NEW PUR HOT MELT ADHESIVES

The products for extremely short processing cycles

Every day, bonded or laminated interior components for automotive applications, like ceiling liners, dashboards or door and side panelling, are subject to extreme stress factors. 2K PUR adhesives on solvent basis, 2K PUR dispersions or reactive polyurethane hot melt adhesives (PUR-HM), meet these challenges. Still, there is some potential for improvement - and PUR hot melt adhesives which have been newly introduced to the market provide the answer.

Figure 1: Vehicle interiors laminated with synthetic leather, like dashboards or side door panelling, have to withstand for instance extreme temperatures.

THOMAS HOHBERG

More efficiency, higher flexibility, improved quality: Vehicle manufacturers and their subsuppliers wanting to be ahead of the competition are choosing optimized processes which operate with short processing cycles.

When new adhesives are developed, the focus is today not only on the adhesive performance with regard to stability and strength data. Adhesives which are to be used for industrial applications must be regarded, and this already while in R&D, as auxiliary products which form part of a joining process of the customer. From this point of view, what becomes very clear is that R&D projects with the objective to increase the productivity of customer processes, have high priority. This target will usually have more impact on value-creation than for instance price.

Motivated by these interrelated factors, new PUR-HM products for laminating interior vehicle components were developed. During the bonding process and while cooling down, these adhesives build up a strength level clearly above the data reached with dispersions. In consequence, the conditions for increased productivity in serial productions were excellent, while at the same time costs were reduced.

Laminating interior vehicle components

When parts for vehicle interiors are laminated, like door panelling, ceiling liners or dashboards, the basic components are covered with a decor material, for instance synthetic leather (Figure 1). This not only improves the visual appearance, but also the feel of the finished structural part. Additionally, the stability testing standards and the requirements concerning VOC levels and fogging performance must be met, as established by the OEMs for the respective regions of use (climate zones 1 - 3).

In serial production, the laminate

bonding methods mainly used are vacuum deepdrawing and press laminating. The adhesive is applied onto the decor material or the core substrate, in individual cases also onto both surfaces. In the case of vacuum deepdrawing, a thermoplastic foil is warmed, prestretched and laminated onto the substrate under vacuum. In this process, the adhesive is activated together with the foil or by the hot decor foil itself. Cooled-down tools also facilitate fast cooling-down of the structural parts, so that after a few seconds in the machine or press, the part can be removed out of the forming stage and the unit is ready for the next component. Decor foils are, however, stretched in laminating procedures of highly formed 3D parts, and reach many times their original surface size. Therefore, the adhesive may have to withstand extreme resilience forces which develop in the structural part while this is still warm after removal from the press. The same applies to the high resilience levels in bonding of folded edges. These folding applications demand adhesive products which build up high initial strength after only a few seconds. In fact, the development of initial strength over time is a major process parameter, and as such a factor determining processing cycles, and in consequence the productivity of the machine.

These demands can be met with solvent-based adhesives, 2K PUR dispersions or reactive polyurethane hot melt adhesives (PUR-HM). Depending on the type of adhesive used, the consequences for the process sequences will show the typical differences, but also potential for improvement.

Solvent-based adhesives

Solvent-based contact and 2K PU adhesives are convincing by their excellent adhesion spectrum, and their easy handling. Depending on the type of adhesive, evaporation times of about 30 seconds may be reached.

Solvent-based adhesives

Processing: Spray and brush application

Characteristics:
- Excellent adhesion spectrum
- Easy processing even on 3D geometries
- Adjustable
- Cold bonding, temperature activation, wet bonding (depending on product)
- Short evaporation/drying time
- Short pressing times (depending on product)
- Problematic aspects of solvents

Dispersion adhesives

Processing: Spray application, rarely by roller

Characteristics:
- High initial strength (high molecular weight)
- Easy processing even on 3D geometries
- Short pressing times (<10 s)
- Free of solvents
- Long drying time / high energy consumption
- Limited coating thickness (skin formation if layers are too thick)

Reactive polyurethane hot melt adhesives (PUR HM)

Processing: Slot nozzle and roller, rarely spray application

Characteristics:
- Wide adhesion spectrum, superior final strength data
- No evaporation time, inline processing and reactivation possible
- Free of solvents
- Flexible bondline, also very suitable for assembly operations
- Multiple reactivation possible
- Average initial strength (average molecular weight)
- Difficult application on 3D geometries
- Long pressing times (> 30 s)

Even if the solvent systems used in modern products are free of halogens and aromatics, the necessary measures for protection in the workplace must be observed when handling solvents. Solvent evaporation must also be taken into account when considering the VOC balance sheet of the company, For these reasons, these adhesives are frequently used only in prototype assembly and in small series.

