Edgebanding wood-based panels

State of the art on the way to the future

Moisture-curing PUR hot melt adhesives are more frequently used in superior furniture manufacturing, especially when a perfect bondline is required. Reactive PUR hot melt adhesives can now be processed on standard machines as well. A patented manufacturing process - to produce these adhesives in granulate form – makes it possible.

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Edgebanding wood-based panels with a wide variety of materials has been a well-established practice in the furniture industry for several decades. Requirements regarding the visual appearance, the progress in manufacturing technology, as well as the almost unlimited diversity of processing materials represent particular challenges to the adhesive technology (Figure 1). The quality of edgebanding is increasingly regarded as an indicator of the entire furniture's quality in modern, superior furniture manufacturing (Info Box 1). The consumer expects an almost invisible and flawless bondline on the furniture piece. The keyword "zero-bondline" became a synonym for this requirement in recent years and is now a well-known term in the industry. It can be read in almost any manufacturer leaflet and heard on all trade fairs, whenever the subject is edgebanding and edging.

The "zero-bondline" as demanded by marketing, requires the part to appear as being "one piece", facing production with major challenges: (Figures 2 and 3).

New technologies were developed by engineering companies and edgeband manufacturers in collaboration with adhesive producers to successfully fulfil these requirements in an industrial environment.

Figure 1: The furniture industry uses a vast variety of edgebanding materials.

Edgebanding methods

Hot melt adhesives are still the state of the art in classic edgebanding. Tank melting units are used to melt the different adhesive systems based on EVA (ethylene-vinyl-acetate), PO (polyolefin) or PUR (polyurethane reactive). The molten adhesive is then applied by rollers or slot nozzles, and pinch rolls or shoes join the edgeband with the substrate. A technology that basically remained the same since the mid-1960s and is used worldwide on a large scale. Today, large industrial units operate at a feed speed of up to 120 m/min, while small entry-level units operate at approximatively 6 m/min. Each individual sector must be provided with suitable adhesives to facilitate ideal processing conditions.

In 2008 the laser technology for edgebanding furniture pieces was introduced. This can be considered the triggering event for the “zero-bondline boom”. A diode or CO_2 laser is used to heat up a thermoplastic functional layer (already co-extruded on the reverse of the edgeband by the manufacturer) to a point where it becomes tacky and can be bonded to the edge of the workpiece. Special absorbers in the functional layer, specifically adjusted to the wave length of the laser, transform the laser energy quickly and efficiently into heat, increasing the temperature to melt and reach the required tack of the functional layer. Today, industrial units can reach a feeding speed of up to 60 m/min with this technology /3/.

Info-Box 1

Edgebanding

The introduction of particle boards in the 1950s is considered one of the most important innovations in industrial furniture manufacturing. Up to this day it remains by far the most used wood-based panel in this industry. For visual and functional reasons the cut edges of these panels have to be covered, respectively finished, in subsequent processing. The term “edgeband” became established for these covering materials many years ago. Edgebands can be narrow strips of veneer, resin-impregnated paper or thermoplastic materials and are available in fixed dimensions or as reels /1/. The process of bonding these materials to the edges of the various wood-based panels is commonly referred to as “edgebanding”.

The so-called plasma technology of Düstec follows a similar course. High-energy air plasma is directed through a nozzle onto the functional layer on the reverse of the edgeband, like the one used in the laser method. The energy is transmitted to the functional layer upon contact, heating it up until it becomes tacky. Although the plasma technology is fully functional, it did not gain general acceptance on the market.

The precise energy input to activate the functional coating make both technologies, laser and plasma, very reliable processes.

Lately, the so-called hot air technology has received widespread attention /4/. Compressed air (approx. 0.6 MPa) is heated in a tank up to approx. 600 °C. What follows next is similar to the plasma method: The compressed hot air is blown through a little slot nozzle onto the thermoplastic functional layer on the reverse of the edgeband, heating it up and reactivating it. This technology is used on a large number of edgebanding machines due to the low acquisition costs /3/. The disadvantages of this system are the high energy demand, long warm-up times, the imprecise heating of the complete edgeband and the possible warming up of surrounding parts of the machine. The latest method of heating or reactivating functional layers is using infrared modules that operate with short wave radiations (NIR, near infrared) in a wavelength above 780 nm. The even lower investment costs of the NIR technology compared to the previous methods, the simple, yet precise reactivation of the functional layer without any warm-up times are of particular interest for entry-level machines (Figure 4).

