made according to the processing speed of the laminator, as the dwell time shortens as the speed increase. The best way to determine acceptable laminating conditions is to run a trial lamination and send samples to our lab for testing.

You may get acceptable results with roll surface temperatures from 275°F to 375°F; however, the bond will be best at roll surface temperatures in the range of 275°F to 325°F depending upon speed. It is important to know that excessive lamination temperatures do not improve the bond, so if we are going to error it's best toward the cool side and conditions should be monitored and tested. Remember that running at cooler temperatures will extend the life of your equipment, and if your laminator is heated by hot oil it will extend the life of the oil and reduce energy costs. With cooler temperatures it is also less likely that the adhesive will over liquefy and be driven into the substrate.

The Heating Process

Most laminating equipment utilizes internally heated rolls to provide a heat source for activating the adhesive. This heating process can be steam or hot oil. The machine, if steam heated should have a pressure gauge so pressures can be recorded and checked, and hot oil heated unit should have a temperature gauge. In the case of a steam heated unit the pressure gauge represents the pressure (and the temperature) in the entire system including the laminating rolls. The temperature gauge on a hot oil heated unit represents only the temperature of the oil, as it exits the heater, and not the temperature of the laminating rolls. There will always be a variance of about 25°F to 35°F between roll surface temperature and oil temperature in hot oil heated units. If the difference is greater that that we would suggest the laminator be checked out completely to determine the cause of this temperature difference. Example: if your oil temperature gauge shows 325°F and is set for 325°F, your roll temperature will probably be about 300°F. This temperature variance is a result of the loss of energy in the transfer process between the oil heater and the steel roll. The amount of this temperature variance will depend on the type, age and condition of the machine, and the recovery rate of the heating method. These conditions should be monitored to avoid lamination problems do to lack of heat or differences in temperature from one side of the roll to the other. The roll surface temperature should also be checked during long lamination runs to insure that the heaters are maintaining the correct lamination temperature.

Machine Maintenance

As with any equipment, routine maintenance is very important and affects the life of the equipment as well as the performance of product laminated on that machine. If the laminator is hot oil heated the oil should be changed per the manufacturerôs recommendations so that char does not accumulate in the hot oil system. This system is a closed loop, which includes the storage tank, laminating rolls, flow lines as well as the pump and heating elements. In steam-heated units the water should be treated to maintain the proper chemical balance for the proper operation of the steam heating unit.

Excessive degradation of the oil will cause the accumulation of carbon deposits (char) on the heaters and inside of the tank and lamination rolls. This accumulation will act as insulation and not allow efficient transfer of heat to the roll surface. Lower lamination temperatures help retard the breakdown of the hot oil, but cannot correct an already carboned up system. If you determine that the system is loaded with char you will need to flush out the system and add fresh oil, and it may also be necessary to remove the char built up on the heaters and in the lamination rolls. Another factor affecting the heat transfer process is the proper working of the heating elements and the oil transfer pumps. Always use only the oil recommended by the manufacturer. Remember to never exceed the maximum operating temperature recommended by the machine manufacturer as unsafe conditions may result and the heating fluid can flash and burn with excessive temperatures. If you have changed to a different heat transfer oil other than the one recommended by the machine manufacture please refer to the product information use sheet for that heat transfer oil to determine its recommended maximum temperature, but never exceed the equipment manufacturers recommended temperature. If using a steam heated laminator never exceed the recommended maximum pressure of the machine manufacturer.

The laminating rolls should be clean and free of defects. Any defect in the roll will be transferred to the finished panel and may be cause to reject that panel. Make sure that no debris is in the board or on the board, as it will damage a lamination roll as the panels are

processed under extreme pressures. The chrome surface of the laminating rolls should be clean, (clean regularly to eliminate build up resins) we want to maintain this rolls in a clean state. These build ups will affect the heat transfer process and can effect the final bond. Rolls can easily be cleaned with original formula GOJO hand cleaner. Apply the cleaner while the rolls are hot but not rotating. Do not clean the roll while rotating as serious bodily injury could happen by being drawn in between the rolls. For rolls with excessive build up of scorched materials, ñEasy-Offò oven cleaner can help remove these heavily loaded rolls. Apply the cleaner with roll temperatures about 275^{o}F allow to dry, reapply and remove with a damp coarse rag. Repeat if necessary.

