Fused Deposition Modelling in Shooting Sports

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Abstract— The paper deals in the study of Fused Deposition Modelling with ABS material used in shooting sports equipment. Further different FDM materials are discussed; their properties and different types are illustrated here. In the end, possible equipment which can be printed and which we have printed is shown.

Key words: FDM, 3D, ABS, Shooting Sport

I. OVERVIEW

As a general overview, 3D printing involves turning a 3D digital model created on a computer or with a 3D scanner into a physical object, allowing users to make almost anything. Unlike traditional manufacturing, which typically uses subtractive processes, such as cutting, drilling, milling, or grinding, 3D printing is an additive process that fuses materials, layer on layer, with heat, chemicals, light, electron beams, or adhesives. Many different and increasingly complex technologies fall under the umbrella of 3D printing and additive manufacturing.

II. 3D IN SPORTS

Additive manufacturing is taking over almost all production sectors. 3D printing reduces manufacturing time, lowers costs and allows for more customisation. These benefits are gradually becoming understood by the sports sector with the adoption of innovative equipment to break new records. Technology is now finding its place in various sports activities, from car racing to football, cycling and golf. Now in Shooting Sports. The technology’s aim is to innovate and improve competitiveness. But while the physical abilities of athletes are now reaching their limits, performance gains through better equipment is becoming more important. Engineers, designers, and technicians are relying on 3D printing to create lighter, more robust parts to outmanoeuvre the competition.

III. FUSED DEPOSITION MODELLING

Fused deposition modelling, which is often referred as “FDM”, is a type of fabrication commonly used within engineering design. Throughout the development and manufacturing production cycle, FDM systems are invaluable every step of the way including conceptual prototyping, design verification and direct digital manufacturing. FDM is ideally suited for the designers who demand part stability and strength. Unlike other additive processes, FDM 3D printed models are created with actual thermoplastics. The result is a prototype that can endure exposure to chemicals, mechanical stress, and a variety of climate extremes. FDM has paved the way for functional use testing, and DDM manufacturing. Extruded prints are supported with soluble enabling complex cavities and geometries. This also makes the process perfect for jigs and fixtures. FDM is a process using molten plastics or wax extruded by a nozzle that traces the parts cross sectional geometry layer by layer. FDM creates tough parts that are ideal for functional usage. FDM works on an “additive” principle by laying down material in layers. A plastic filament or metal wire is unwound from a coil and supplies material to an extrusion nozzle which turns the flow on and off. The nozzle is heated to melt the material and can be moved in both horizontal and vertical direction by a numerically controlled mechanism which is directly controlled by a computer-aided design software package. The model or part is produced by extruding small beads of thermoplastic material to form layers as the material hardens immediately after extrusion from the nozzle plant.

