Features and Benefits

- Current market has virtually no economical means of producing customized air vents.
- Air vents can be customized to any unique design (i.e. car logos, college logos, flame designs).
- The traditionally manufactured air vent consists of 12-20 individual parts, but with DDM all of the components are built as one consolidated part.
- No assembly required.
- Geometry easily customized to accommodate any vehicle vent profile.
- Able to add embedded features such as hidden compartments for replaceable air fresheners, for a more aesthetically pleasing look.
- Specially designed center flap includes features to create the necessary interference fit required to hold the vent in various positions.
- Able to construct complex geometries on a small scale without added manufacturing cost.
- Vents created using FullCure Vero materials used in the direct printing process performed by the Objet Connex500 machine. This allows for a variety of colors to match the interior of a vehicle.
- Multi-material build permitted by Objet Connex500 machine allows for a comfortable, rubber material to be added to the adjuster without addition assembly.

Groove designed into vent body to create interference fit when adjusting vent.

Customized vent for a Ford Mustang.
**Introduction**

After extensive research into the custom car part market, we found that the ability to customize air vents was extremely limited.

![Cheesy chrome stickers for air vents](image)

**Figure 1: Cheesy chrome stickers for air vents**

In fact, the only thing discovered was putting chrome stickers over the flaps. As can be seen in Figure 1, people are desperate to customize their air vents but do not have sufficient means to do so. For this reason as well as the several areas where DDM technology would be fully utilized, we chose to customize air vents.

**Innovative Aesthetics and Geometrical features**

The DDM design process allows for any customization to any unique design that can be modeled but also creates the need for geometric features that allow mobility in assemblies. Figure 2 illustrates some of these innovative aesthetics which would not be possible using traditional methods. Figure 3 shows an example of a feature that is necessary for the part to be built all at once using a DDM process.

![Innovative aesthetics](image)

**Figure 2: Some innovative aesthetics**

(flames and Ford Mustang symbol)

![Interference fit allowed by groove](image)

**Figure 3: Interference fit allowed by groove**

**Degree of personalization**

For an individualized air vent, the customization process is facilitated by the fact that only a customer only needs to provide a two-dimensional design which can be easily CAD-modeled and produced. A customer could choose any unique design such as college logos, car symbols, and popular flame designs (see Figure 2). Along with this flexibility, each vent can be easily customized to fit any vent profile for any vehicle.
**Parts consolidation**

A traditionally manufactured air vent consists of 12-20 individual parts, but with DDM all of the components are built as one consolidated part. There is absolutely no assembly required and the vent still maintains full functionality. Figure 4 illustrates how parts consolidation affected the vent for a Jeep Cherokee.

![Figure 4: Picture of all traditional parts for a Jeep Cherokee air vent (black parts) consolidated into one customized piece (blue and silver)](image)

**Choice of DDM process**

Because the air vents will be used inside people’s cars, it is necessary for them to be aesthetically pleasing. A prominent stair-step effect that is so prevalent in DDM processes would not be acceptable. Due to the small nature of the vents, many of the complex geometries that come with customization require a process with a very high resolution. We also wanted to have a process that would allow for the construction of multiple materials during a single build. This ability permits the addition of the rubberlike Tango material in the areas shown in Figure 2 without added assembly. With all of these constraints in mind, we researched and discovered the best process to use. The DDM process we chose to produce these parts is Direct Printing with photopolymers using the new Objet Connex500 machine.

Direct printing with the Objet Connex500 machine meets all of our criteria. This process allows the unique ability to print parts and assemblies made of multiple model materials with different mechanical or physical properties all in a single build. With this capacity to make multi-material builds, the process does not lose resolution or require thick layering. This revolutionary machine is capable of building with more than one material while using just 30 micron layers. With such small layering, the process eliminates the stair-stepping effect and gives us the “highest resolution available” which will satisfy the aesthetics need with little to no post-processing.

![Figure 4: Addition of rubber Tango material without assembly](image)

![Figure 5: How the Objet process works](image)
**Choice of DDM material**

The material requirements of our customized air vents have to do with the thermal and strength properties. The thermal requirements are only those necessitated by the surrounding environment, namely the interior of the vehicle. Current research shows that the interior of a vehicle can reach up to 130-140°F in the dead heat of summer and can drop to -30°F during the winter. These extremes in temperature greatly outweigh those that would be produced by the car’s air conditioning or heating systems. After researching the different materials available for the Connex500 machine, we found the FullCure Vero family of photopolymers met all of our requirements. According to Objet, the FullCure Vero family maintains their properties when tested up to 230°F which is well beyond the 130-140°F threshold. The material will also maintain its properties for the extreme cold.

Air vents are not typically high-stressed parts. With the tensile strength of these materials ranging from 49.8-55.1 MPa, using the FullCure Vero family of materials will suit our needs perfectly.

The Vero set of photopolymers also comes in a wide assortment of colors to help match the interior of the vehicle. Another benefit that comes with the Vero material is that paint readily adheres to its surface if the specified color is not available. If a rubber-like material were necessary, the Tango family of materials would be used.

**Cost/Benefit Analysis**

There are several things that factor into the cost of producing these parts such as engineering design time, production and support material, and machine production time. After contacting Objet for pricing, materials cost came out to be $900 per 3.6 kilogram cartridge for the Connex500 so we estimate, with design and production time, each vent will end up costing approximately $100 per vent. This is not an unreasonable price as people normally purchase custom decals and customized lights for well over $100.

We established two main areas that would most benefit from these vents: 1) vehicle-customization aficionados and 2) reproduction of obsolete parts. Here is a cost/benefit analysis of both:

1) Customizing the air-vent in its entirety is not economically possible unless using an additive process. Creating the tooling necessary to produce a unique air vent with traditional methods would cost into the tens of thousands of dollars. For this reason, the customization enthusiasts have left their vents un-tampered. The direct printing process allows complete personalization and part consolidation (see Figure 4) of the vent as well as the capacity to produce it and sell it at the same price as the un-customized vent built using the same DDM process. An added benefit of the DDM process is the ability it has to add luxury items such as a pocket to hide an air freshener or comfortable rubber on the adjuster.

2) Just as it is not possible to economically produce one-of-a-kind custom air vents, the same is so for the reproduction of obsolete vents. Many people devote a lot of time to auto restoration and usually find it difficult to find parts (i.e. air vents). With an additive process, it is possible to recreate obsolete air vents as well as add the personalized custom touches classic car fanatics love all at the same price of around $100 (price may vary slightly with amount of material used).

Most of our parts would likely be sold in sets of five or six for each car because most people will have the vent individually customized given the option at little or no extra charge. However, some parts could easily reach the low hundreds in production if it were a popular design. In order to simplify the process for many of customers, we would provide a catalog of the popular vent designs that they could choose from, making an even faster production time.