Designing A Mini Conveyor Belt

By Linnea Warburton

NOTE: Condensed, my report makes up less than four pages. However as not to ruin the formatting of the part list table and the engineering drawings, I have let these sections have their own pages even though it visually pushes the report to 5 pages.

Description of the Product: 3D printing is a common method of manufacturing prototypes and specialty parts. Compared to other manufacturing methods however, 3D printing is not ideal for mass manufacturing. One solution to this problem is the use of a modular 3D printing system that involves a nozzle with X-axis motion and a conveyor belt that moves individual layers. For this final project I will be designing a mini conveyor belt to move the individual printed layers for a modular 3D printer. Compared to traditional conveyor belt systems, my design has three key differences. First, the conveyor belt system is very small, small enough to fit on a table. Second, the load on the conveyor belt is very small as the printed layers are very light. Third, the conveyor belt will need to move at very slow speeds, between 40-120 RPM.

Conveyor Belt Components: Conveyor belts usually consist of a drive pulley connected to a motor and an idler that spins freely (See Figure 1A). I will focus primarily on the pulley-shaft systems for the purpose of this project, and the accompanying bearings and shaft collars, and I will not be focusing on the motor to drive shaft connection or the motor mounting scheme. I will need a conveyor belt, and a linear guide that the belt will lie on. I will also need parts to attach the pulleys to the linear guide.

Motor Choice: Since the load on the conveyor belt is very low, the motor does not need to produce high torque and I will not use an additional gear system. While AC motors are often used for conveyor belts with fixed speeds, for my purposes I may need to adjust the speed based on the object I am printing. Thus, a DC motor is a better choice. I do not need precise position control, so I will not use a servo motor or stepper motor, and I need continuous rotation, so a servo motor is not a good choice. I will use a Brushless DC motor so it is more efficient and has a greater lifespan. I have no space requirements, so I will use a parallel shaft set-up with no additional gears (See Figure 1B).

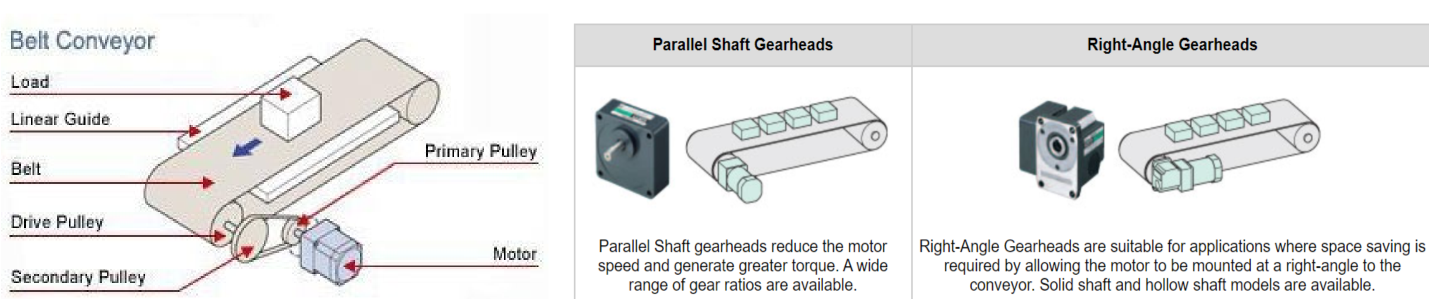
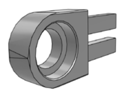
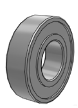
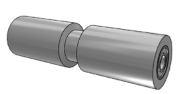


Figure 1. A) Layout of a typical conveyor belt system. B) Parallel Shaft versus Right-Angle Gearhead layouts [Oriental Motors, https://www.orientalmotor.com/applications/conveyor-belt.html]