The nozzle in a 3D printer has one of the most important jobs of all the mechanical systems. It is the last mechanical device that is used to build up a 3D object and its design and functionality is extremely important when it comes to the accuracy and build quality of the printer. The biggest contributor to the performance of the nozzle is its orifice size. Typically, the nozzle size used on many 3D printers is 0.4mm. This size is small enough to produce high quality parts while maintaining reasonable build times. Printers such as the Makerbot Replicator use this size nozzle. Depending on the overall goal of the part being printed however, these nozzles can be changed to larger diameters in order to increase the speed of the print job. While doing so will decrease the horizontal accuracy, parts that will be used as rough drafts or that will be post processed with fillers or paints will still perform as intended. It is important to never set the layer height higher than the nozzle size. This will dramatically decrease the bond strength between the layers and overall build quality. For example, if a 3D printer is using a 0.6mm nozzle, then the maximum layer height should not exceed 0.5mm. While the nozzle is used to direct molten plastics in a precise manner, it’s other job is to convert the solid coil of plastic material into the molten state by utilizing a heating element within the extruder assembly. This heating element can be a vitreous enamel resistor, a nichrome wire, or a cartridge heater. In addition to the heating element, there is usually a thermistor (temperature sensor) integrated into the extruder assembly to control the required temperature for the specific material being used. For example, one of the most common materials used in FDM is PLA (polylactic acid) which has a melting temperature of around 160 degrees Celsius. In contrast, another very popular material used is nylon. This material requires extrusion between 240 and 270 degrees Celsius. It is very important to use the correct extrusion temperature in order to minimize the risk of the nozzle jamming and also maximize the bond between bead layers. The design of the extruder is very important to not only the printing accuracy, but also to the overall performance and maintenance of the printer. While the bottom end of the extruder must be able to heat the material to a desired temperature within a few degrees, the upper end must remain as cool as possible in order to avoid jamming. This is due to the feed mechanism located above the extruder, which requires the filament material to be in a completely solid state in order to function properly. One way to decrease heat transfer from the heating element to the feed mechanism and in turn decreasing the chance of jamming is to use fans to cool the top end of the extruder. Depending on the type of model being printed, and the type of material being used, a heated bed may be important to maintain the structure's shape while it cools. Since plastics shrink as they cool, a quick temperature drop could cause the corners of a part to curl up off of the printer bed. To minimize this risk, some printers incorporate an electronically heated bed that keeps the temperature steady. This allows the model to cool at a more even rate and improve its overall dimensional accuracy.

Standard lead time	Minimum of 4 working days (or 48 hours for models using the Fast Lane service), depending on part size, number of components and finishing degrees
Standard accuracy	± 0.15% (with lower limit on ± 0.2 mm)
Layer thickness	0.18 – 0.25 mm (varies depending on the chosen material)
Minimum wall thickness	1 mm
Maximum build dimensions	Dimensions are unlimited as components may be composed of several sub-parts. The maximum build envelope is 914 x 610 x 914 mm
Surface structure	Unfinished parts typically have a rough surface but all kinds of fine finishes are possible. FDM parts can be sandblasted, smoothed, coloured/impregnated, painted and coated

Table 1: Technical specification for FDM

IV. Material for FDM

A. ABS (Acrylonitrile Butadiene Styrene)

ABS is a widely used engineering thermoplastic with high durability and fine feature detail. Printed ABS has up to 80% of the strength of injection-molded ABS, making it highly suitable for functional applications. This material is opaque and available in several color options. Applications include snap-fits, end-use components, jigs and fixtures, concept modeling, and testing for form, fit and function.

	Units	Range
Density	g/cm³	1.05
Tensile Strength	MPa	22
Tensile Modulus	MPa	1627
Flexural Strength	MPa	41
Flexural Modulus	MPa	1834
Notched Izod Impact	J/m	107
Unnotched Izod Impact	J/m	214
Heat Deflection Temp	°C	at 0.45 MPa: 90 at 1.81 MPa: 76
Elongation at Break	%	6

Table 2: Data Sheet
Actual values may vary with build condition

B. ABSi (Acrylonitrile Butadiene Styrene – Biocompatible)

ABSi is an ABS type thermoplastic with high impact strength. This material is stiffer and more durable than the standard ABS material, and appears translucent. That makes ABSi ideal for applications which require light transmission or flow monitoring, such as in the automotive industry or for medical device prototyping. The ABSi material used in FDM is USP Class VI approved, a standard related to the pharmaceutical and biotechnology industries.

C. ABS-M30 (Acrylonitrile Butadiene Styrene)

ABS-M30 is 25-75% stronger than the standard ABS material, with higher durability, ideal for realistic functional tests. This material results in smoother parts with finer feature details. ABS-M30 is opaque and is available in several color options. Ideal applications, similar to those of ABS, include end-use components, jigs and fixtures, concept modeling, and testing for form, fit and function.

