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Expandable graphite: Perfect flame retardant for polyurethane

With expandable graphite as flame retardant, polyurethane (PU) parts can comply with the strictest fire prevention requirements. However, the shear sensitivity of the material requires a reduction of the mechanical stress during processing to a minimum. Appropriate adaptation of the metering and mixing technology is recommended for this reason.

1 High market demands

Components of PU structural foam must comply with strict fire prevention requirements during application. This first and foremost applies to components exposed to high temperatures in the engine area of motor vehicles **(fig. 1).** Furthermore, flame retardant for batteries and electric lines is an important aspect because here, there is a general hazard of overheating or short-circuiting. PU structural foams are also used in the aviation and rail industries, for example as seat cushions, armrests or headrests, which must comply with strict fire protection requirements. PU processors increasingly use expandable graphite as an addition to the conventional flame retardants to enable the components to meet these specifications.

2 Protective layer prevents spread of fire

Expandable graphite is a special modification of graphite in which small molecules are embedded between the carbon layers. The result is known as Graphite Intercalation Compound (GIC). Under heat exposure, the carbon layers are pulled apart from each other in the GIC like a bellows so that the graphite particles expand to a multiple of their initial volume. In this way, a protective layer is created on the polyurethane surface, also called an intumescent layer, which prevents the fire from spreading.

Expandable graphite has a number of advantages compared to other flame retardants for PU. Expandable graphite is not compounded by a reaction but remains in the PU matrix as a molecule of its own. Adding expandable graphite only slightly impacts the application and aging properties of the PU foam. Compared to liquid flame retardants, expandable graphite also has the advantage that as a solid, it cannot diffuse from the PU matrix. This retains the fire-protecting effect of expandable graphite

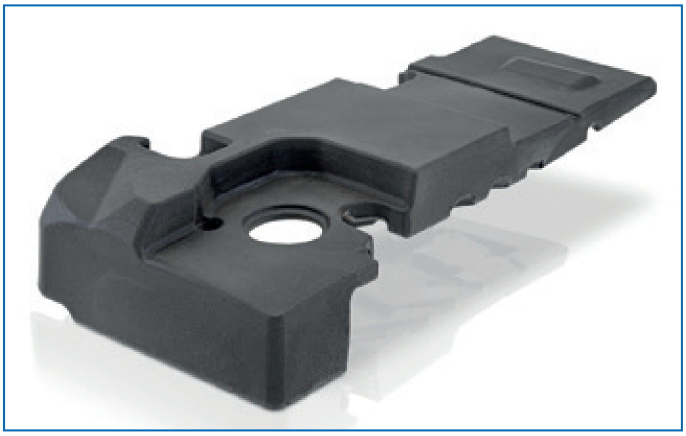
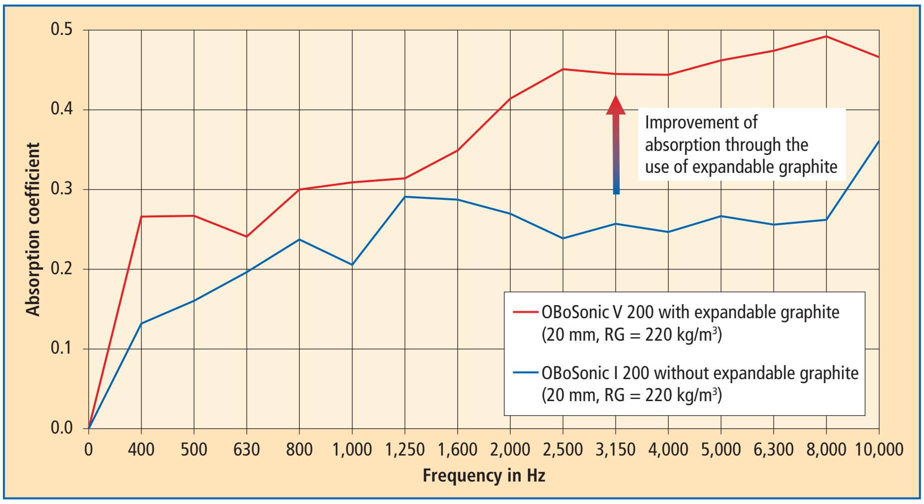


Fig. 1: *Parts made of PU structural foam are exposed to high temperatures during their application in the engine area*

Fig. 2: *Adding expandable graphite as a flame retardant improves also the noise-reducing property patterns of PU parts*



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All figures and tables, unless otherwise stated, have been kindly provided by the authors.

for long time periods. Economical aspects also favor expandable graphite because it is a cost-effective alternative to conventional PU flame retardants. Furthermore, studies have demonstrated that expandable graphite can improve the acoustic property patterns of PU parts. This effect is linked to the fact that the expandable graphite particles lead to higher porosity, thus improving the absorption coefficient of the material **(fig. 2).**

