'Snow Problem Powder Coating Guide

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Abstract—This white paper provides a description of the process of powder coating used by Robot in 3 Days team 'Snow Problem. It describes the process of powder coating and how to get the process started for a team.

1 Summary

Powder coating is a coating that can be applied to metals that is much more durable than painting. It is applied by spraying a fine powder onto a part and then baking that part in an oven for a short period to cure it. Powder coating is a great way to make any teams robot stand out much more, and can be done in house with relative ease. We will cover what you need to powder coat, how to build an oven to bake your parts in, and how to apply the coating.

2 What is needed to start powder coating

2.1 Oven

The first major part to start powder coating is the oven which is used to bake the parts in. The oven will need to hold a temperature of 400 degrees Fahrenheit for 20 to 25 minutes while your part bakes. Standard household ovens, and toaster ovens will achieve this, but should **not** be used for cooking food for consumption after being used for baking powder coated parts. As these standard ovens did not meet our size requirements we built our own which will be covered later.

2.2 Powder coating gun

The next item you will need is a powder coating gun which applies the powder to the part. The most common one I saw was the Eastwood Dual Voltage Gun. It allows for a higher voltage to be used for larger parts which I found to be nice for the occasional larger piece, but for an FTC team or a team on more of a budget you can get away with the single voltage gun just fine.

2.3 Air compressor

An air compressor is required to operate the powder coating gun and if you do not have one, a pancake compressor can be purchased for relatively cheap and opens up a lot more pneumatic tool options to your team in the future.

3 Building Your Own Oven

3.1 Determining Oven Size

First you will need to determine the size of the oven that you will need. Our oven is 8 inches wide by 8 inches deep by 4 feet tall. This was originally designed with FRC size parts in mind allowing for long chassis parts to fit in with ease for length. I have found it to be more than long enough as only the chassis parts utilize most of the oven so I also added in a 2nd tier to the oven that can be removed when baking larger parts. After using the oven that we had initially designed, I believe that one that is slightly wider and deeper will be more beneficial as it allows to hang more parts with more space.

3.2 Considering Commercial Options

After deciding what size oven you want, look to see if you can use a large toaster oven or a small commercial powder coating oven. Using a commercial product will save a lot of the hassle with building something like this. For an oven that could hold parts as long as we needed many of the ovens were thousands of dollars which is a bit price prohibitive. Another factor is many of the larger ovens run off of 220V which we did not have access to.

3.3 Estimating heating requirements

To decide what you will need for heating elements I would suggest looking up a BTU calculator. Ours told us, with average insulation, 500 watts would cover it which may be true, but to get the oven up to the proper temp quick enough we figured increasing the amount by 3 would be about right. With our 1200V toaster oven elements we heat up in about 10-15 minutes. Given the option of 220V we may have chosen electric stove or oven heating elements to generate heat.

3.4 Constructing the frame

For constructing the oven we would highly recommend using all aluminum due to the ease of working with it. After constructing the structure of our oven out of steel and the sheeting out of aluminum there was an apparent issue with the rate of expansion of the aluminum in comparison to the steel causing the aluminum to buckle out.

The construction should be fairly straight forward. Some 1x1 tubing or tube of choice and make a rectangle for each face. For an example of how we designed ours reference figure 1 which shows a cross section of the top view of the oven. For the top and bottom reference figure 2 which shows how the top and bottom fit in to make the structure complete.

3.5 Wiring the oven

To start wiring your oven you will want to purchase high temperature wire as the insulation for most wire will start to melt at the temperatures the oven will reach. Also any

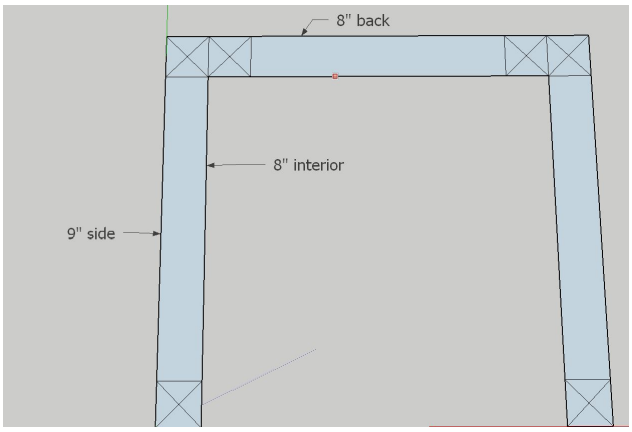

Fig. 1. A cross section of the oven from the top view. Showing how we designed it to join the back and sides.