Roll Temperature

By using a pyrometer you can check the temperature of the laminating roll surface. Using an IR pyrometer will not give accurate results due to the reflection off the chrome surface, on chromed surfaces contact pyrometers work best. IR pyrometers can give consistent results ONLY if the readings are taken off of the adhesive paper surface at the same angle each time. Purchasing a pyrometer is a worthwhile investment and its use should become part of your QC program. We have included the information at the back of this primer regarding the pyrometer we use. We believe that daily checking and recording of the surface temperatures leads to more consistent lamination and highlights temperature issues before they become detrimental to the quality of your lamination. The time spent checking roll surface temperatures is small compared to the loss incurred from poorly laminated board.

On hot oil heated laminators once you have determined the temperature variance between the oil set point and the laminating roll you can determine the appropriate setting for the oil temperature on your machine. If the variance should change, it can indicate that a heating element is not working, the oil is not pumping properly, or that the oil should be changed. The manufacturer has recommendations for changing the oil and they should be followed. Improper servicing of your laminating equipment will decrease its life and

lower performance of your laminated product. In a steam heated laminator this need not be addressed, as the pressure and therefore the temperature are equal through out the system.

Setting The Temperature

Once testing has determined the proper temperature for correct lamination the laminator should be set to that temperature and allowed to preheat. During this process the rolls should be rotating to help equalize the temperature as well as avoid the development of hot spots and warping of the oil heated rolls. Increasing the temperature adjustment at the beginning of the day to speed up the preheat process, has no effect on the speed in which the laminator preheats; the heating element is either off or on and they can only heat at their rated wattage. If you want to be able to start laminating when your shift starts a time clock to turn on the heaters before that time would work best.

If it is necessary to increase or decrease the temperature, remember it can take as long as one hour for the results to take place on the surface of the roll. This is especially true for temperature decreases. The reaction time of steam-heated laminators is considerably faster than the time required for oil-heated units, but both units will require time for the lamination rolls to loose temperature.

Once the correct temperature has been determine it should be set and monitored as needs require.

Some factors affecting the temperature requirement of the laminator are the ambient room temperature and the temperature of the board to be laminated. Obviously the temperature requirement for a laminator operating in the summer in New Mexico would not be the same as operating in the winter Minnesota. Remember, in the lamination process we are trying to soften the adhesive to semi-plastic state for proper lamination. If the room and substrate temperatures are hotter or colder than the normal conditions, it will take more or less heat energy to accomplish this. Seasonal temperature adjustments

should be part of your QC program for the equipment. If the substrate is extremely cold, you may find that after running several bundles of board the laminating roll temperature has decreased to an unacceptable temperature and that the bond is poor. This condition is a common problem on oil-heated units as the recovery rate is much slower than steam-heated units, but both laminators should be monitored closely when laminating with cold board. The roll surface temperature should be monitored with a pyrometer. All substrates act as a heat sink and take heat out of the laminating roll but cold board draws heat faster than the hot oil can replace it. (While you may think that you can laminate frozen board by running slower or increasing the temperature, it is asking for problems.) For the adhesive to bond properly the surface of the board, the adhesive, and the paper must come up to the same temperature and cool down at the same rate. The sudden cooling from cold board shocks the adhesive and proper bond strengths are not developed.

PRESSURE

The next factor in the equation is the pressure. When we talk about pressure it is important to remember that we have two pressure settings that we use in hot roll laminating, set up pressure and run pressure.

Please remember that the machine should be at laminating temperature before set-up is performed. If the laminating rolls are not up to temperature the expansion that takes place when they heat up will make the set-up pressure too high. This will make it very difficult to feed boards into the laminator.

The machine is set up to the thickness of the substrate being used. For most laminators, this consists of opening the gap between the laminating rolls and placing the appropriate thickness of board inside. The screw stops are backed out and the top-laminating roll is lowered onto the board at the desired set up pressure. The set up pressure is determined by the qualitative and surface consistency of the substrate. Higher set up pressures is

required to even out the surfaces of the substrate so proper lamination can take place. The stops are then finger tightened and thus the gap of the nip is properly set. Once the proper set up pressure is determined for each substrate it becomes part of the procedure for laminating that specific combination of board and paper. This will typically be in the range of about 200 psi. to 300 psi. for particleboard, slightly less for plywood (depending on the thickness consistency of the plywood) and slightly more for MDF.

