

APPARATUS FOR DISPENSING FILAMENT

FIELD OF THE INVENTION

The present invention relates to an apparatus for dispensing filament. The apparatus is particularly suited, but not limited to dispense filament to a three dimensional (hereinafter 3D) printer for 3D printing or rapid prototyping and will be described in this context.

BACKGROUND ART

3D printers using the fused deposition modelling (FDM) technique to produce objects require a material feedstock in order to function. Such material feedstock is typically in the form of a long polymer filament. As the filament from a spool has to be dispensed from the outer edge of the spool inwards to avoid twisting and entanglement, 3D printer filament spools are typically side dispensing. This means that the filament spools are mounted as side attachments to the 3D printer machine and the filament from the spool is fed into the 3D printer from a side.

These side attached filament spools are generally not factored in as part of the 3D printer machines' overall design. As such, the overall 3D printer machines with side attached filament spools are usually bulky, cumbersome and awkwardly shaped which makes it difficult to be stored without removing the side filament spools.

In addition, 3D printer filament spools generally requires manual loading of the filament on the spool. This process involves taking a loose end of a predetermined length of filament and threading it into the machine via a feeding tube, also known as a "Bowden Tube".

Various ways have been used to alleviate the above mentioned problems, including specially designed filament spools mounting for mounting to the bottom of the 3D machines and automating the loading of the filament. The resulting design is thus a regular cube or cuboid shaped structure which is less bulky and cumbersome. However, such machines with bottom loading

are generally complicated and incur a higher cost of production. Moreover, a bottom loading system works against gravity and may be deemed to be ineffective from an energy consumption point of view.

As the filament is a consumable item, users who run out of filament have to purchase and replace the filament and spool. For customized spool with bottom loading such as the one mentioned above, the cost of replacement may be high.

The present invention seeks to provide an apparatus that alleviates the above mentioned drawbacks at least in part.

10 SUMMARY OF THE INVENTION

In accordance with an aspect of the invention there is an apparatus for dispensing filament suitable for three dimensional printing comprising a filament container for holding filament, the filament container rotatable about a central axis and comprising an outlet positioned along the central axis;
a filament loader operable to extract filament from the filament container via the outlet; wherein as filament is extracted the filament container is rotated about the central axis simultaneously in a controlled manner such that tangling of the filament within the container is prevented.

20 BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of the embodiment of the invention comprising a filament container, a filament dock and a feeding system;

Fig. 2a shows the embodiment from a bottom perspective, with filament emerging from the funnel, after it has passed through the feeding system;

Fig. 2b shows a side view of the embodiment, with filament emerging from the funnel, after it has passed through the feeding system;

Fig. 3 is a top view of the filament container depicted resting within the filament dock;

Fig. 4 is an exploded view of the filament container and filament dock;

Fig. 5 is a detailed exploded view viewed from bottom perspective comprising
5 mechanical components;

Fig. 6 is another exploded view from a side perspective view;

Fig. 7 is an exploded view of the embodiment with particular emphasis on the drive mechanism; and

Fig. 8 shows the feeding mechanism enclosed within the feed system in more
10 detail.

Other arrangements of the invention are possible and, consequently, the accompanying drawings are not to be understood as superseding the generality of the preceding description of the invention.

PREFERRED EMBODIMENT OF THE INVENTION

15 In accordance with an embodiment of the present invention there is an apparatus 10 for dispensing filament 12, in particular dispensing filament 12 to a three dimensional printer or a rapid prototyping machine. The apparatus 10 comprises a filament container 14 for fitting into filament dock 60 and a feed system 80.

20 It is to be appreciated that the filament dock 60 and the feed system 80 may be integrated with an existing 3D printer or added as a separate modification to an existing 3D printer.

In the context of the invention, the term 'filament' includes, but is not limited to polylactide (PLA) filaments in various dimensions (e.g. 3mm), colours, and
25 enantiomers such as poly-D-lactide (PDLA), poly-L-lactide (PLLA), and mixtures of enantiomers in various ratios.