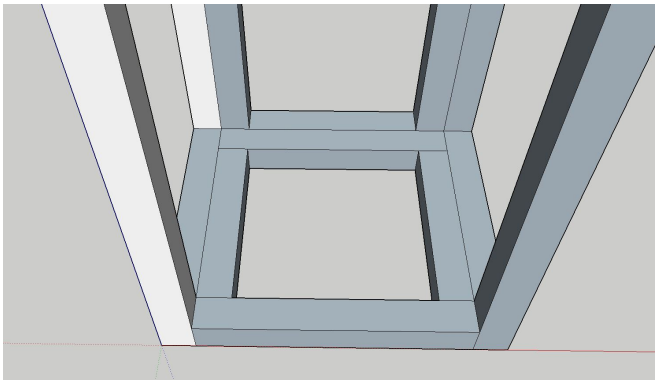

Fig. 2. A view of how the bottom and top join up with the side panels.

wiring joints that are made should use high temp wire nuts as most solder will melt at the temperatures the oven is reaching.

You will want to start with mounting your heating elements and wiring them into the solid state relay. Figure 3 shows a rough idea of how the solid state relay and PID controller will hook up into your power supply. The thermocouple must be mounted somewhere in the oven near where you will expect parts to be to give an accurate reading. All of our electronic connections were made in a PVC electronics box that sits on top of the stove, but it does need some separation between it and the oven to keep a cooler temperature.

3.6 Insulating and sealing the oven

Now once this structure is built, the corners need to be sealed to keep hot air from escaping. We used High temp JB weld which worked fairly well to start, but after a number of uses it started to crack and break down. Using a high temp silicon calking material would probably be a better choice.

We insulated the sides of our oven with unbacked fiberglass insulation as it could compress to the correct size and we knew it would withstand the high temperatures present in the oven. Once the insulation is in place you can rivet the exterior sheeting onto the oven.

To seal the door we used an adhesive backed wood stove door gasket which was as simple as peeling it off and

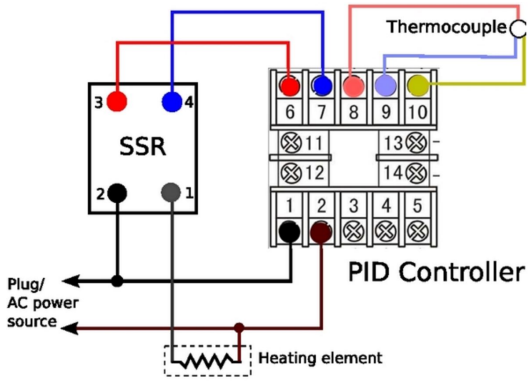

Fig. 3. A view of how the bottom and top join up with the side panels.

attaching it to where the door meets the frame. Adding a gasket is very crucial, we noticed that before we attached it the oven had difficulty reaching the desired temperature whereas after we attached it the oven easily reached the proper temperature.

3.7 Finishing Touches

Some method of hanging the parts must be added to the oven. What we did was add threaded rod every 2 inches along the top allowing for 3 rows of parts to be hung at a time. The threaded rod was held in place by nuts jammed together on either side of the interior sheeting.

If you so desire you can paint the oven with a high temp paint used for grills, but be warned that the powder that gets on the inside and out will change the color of the oven so it will be colorful regardless.

To attach the door we used an aluminum piano hinge as it supports the door for the entire length.

To finish the oven at this point you will want to install some sort of latch to keep it shut we tried a few solutions and level latch toggle clamps seemed to be the best solution.

Creating a base is also a good idea to isolate the oven from the floor. Our design was just some tubing the size of the base bolted onto the bottom.

3.8 Turing the oven on

The first time you turn the oven on you will want to do it outside for fire hazard and for proper ventilation. Any oil residue from cutting the metal will be burned off so try to wipe everything down very well before turning it on.

