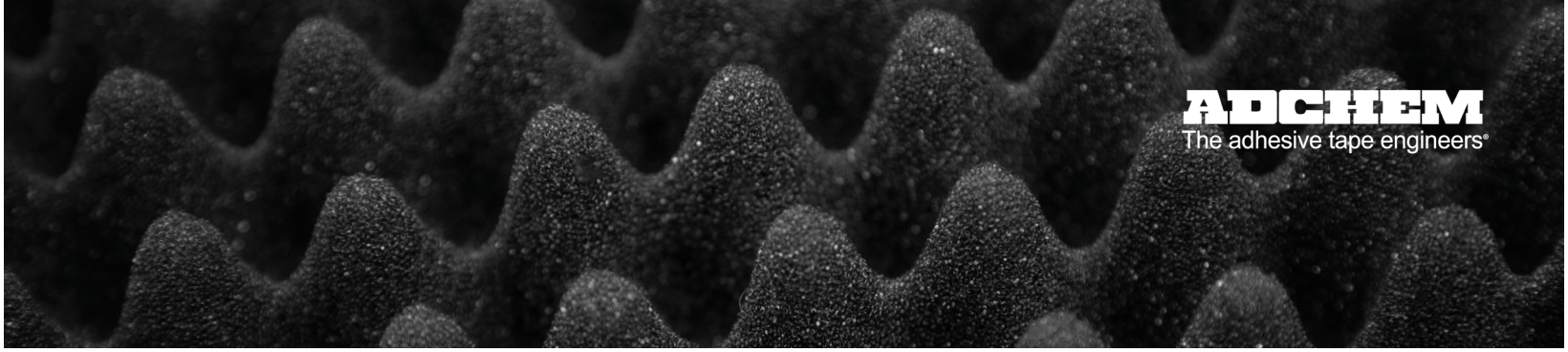

Foam Adhesion: Identifying the Challenges and Solutions

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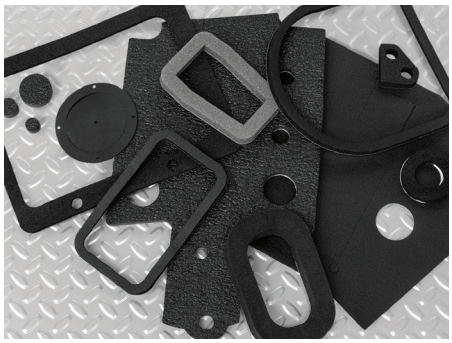
August 2023

Summary

There are a number of variables that can impact the efficacy of the adhesive system, and they are often seen in conjunction. This can cause a foam adhesive system to encounter different challenges throughout its lifecycle. By identifying and addressing these challenges, we can develop processes and technologies that will allow us to mitigate them for the entire lifecycle.

Identifying the Challenges of Adhesives and Foam Substrates



Foam Substrates
One of the primary aspects of foam is that it can take many different forms and consistencies. The versatility of foam that makes it so widely applicable is also what causes difficulties during foam adhesion. Foam can vary by weight, rigidity, porousness, and, perhaps most importantly, application. Each of these variables requires unique characteristics and functions from the foam and the adhesive system.

Surface Texture
Foam surface textures range from smooth to rough, and each texture requires special adhesives for bonding. For example, smooth surfaces often require specific surface treatments, such as abrading or corona treating, to ensure an effective bond.

Skived/Skin
Sometimes converters want to bond to “skived” foam where the cellular structure of the foam is exposed, and other times they want to bond to the “skin” of the foam. The challenge with skived foam is that there is less surface area for the adhesive to contact, and this can cause the adhesive to “bridge” over the open cell structure. Alternatively, foam with the skin intact presents its own set of issues. The skin may contain release agents or other surface contaminants that can interfere with the adhesive’s ability to bond effectively. The skin also has the highest concentration of ingredients that could migrate to the skin surface and cause bonding problems.

Adhesive-Foam Compatibility

Some adhesive materials contain solvents and monomers that can swell and collapse particular types of foam. Destructive chemical reactions can also occur in the opposite direction because polymeric materials contain additives that can migrate to the surface and destroy the adhesive bond. Adhesives must be formulated to resist chemical interaction with surfactants, plasticizers, waxes, oils, and other substances. This can be particularly complicated as foam manufacturers continually evolve and improve their formulas, altering the chemical composition of their products and potentially impacting the efficacy of the adhesive.

