Openbuilds Adhesive Experiment Sheet:

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Goal:

1) Test how well different adhesives bond Openbuilds GT3 timing belt (Openbuilds SKU 626).
2) Tests verify if using an alcohol (IPA) wash prior to bonding improves how well the belt bonds.
3) The goal is to make a loop of belt which has both a strong join, and is flexible.

Introduction:

Openbuilds sells GT3 timing belts, which are used often in 3D printers. The pitch of the belt (p) is the distance between the teeth in the belt. In the case of Openbuilds GT3 timing belt, pitch p = 3mm between teeth.

The belt itself is mostly made of neoprene with some lubricants baked in, and has the following structure. It is made of three layers. You can see the structure of the belt shown below

a) the top layer with the rubber teeth made of neoprene rubber,
b) the middle layer which is a fiber belt providing reinforcement/resistance to stretching, and
c) the smooth rubber bottom layer made of neoprene rubber

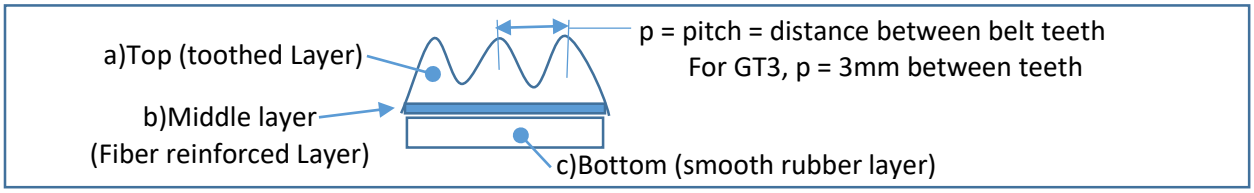

Figure 1: Openbuilds GT3 structure

Materials:

1) Openbuilds GT3 Timing belt (SKU 626)
2) Sharp exacto-blade or box cutter
3) IPA (isopropyl alcohol)
4) Clamp (self-locking pliers, or c-clamp)
5) Cup for holding IPA during alcohol wash
6) Alignment jig for ensuring belt-teeth are properly spaced at patch point (either 3D printed alignment jig with same pitch as belt, or length of GT3 used as an alignment jig).
7) Oil for alignment jig to prevent adhesive from bonding to surface

Adhesives to test: (List included materials in the workshop, and specially ordered adhesives)

a) Gear-aid Aquaseal +Neo contact cement for neoprene
b) Pro-line tire glue 6031-00
c) Loctite black 480 prism instant adhesive
d) Starbond Black Medium-Thick High Performance Premium Cyanoacrylate
e) Armour Coat All Purpose White Glue (wood glue)
f) JB-Weld Steel Reinforced Cold Epoxy
g) Oatey PVC Cement
h) Amazing Goop Marine Adhesive & Sealant
i) Certified™ Tire and Patch kit (bicycle tire repair kit)
j) JB-Weld Hi-Temp RTV Silicone & Gasket

Procedure:

The ends of the belt are bonded together using a **scarf joint**.

a) **TAKE MEASUREMENTS**: Measure the perimeter P of the loop needed. This is Perimeter length P. Ex, if the belt loop has a measured perimeter of 300mm, then P = 300mm.

b) **CUT BELT TO LENGTH L**: To make the belt loop using the scarf joint. We need to cut a length of belt L = P + 3p (overlap) + 3p safety margin. EXAMPLE: So if belt perimeter P is 300mm, and belt pitch p is 3mm, then we need to cut a belt loop

L = P + 3p (overlap) + 3p (safety) = 300mm + 9mm (overlap) + 9mm (safety) = 318mm. *

*Remember, always cut BETWEEN TEETH.