4 Powder Coating Your Parts

4.1 Safety

As your safety is more important than a powder coated part, always remember your personal protection equipment. To start, when applying the powder use a respirator. The powder is very fine and often gets past a standard dust mask. Cover your eyes with safety goggles or at least safety glasses to keep the powder out of your eyes. Make sure you apply the powder in a well ventilated area.

When baking the parts make sure to always wear long sleeves and high temperature gloves whenever you touch the oven. The parts are very hot and a quick touch will cause

a severe burn. Keep an eye on the oven and have a fire extinguisher on hand in case of something going severely wrong.

4.2 Purchasing Powder

To purchase powder coating powder there are many websites that sell it. If you are trying to match a powder to a certain color try to find a powder vendor with RAL color options. The website rgb.to has an option where you can enter many color formats and convert it to another. Given this you can enter the color you want and convert it to the RAL number and purchase the matching powder.

Be aware that the amount of shine can vary greatly from various powders. By default most of them have a high shine from what we have seen.

When we powder coated our robot this year we used about 8 oz of black for the drive train and a pound and a half of blue for all of our mechanisms.

4.3 Preparing

Once you have your piece cut to its final dimensions and all of your holes drilled in it you must deburr all of the edges and holes. Next you must clean off all of the metal shavings, oil, sharpie marks, and any other impurities on the part. If there is oil left inside tubing and it gets put in the oven it will smoke off all of the oil and it can drip off removing some of the powder coating. There are commercial options available for cleaning the parts, but we have found isopropyl alcohol to be adequate. Once it is clean try to keep touching the parts to a minimum to prevent adding oil from your hands to the part.

4.4 Coating

To start you need to fill the gun with the powder you want to use. Next you must attach a conductive wire to the part and then hang the part by that wire. Hang the part in a well ventilated, and easy to clean area. Attach the lead from the powder coating gun to the wire connected to the part. We found 8 PSI to be the optimal pressure to spray the part with. Continue spraying the part from 4-6 inches away until the part is evenly covered.

4.5 Baking

Once your part is evenly coated and the oven is preheated to 200 Degrees Celsius you can open the oven and hang the part. Close up the oven and let the part bake for a minimum of 15 minutes. If you are doing multiple parts try to keep track of which ones went in when, or just make sure all the parts got up to temp for at least 15 minutes before pulling them out. When they are done pull them out and hang them somewhere where they can cool away from anyone touching them while they are hot.

4.6 Recoating

Some coatings require multiple coats like with a bottom layer of chrome, a second layer of color, and a top coat with sparkle, or a protective clear coat. In order to do this let the part cool until you can handle it again, clean the gun, change the powder, and respray it. This process can be repeated about 3 times before the powder coating will get thick enough that further coats won't adhere well due to the powder not being attracted to the part as strongly.

5 Cost

Below we have broken down the cost of building your oven and accessories that may go along with making your powder coating set up. If you need to purchase everything the entire setup will cost you almost $ 600 before powder. If your team is willing to go with a toaster oven and the less powerful gun you can get the entire setup $ 250.

Oven Build Cost

Item	Cost
Structural Tubing	$ 60
Aluminum Sheeting	$ 100
Hinges	$ 10
Latches	$ 5
Door Seal	$ 25
PID controller, Solid state relay, thermocoupler	$ 40
High temperature wire	$ 25
Electronics box	$ 10
Toaster Oven	$ 30
Rivets	$ 15
Oven Total	$ 320

Accessories

Item	Cost
Powder Coating Gun	$ 120
Pancake Air Compressor	$ 100
Pneumatic hose and accessories	$ 35
Respirator	$ 30

6 Final Thoughts

Overall we have learned a lot over the process of building our powder coating oven and powder coating our robot this year. We have found that it makes a large difference in the presentation of the robot. The learning curve for powder coating is very low so once you have a setup and do a little of practice you can create professional looking parts in no time.

7 Contacting the Authors

Team 'Snow Problem may be reached in order to ask questions on our Chief Delphi thread, on Twitter (@SnowProblemz), or via our Twitch stream during the three day build. After the build, we will still be answering questions on the thread and via email (at gofirst@umn.edu). We are doing this for you, the FRC community, and are happy to answer questions and discuss our designs with you.