

Panel Duct and Register Development

Case Study

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Modern vehicles present unique packaging challenges to interior equipment designers, especially when it comes to finding space for heating and ventilation ducts. Yet this is one of the most important systems for passenger comfort and car buyers are demanding premium performance. A well designed panel duct and register system offers four key elements:

- High air flow volume on demand
- Quiet operation
- Balanced air flow volume to both passenger and driver sides
- Wide range of directional control using the panel registers

Flow volume is limited by two factors. First, the size of the fan and motor dictate the maximum flow volume that the system can deliver. Second, the shape and size of the ducts and registers create a flow resistance (pressure loss) which reduces fan output. More flow could be supplied by a larger fan, but this would consume more power and generate more noise. Airflow Sciences Corporation (ASC) specializes in the more practical approach of minimizing duct pressure losses to increase total flow volume.

Major sources of pressure loss include sharp corners and rapid expansions in the ducts which cause flow separation. When flow separates from the wall of the duct, it typically forms a turbulent recirculation zone as illustrated in Figure 1. This zone effectively reduces the area of the duct and chokes off the flow. Turbulent, separated flow also contributes to high noise levels.

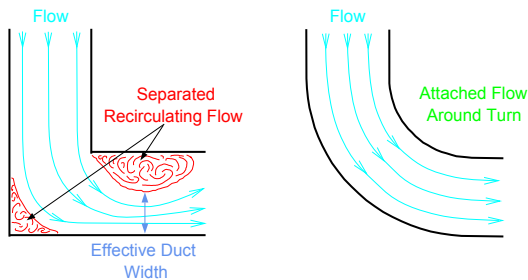


Figure 1 - Characteristics of separated and attached flow

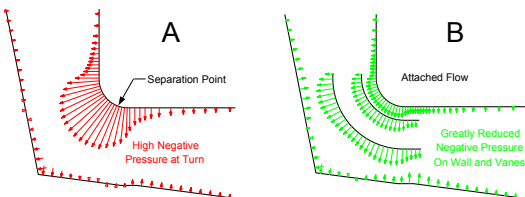


Figure 2 - Pressure distributions in separated and attached flow cases

ASC has developed a series of computer programs that predict pressures on the interior surfaces of the ducts and analyze those pressures to determine if the flow is separated. Flow in the duct elbow shown in Figure 2-A separates from the surface near the highly negative pressures along the inside turn. In this case, the addition of turning vanes to the elbow (Figure 2-B) reattached the flow, thus increasing flow volume and reducing noise. With simple modifications such as these, ASC has increased the flow volume through panel duct systems by as much as 25%.

In addition to maximizing the total flow volume, an acceptable split of air flowing to each panel register must also be achieved to ensure both driver and passenger comfort. ASC's numerical analysis techniques, applied in conjunction with testing, allows our engineers to design panel duct systems with optimal flow balance.

Instrument panel registers function in various ways and come in many different shapes and sizes. These variables are often determined by the desired appearance of the vehicle interior. However, an attractive register does not necessarily provide good directional control over the air stream. Most automotive designers have no means to quickly determine why the registers don't function properly, let alone how to fix them. ASC can do both.

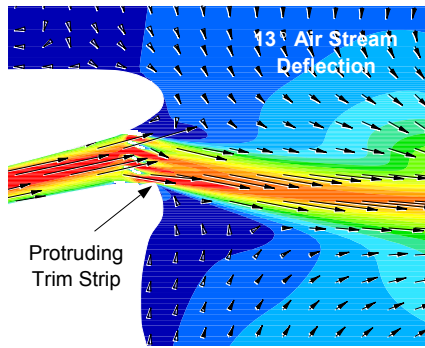


Figure 3 - Panel register with reduced directional control

Using sophisticated numerical simulation technology, air flow through the registers can be analyzed on a computer. Graphical results provide rapid insight to the root causes of poor directional control. Consider the cross-sectional view of the register shown in Figure 3. The arrows indicate the direction in which the air is moving and the colors indicate the speed. Note that the flow passing through the lower vanes impinges on a small trim strip, thereby limiting the downward deflection of the airstream. A slight recontouring of the trim piece shown in Figure 4 resulted in a 40% increase in downward directional control. The minimal change pleased both the automotive styling department and the climate control engineers.

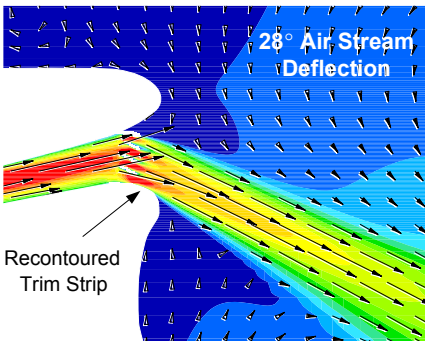


Figure 4 - Minor changes significantly improve directional control