Adhesive as a functional layer

Edgebands that are not processed by conventional direct applications, receive a thermoplastic functional layer on the reverse. This approx. 0.2 mm thick polymer layer is already applied during the manufacture of the edgeband by co-extrusion. An important feature of the “optical zero-bondline” – the visually almost undetectable transition from the edgeband to the functional layer – is achieved by matching the colour of the functional layer exactly to the colour of the edgeband. Over the past years however, the limited availability of the highly diverse edgeband materials and high minimum order quantities have led to a demand for more flexible solutions.

Modern PO hot melt adhesives can be ideally compounded by means of a

Figure 2: A “zero-bondline” is extremely demanding on the bonding process.

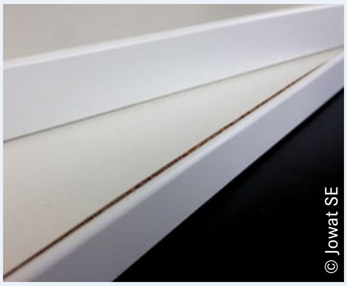

Figure 3: Comparison between a superior and an inferior bonded edge.

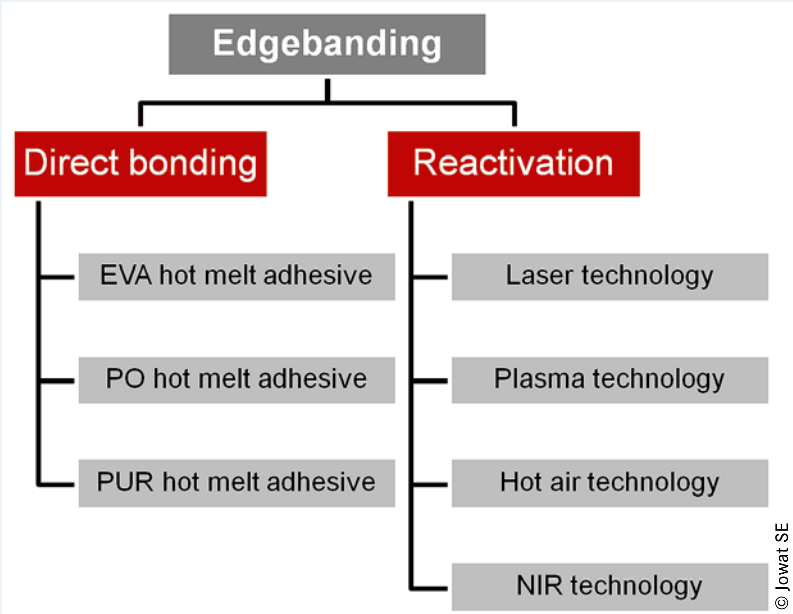

Figure 4: Standard technologies in edgebanding processes.

modular formulation concept to achieve the desired requirements (wide range of adhesion, hard bondline, high heat resistance, good flexibility at low temperatures, short open time). The growing variety of suitable PO polymers broadens the range of "tailor-made hot melt adhesives". Additionally to the standard Ziegler-Natta catalysis an increasing number of PO polymers are manufactured today through metallocene catalysis and well suited for edgebanding applications (postcoating and direct bonding) in the furniture industry. Incorporated special additives in the adhesive applied to the reverse ideally absorb the energy in the defined laser wave length. This ensures efficient heating up of the adhesive to an optimum temperature for reactivation and superior bonding. This technique also allows the use of different reactivation methods for all kind of edgeband materials. Whether wood veneer edges, thermoplastic edges or lower priced resin-impregnated paper edges – there are no limits to adhesive postcoating.

Increasing demands in quality

Has the technology of reactivating the reversely applied functional layers of edgebands become established? Is it replacing the conventional, direct bonding method on large scale in edgebanding?

