

MALTI3D – 3D Printing Solutions

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3D printing offers us the ability to custom print complex shapes. There are specific designs that are only possible through 3D printing. From an engineering standpoint, it is a godsend. This has the potential to revolutionise the manufacturing industry. But if 3D printing is so great, why hasn't it taken off on an industrial scale yet?

Layers in a 3D printed boat
Photo courtesy of
Helenio Borg Muscat

While the answer inevitably boils down to money. While 3D printing has enjoyed relative success in the hobbyist market, the same cannot be said for industrial production. Besides the initial cost of the 3D printer, buying the plastic, maintaining the printer, and shipping costs all quickly add up. Apart from that, there is a limited choice of plastics that can be 3D printed, especially when using filament-based 3D printers.

One of the most widely-used processes for manufacturing plastic parts is injection moulding. Essentially, molten plastic is pressurised into a mould to create the desired shape. Its speed and scalability have made it the

manufacturing method of choice for mass-produced plastic goods. However, injection moulding isn't the only way to process plastic into 3D shapes.

The MALTI3D Project (led by Dr Arif Rochman, Senior Lecturer with the Faculty of Engineering, University of Malta [UM]; with Prof. Ing. Joseph Buhagiar, Associate Professor with the Faculty of Engineering, UM; Prof. Alfred Gatt, Associate Professor with the Faculty of Health Sciences, UM; and Albert Curmi, Research Support Officer with the Department of Industrial & Manufacturing Engineering) in collaboration with project partner Abertax Quality Ltd, is looking at alternatives. To better understand, we first need to take a look at how 3D printing works.

PELLETS VS FILAMENTS

Specifically, we need to examine the material used. 3D printing usually involves some type of plastic, either in pellet or filament form. Pellets, which are used to make filaments, cost around €4 per kg at the lower end. However, filaments cost around €30 per kg, despite the fact that it takes approximately 1 kg of pellets to make 1 kg of filaments. 'This is because converting pellets to filaments involves an extra heating cycle: melting the plastic pellets and refining them into filaments. This involves manpower, time, and electricity, which drives the price up. Not to mention additives such as colourants and bonding modifiers,' explains Rochman. ➤



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Detail of plastic pellets used for 3D printing
Photo courtesy of Albert Curmi

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Detail of a 3D printed boat
Photo courtesy of Helenio Borg Muscat

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3D printed lamp
Photo courtesy of Albert Curmi



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Finding a way to 3D print using pellets meant that the MALT3D team had to get creative.

3D printers work by depositing plastic layer by layer, starting from the bottom and gradually building on top of the previous layer until the desired shape is formed. While relatively simple in principle, it is imperative that the filaments used have a precise diameter. Imprecisions in the filament can result in inconsistencies and ultimately harm the final product.

While filaments are usually uniform in diameter, pellets as raw material are not. Incidentally, this accounts for the price discrepancy between the two. Pellets can vary in size, in some cases by up to 1mm. While this might not sound like much, this variation can cause issues during the printing process. Finding a way to 3D print using pellets meant that the MALT3D team had to get creative.