The filament container 14 comprises a top portion 16 and a bottom portion 18. Top portion 16 is preferably shaped as a circular plate. At the centre of the

top portion 16 is formed a hole 20 for fitting a mandrel 22 (not shown) operable to coil filament. A plurality of protrusions 24 is disposed around circumference of top portion 16. The plurality of protrusions 24 is operable to be fitted to receiving slots 28 of the bottom portion 18 so as to secure the top
5 portion 16 and bottom portion 18 of the filament container 14.
Top portion 16 further comprises a series of radial arms 26 for maintaining structural rigidity of the top portion 16.

Bottom portion 18 is formed as a container for storing the filament 12 and is shaped to receive the top portion 16. Bottom portion 18 comprises an outlet
10 30 for dispensing the stored filament and receiving slots 28 adapted or aligned to receive the plurality of protrusions 24. At the centre region of bottom portion 18 is formed the outlet 30 for dispensing filament. The circumference of bottom portion 18 comprises a flange 32 formed to seat on guide wheels 62 of the filament dock 60.

15 The filament container 14 may be made of disposable material such as polypropylene (PP) or polylactic acid (PLA).

Filament dock 60 is shaped to receive the filament container 14 therein. In the embodiment the top of the filament dock 60 is a square shaped plate, but may be any other shaped plate to fit the overall design of the 3D printer as
20 necessary. The square shaped plate has a centre-depressed portion 61 to receive the filament container 14. Filament dock 60 comprises a plurality of guide wheels 62 and a funnel 64. Guide wheels 62 may be ball-bearings. When the filament container 14 is properly disposed or positioned within the filament dock 60, the flange 32 of the filament container 14 contacts the guide
25 wheels 62. Guide wheels 62 are operable to constrain the movement of the filament container 14 as well as facilitate the rotation of the filament container 14 about a common-centre axis of the filament container 14 and filament dock 60. Centre-depression 61 comprises a contour 66. Guide wheels 62 thus contact the flange 32 of the filament container 14 and the contour 66 when the
30 filament container 14 is positioned within the filament dock 60. The contour 66 ensures that the container cannot be loaded in an upside-down position and

thus avoid operational errors arising from improper loading of the filament container 14. At the centre of the filament dock 60 there is a funnel 64 that directs filament to the feed system 80. Funnel 64 is aligned with the outlet 30 when the filament container is positioned within the dock 60. Guide wheels 62
5 protrude from slots on the dock 60 to interface with the flange 32 on the filament container 14. These guide wheels 62 may be mounted on vertical rods 63 which are a part of the filament dock 60.

The feed system 80 comprises a frame 81 and a spindle 82, preferably a flatted spindle. Spindle 82 is driven by a motor, preferably a stepper motor 92
10 for a relatively better control. Frame 81 is preferably an aluminium frame. The flatted spindle 82 drives a worm gear 84. The worm gear 84 is driven to be biased against a spur gear 255. The spur gear 255 in turn drives a shaft 256. The other end of the shaft is attached to a drive gear 257, preferably a knurled drive gear. Knurled drive gear 257 comprises teeth 258 operable to
15 grip onto the filament 12 when filament 12 is passed through funnel 64. In this regard, filament 12 is operable to be passed through between a smooth plunger 86 and the knurled drive gear 257. During feeding the filament 12 is pressed by the teeth 258 and one side of the smooth plunger 86. The movement of teeth 258 in an appropriate direction (clockwise or anti-
20 clockwise) pushes the filament 12 towards the 3D printer.

The drive gear 257 is connected to a drive shaft 256. The drive shaft 256 is operable to transmit power from the motor 92 to the drive gear 257. The motor 92 is located in a corner adjacent to the filament dock 60. The motor 92 is orientated such that the flatted spindle 82 is operable to be in a vertical,
25 downward pointing direction. Torque is transmitted from the motor 92 to the drive shaft 256 with the use of the worm gear 84; the worm gear 84 being fitted to the motor 92 which interfaces with a gear 255 fitted onto the drive shaft 256.

On the other side of the smooth plunger 86 is an electromagnet 88. The
30 electromagnet 88 is operable to pull the plunger 86 away from the drive gear 257 when loading filament 12. A gap is required between the drive gear 257

and the plunger 86 during the loading process whereby filament 12 is loaded into the 3D printer machine. Without this gap, filament loading would have to be done manually by pushing filament 12 against a spinning drive gear 257.