The standard edgebanding process, where all kind of edgebands are bonded directly to various wood-based panels, is still the most common method of edgebanding. While other adhesive systems are pushing through, EVA-based adhesives are still the established technology and the most widely used adhesives. Additionally to EVA hot melt adhesives, there are the PO-based hot melt adhesives, whose use has increased since the mid-90s. The success story of PO adhesives began in the kitchen industry, where adhesives with a heat resistance of more than 70 – 80 °C were required. PO hot melt adhesives can be processed like the related EVA hot melt adhesives without any technical modifications to the equipment and became an efficient solution. The use of hot melt adhesives based on polyolefin increased especially in recent years due to higher quality requirements in edgebanding, and this trend continues.

There are various adhesive systems available today to obtain a "zero-bondline" at a high quality, provided that the edgebanding process was conducted correct and error-free. For the end consumer it is almost impossible to distinguish between the different products.

When it comes to highest quality in edgebanding and perfect bondlines,

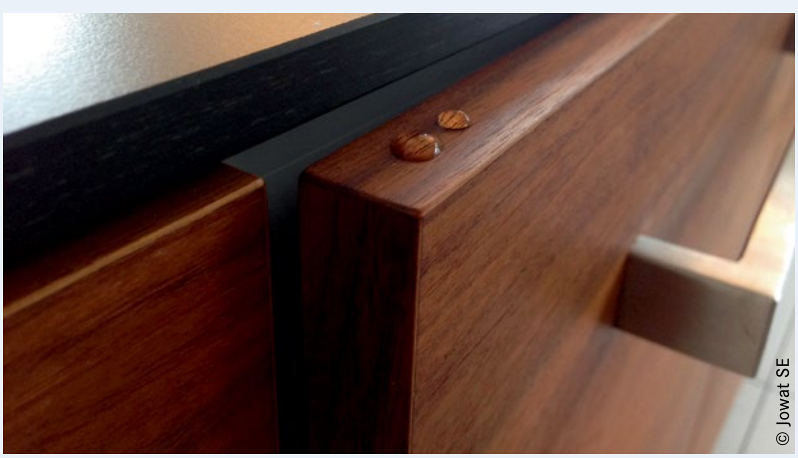

Figure 5: PUR hot melt adhesives offer excellent resistance to water and chemicals.

PUR hot melt adhesives are currently the first choice. Today, top-quality edge-banded furniture components demonstrate heat resistance values above 120 °C and a high resistance to water and chemicals, as well as a superior, almost invisible bondline (Figure 5).

PUR hot melt adhesives for everyone

Post-curing hot melt adhesives based on polyurethane (PUR) require more caution during processing. These adhesives are supplied in moisture-proof packaging and are processed in special melting units to avoid contact with the moisture in the air.

The continuously increasing acceptance of PUR hot melt adhesives in edgebanding is proven by the steadily rising sales numbers of edgebanders adapted to the PUR processing technology and by the growing demand for PUR upgrades of standard edgebanding machines.

The newly available PUR in granulate form, enables an easy introduction to these kind of adhesives. The granulate form is not only of interest for processors new to the PUR hot melt technology, but above all, also for small industrial companies that absolutely require PUR edgebanding for specific objects (Figure 6).

Processors who only have melt and applicator units for non-reactive hot melt adhesives, had to make expensive modifications to the applicator equipment, to process the high-quality, moisture-curing PUR adhesives as well. Especially these companies are now able to utilise the existing application technology without any additional investments for processing reactive PUR hot melt adhesives in the granulate form as well (taking into account some precautionary measures).

The common view at the beginning of this millennium was still that moisture-curing one-component moisture-curing hot melt adhesives cannot be granulated because of their high sensitivity to water /5/. Meanwhile, several patented methods are available on the market for this technology. One of the methods developed for handling moisture-curing materials might appear to the laymen quite astonishing: The production of spherical pellets or granules underwater (Info Box 2) /6/.

Low-monomer, respectively monomer-reduced systems

The reactive component in one-component PUR hot melt adhesives are isocyanate groups. The individual ingredients of PUR hot melt adhesives are of very low volatility at room temperature.

Figure 6: The high-end solution from Jowat for edgebanding: PUR hot melt in spherical pellet form, granulated under water.

With increasing temperature, e. g. during processing at 140 °C or higher, vapours containing isocyanate may be released. The permitted threshold limit value (AGV Arbeitsplatz-Grenzwert) in Germany for monomeric MDI is 0.005 ppm in the air /7/.