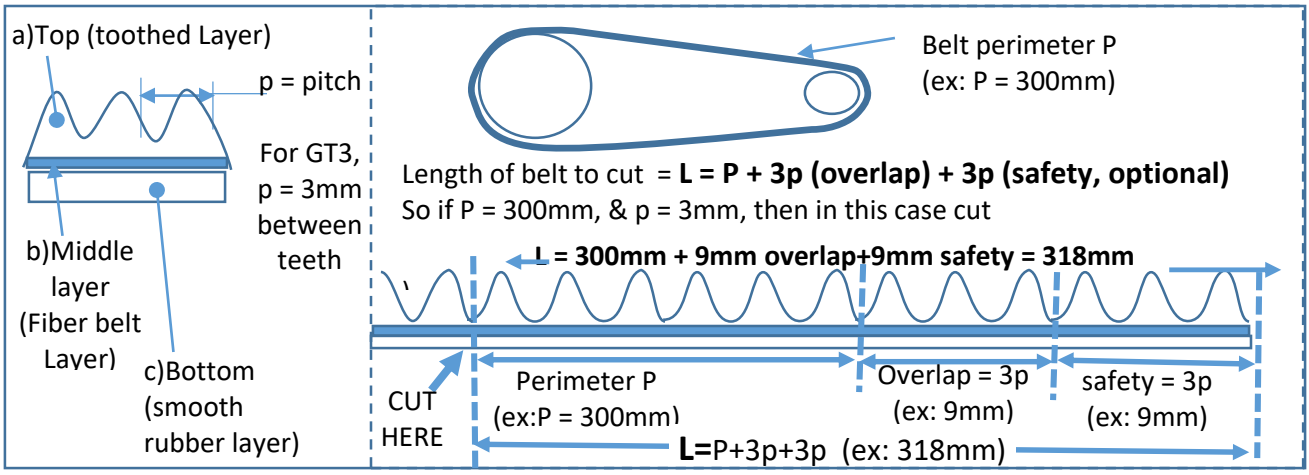

Figure 2: Measuring and cutting a length of belt

c) **PRACTICE TOP AND BOTTOM SCARF JOINT CUTS**: If you have no experience in making scarf-joints in this material. Then practice making scarf-joints on a test length of GT3 timing belt (ex: 45mm long test piece). Practice making top & bottom scarf-cuts until you can do it reliably.