After setting the gap for the correct board thickness, the nip is opened and an even burn mark should be observed across the full width of the substrate. This burn mark in the board surface should be uniform across the width of the board and about 1/8" to 3/8" in width. If this mark is uneven, something is wrong in the set-up. However the burn mark may be slightly wider at the edge of the board, excessive width of the burn mark on the edges can lead to lamination problems as the edges are thicker than the center of the board but a slight difference is to be expected. A burn mark that is wider on one side and narrower on the other will translate into good bond on one side and poor bond on the other side. Excessive set up pressures can make it difficult to feed board into the machine. Improper set-up can also cause the laminate to wrinkle or track unevenly. The set-up procedure should be performed each time the substrate type or thickness is changed and at the beginning of each day.

If the burn mark looks good the machine can be adjusted for the run pressure. This pressure can be whatever is determined to yield a consistently good looking panel. The normal run pressure ranges are about 200 psi. over the set up pressure to the maximum pressure allowed by the equipment manufacturer.

DWELL TIME/SPEED

Line speed should be determined by production needs, the amount of automation incorporated in the process and the amount of labor available to run the laminator. The laminator with automation can be run at a high production rate with one person to

oversee the operation of the laminator and a lift truck driver to reload the in feed and unload the out feed. Using slower line speeds without automation, 30 to 50 feet per minute, will usually require only 2 people to operate the laminator. One person will feed the machine and one will separate the panels and stack. They will load and unload their own product with a lift truck If your production requires a higher line speed, over 50 feet per minute, additional personnel or automation should be considered.

Once the required line speed has been determined, make sure the laminator can sustain the proper temperature while running at that speed. Higher line speeds will require higher temperature settings as the dwell time required to reactivate the adhesive will be shorter. Slower line speeds allow greater time for the transfer of the heat in the rolls to the paper. Higher running speeds shorten the dwell time and may require higher temperature settings depending on the diameter of the lamination rolls (the larger the diameter of the lamination rolls the more wrap the paper has around the roll, thus increasing the dwell time to allow greater heat transfer) and the ability of the heating method to supply the BTU's required.

Remember if you increase your line speed you must increase your roll temperature. If you decrease your line speed you must decrease your roll temperature. It is best to run tests to determine the best settings to accomplish running at different speeds. Our lab is available to assist you in this process.

It is important to note that proper pressure is necessary to complete the laminating process. If temperature and line speeds are correctly set and the pressure on the board is wrong, the bond to the board will not be as good. It is important to remember that all three factors; temperature, pressure and dwell time/speed must be correct to make consistent panels of good quality.

Excessively high pressure can appear to sometimes compensate for low heat and, excessive heat can appear to sometimes compensate for low pressure. But compensating the quality of the lamination process could lead to improperly laminated panels that may

look good to the eye but lack the full bond strengths of a properly laminated board. It is always best to maintain the process within the proper limits because if all parameters are where they should be the normal variances in procedures and processes are accounted for because these normal variances will not put you outside the "window" for proper and consistent lamination. Always remember that if all parts of the equation are given proper attention the end results will be superior. Do not be tempted to overlook one parameter and try to compensate by emphasizing another parameter.

Now that we have covered the three most important factors in regard to controlling the lamination process let's look at some minor factors that are also important in this process so we can better understand the relationship between these other factors.

THE AFFECT OF PAPERS IN LAMINATION

The type of paper being laminated can affect the required laminating temperature. While most think that the heavier the paper the more temperature required, this is not always true. A heavy basis weight paper that is post impregnated at 80 grams will transfer heat faster than a pre impregnated 80 gram due to the difference in the density of the papers. Dense substrates transfer heat faster than lower density substrates. (That is why we don't have insulation made from dense materials.) Consideration should also be given for black papers. The incorporation of carbon black in these papers increases the transfer rate of the paper. Obviously if the density of the papers are the same a 30 gram paper would need lower temperatures than a 80 gram paper with all other considerations taken into account.