In addition, mixtures containing monomeric MDI, as is mostly the case for PUR hot melt adhesives, are also subjected to certain labelling requirements by law. With the implementation of GHS (Globally Harmonized System of Classification, Labelling and Packaging of Chemicals) several H and P phrases are mandatory. Especially at a free monomer content of more than 1 %, the phrase H351 label ("Suspected of causing cancer") and the related symbol indicate the potential health hazard.

Application units on modern manufacturing machines processing PUR hot melts are usually encapsulated and have an additional vapour extraction system. Various measurements conducted during running operations have repeatedly proven that there is no excessive, hazardous MDI concentration even when standard PUR hot melt adhesives (subjected to labelling) are handled properly. However, due to the minimizing principle to reduce emissions at the workplace, the demand for mon-

Info-Box 2

Underwater granulation

During the underwater granulation process, the molten material to be granulated is extruded through at least one hole in a perforated plate into a cooling liquid, i.e. water. The extruded material (melt-flow) can be cut off, for instance, by fast rotating knives. When the polymer is cut off by the rotating knives under water, the temperature difference between the polymer and the cooling water causes a rapid contraction of the cut string, to form a spherical shaped pellet or granule. Compared to other forms, the spherical shape is of significance especially in drying processes that rely on diffusion, but also of advantage for dosing and feeding, due to a minimal contact surface and optimal flow property.

Info-Box 3

Renewable raw materials

In contrast to fossil raw materials (gas, petroleum, coal), renewable raw materials come from agricultural or forestry production and are used outside the food and feeding sector. Vegetable oils, sugar, starch, proteins and wood are just some of the most important materials used in the chemical industry. Renewable raw materials usually require more or less complex chemical processing before they are suited for industrial use. Nature does the main part in this regard by providing the organic carbon sources through photosynthesis. All Man then has to do, is to replace the process that takes millions of years in nature of transforming this organic carbon source into oil and coal, with precise synthesis steps. A decision about the possible use of a material considering all ecological and economical aspects is only possible after analysing all processes. Products based on renewable raw materials are still more expensive and there is a lot of uncertainty in future prognoses. But sustainability is not the only motivation: A reliable supply and independence from raw material imports are additional driving forces for the chemical industry, where particularly the adhesive sector is often affected by certain bottlenecks and raw material availability. Industries and institutions that are actively researching in the adhesive sector receive special public fundings to support them in their efforts. In September 2014, the BMEL (the German Federal Ministry of Food and Agriculture) and the FNR (German Agency for Renewable Ressources) initiated a fund explicitely for adhesives.

omer-reduced PUR hot melt adhesives will increase.

In the meantime, many adhesive manufacturers are already offering such low-monomer systems, but they all have to achieve the impossible. Monomers are not only an unwanted component from the manufacturing process, but an integral part of each reactive PUR adhesive system. Monomers are small and mobile, and can easily diffuse to the substrate surface and influence the performance of the adhesive positively. Therefore, crosslinking of monomer-reduced adhesives is slower. According to the distribution of molecular weight by Schulz-Flory, it is technically impossible to achieve a complete conversion of the monomer in a production process if a defined molecular weight / chain length and viscosity range is targeted. Residual monomers need to be extracted after the desired chain build up – a task that can hardly be accomplished by the adhesive manufacturer. The adhesive industry can only rely on appropriately manufactured prepolymer systems from the major raw material suppliers. Up to this day, low-monomer or monomer-reduced systems have therefore a higher viscosity and are intrinsically softer due to a higher content of polyether in the polymer backbone. Technically it is possible to manufacture adhesive systems with a low

Figure 7: Renewable raw materials are continuously gaining significance in the chemical industry.