Part List	**Number of Parts**	**3D Preview**	**Part Number / Link**	**Manufacturer**
Motor	1		4800	Polulu
Conveyor Belt	1		HBLTDSG100-6.08_info-20-20	Misumi
Linear Guide	1		HFSDCV-29140-2949	Misumi
Pulley	1		ROBAC30-8-L100-H0.3	Misumi
Pulley Holders	4		PLHDB-FE	Misumi
M3 Screw for attaching Pulley Holders	4		91290A109	McMaster-Carr
Shaft Collars	4		PSCCJ8-5	Misumi
Shafts (For both Drive Pulley and Idler)	2		1265K64	McMaster -Carr
Bearings	2		B6900ZZ	Misumi
Idler (with integrated bearings)	1		ROFAWM30-8-L110-X14.0-Y11.8-Z4.5	Misumi
Allan Key set	1		5511A41	McMaster-Carr

Engineering Drawings

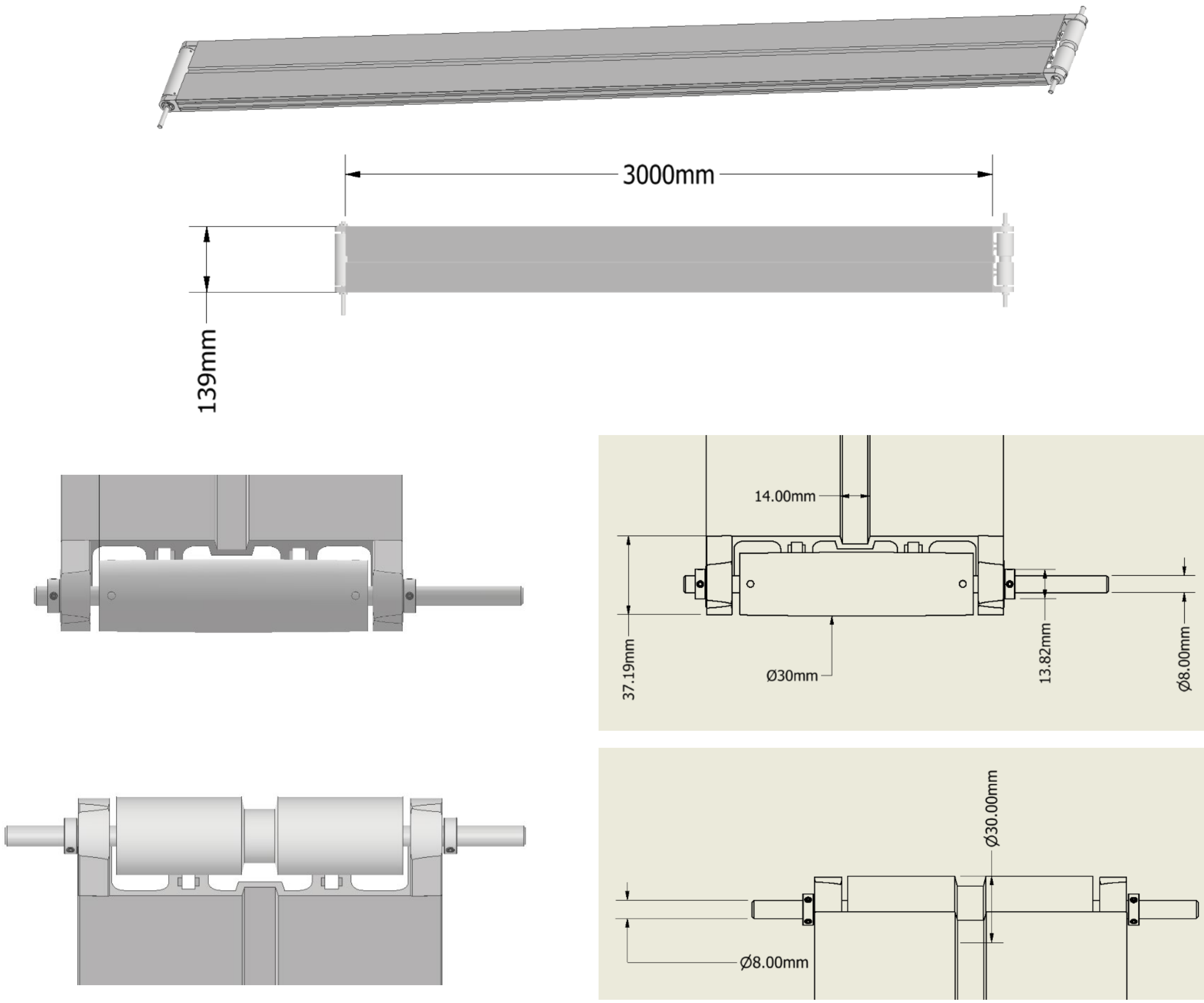


Figure 2. From top to bottom: Isometric view of the conveyor belt system. 3D view and drawing of Drive Pulley system. 3D view and drawing of the Idler system.

Bearing Force Calculations

While I have chosen my initial parts, I need to ensure that the bearings I have chosen will withstand the forces applied. Below I have included calculations for the torque and tensions in my conveyor belt system. We will ignore Fc, hoop tension for the purpose of this calculation because the belt is moving so slowly. We will calculate the force on the bearings using the following equations.

T = ½ D (μWg)
T = Torque (N*m)
D = Pulley diameter = 0.03m
μ = Friction coefficient = 0.8 [Manufacturer's website]
W = mass of load (Kg) = 0.2
G = gravity acceleration = 9.8 m/s2

T = ½ * 30mm * 0.8 * 9.8 * 0.2 = 0.02352 N*M

F1 - F2 = 2T / D
F1 - F2 = 1.568 N

F1 = b*Fa * Cp*Cv
b = Belt width = 0.1m
Fa = Max allowable tension = 4 N*m [Manufacturer's website]
Cp = pulley correction factor = 0.7 [Shigley's]
Cv = velocity correction factor = 1 [Shigley's]

F1 = 0.1 * 4 * 0.7 * 1 = 0.28N
F2 = - 1.848N

F_bearings = $\sqrt{F1^2 + F2^2 - 2 * F1 * F2 * cos(\theta)}$
Θ = 180° because the pulleys are the same size

F_bearings = 1.568N