SUBSTRATE CONDITION

The substrate needs to be a smooth clean substrate that is free of defects and

contamination. The adhesive layer may hide small defects in the surface but larger defects will telescope and be visible in the surface. The substrate should be between 50^{o}F and 80^{o}F in temperature and dry. Any extreme temperature deviations such as frozen board or excessively hot board will affect the temperature requirements of the laminating equipment, and adjustments need to be made to the conditions if possible to stay within an acceptable range of conditions for lamination.

BRAKE PRESSURE

This sole purpose of the brake is to keep the roll of paper from spinning freely between boards and to hold the paper firmly against the laminating roll so the transfer of heat into the substrate is equal. If insufficient brake pressure is used, the roll will spin freely and loose surface contact with the laminating roll causing improper heat transfer.

If excessive brake pressure is applied, this may cause to roll to telescope. If the roll telescopes this causes the paper laminate to move from the proper alignment relationship with the board fence that is fixed and will result in the paper laminate edges not lining up with the edge of the board. Excessive brake can also cause web breaks between panels.

Correct brake pressure is achieved when the paper roll is prevented from spinning freely and the paper is held tightly against the laminator roll. The brake pressure must be manually adjusted down as the roll diameter decreases if your laminator is not equipped with automatic tension controls. A large roll of laminate will require more brake pressure than will a small roll. Remember as the roll diameter decreases the effect of the tension increases due to the reduction in diameter of the roll. If your laminator does not have automatic tension control it will be necessary to dial down the brake pressure as the roll progresses gets smaller in diameter.

We suggest a brake pressure of 60 to 80 psi. for full rolls and decreasing it as necessary down to about 40 psi. (at about one half of the diameter) as the roll decreases in diameter.

If you notice the roll beginning to telescope, lower the brake pressure. If you notice the laminate buckling between panels or loss of contact with the laminating roll, increase the brake pressure. Remember only make small changes when required.

MACHINE ALIGNMENT AND LEVELING

The relationship of the board to the machine plays an important part in minimizing rejected boards. The two most important factors to remember when laminating are that "the paper has very little stretch" and "we are using a thermoplastic adhesive."

When we look at the fact that paper has very little stretch we must remember that the boards leading edge must start into the laminator parallel with the rolls. The board fence must be in proper alignment, (perpendicular to the rolls). If these factors are not true when the board first gets into the nip of the laminating rolls it will track as it entered the rolls. Unfortunately the paper that is in the unwind stand is in alignment with the machine, so if the board is not feeding straight through the laminator, and the paper can't stretch to ease this misalignment, it will have to break or wrinkle to relieve the uneven tension. The best way to determine if the board fence is in alignment with the rolls is to watch what happens as the board is fed into the laminator. A board that pulls away from the fence, or jumps behind the fence as it passes the end of the fence as it is processed is not in alignment and will cause problems. A slight 1/8" movement away or towards the fence will most likely not be a problem and needs not to be addressed, it is only if it is excessive or is causing problems in lamination. This misalignment will present more of a problem with recoatable papers as these paper have less slip in their topcoats.

A second part of this issue is the leveling of the machine to the out take table or roll conveyor. It is important to realize that hot melts are thermoplastic adhesives and because of this they do not build complete bond strengths until they have completely cooled. With this in mind it becomes important that the out take table or roll conveyor is level with the machine. If it is not you will have delaminating on either end of the board.

The adhesive has not had time to set on the board that has just been laminated (and is still somewhat hot) when the board lifts or drops as it leaves the laminator, because the adhesive has not completely set and it will cause the paper to peel back on edge of the board.

QUALITY CONTROL

Obviously it is important to know the quality of the lamination coming off you laminator, but you cannot do a destructive test such as the LMA recommended steam test on every panel without loosing production time and many panels. You can however perform some tests as you laminate to determine the quality of the panel. Destructive tests should be performed periodically, and taking advantage of AACC's lab testing service can routinely add to the quality of your lamination and help keep track of trends. There is not a charge for this service and we run these tests daily.

An immediate evaluation of the bond quality is to pull back the edge of the paper after lamination. This is best accomplished by grasping about a one inch wide strip and slowly pulling up on the paper. The results should be minimal pull back from the panel once past the sanding snipe on the board edge. This can be done by your laminating crew as they laminate during the day. It is advisable to check both sides of the panel being laminated from time to time, because of the temperature differences from one side to the other side of the roll on some laminators.

