So Test Therefore, Who Join Forever

Direct Fastening into Plastic for 3D Printed Components

Alongside clip joints, welding and cementing, the incorporation of technical screw connections into the component assembly is one of the most important jointing methods. Together with the screw manufacturer Ejot, the compound producer Lehvoss has investigated the suitability of 3D printed components for screw connections. Three materials underwent the practical test for this purpose.

Whether for small series of plastic parts or prototypes in assembly trials and validation, a reliable screw connection comparable to those in injection-molded goods is also demanded for 3D printed parts.

The aim of the investigation presented here was to demonstrate the high quality standard of available printing materials, the reproducibility in the printing process and the basic attributes of screw connections in printed parts. Lehmann&Voss&Co. assumes that all jointing methods used with injection molding materials can also be applied to its 3D printing materials for fused filament fabrication (FFF). These materials called Luvocom 3F are specially optimized for FFF technology. And, according to the manufacturer's information they can certainly stand up to a comparison of their mechanical properties with those of components produced in classical techniques.

In order to test the suitability of these materials for screw connections, jointing trials were conducted in cooperation with Ejot GmbH & Co. KG of Bad Berleburg, Germany, on 3D-printed screw bosses. The Ejot Evo PT screw, which has recently launched onto the market, was used for the jointing experiments. Apart from the optimized positioning characteristics in this type of screw, the installation torque is almost independent of the insertion depth. To enable a comparative investigation of screw fastening, standard bushes were injection molded in the existing Ejot screw boss tool using the materials to be compared. Analogous Luvocom 3F materials were printed in the 3D printing laboratory at Lehmann&Voss&Co.

On the left, the injection-molded screw boss, in the center the printed version. On the right of the picture, the Ejot Evo PT screw © Lehvoss/Ejot

As a certain level of dimensional inaccuracy always occurs in the printing of drill holes due to the procedure used, the hole for the screw (guide hole) was recalibrated in each case in order to observe a reliable experimental standard. All the bosses for testing were produced using the FFF technique.

Unreinforced Polypropylene Attained the Customary Values in the Test

Unreinforced polypropylene (PP) is not an easy material to print. In some cases, the material can also prove to be challenging in injection molding, particularly for thick-walled screw bosses. Occasionally slow crystallization occurs with pronounced cavitation. This was not observed for Luvocom 3F PP 9929 NT, which was also injection molded in these trials. As a result, it was possible to create screw connections with very good, reproducible parameters for all injection molded bosses. Calibration of the screw hole on the printed boss showed that if a technically practical geometry is selected for the guide hole, screw fastening values can be achieved that are almost at the same levels as those of the injection molded boss. This affected all characteristic parameters – such as installation torque (Me), tightening torque (Ma) and stripping torque (Mü). The range of fluctuation for all three values was within the usual technical orders of magnitude.

Better Scores for Polypropylene with Carbon Fiber-Reinforcement (PP/CF)

In these experiments, it was observed that screw-fastening values were achieved for a polypropylene with carbon fiber-reinforcement (PP/CF, Luvocom 3F PP CF 9928 BK) that were approximately 60 % above those of an un-