EXTRUDER SCREW

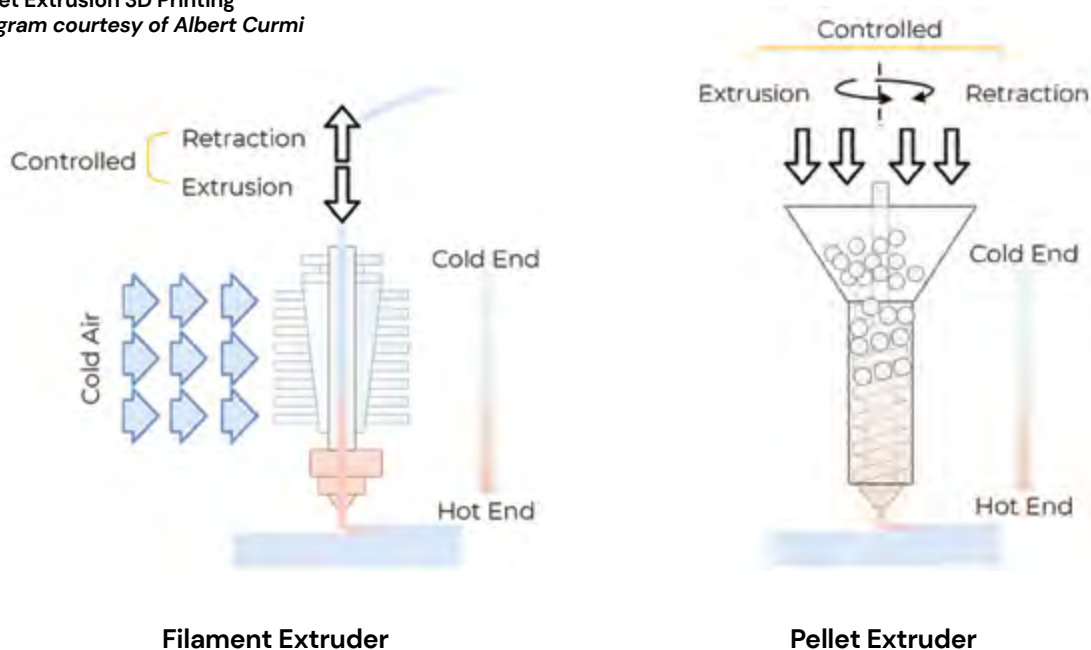
The heart of the problem lies with the way the pellets themselves are processed. Curmi explains how, 'the most popular way of processing pellets is by using the so-called plasticising or extrusion screw. The screw connects to the plastic pellets, squeezing and heating them to convert into a plastic melt with a honey-like viscous consistency. It is important that there are no voids or trapped air. This liquid can then be turned into any desired shape.'

The issue is the size of the extruder screw. Most industrial screws are at least 28cm in length, and the more plastic you have, the bigger and longer the screw needs to be. Compared to the size of the printer, which usually has a build volume smaller than 300mm by 300mm by 300mm,



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Diagram showing Filament vs Pellet Extrusion 3D Printing
Diagram courtesy of Albert Curmi



the screw would be disproportionate. Making the screw smaller was the first challenge Curmi faced.

'We had to "break" a few rules to make this work. Traditionally, there is a ratio to calculate the length of the screw, called the length-to-diameter ratio. If we followed this, the extrusion screw we needed would be ridiculously long for a 3D-printing machine,' Curmi explains. The screw was hence decreased in size to fit closer to a 3D printer's form factor, but in doing so, the extrusion characteristics changed significantly. Calibrating and adjusting for these new features was one of the main challenges for the team.

PLASTICS

Having addressed the issue with the screw, the next challenge was the plastic itself. 'Not all plastics are made equal. They can vary in viscosity, and this needs to be taken into consideration. In some cases, you need to change the screw design completely, for example,' Rochman explains.

Plastics can be divided into 3 categories: commodity, engineering, and high-performance plastics. The MALT3D team was able to print using commodity and engineering plastic pellets, achieving the same printing results as in filament 3D printing. High-performance plastics can also be successfully 3D printed, but they present their own set of challenges.

'We worked with PEEK Polymer, which is a high-performance plastic. This plastic has a good strength-to-weight ratio, making it a good replacement of metal parts whilst being easier and cheaper to mass produce. It is particularly useful in the aviation industry, where weight is a large factor, as well as certain medical implants,' explains Curmi. Eventually, the team did manage to print using PEEK; however, Curmi admits that high-performance plastics were by far the most challenging material.

Besides managing to reduce printing costs, printing directly from pellets offers another advantage: environmental sustainability. With

filament printing, you have two heating cycles: one to convert pellets to filaments and then another from the filament to the final product. By essentially skipping a heat cycle, 3D printing from pellets reduces the energy consumption, allowing for a greener final product.

The Malta Council for Science and Technology funded the MALT3D project through the FUSION: R&I Technology Development Programme (R&I-2018-009T) whose main goal is to fund the development of innovative, patentable, and commercial ideas onto the market. Curmi and the whole MALT3D team are optimistic that, in the near future, the MALT3D printer can be commercialised and will offer users a new and cheaper 3D printing system with full freedom in material selection. This will include polymer property modification by adding additives or reinforcing fillers and blending with other materials, as well as in the creation of their own novel compounds and composites. **T**