It is important that this test is done a few seconds after the panel leaves the nip. If the test is performed too close to the nip the adhesive will not have set and be soft so the bond will not be complete.

Also relating to the ñopenò state of the glue, the panels should not be separated too close to the nip. The softness of the hot adhesive can result in pull back of the laminate at the leading and following edge of the panel. It is advisable to separate the panels as far from

the laminating rolls as possible, thus allowing more time from the adhesive to set. This distance will ensure that the glue has returned to its solid state.

The method for separating the panels can also affect your quality and the number of boards rejected. The best way of separating the panels is to make a slight break between the panels and then allow the weight of the panel as it lowers itself to the scissor lift table to finish the job. This requires very little effort from the operator and will result in a clean break in the paper. If the panels are separated with a vertical motion, pull back on the edges of the panel can occur.

TROUBLE SHOOTING

If you have delaminating, determining the cause and making corrections is important. The first step is to look at the area that is bad to see if we can determine the cause by looking at the adhesive side of the paper. There are may possible causes for delaminating but the two most common are "too much heat" or "too little heat".

If you have a delaminated area and the adhesive is still present in large amounts on the back of the laminate, you did not have enough temperature and/or pressure. Usually this type of failure is due to a lack of heat, and this will require an increase of temperature or a decrease of line speed thus increasing the dwell time. If it is only in one small area on the board it might also be due to a low spot in the board. In this instance an increase in the set up pressure should help flatten the panel to eliminate this problem.

Please note that it is possible sometimes to relaminate a panel that did not initially have enough heat by running it through the laminator again at a slower speed and higher temperature to relaminate it to the board. This will allow you to salvage that panel.

If your observation shows that there is virtually no glue on the laminate, you have over heated the adhesive with too much heat or too slow of a speed. The glue has left the

laminate and penetrated into the substrate. This indication of too much heat or insufficient line speed will require a decrease of temperature or increase in line speed. Please note it will not be possible to relaminate these panels. If the panel has been exposed to too much heat, reprocessing this panel just worsens the problem.

If you do not have delamination but you question the bond, you should do some additional testing to observe the quality of the bond. Take a razor knife and cut a ñXò through the laminate into the substrate. Gently lift the intersection point of the cut and observe the bond. A good bond will be indicated by board particles clinging to the laminate and the laminate will be difficult if not impossible to lift from the panel without tearing. If no particles are present you need to look at your laminating conditions (temperature, pressure, dwell time/speed) and determine what is the cause of the failure to bond, and make changes according to your findings. After making these adjustments take the time to retest a panel to determine if the changes you made have corrected the problem. This will cost time and a panel, however, it is better to spend the time and money to test to ensure proper lamination quality than to run the production without knowing the quality of your lamination.

For a more complete description of trouble shooting issues please see our guide on our website at ***aacc-hotmelts.com***.

SHUT DOWN

At the end of the shift when it is time to shut down the machine, one last detail can greatly extend the life of a hot oil heated system. Turn off the heaters and continue to keep the rolls rotating for at least fifteen minutes. ALWAYS turn the heating elements off at least 15 minutes before shutting the machine down. This will allow the oil to begin cooling and prevent charring of oil on the heating element. This charring is one of the major causes of inefficient heat transfer in the system.

Remember it is important to have the rolls rotating in hot oil systems while the rolls are heating or cooling. In extreme situations an oil heated roll that remains static could warp. Always rotate the laminating rolls from start up until cool down is completed.

This cool down process is not necessary if the laminator is steam heated. The heater and the laminator can simply be turned off allowing the rolls to cool unattended.

CLOSING

Thanks for taking the time to review this primer on lamination, these guidelines hopefully will give you the necessary information you need to insure the quality of your lamination. Remember that your paper supplier, along with AACC are available to help answer any questions that might arise. We both work hard to insure that you get the most consistent product and the best service available. Remember our web site at ***aacc-hotmelts.com*** has the most current information you need to better manage your inventory, from current inventories to recent shipments, to the form for sending samples to the lab for testing. It's all there 24/7 for your use. If you need information on anything including new equipment, please just let us know.

American Adhesive Coatings Company
Telephone 978-688-7400
Fax 978-691-5015
Email aacc@tiac.net
Web site aacc-hotmelts.com