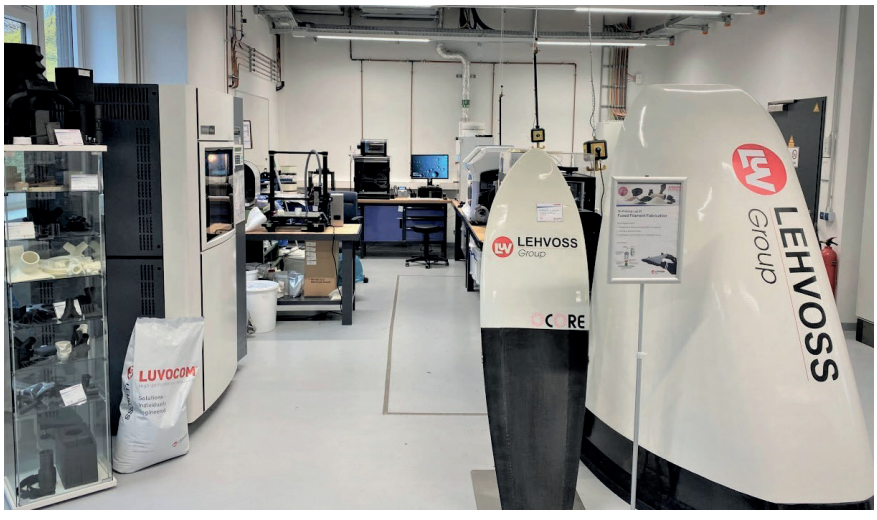
reinforced PP. No significant differences can be detected in terms of the torque measurements if the pre-hole diameter is varied from 3.2 mm to 3.4 mm. On the contrary, the measured values remain at almost the same level. There is a clearly delineated optimum for the stripping torque (low dispersion of measured values) at a guide hole diameter of 3.3 mm. The comparably low elasticity of the material has a distinctly positive effect in this case.

A Reliable Jointing Technique for PA/CF

Luvocom 1/CF15/HS (PA66 CF/15) is a very high-performance product for injection molding. High tightening torques are possible for the screw bosses produced from this material by injection molding. Both the installation torque (0.6 Nm) and the stripping torque (3.8 Nm) are stable with a large safety margin to the tightening torque. Moreover, the installation torque and stripping torque are very clearly defined with a narrow range of values and a small standard deviation. The large gap between the stripping torque and the tightening torque, in particular, indicates that the fastening operation is governed by a reliable process that can be mastered in all situations.

Luvocom 3F PAHT CF 9742 BK was processed for purposes of comparison. This is a highly developed material for FFF. The formulation differs from that of the injection-molding material tested but does also contain 15 % CF. The mechanical parameters, such as tensile strength at break and elongation at break, are at a higher level in the injection molding material. In the printed boss, this can be seen in the somewhat lower screw fastening values. Nevertheless, reproducibly good torque values were achieved (Me = 0.55 Nm; Ma = 1.6 Nm; Mü = 2.8 Nm). Here too, there is a sufficiently large safety margin between each of the torque values. The material Luvocom 3F PAHT CF 9742 BK enables a direct connection to be achieved with the Ejot Evo PT in a reliable process.

The continuous series of experiments described here has been able to demonstrate that a reliable process can be achieved for the direct fastening in printed parts with the Ejot Evo PT self-tapping screw. Components produced by 3D printing achieved strengths that are comparable with their injection-molded counterparts. This makes applications possible in series production.



A view inside the Lehvoss pilot plant for 3D printing. Materials were investigated for use in FFF (Fused Filament Fabrication) © Lehvoss

High-Strength Materials across All Axes of Strain

One positive observation in the trials was that no screw bosses suffered radial tension failures (splitting). Neither did any peeling of layers occur in the z plane. In 3D printing this is the build axis, which coincides with the screw connection axis. It is of particular importance because in 3D printing the z plane is comparable with the joint line in injection molding. In printed parts, this is generally a zone of weakness. According to the manufacturer, this proves that Luvocom 3F materials can be regarded as high-strength materials across all axes of strain. It is therefore also possible to achieve strength values in 3D printing that are directly comparable with those of injection-molded parts. The measured values determined for printed parts in this preliminary investigation were without reservation in the same orders of magnitude as are customary for injection-molded parts.

Overall it may be stated that reproducible and validatable screw connections can be reliably implemented with the Ejot Evo PT in 3D printed parts. As is the case with all direct screw connections into plastic, optimum dimensioning of the screw boss and particularly the diameter of the guide hole are critical. Additional parameters such as the screw surface or the speed of the screwdriver have an effect on the overall result, but were not varied in this case in order to keep the scope of testing within reasonable limits.

An approach in which the forecasting program Ejot Evo Calc is to be used to allow the dimensioning of screw connections in printed parts to be calculated in advance is under discussion and being planned for the future. ■

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