Dispersion-based adhesives

Dispersions are well-suitable for application by spray method onto complex 3D structures, the use of 2K PU dispersions has also become established as standard in lamination. After drying, the adhesives are activated by heat (approx. 60 – 70 °C) and bonded by pressure.

In order to build up good adhesion, sufficient pressure is required due to the high molecular weight of the polymers used – but this also means that very high initial strength results can be achieved. The short pressing time of approx. 10 seconds is ideal for reaching optimum productivity in operations with complicated laminating machines, for instance those necessary for bonding processes in edgefolding operations.

A factor which draws more and more criticism is, however, the high consumption of energy and the long time required for drying. For the evaporation of the water contained in the dispersion, usually additional drying units are required, space and energy are needed.

Reactive polyurethane hot melt adhesives (PUR-HM)

Bonding with reactive PUR frequently leads to the best results, because in addition to the thermoplastic solidification, the adhesive undergoes chemical crosslinking with moisture after application. This means that during processing, the PUR hot melt in the melt unit must be protected from exposure to moisture, to prevent a premature reac-

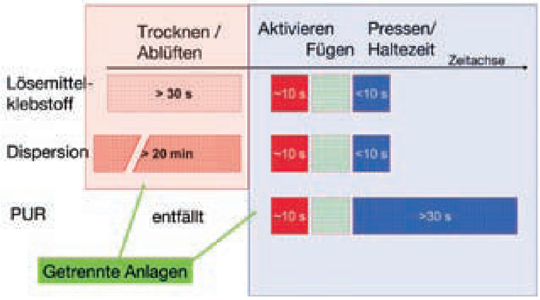

Figure 2: Time gained using PUR technology

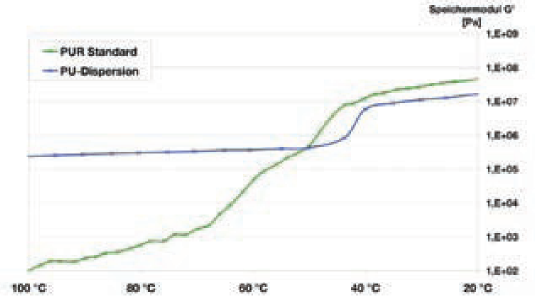

Figure 3: Comparison PU dispersion / standard PUR

tion of the adhesive and the associated rise in viscosity.

Processes are ideal which permit application of the adhesive onto a flat, plane decor surface – for instance onto a textile, a decor foil or a carpet – using a slot nozzle or roller coater. Depending on the type of adhesive, the components precoated this way may immediately undergo further processing or be stacked, rolled and held in intermediate storage for several hours. Another advantage of the PUR HMs is the chance to process inline without a separate drying or evaporation cycle.

The polymers used generally exhibit an average molecular weight, in contrast to the dispersions and solvent-based adhesives, PUR hot melts must be applied in molten form.

This frequently results in medium initial strength data, with a delayed buildup in strength based on the crystallization rate. Prolonged pressing times are usually the consequence in comparison to dispersion adhesives.

Gaining time by using PUR hot melt adhesives

When comparing the process curves of the three adhesive groups in Figure 2, the time gained by using the PUR technology becomes immediately apparent.

As a rule, the drying process, and the laminating process itself – with activation, joining and pressing – are carried out in separate machines.

When PUR hot melt adhesives are used, the units for drying are no longer necessary, which means less energy consumption and less floor space. Even when considering the more demanding application technology for reactive hot melt adhesives, these advantages remain unchanged, and this can be used profitably in new plant conceptions.

Conversion without loss in productivity

If for instance existing dispersion units are to be converted to PUR, the longer duration of pressing of about 30 – 40 seconds for PUR can lead to possible capacity bottlenecks in the laminating process.

Therefore, a new PUR product was desired, which permits to operate with existing machines designed for dispersion or solvent systems, requiring the lowest possible work and time investment, and not leading to losses in productivity. The prerequisite for this is a very fast buildup of strength, which proceeds practically without delay parallel to the cooling-down – ideally this should be as fast as for dispersions.

In order to carry out accurate measurements of these characteristics, the Dynamic-Mechanical-Analysis (DMA) is a suitable method. The storage module G´ here progresses parallel to the increase in viscosity and to the cohesion of the adhesive.