5 The invention will next be described in the context of its operation. A control algorithm implemented in the form of printer driver software may be used to control the loading and feeding of filament 12 into the 3D printer. A user may control the 3D printer via a user interface which comprises activating the 3D printer to operate between at least the following two modes:-

a 'loading' mode and

10 a 'feeding' mode.

Filament 12 is loaded by first inserting the leading end of the filament 12 into an inlet on the bottom portion 18 on the filament container 14. This leading end is attached to a mandrel inserted via the top plate central hole 20. The mandrel is spun, winding filament 12 into the filament container 14. When the
15 filament container 14 is filled with a predetermined amount of filament 12, the mandrel will be removed. The leading end is pushed through the central hole 30. At the opposing end, excess filament is trimmed off. Both leading and trailing ends are then bent to ensure it does not retract into the container 14.

In order to load the 3D printer with filament 12, a user activates the 'loading'
20 mode. Upon activating the 'loading' mode, the printer triggers the electromagnet 88 in the feed system 80. The electromagnet 88 pulls the spring-loaded smooth plunger 86 away from the drive gear 257. As mentioned earlier, a sufficient gap is formed between the plunger 86 and the drive gear 257. This gap allows filament 12 from the filament container 14 to slip past
25 the drive gear unimpeded.

The user then puts the filament container 14 into the filament dock 60. A length of exposed filament 12 will protrude from the bottom of the container 14. This exposed filament 12 slips into the funnel 64 at the bottom of the filament dock 60 and then enters the feed mechanism. Entry is unimpeded

due to the smooth plunger 86 having been pulled back by the electromagnet 88.

The user then disables the loading mode. This de-magnetises the electromagnet 88 and the smooth plunger 86 return to its original location
5 where the gap is closed. This means the plunger 86 is now pressing the filament against the drive gear 257.

When the user activates the 'feeding' mode, the drive gear 257 activates teeth 258. Teeth 258 then begin to move the filament 12 towards the extruder system.

10 The interaction between the electromagnet 88 and smooth plunger 86 to achieve the loading mode and feeding mode is as follows:-

Smooth plunger 86 is spring loaded and biased against the electromagnet 88 such that when electromagnet 88 is activated and pulls the plunger 86 away from the drive gear 257, the spring is in a compressed state, creating the gap
15 necessary for the 'loading' mode. When the electromagnet 88 is deactivated, the spring automatically returns to relaxed state, moving the smooth plunger 86 back towards the drive gear 257 and press against the filament.

The described invention is compact and has an automatic loading system for filament. The top down loading instead of side loading of filament provides a
20 more compact design. The described filament container, dock, and feeder may be easily incorporated with existing 3D printers with some modification.

As the wound (coiled) filament 12 is pulled through the outlet 30 and funnel 64, a rotational force is generated. The resultant rotational force rotates the filament container 14 relative to the filament dock 60 and prevents
25 entanglement of the filament 12 within the filament container 14.

It is to be understood that the above embodiments have been provided only by way of exemplification of this invention, and that further modifications and improvements thereto, as would be apparent to persons skilled in the relevant

art, are deemed to fall within the broad scope and ambit of the present invention described herein. In particular,

- The filament container 14 itself can be substituted by simply placing filament inside the filament dock 60. This filament then needs to be threaded through the dock's funnel 64 and into the feed mechanism 80.
- While the electromagnet 88 could be omitted, this would disable automatic filament loading. Without the electromagnet 88, the user would have to manually press filament 12 down into the feed mechanism 80 to ensure the drive gear 257 grips it and pulls it through.
- The interaction between the electromagnet 88 and smooth plunger 86 may be achieved via other types of biasing means instead of a spring.

The Claims Defining the Invention are as Follows:

1. An apparatus for dispensing filament suitable for three dimensional printing comprising:-
 - 5 a filament container for holding filament, the filament container rotatable about a central axis and comprising an outlet positioned along the central axis;
 - a filament extractor operable to extract filament from the filament container via the outlet;
 - 10 wherein as filament is extracted the filament container is rotated about the central axis simultaneously in a controlled manner such that tangling of the filament within the filament container is prevented.
2. An apparatus according to claim 1, wherein the loading of filament is
15 automated with the aid of an electromagnetic circuit.

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