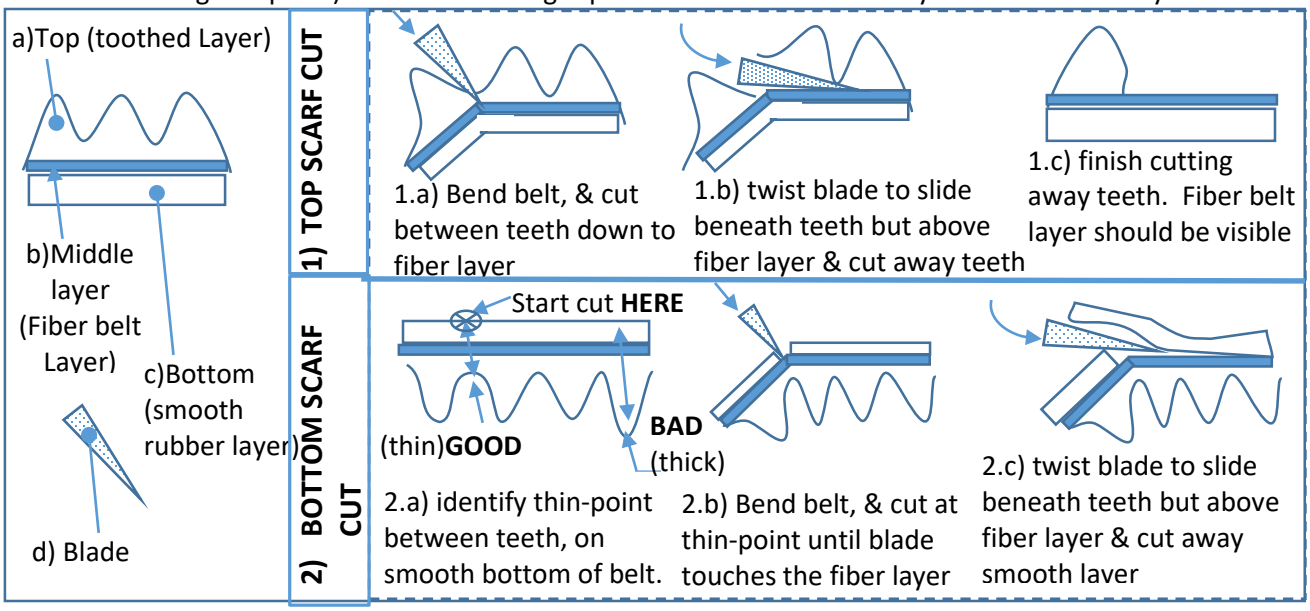

Figure 3: Guide to making Top & Bottom Scarf Joints

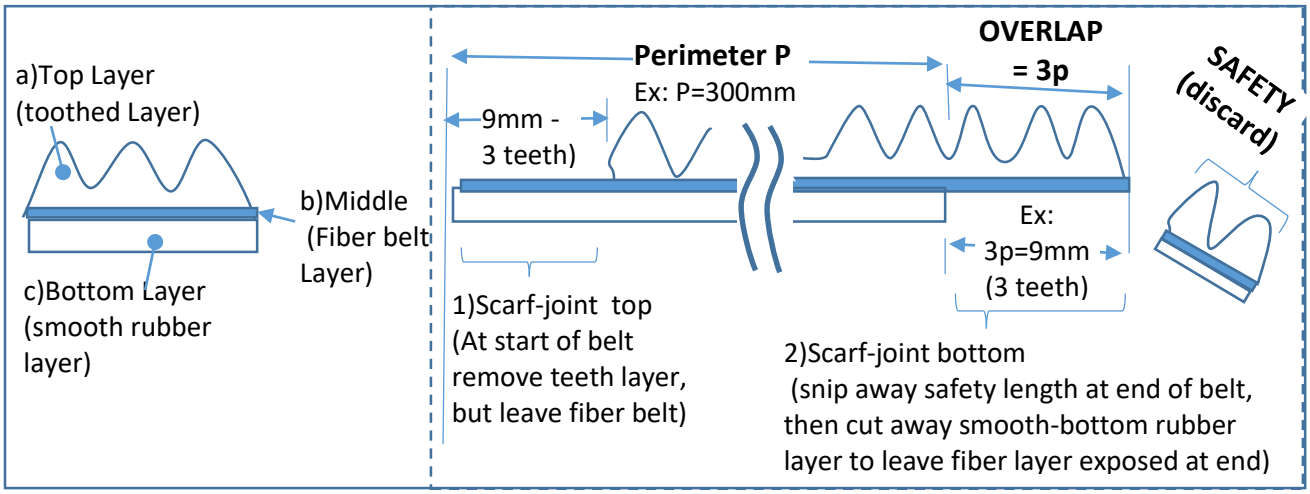

Figure 4: Trim off the extra safety length prior to Bottom Scarf-Cut

d) **TOP SCARF JOINT**: Take a blade and cut away 9mm (3 teeth) worth of rubber from the toothed layer, but take care to leave the fiber belt middle layer (mostly) undamaged. This is now (1) the top scarf-joint. If a mistake was made while cutting away the teeth, and the middle layer was sliced through, then cut away the bad section of the top scarf-joint, and use the safety length portion of the belt to re-do the top scarf-joint.

e) **CUT AWAY SAFETY LENGTH:** A safety length was included, because it can sometimes be difficult to make the top scarf joint without completely cutting through the fiber layer. If the safety length was unused when making the top scarf-joint, then trim it away now. Belt length is now

L = P (perimeter) + 3p (overlap). (SAFETY LENGTH WAS REMOVED)
Ex: if P = 300mm, and p = 3mm, now L = 300mm+9mm=309mm

f) **MAKE BOTTOM SCARF JOINT:** The bottom scarf joint is easier to make than the top scarf-joint. To make the bottom scarf-joint, take the blade and trim away the smooth bottom layer down to the fiber layer on the opposite end of the belt. Do this over 3p = 9mm (3 teeth) of length. Make sure to not cut through the middle fiber layer. This is now (2) the scarf-joint bottom.

g) **FIT ENDS TOGETHER, THEN TRIM IF NECESSARY:** Bend the length of belt around into a loop, so the top scarf-joint and the bottom scarf-joint overlap. Verify that pitch p between teeth has been preserved over the scarf joint by using either a length of GT3 belt, or a 3D printed jig with the same pitch spacing as the GT3 belt. There should be a small gap under 1mm (g < p/3) on the underside of the scarf joint. If