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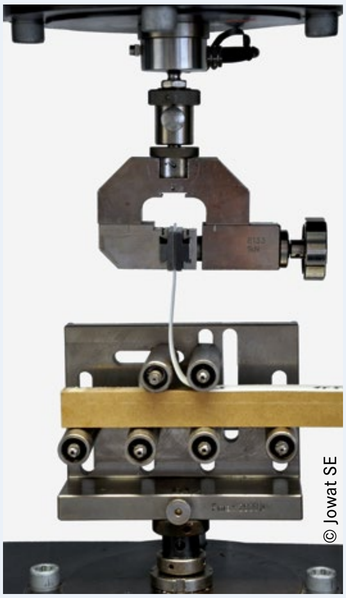
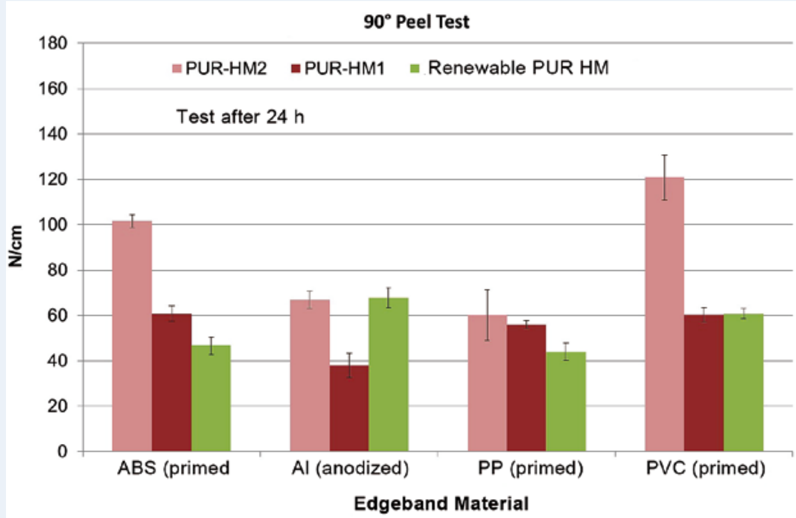


Figure 8: The standard peel test is used to evaluate the bonding performance



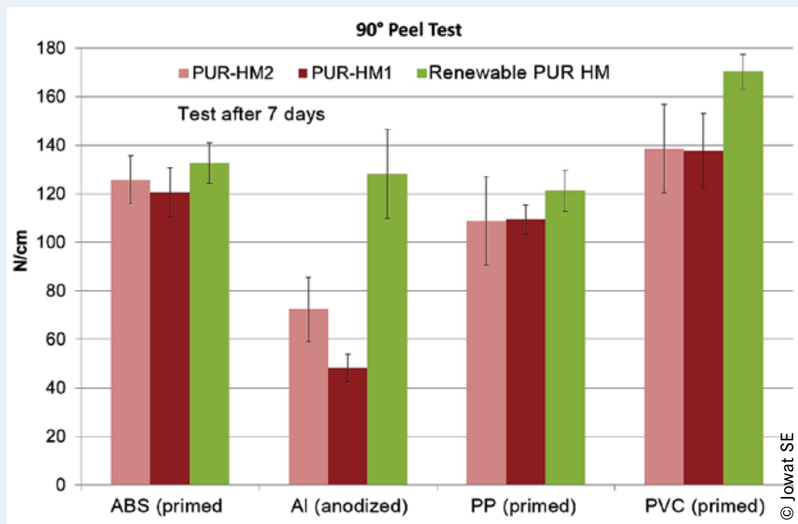


Figure 9: Peel test comparison (after 24 h and 7 days) between a PUR hot melt adhesive based on renewable raw materials and two standard adhesives based on fossil materials

monomer content. However, it is very difficult to achieve an equal (1:1) performance compared to PUR adhesives of identical make-up, but subjected to labelling requirements.

Renewable raw materials are in trend

Intensified research efforts in the area of renewable raw materials from previous years are becoming more and more commercialized (Info Box 3). Almost all adhesive manufacturers are active in this sector and are marketing more and more products with an increased content of renewable raw materials (Figure 7). The amount of bio-based raw materials available to developers is growing steadily. To be competitive on the market with a product that is often more expensive than other alternatives it is not sufficient in most cases to carry the attribute "renewable". However, renewable raw materials frequently provide properties that cannot be obtained with commonly used products. Variations of the source materials and differences in the synthetic routes are the reason for that. For instance, Jowat SE has developed an adhesive for edgebanding based mainly on renewable raw materials. The PUR hot melt adhesive has a high content of bio-based polyesters with slightly different characteristics that influence especially the crystallization behaviour. The resulting adhesive is setting a bit slower compared to two conventional edgebanding adhesives by Jowat, but has a significantly broader range of adhesion and a superior performance, particularly when bonding metals (Figures 8 and 9). ■

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