3 Challenging processing

Processing PU systems with expandable graphite presents particular challenges to the mixing and metering system and the mixing head. Particularly, one must note that the flame-retarding effect of the expandable graphite can diminish if the expandable graphite particles are exposed to excess mechanical stress during processing. KraussMaffei has responded to these requirements and now offers complete solutions for processing PU systems that contain high percentages of expandable graphite as a flame retardant **(fig. 3).**

To achieve a proportion of 30 to 40 wt% of expandable graphite in the PU component, the polyol component must contain up to 80 wt% of expandable graphite. For this purpose, KraussMaffei has developed a premixing station in which the liquid polyol and the powdered expandable graphite can be mixed automatically. A screw conveyor feeds the expandable graphite into the mixing tank under low mechanical stress. There, the mixture of polyol and expandable graphite is homogenized by a specially designed agitator. A diaphragm pump then conveys the high-viscosity mixture into the daily tank. The premixing station replaces the manual mixing of polyol and expandable graphite and thus makes extensive automation of the mixing operation possible. The homogeneity of the mixture and the reproducibility of the mixing process increase significantly.

Metering the high-viscosity mixture of polyol and expandable graphite using axial piston pumps is not feasible due to the abrasive property patterns of expandable graphite. Therefore, particularly resistant metering pistons are used for metering the polyol component from the daily tank to the mixing head. Piston metering also reduces the mechanical stress on the expandable graphite in the polyol component to a minimum. Metering is possible with a single piston or with two anticyclically moving pistons depending on the system configuration.

4 High foam quality by T-mixing

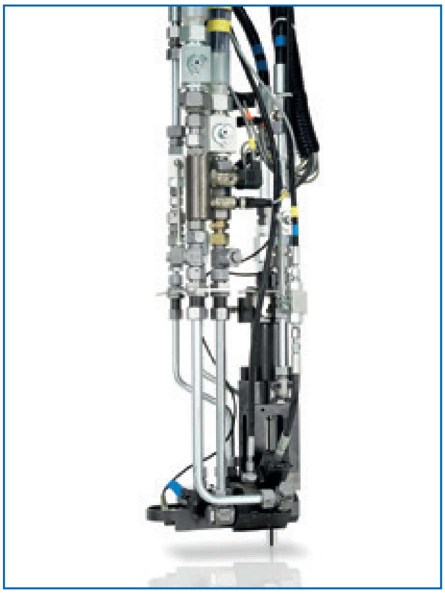
KraussMaffei has developed the MK8/12 ULKP-2KT-BP mixing head **(fig. 4)** for processing PU systems containing expandable graphite (e.g. OBoSonic V200 from FoamPartner). The output capacity of this mixing head is between 150 and 300 g/s. Due to the high viscosity of the polyol component, the principle of T-mixing is applied here, in other words, the isocyanate component is split into two substreams and fed to the mixing chamber through two opposing nozzles. The polyol jet hits the isocyanate substreams orthogonally, which causes very good mixing of the components despite the high viscosity, consequently ensuring high foam quality.

Fig. 3: The mixing and metering systems for PU systems that contain expandable graphite are equipped with a screw conveyor and a premixing station

Furthermore, the mixing head is equipped with a module that allows for rerouting the polyol component in the break times between the shots through a bypass at the mixing head. This means that the recirculated polyol component does not pass through the nozzle of the mixing head, which reduces the mechanical stress of the expandable graphite contained in the polyol also between the individual shots. As the changeover takes place directly in the mixing head, dead space is minimal.

PU systems with a high percentage of expandable graphite can also be processed in low-pressure systems. This processing method, however, has significant disadvantages compared to high-pressure mixing. First, mechanical mixing results in high mechanical stress on the expandable graphite so that there is the danger of a reduction of the fire-protecting capacity of the material. Another essential disadvantage of low-pressure processing is the fact that the mixing element must be flushed after every shot to prevent the components from curing. Here, material and, potentially, solvent waste is created, which has a negative effect on the cost-efficiency of the production process. In comparison to this, the high pressure mixing heads from KraussMaffei have a self-

Fig. 4: In the MK8/12 ULKP-2KT-BP mixing head, the polyol component is fed to the mixing chamber through two opposing nozzles (T-mixing)



cleaning function that reduces the loss of material. In addition, the high pressure counterflow injection mixing has the advantage of being able to accommodate system components with higher reactivity in the process. This allows shorter cycle times and significantly increased plant efficiency to be achieved.

5 Conclusion

The fire protection properties of PU structural foams are significantly improved by expandable graphite. The components meet the specifications of the UL94-V0 fire test and other relevant standards of the automotive industry. Due to the increasing installation of electric drive units in motor vehicles and the components required for them, fire protection for PU components will become even more important in the future. Systems containing expandable graphite are already being implemented in applications in the rail and aviation industries as well.

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