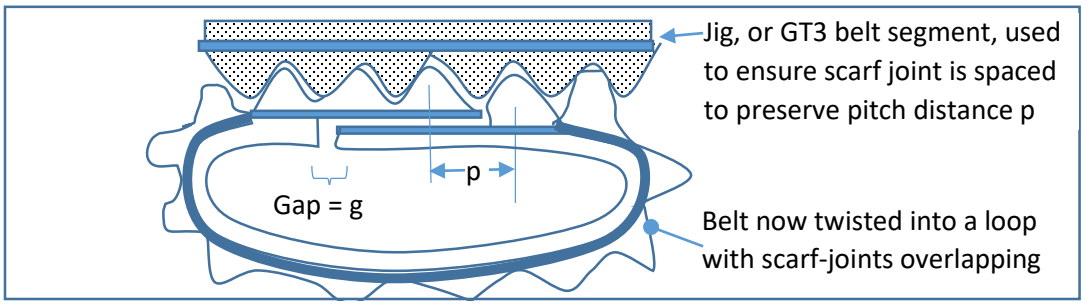

Figure 5: Testing the belt loop

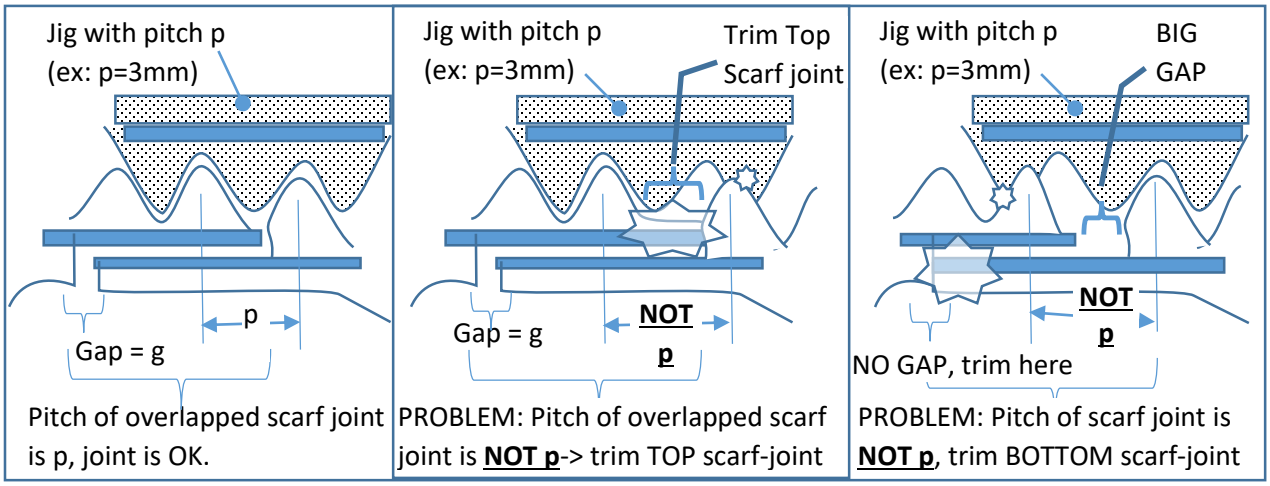

Figure 6: Troubleshooting the scarf joint

h) **ALCOHOL WASH:** There are lubricants in the belt material that will prevent some adhesives from bonding. They must be washed out from the material before the adhesives can bond. In this case we used IPA (Isopropyl Alcohol @100% concentration) as the solvent. To remove these lubricants, soak the exposed scarf-joints (top and bottom) in IPA for a minimum of 1 hour (agitate every 20-30 minutes during wash to clear away dissolved material from exposed scarf-joints while soaking), then remove scarf-joints from the IPA and let the ends dry. It's ok to soak the exposed scarf joints overnight, but remember to agitate/shake at least once.

i) **APPLY OIL TO JIG:** Apply a light coating of oil to the alignment jig (either a length of belt, or 3D printed jig) to ensure that the adhesives from the belt will not stick to the jig.

