FROM COMPONENTS TO SYSTEM APPROACH OPTIMIZATION OF AIR-WATER HEAT PUMPS

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Abstract: Air-water heat pumps are currently the most frequently used heat pumps in Europe. This is due to the easy connection of the heat pump to its heat source “ambient air”. Complex drill holes or collector systems are not necessary. However, adverse effects are low efficiency and higher noise levels.
The presentation shows how the air flow within a heat pump can be optimized. The objective is to transport ambient air to the evaporator with as low energy demand as possible. This will be achieved by using air direction elements such as guide vanes or diffuser, which convert dynamic pressures into static pressures. These air direction elements have, however, one important disadvantage: They need space which is normally not given in heat pumps.
The new construction ZAplus will be demonstrated. It combines all the advantages with minimal needed space. The development of ZAplus is based on extensive CFD-calculations. For optimal implementation of the geometry, high-performance composite material is used. On the basis of different comparative measurements, impressive advantages in the field of efficiency and acoustics in comparison to conventional solutions will be shown.

Key Words: heat pump, efficiency, noise, fan, ZAplus, optimization, pressure

1 INTRODUCTION

Efficiency or COP of air source heat pumps depend of many factors, following we will focus on the air side and show remarkable improvements. The required air flow through the evaporator must be efficient as possible.

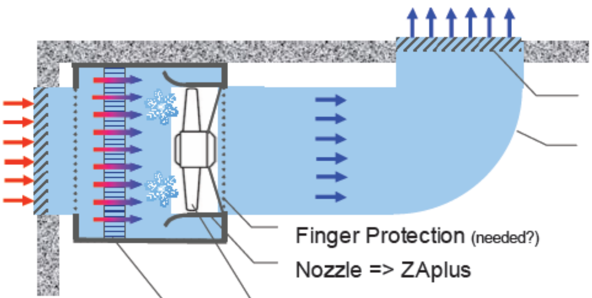


Figure 1: Air side of air source heat pump

Following basic formula for calculation the power demand of a fan indicate how to optimize the system.

$$P_{Fan} = q_v \times (p_{stat} + p_{dyn}) / \eta_{Fan} \quad (1)$$

P_{Fan} … power demand of fan
q_v … air volume flow
p_{stat} … static pressure drop
p_{dyn} … dynamic pressure drop
η_{Fan} … total efficiency of fan

To have a minimum in power demand, we have to achieve following points:

- High efficiency of fan
- Minimal air volume flow
- Minimal static pressure
- Minimal dynamic pressure

High efficiency of fan

The optimization of components, in this case of the fan, is a first approach to improve a heat pump. Notable improvements in efficiency and acoustics could be reached during the last years. However, one component is only one part in the entire system. Optimized fine-tuning of the individual components will be the next step.

Minimal air volume flow

The air flow volume determines the energy input on the heat pump and therefore has to be controlled properly. Speed controlled fans are used here. In heat pumps, EC motors have been used most commonly during the last years. Reasons for using EC fans are their high efficiency, even for reduced speed, as well as their integrated speed controller. The required airflow can be adjusted easily and efficiently to the needed heating performance.

Minimal static pressure

The airside pressure drop of a heat pump is mainly determined by the heat exchanger. It is to be noted that as a result of condensation and icing up of the heat exchanger an additional pressure drop can occur. This effect however can clearly be influenced by a better design of the heat exchanger. Due to less icing up and optimal defrosting methods, the seasonal performance factor can be improved. However, there is room for substantial improvements of air flow.
These and more improvements were shown in the study of Hochschule Luzern, see references.

In the following, an optimal nozzle/ housing for axial fans will be presented.

2 OPTIMIZATION OF AIR FLOW

Fans respond sensitively to interferences in inflow. That is why turbulences in front of the impeller are to be avoided. Especially turbulences in the working area of the impeller can lead to disruption in air performance, efficiency and acoustics. Air flow in axial fans can be divided into axial, centrifugal and circulating flow parts. There is a lot of useless dynamic that can be optimized.

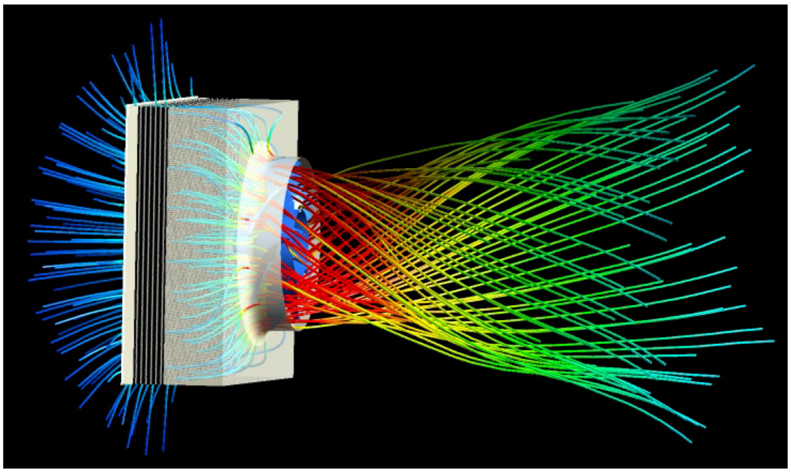


Figure 2: CFD - VISUALIZATION OF AIR FLOW

This situation has been known for a long time. Therefore different flow optimizing components are used.

