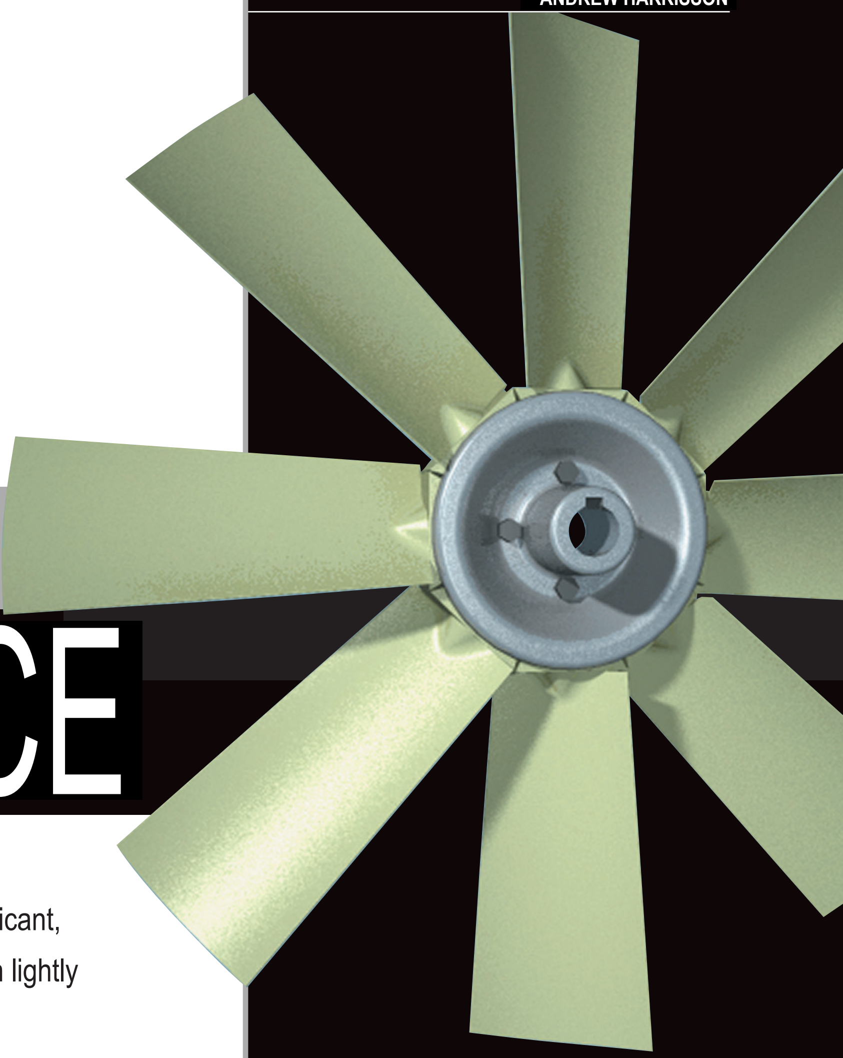
ANDREW HARRISSON



# ZERO TOLERANCE

Tip clearances only marginally more than required can greatly reduce engine cooling. Other, seemingly insignificant, factors make impeller mounting a matter not to be taken lightly

Vehicles are growing more and more advanced, with engineering breakthroughs becoming increasingly commonplace, and as a result, a great deal more is being expected of the engine cooling system. In order to meet these expectations, it is important to have an understanding of the system effects that can influence an impeller's performance. Simple things such as impeller tip clearance, location and inlet geometry have a huge effect on an impeller's performance. Individually, each can reduce the airflow by 15%, leading to a potential total drop in airflow of 40% in common applications.

To get a greater understanding of the factors affecting an impeller performance within such an application, Multi-Wing has initiated a series of tests to analyse them individually. The following discussions of these factors draw results from five separate reports conducted in-house at its test facilities in Vedbæk, Denmark.

**Effects of inlet geometry**

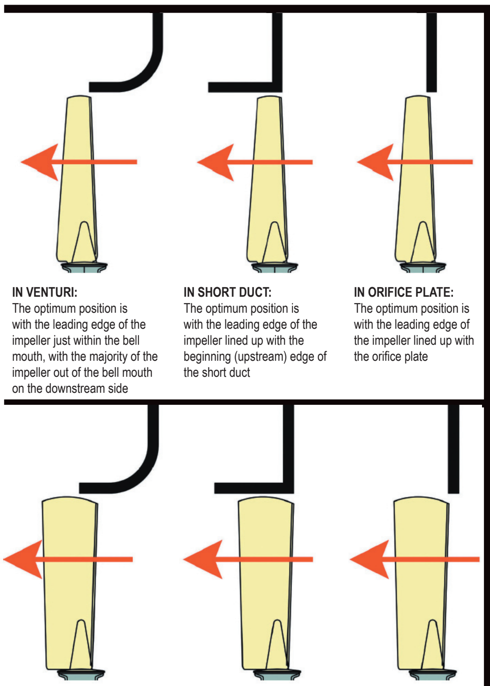
There are three commonly used inlet geometries, namely:

- Venturi, or inlet cone;
- Short, sharp-edged duct;
- Circular cut-out, or orifice plate.