j) **APPLY GLUE TO EXPOSED SCARF JOINTS, THEN CLAMP:** Now apply adhesive to the exposed fiber belt areas of the scarf joints align the teeth with the oiled up jig and squeeze the two belts together using a c-clamp, or locking pliers. Let bond while clamped for 24 hours, then you have your new bonded belt.

k) **APPLY A STRIP OF FIBER REINFORCED NEOPRENE TO THE BACK OF THE BELT (OPTIONAL)**: Take a 1/16" thick strip of fiber reinforced neoprene. Cut a strip to match the width of the belt, and the length to be reinforced. Soak in alcohol to clean any lubricants, then glue and clamp the strip to the back of the belt, over the scarf joint. This is added (optional) reinforcement.

l) **OBSERVE BELT FOR LIFTING EDGES & GLUE THEM DOWN**: Sometimes an edge might peel up where there was insufficient glue applied. Clean away any oil, then apply more glue to that point and re-clamp for 24 hours.

Adhesives Tested:

The following adhesives were tested in this experiment using the procedures outlined above for making loops of belt using scarf-joints, but without attaching a 1/16″ thick fiber reinforced neoprene strip on the back of the belt. Testing was performed both by

a) Including an alcohol wash of the scarf joints (**results with alcohol**)
b) Avoiding the use of alcohol with scarf joints (**results without alcohol**)

Best results in this case imply that the scarf-joint has both a strong bond, and is flexible.

*NOTE: Adhesives here were the adhesives we had on hand. They may not have been used for their original intended purposes, and this test only represents how well they work when trying to bond neoprene rubber based timing belts.

Types of adhesives tested include:

a) Contact cement for neoprene (used for repairing wetsuits)
b) Epoxies and cyanoacrylate glues
c) Wood glue / white glue
d) Tire repair kit
e) PVC cement
f) Silicone adhesives/ gasket making solutions.

Results Table:

	Adhesive	Results with alcohol	Results without alcohol
1	**Gear-aid Aquaseal +Neo contact cement for neoprene**	**WINNER!!!! BEST RESULTS** (bonded well, & flexible)	X-FAIL
2	**Pro-line tire glue 6031-00**	Slightly stiff	Slightly stiff
3	**Loctite black 480 prism instant adhesive** (*Note: runny and messy. Use gloves)	Slighly stiff	Slightly stiff
4	**Starbond Black Medium-Thick High Performance Premium Cyanoacrylate**	Stiffer than #1 but OK	VERY STIFF = Fail
5	**Armour Coat All Purpose White Glue**	X FAIL	X FAIL
6	**JB-Weld Steel Reinforced Cold Epoxy**	X FAIL	X FAIL
7	**Oatey PVC Cement**	X FAIL	X FAIL
8	**Amazing Goop Marine Adhesive & Sealant**	FAIL (Flexible but weak)	X FAIL
9	**Certified Tire and Patch kit** (bicycle tire repair kit)	X FAIL	X FAIL
10	**JB-Weld Hi-Temp RTV Silicone & Gasket**	X FAIL	X FAIL

Conclusion:

The neoprene contact cement (in this case the brand “Gear-Aid Aquaseal + Neo Contact Cement for Neoprene”) was the best adhesive for this experiment in both strength and flexibility, but would only bond if scarf-joint ends had been soaked and agitated in IPA (Isopropyl Alcohol, in this case 100% concentration) for a minimum of 1 hour (with agitation every 20-30 minutes).

It was also possible to use

a) “Pro-Line Tire Glue 6031-00”,
b) “Loctite Black 480 Prism Instant Adhesive”
c) “Starbond Black Medium-Thick High Performance Premium Cyanoacrylate”

These adhesives also worked, but they produced stiffer, less flexible joints than the alcohol washed contact cement joints. They were not as optimal for tank-treads or timing belts, but may find use in making rack and pinion arrangements.

References:

1) Surface treatment with IPA alcohol, and use of neoprene adhesive are based on information taken from the following reprap forum https://reprap.org/forum/read.php?1,670647,888356

2) The scarf-joint was taken from Robert Murray-Smith’s tutorial shown here https://youtu.be/1zdl_kSc0Ik