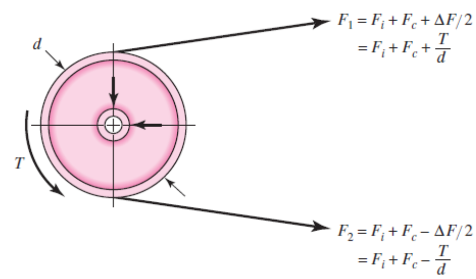


Figure 3. Forces acting on a pulley [Shigley's Mechanical Engineering Design, Ninth Edition]

These bearings can withstand 2700N of force, so I can conclude that they are strong enough for this application.

Fabrication and Assembly Processes: After receiving the parts from Misumi and McMaster-Carr, I will assemble the conveyor belt system in the following order.

1) Slide the drive shaft into the drive pulley. Tighten the screws in the drive pulley with an Allan key until the shaft cannot slide out.
2) Push the bearings into the pulley holders
3) Slide the bearings onto the two ends of the drive shaft
4) Attach the pulley holders loosely into the sides of the linear guide
5) Slide the two shaft collars onto the ends of the drive shaft, so that they are outside of the pulley holders
6) Make sure the pulley is evenly placed between the two pulley holders. Then, tighten the shaft collars with an Allan key
7) Tighten the M3 screws connecting the pulley holders to the linear guide

8) Slide the second shaft into the idler. The idler has integrated bearings, and does not need to be tightened onto the shaft
9) Slide the pulley holders onto the two ends of the idler shaft
10) Attach the pulley holders loosely into the other end of the linear guide, so that they are flush with the end of the linear guide
11) Place the belt around the linear guide, the drive pulley, and the idler.
12) Slide the two shaft collars onto the ends of the idler shaft, so that they are outside of the pulley holders
13) Make sure the pulley is evenly placed between the two pulley holders. Then, tighten the shaft collars with an Allan key
14) Push the pulley holders forward, coming out of the linear guide until the belt is very tight
15) Tighten the M3 screws between the pulley holders and the linear guide with an Allan key