Development of conductive compounds for functional part printing using FDM

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Sector: Consumer goods
Challenge: To obtain a plastic with electrical conductivity to replace metal in applications where freedom of design and lightweight properties are essential requirements.

Solution: Selection of materials, load distribution and optimisation of processing conditions are key to obtaining a compound with surface electrical conductivity.

CHALLENGE

Conductive compounds can be used for applications such as heated plastics, capacitive sensors, electromagnetic shielding, ATEX and anti-static electricity protection.

Conductive compounds can be used to extrude filaments and print functional parts with proper balance between productivity, quality and final properties. Therefore, the challenge consisted in obtaining a plastic with the electrical properties of a metal to replace the metal in applications where freedom of design, customisation and lightweight properties are essential requirements. To this end, AIMPLAS developed compounds consisting of a plastic matrix and carbonous conductive loads.

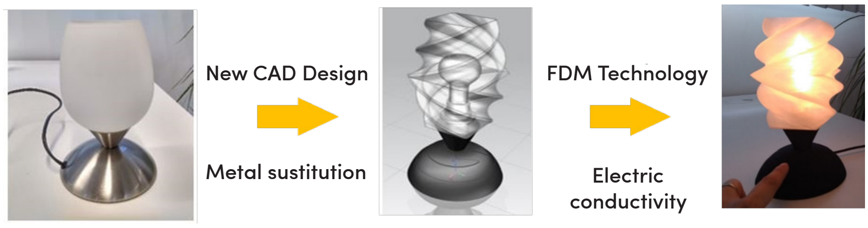
A compound with conductivity properties can be obtained by adding carbon-based loads to thermoplastic materials. However, the functional properties obtained depend directly on the type of load and the distribution achieved in the matrix.

The challenge posed by obtaining conductive compounds that are appropriate for FDM printing lies in the proper distribution of the carbon nanoparticles, necessary to obtain isotropic material, or another material with the same properties in all directions. Likewise, both distribution and the percentage of the load added are crucial in determining the correct processing properties of the material in extrusion lines to obtain the coiled filament and subsequent feeding and melting in the printer.

Once a conductive filament is obtained, it must be printed at a speed that enables high productivity, functionality and a high-grade aesthetic finish of the part. This requires a balance between the formula of the design and optimisation of the processing conditions and the design of the finished product.

In the development of conductive compounds, AIMPLAS has taken on the challenge to manufacture a lamp to replace both materials and manufacturing technologies. The traditional methods used to manufacture table lamps involve using several materials, such as metal, technology that requires using glass and is high-energy consuming and moulds that require a large investment and high productivity to amortise costs.

AIMPLAS proposes manufacturing a table lamp using FDM, using a commercial lamp with a metal base and glass lampshade as a model.



SOLUTION

AIMPLAS has developed conductive thermoplastic compounds using bio-based materials and carbonous loads. This innovative formula has capacitive properties that allow it to be used in lamp manufacturing by applying additive manufacturing technology.

Proper selection of materials and optimal distribution of loads during the compounding process, optimisation of filament extrusion conditions and the printing parameters are key to obtaining a compound with superficial electrical conductivity in the semiconductor range (>10-2 S/cm), as well as printed products with complex designs that maintain conductivity to function as capacitive sensors.

In the filament validation process, the best results for electrical conductivity have been obtained by printing at 230ºC and 40 mm/s. However, the printing speed can be increased to 90 mm/s when printing the designed parts (lamp base) and still obtain good results and properties.

It has been verified that the developed material is appropriate for the manufacture of customised design lamps by 3D printing using FDM. This technology has made it feasible to print both the touch-sensitive lamp base and the lampshade which, although not necessarily manufactured with a conductive compound, is required by the market to be provided in a variety of shapes.

The primary functionality provided by these lamps is that they are touch-sensitive, meaning that they can be switched on and off and their light intensity changed by touching the base, depending on the model design.

The table lamp base is produced after the model and it is usually manufactured in metal, although it can be manufactured from a conductive thermoplastic compound that also offers reduced environmental impact.

ADVANTAGES

The main advantages of additive manufacturing and especially of the development of conductive filaments are as follows:

- **Freedom of design**: Using FDM as an additive manufacturing technology is an opportunity to design and produce a variety of geometrical shapes. Moreover, the parts manufactured by using FDM have a good surface finish and do not require additional treatment after printing.
- **Personalisation or customisation**: This successful case study presents the final prototype obtained for a lamp design. However, the same filament formula can be used with different designs to obtain a variety of shapes that satisfy consumer preferences.
- **Fast manufacturing**: FDM technology enables obtaining a finished part in a few hours. In this case, the conductive filament can be printed by using high-speed printing (90 mm/s), compared to the lower speed required by commercial materials (50 mm/s). The printing speed obtains good process stability, surface finish quality and conductivity performance.
- **Weight reduction**: The replacement of materials such as glass or metal with plastic reduces the weight of the lamp. Using bioplastics in combination with conductive compounds has resulted in reducing lamp weight by 55%.
- **Lower environmental impact**: Carbon imprint is reduced by replacing the metal (lamp base) and glass (lampshade) with thermoplastic material.