When examining the data compared in Figure 3, of a dispersion and a tried-and-proven PUR which is used for lamination, the dispersion exhibits a steep rise in strength at about 45 - 40 °C, which correlates well with bonding results from the field. This does, however, not apply to the PUR, which already should exhibit a higher strength than the dispersion at 50 °C. The error, which is also seen in the uneven curve, is based on the standard programming with which the DMA takes readings. The accurate temperature setting and adjusting here allows readings at the individual points of measurement, close to the thermal equilibrium. Thereby the hot melt has time to undergo at least partial crystallization, thereby building up additional strength. This, however, is exactly the time which is found in practice in longer holding times.

If in contrast the readings are taken as illustrated in Figure 4 during fast cooling-down, with the factor G´ opposite the time axis, the results found correlate much better with the findings from the field.

The strength increase of the dispersion (blue) reflects the temperature reduction (orange) very well. Here, even the short-term excessive cooling-down

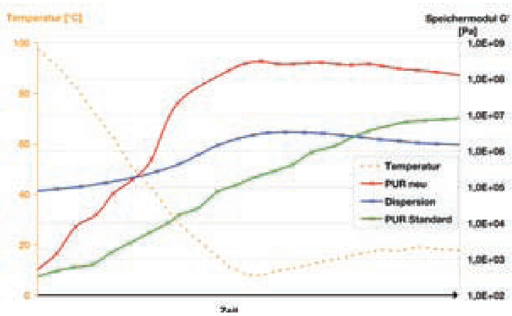

Figure 4: PUR adhesive new

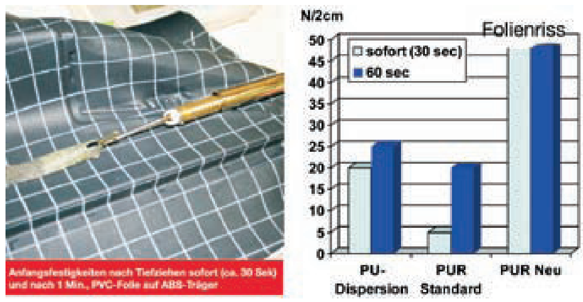

Figure 5: Initial strength after deepdrawing

below the nominal temperature of 20 °C is represented in the curve – while the increase in cohesion for the standard PUR hot melt (green) only starts delayed, but then also approximately matches the data for the dispersion. These results are parallel to the bonding results from the field.

The new PUR hot melt adhesive allows shorter production cycles

Any PUR hot melt adhesive which shall equal the same short production cycles (especially the times in the machine) found with dispersions, should also reflect the drop in temperature by a corresponding rise in the G´ values. The newly developed PUR (red) which resulted from a development project, exhibits exactly the performance desired when examined by DMA: The strength rises as soon as the temperature drops, and the level of strength reached is clearly above the one for the dispersions.

The bonding performance was examined for compliance with the DMA results, by laminating a typical PVC decor foam foil to ABS substrates in vacuum deepdrawing.

In two short cycles, after only 30 seconds approximately, and one minute after lamination, the peel strength of the bond was determined. The results in Figure 5 show that for the dispersion, there is only a minimal difference in increase of initial strength between 30 and 60 seconds.

The standard PUR hot melt already exhibits very clearly how time affects initial strength; after 30 seconds, this would not be a strength result which would be acceptable for edgefolding operations. After 30 seconds, the newly developed PUR hot melt, however, already has a much higher strength than the dispersion. Material failure in the PVC foil (at approx. 50 N/2cm) is noticeable when a strength test is made immediately after bonding.

This performance was supported when the product was used on customer machines. Directly after lamination, on machines originally designed for processing dispersions, the strength data were above those for the processed PVC foils, with pressing times remaining unchanged.

On the way to the ongoing first serial production, all tests on structural parts which were demanded by the OEM BMW were passed without problems.

Using all advantages of the PUR technology, these new PUR products which were especially developed for short production cycles can now also be used for extremely fast cycles in serial production (superfast pressing times < 10 sec.); this was up to now limited to dispersions. Provided the conditions for adhesive application and the activation temperatures are met, it is possible to even convert from dispersion technology to PUR wit minimal changes.

Conclusion

Any development of an adhesive tailored for a specific application is also the result of a close cooperation between the adhesives manufacturer and the processor. With the new PUR products, interior vehicle components can now be laminated with huge advantages for processors on the market: Processing cycles become much shorter, and the new PUR products can even be used on existing lines which were so far designed to operate with dispersion or solvent-based systems only. ■

Author

Dr. Thomas Hohberg (thomas.hohberg@jowat.de, +49 (0)5231-749-147) is Director Industrial Division Automotive and Textile Adhesives at the Jowat AG in Detmold