Foam Compression

A foam's compressibility dictates and limits how much pressure can be applied by the converter when the pressure sensitive adhesive (PSA) is applied to the foam and the material travels through the laminating equipment. In general, stiff foam materials hold up to considerable pressure. Alternatively, some highly compressive foams cannot recover from applied pressure, while others have good memory characteristics and can withstand significant pressure.

Manufacturing

Foam manufacturers and adhesive manufacturers do not typically work together. As a result, production engineers and product designers will generally select the foam material(s) and subsequently identify an adhesive system that works with that material, applying it universally to that type of foam. Unfortunately, in practice, there are no "one size fits all" adhesive solutions that will work for all foam material applications, making it possible to use the wrong adhesive for a given application.

Release Liners

Most foams have to be adhered to both the release liner and the final substrate. The release liner must remain securely attached throughout the early lifecycle stages (e.g. transportation, fabrication, etc.) and be easy to remove during application. In other words, the system must have a "tight release" during processes such as lamination, cutting operations, storage, and more. It must also have an "easy release" to enable automated or manual removal during the application process.

Bear in mind, the adhesive requirements for the temporary function of the release liner and the adhesive requirements for the permanent function of the final substrate are in direct opposition to each other.

Fabrication

Generally, foam is not market-ready after leaving the manufacturing line. It often needs to undergo fabrication to fit the use(s) of the application. When an adhesive impedes or fails during the fabrication process, it can lead to product damage, waste, and manufacturing disruptions.

Environment

As with many materials, foams and adhesives can be highly susceptible to environmental changes, including drastic differences in temperature, humidity, and exposure to chemicals such as grease. These varying environmental conditions can change the consistency and rigidity of the foam and adhesive, creating potential for a different interaction between the foam substrate and adhesive or the adhesive and the final substrate. The environment can change at any point during transportation, storage, or application, meaning that adhesives must be able to remain intact and effective in a myriad of different environments and applications.

Practical Application
To better understand these challenges, imagine a foam component with adhesive that has been die-cut from a sheet. For this component to function properly, it must lie flat and remain in place while being transported a thousand miles. Moreover, during transportation and handling, the release liner on the foam component must remain intact, whether in a hot, humid truck in Florida or a below-freezing truck in Alaska.

Once the component arrives, the installer must remove the release liner from the foam and affix the foam to a car door. After being applied, the adhesive must have the ability to withstand grease, solvents, UV light, the stress of the door slamming hundreds of times, and temperatures that reach 40°F below zero.

Although the foam adhesive system will face a range of variables throughout its lifecycle, the resulting challenges can be anticipated, addressed, and mitigated through necessary expertise and effective design.

Addressing the Challenges of Adhesives

Identifying the challenges an adhesive will face is the first step in addressing adhesive failures. The next step is to put practices in place and create technologies that will effectively address and mitigate these challenges.

Environment
For the first half of the foam lifecycle, it is possible to control the environment by taking appropriate measures during manufacturing, transportation, storage, and more. These measures are typically recommended by adhesive and foam manufacturers and include storing the foam flat in a cool, dry area. Once the foam has been applied and the final product is in the hands of the end user, it is impossible to control the environmental conditions. There are two solutions to this – first, the system should be designed to withstand outliers of the application (e.g. extreme temperatures, excessive force, weather exposure, etc.), and second, the end user should be made aware of the system's capabilities and parameters to prolong the life of their overall system.

Manufacturing
During manufacturing, it is best practice to specify an adhesive that accounts for both the characteristics and specific application of the foam; however, this practice can be difficult. For the engineer to identify which adhesive is best for the foam and the application, they must understand both the requirements of the application and the unique capabilities of the adhesive. Coupling these two variables during the design phase can help ensure optimal success for the adhesive system once adhered to the final substrate. In many cases, engineers or foam manufacturers can work directly with adhesive manufacturers to identify the best adhesive system for the application.