D. ABS-M30i (Acrylonitrile Butadiene Styrene – Biocompatible)

Similar to ABS-M30 in its high strength, durability and fine feature detail, ABS-M30i is additionally biocompatible in its raw state and complies with ISO 10993. With these material properties, the material is suited for end-use components as well as form, fit and function testing. Its biocompatibility certification makes ABS-M30i ideal for applications in food and drug packaging, and the medical devices industry.

E. PC (Polycarbonate)

Polycarbonates (PC) are among the most widely used industrial thermoplastics owing to the material's excellent impact strength and temperature resistance. The mechanical properties of PC make this material ideal for demanding engineering environments or applications requiring high flexural strength and tensile strength.

F. ABS-ESD7 (Acrylonitrile Butadiene Styrene – Static-Dissipative)

ABS-ESD7 is a durable and electrostatic-dissipative material. The static-dissipative property makes ABS-ESD7 particularly suitable for applications where a static charge could impair performance, such as electronic products with circuit boards. Other applications for this material include end-use components, industrial equipment and jigs and fixtures for the assembly of electronic components.

G. PC-ABS (Polycarbonate ABS)

PC-ABS is a blend of polycarbonate and ABS plastic which combines the strength and heat resistance of PC with the flexibility of ABS. PC-ABS exhibits high impact strength and thermal resistance, making this material an ideal choice for demanding engineering environments. Applications include snap-fits, end-use components, jigs and fixtures, concept modelling, and testing for form, fit and function.

H. PC-ISO (Polycarbonate ISO)

PC-ISO blends have high impact strength, thermal resistance and durability. This industrial thermoplastic is widely used throughout packaging and medical device manufacturing because of its strength and health standards. The PC-ISO material used to build FDM parts is biocompatible in its raw state, being USP Class VI approved and also ISO 10993-1 rated.

V. FDM WITH ABS AND SHOOTING SPORTS

Shooting sport has huge scope for innovation in equipment used by shooters, starting with Fore sight to the butt of rifle, from pistol grip to big bore cheek. We have experimented and developed cheeks, pistol grips, triggers, fore hand grip, peep sights with ABS using FDM. Some of 3D models are shown which are printed.

Fig. 1: Rifle frame with Butt. Butt assembly

Fig. 2: Pistol Grip for Rifle

Fig. 3: Tactical Pistol Grip

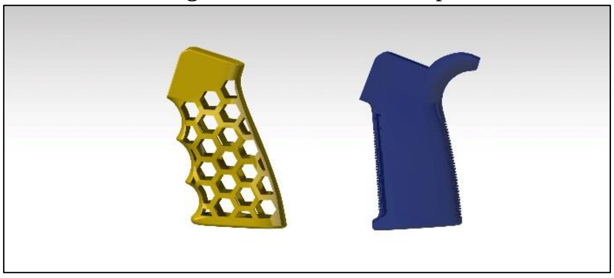

Fig. 4: Frame Type Pistol Grip for Rifle

Fig. 5: Pistol Grip

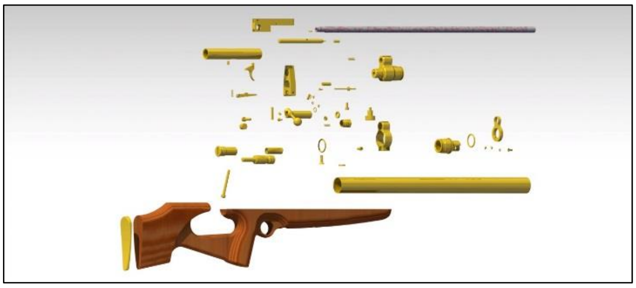

Fig. 6: Disassembled Rifle 3D printable parts

VI. CONCLUSION

As FDM is bringing revolution in other sports so it will in Shooting Sports, as ABS is the best suited material for making parts it reduces the manufacturing time, increase the possibility of local research at the level of shooter to test her/him with it. On the other side it is making all equipment more custom, made to best suite the shooter. And it is also making the equipment more affordable.

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