White Paper

Designing-in Light Curing Adhesives

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Introduction

The advantages of using adhesives over mechanical fasteners have been well documented[1]. They include distribution of load and stress over wider surface areas, elimination of joint fatigue, improved impact resistance, reduction in finishing - and they can provide aesthetic enhancements.

Design engineers will earn the gratitude of their production engineering colleagues if they can specify or allow for a light curing adhesive. In addition to the performance advantages listed above, light curing adhesives can provide very significant process advantages. They are single part, which means that no mixing or mixing equipment is required, and there is less waste. They cure very quickly, typically in seconds - and "on demand", in that they only start curing when exposed to light of the correct wavelength. This reduces the need for jigs and tools, and minimises WIP and factory space needs.

Structural Bonding

Light curing adhesives produce true structural bonds to glass, metal, ceramic and many plastics, including ABS, PC, PMMA, PA and PVC (as well as many less well-known polymers). They are used in assemblies with multiple substrate types (i.e. glass/steel/plastic). With the correctly chosen formulation, tensile shear and peel strengths are high (2,500 to 4,000psi at break). In general, they are resilient, tough and provide good impact strength. They are available in a hardness range of Shore A80 to Shore D80 (and in the Shore OO range for light curable gaskets). There are viscosity variations to suit wicking and thin bondlines, or to fill gaps; to be self-levelling, or to be applied to a vertical surface. Operating temperature window is typically -55ºC to 150ºC.

Curing

Historically, these materials were cured with UV light, reacting to light in the near-visible, long-wave UV-A range (315-400nm). Since many plastics have UV blocking ingredients in them to help prevent the embrittlement and yellowing caused by ambient UV light, plastic bonding adhesives use a synergistic combination of UV and visible light to generate fast and effective cures. UV curing equipment based on metal-halide lamps produce broad spectrum light suitable for curing most materials. The latest developments in curing technology include curing equipment based on LEDs, which produce a narrow spectrum light, centred around a specific wavelength (i.e. 385nm or 395nm). Whilst not a drop-in replacement for broad spectrum lamps, UV LED curing lamps are becoming more popular, and adhesive formulations are emerging which are optimised to cure with their output.

Figure 1 – Curing lamps based on LEDs are becoming more popular

Implementation

Due to the on demand cure, single component formulation and viscosity choice, light curing adhesives are very easy to employ in automated processes. They can be applied with a wide variety of dispensing technologies and with repeatable precision. As the cure is so fast, quality assessment procedures can be implemented immediately after assembly, or indeed sometimes in-line as part of the process. Yields are high, since the process is readily controlled and robust.

Design Considerations

So what does a design engineer need to think about in order to specify a light curing adhesive?

1) Substrates
   As previously discussed, the adhesives can be used with many substrates, including a wide range of plastics. But in common with all adhesives, low surface energy polymers like PTFE or polypropylene are not readily bondable with light curing adhesives. Polyolefins may be surface treated in order to improve wettability and therefore adhesion, and so attain adequate bond strength. Also, the technology has poor adhesion to rubber or silicone, so if possible, choose other substrates in your design.

2) Bondline design
   Whilst the adhesives are gap filling or can wick into tight bondlines, optimal bondline thickness is on the order of 0.125mm. With the correct viscosity choice, the adhesive can be very forgiving to tolerance variations in the fit of the parts. This can save money by being able to specify less accurate mould tools than if the assembly were designed to be solvent welded or press-fit.

3) Light transmission
   The acrylated-urethane light cure chemistry needs to be exposed to light of the correct wavelength in order to cure. Light must reach the adhesive in the entire bondline; the light cure does not propagate into shadowed areas by itself. This means that most suitable applications are when at least one of the substrates is clear. However, the latest developments in plastic bonding adhesives include formulations with a UV/visible light cure and a secondary ambient moisture cure system for shadow areas.

Figure 2 - Light curing adhesives bond many types of plastic

Conclusion

There are many proven applications in industries like electronics, automotive, medical devices, electronic displays, optics, glass and appliances – and all manner of plastic-based assemblies. The technology brings with it inherent productivity gains which can save money and increase competitiveness.[2]

References

1) "Where Adhesives Beat Mechanical Fasteners" - Nicole Langer, *Machine Design*, August 2005
2) "Light-Curable Adhesives" – Virginia P Read, *Appliance Design*, February 2010

Picture credits

Figures 1, 2 – www.dymax.com

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