Chemistry

Adhesive manufacturers can alter the adhesive chemistry to better address the application requirements and challenges. While this may seem like a simple solution, creating an effective foam adhesive is a careful balancing act. An adhesive's chemistry must address the significant variability of the foam, the environments, and the applications it may encounter throughout its lifecycle. As already established, these aspects are tremendously diverse and often require one-off considerations. This makes it difficult to engineer adhesive systems that are reliably functional throughout their lifecycle and can be broadly applied for many different applications.

For example, certain applications require the adhesive to have a 100% foam tearing bond. In this case, the strength of the adhesive is greater than the internal strength of the foam, leading to the destruction of the foam itself. In other applications, the adhesive is expected to remove cleanly from the foam to prevent the foam from tearing at all.

There is no silver bullet adhesive that will work for all applications and also address every potential challenge. In many cases, an adhesive will have to be adapted to support the unique requirements of a specific application.

Creating Solutions that Mitigate Adhesive Challenges

There are many factors to consider when engineering adhesive systems, and perhaps the topmost are the chemical composition and mechanical properties of the foam(s) and the substrates. Substrates can be highly variable and include things like glass, plastic, metal, painted surfaces, and even human skin. Additionally, an adhesive system must be designed to meet the particular performance requirements and environmental conditions of the end-use application. With these design requirements in mind, there are specific steps adhesive manufacturers can take to preemptively address challenges that may impact the performance of the adhesive system.

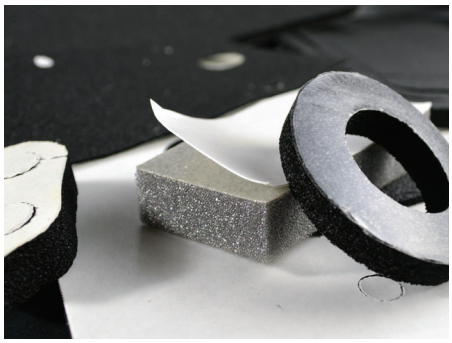
Conduct Foam Bonding Studies

An adhesive manufacturer should conduct general foam bonding studies to explore how well the adhesive will bond to both the foam and the substrate. These studies evaluate various types of foam, substrates, and adhesives to ensure the chemical bond is sufficient to withstand the rigors of potential real-world applications.

Publish Foam Bonding Studies

The results from these studies should not be buried in an archive. Publishing the bonding reports is critical for engineers to make informed decisions regarding which adhesive is right for their foam and applications. When selecting an adhesive, identify manufacturers that have published their foam bonding reports to ensure there is science supporting the requirements of the application. Prior to engineering a foam adhesive system, engineers should carefully evaluate the bonding reports to ensure that the materials they select will be appropriate for the application.

Innovate
Foams are constantly evolving, and adhesives need to keep pace with these changes while allowing for new foam innovation. Consistently developing and testing new adhesive solutions that can evolve with foam manufacturers or even drive change in the foam industry is critical to overcoming the many challenges of adhesive and foam substrates.



Collaborate with Foam Manufacturers
Foams and adhesives work in conjunction, and so should adhesive and foam manufacturers. By sharing chemistry and research, both manufacturers can provide more effective solutions for their customers.

Seek Technical Support
Many applications are unique and can face any (or all) of the challenges outlined in this paper. Optimal success can often require a personalized consultation with a technical expert who can make bonding condition recommendations to achieve specified performance.

Utilize a Broad Portfolio
Given that there is no one-size-fits-all tape for every application, one of the best solutions to adhesive and foam challenges is having access to a broad portfolio of adhesive solutions. This will offer the diversity needed to engineer the optimal solution for a given application without sacrificing performance.

Conduct Proper Testing
There is no way to confirm that an adhesive can withstand required conditions without undergoing specification testing of the materials against the barriers of the challenge itself. Identifying materials that cannot meet the specific needs of the application can help engineers create longer-lasting foam adhesive solutions.

Conclusion

Applications for foams and adhesives are tremendously varied and play an important role in many industries. For this reason, ensuring foam adhesion is critical for many foam specifiers, manufacturers, and end-users, as foam cannot perform its intended function if it does not remain intact.

Together, through innovation and collaboration among manufacturers and engineers, we can create the necessary practices, methods, and technologies to mitigate the challenges that disrupt foam adhesion and evolve the industry.

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References

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