The venturi is the most favourable with regard to performance, efficiency and noise. The best venturi can provide 20% more airflow while maintaining a noise level of 3-4 dB(A) below the other inlet geometries, particularly in applications where tigh tip clearances can be maintained. It is, however, the most expensive of the options to manufacture, and requires the most space. A venturi with a radius of 10% of the impeller diameter can effectively reduce the available area to house an impeller by 20%. The short, sharp-edged duct is the second most favourable option. It is less expensive to manufacture and requires less space than the venturi. Noise can be an issue, however, particularly when the air is drawn over the sharp edge. When manufacturing a short, sharp-edged duct, the inlet edge should be level with the mounting plate to ensure the air cannot travel

TABLE 1: Airflow differences for various tip clearances

| Tip clearance | Reduction of airflow of the blowing configuration over the sucking configuration |
|---|---|
| 0.5% | -4% |
| 1.0% | -5% |
| 1.5% | -10% |




FIGURES 1 & 2: Optimum placement for 4Z and 6Z impellers (top and above respectively) according to airflow direction and blade geometry

through more than 90°. There are, however, occasions when the turbulent flow produced in non-ideal conditions can result in a more even flow through the entire surface area of a radiator, resulting in better cooling.

In general, the orifice plate is the least favourable, but is far cheaper and requires the least amount of space. The unfavourable effects of this inlet geometrycan be drastically reduced by selecting blade geometries designed for these conditions like the 6 series (6H and 6Z) of Multi-Wing impellers.

**Tip clearances**

An impeller will always perform better when the gap between the blade tips and housing is as small as possible.Traditionally in engine-mounted applications, a large gap around the impeller was required in order to ensure the blades would never come into contact with the housing in which it sat. This is due to the difficulties in machining perfectly round housings and movement of the impeller in relation to its housing. The impeller was commonly mounted directly onto the engine which was mounted on vibration isolators, while the housing was mounted directly onto the chassis. However, because more and more cooling applications are now using electric or hydraulic motors to rotate the impellers, or have the housing rigidly mounted to the same body as the impeller, there is often no requirement for such conservative tip-clearances.

A tip clearance of 0.5% of the impeller's diameter (i.e. 5mm clearance on a 1,000mm impeller) is an optimum tip clearance. A tip clearance of 2% (20mm clearance on a 1,000mm impeller) can result in a reduction of over 10% of an impeller's airflow.

In the event that tight tip clearances cannot be maintained, selection of the most appropriate blade geometry can greatly reduce the negative effects of poor tip clearance.

**The correct blade geometry and location**

With the advent of advanced technology within the air-moving industry, such as 3D modelling, computational fluid dynamics, rapid prototyping and accurate performance measuring techniques, advanced impellers are being developed to suit specific requirements.

An airfoil impeller will provide greatest efficiency; a low-noise fan can achieve a reduction on noise by 3-4 db(A); and an impeller designed to run in poor conditions will greatly reduce the negative effects of those conditions.

It is important to consider the inlet geometry and tip clearances your system can maintain, and then knowing your system requirements, select the most appropriate blade geometry for your applications. To achieve this, Multi-Wing offers the Optimiser software, which takes into consideration the inlet geometries and tip clearances when making a selection. This will help to ensure that the most appropriate impeller is selected for any requirements.

The actual placement of an impeller within the inlet can also have an enormous effect on the system's cooling ability. Traditional rules of placing an impeller 1/3 within the housing and 2/3 out do not always hold true with modern impeller geometries and applications.

A series of recent tests performed within Multi-Wing's wind tunnel facilities have shown that the optimum impeller placement varies for airflow direction and impeller geometry. A summary of optimum placements for impellers in a pushing configuration can be seen in Figures 1 and 2. These tests found that tip clearances had little effect on the optimum impeller placement.

**Airflow direction**

Commonly referred to as pushing or pulling, or blowing and sucking, tests have shown that the sucking configuration is the optimum setup under laboratory conditions at constant temperature (Table 1).

What is not shown in this laboratory test is that the temperature of the air moving through the impeller in a sucking configuration will be higher due to the radiator raising the air temperature.

It is estimated that an increase in air temperature of 50°C from 25°C to 75°C will reduce the airflow by approximately 4%, negating any advantages of the sucking configuration.

**Conclusions**

The above discussion highlights the need for an understanding of the installation effects on an impeller's performance, as a poor choice in each of the above-mentioned criteria could result in a total reduction of 40% less airflow than optimum, as well as increases in noise and lowering of an impeller's stall point.

Understanding the engineering aspects of these factors, and being able to quantify them will enable a more efficient and desirable system to be developed for any application. Make use of the engineering expertise of your impeller supplier if you do not have the expertise within your organisation. Your local Multi-Wing distributor will be able to advise you of these factors and offer free tools such as the Multi-Wing Optimiser software to assist in your selections.

Copies of any of these reports can be made available by contacting your local Multi-Wing distributor or by requesting them from the Multi-Wing website at www.multi-wing.com. **iVT**

*Andrew Harrison is an application engineer at Multi-Wing International a.s.*