Understanding Viscoelastic Material Behaviour in Car Body Engineering and Manufacturing

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ABSTRACT

Viscoelastic material behaviour is present in all polymeric materials in passenger vehicles. The range of polymeric materials in cars covers not only many chemical bases but also different physical states. A number of examples are shown and discussed. Therefore, understanding viscoelastic material behaviour is essential in car body engineering and manufacturing.

INTRODUCTION

The presence of some of the viscoelastic materials in passenger vehicles is shown in Figure 1. Clearly, the range of polymeric materials in cars covers not only many chemical bases but also different physical states. Modern cars depend more than ever on the correct performance of these materials. Polymer solids are expected to perform properly below, at and above the glass transition temperature during the service life of cars. Reactive polymers are expected to perform properly in car production. Therefore, an understanding of viscoelastic material behaviour is essential in car body engineering and manufacturing.

ADHESIVES AND SEALANTS

A wide range of adhesives and sealants are used in modern cars. The primary function of adhesives are to join similar or dissimilar materials such that the required performance characteristics of the car is achieved during its lifetime. Generally, this includes durability, safety, handling, comfort or NVH aspects. The primary function of sealants is to ensure water and air tight joints in the car body. These materials are mainly a rheological challenge during manufacturing due to the complex nature of modern car production. For instance, wash-off behaviour of adhesives and sealants can be related to their rheological properties. Moreover, sealing of weld flanges can be optimized by understanding the rheology of seam sealants.

PAINT SYSTEMS

Modern cars have complex paint systems. In general, the surface of sheet metal is washed prior to the application of a zinc-phosphate layer, followed by application of elctrocoat paint. This is the first paint layer. The electrocoat is cured at elevated temperatures. The rheological behaviour of the electrocoat during curing cannot only cause electrocoat run effects but also result in poor edge coverage of metal substrate edges. During the service life of the car, poor electrocoat edge coverage can result in car body corrosion.

After the electrocoat, a primer surfacer is applied, followed by a base coat and, finally, a clearcoat. During clear coat application the clear coat can run and sag if the rheological properties are unfavourable. Therefore, an

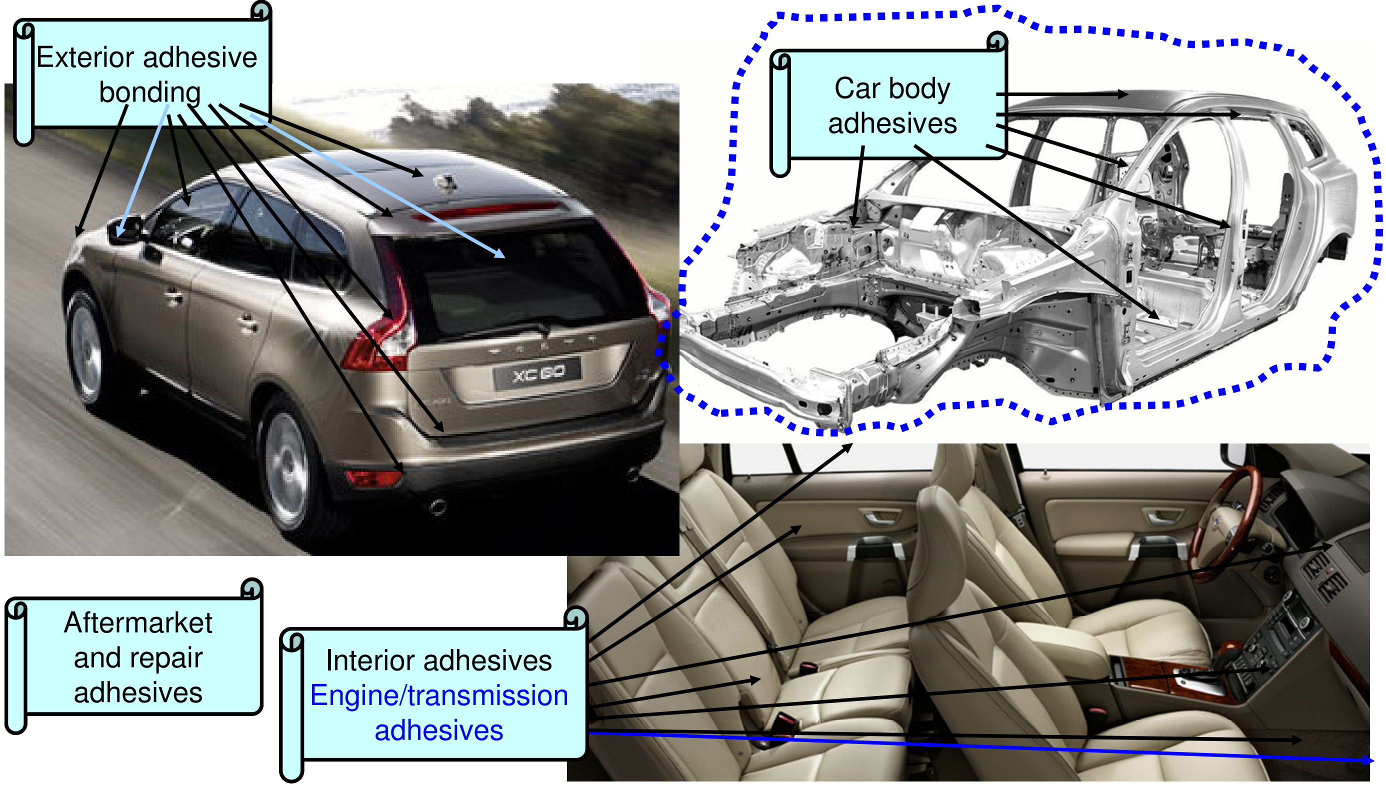

Figure 1. Some of the viscoelastic materials that are present in passenger vehicles.

understanding of paint rheology is necessary to optimize paint texture on visible surfaces of a car.

REACTIVE POLYMERS

Most of the polymers used in car body engineering and manufacturing are reactive polymers that change their chemical and physical state during car production. An understanding of the thermal curing behaviour and its impact on the rheological behaviour of the cured material is essential in order to obtain proper car performance characteristics.

GLASS TRANSITION TEMPERATURE

The glass transition temperature plays a significant role in car body engineering. For instance, direct glazing adhesives have to maintain their flexibility over a large temperature range in order to function properly while the car is in service. Likewise, damping materials are used in sound deadening applications, and their damping properties have to function over a large temperature range.

The use of the time-temperature superposition principle can sometimes be helpful to understand the viscoelastic behaviour of polymeric materials in car body engineering that lie outside the measuring range of a rheometer.

OIL RHEOLOGY

The use of oils in car production fulfills two main requirements:

1. corrosion protection of sheet metal prior to stamping, and
2. lubrication during stamping of parts.

The rheology of oils may be somewhat less complex than the rheology of other polymeric materials in car body engineering and manufacturing. Nevertheless, oil rheology plays an important role in car production. The increasing use of aluminium in light weight vehicle design introduces new dry lubricants with challenging rheological properties.

CONCLUSIONS

A number of examples from car body engineering and manufacturing emphasize the importance of a thorough understanding of viscoelastic material behaviour. Modern cars depend more than ever on the correct performance of viscoelastic materials.