Inflow nozzle
Inflow nozzles lead to an optimal turbulence-free airflow of the impeller. The geometry is basically dependent on the flow speed and the upstream suction chamber. As mentioned before, turbulences are to be avoided and a homogeneous air velocity over cross flow section of the heat exchanger is to be ensured.

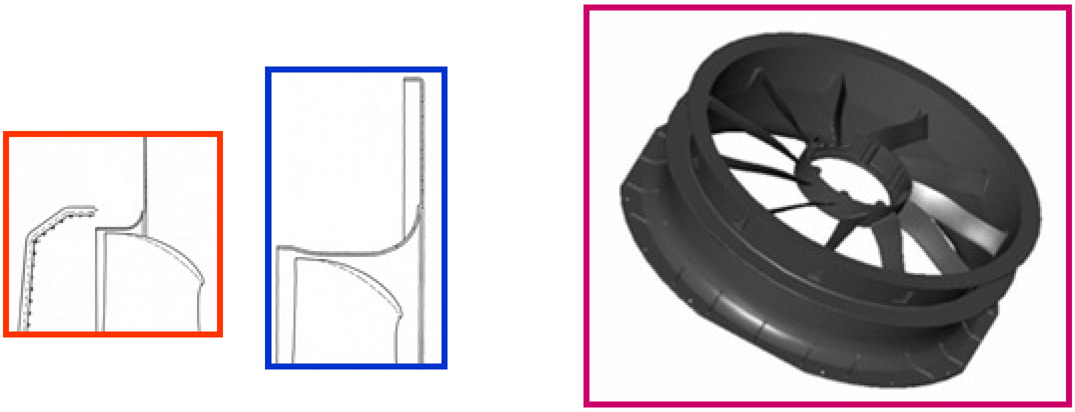
Guide vanes
Guide vanes guide circulating flow components. The objectives are on the one hand to achieve an optimal airflow of subsequent impellers (e.g. turbines) and on the other hand to reach an axial flow and a reduction of air velocity to change dynamic to static pressures. That is exactly the approach that ZAplus is using.

Diffusers
Diffusers expand the cross-sectional area and reduce the flow speed. Therefore the pressure is changed from dynamic to static pressure.

In the following, ZAplus will be presented.

3 ZAplus THE BEST WAY TO OPERATE AN AXIAL FAN

Traditionally short bell mouths are competitive parts of housings of a fan operated devices. Due to material and production processes the constructive possibilities are limited, so the aerodynamic performance is poor. Today state of the art is a full bell mouth, here the complete impeller is working inside the nozzle. This is on time and material basis more complex and more expensive. Both solutions need additional support for the fan. A finger protection is often included within the support.



short bell moth full bell mouth ZAplus

Figure 3: Nozzles for axial fans

ZAplus improves the air flow situation by a new CFD-based design of nozzle, diffuser and suspension as guide vane. The development focused on reaching best efficiency using minimal space. A combination of all described flow improving components must be used to be constructive. The construction is only possible when using high performance composite material. In addition to effective degrees of freedom in design, the material offers high chemical resistance and a reduction in weight. In the following, the airflow improvements will be presented.

4 BENEFITS OF ZAplus

Based on comparisons carried out with the ZIEHL-ABEGG selection program FANselect (www.fanselect.info), we will show the improvement by using ZAplus against a “poor” short bell mouth and a “state of the art” full bell mouth. All these data were determined on measurements made in our R&D-center InVent, where the largest combined air performance and sound test rig for fans is located. The characteristic air performance curves are measured in compliance with DIN EN ISO 5801 and AMCA 210-99 with free intake and free blow out (installation type A). The measurements are TÜV and AMCA certified.
The following diagrams include first the complete performance of a FE2owlet axial fan size 500 mm with ECblue drive size EC116 on 1440 rpm. Here the pure aerodynamic improvement over the complete operation area was visualized. Additionally the real comparable improvement by going to the duty point of 6.000 m³/h air volume flow and a static pressure drop of 100 Pa were presented. This duty point is shown as a star in the following diagram. Here the fan is running in different speeds, depending on the built-in situation, short bell mouth, full bell mouth and the ZAplus system. First shown on European Heat Pump Summit 2013.

Improve air power

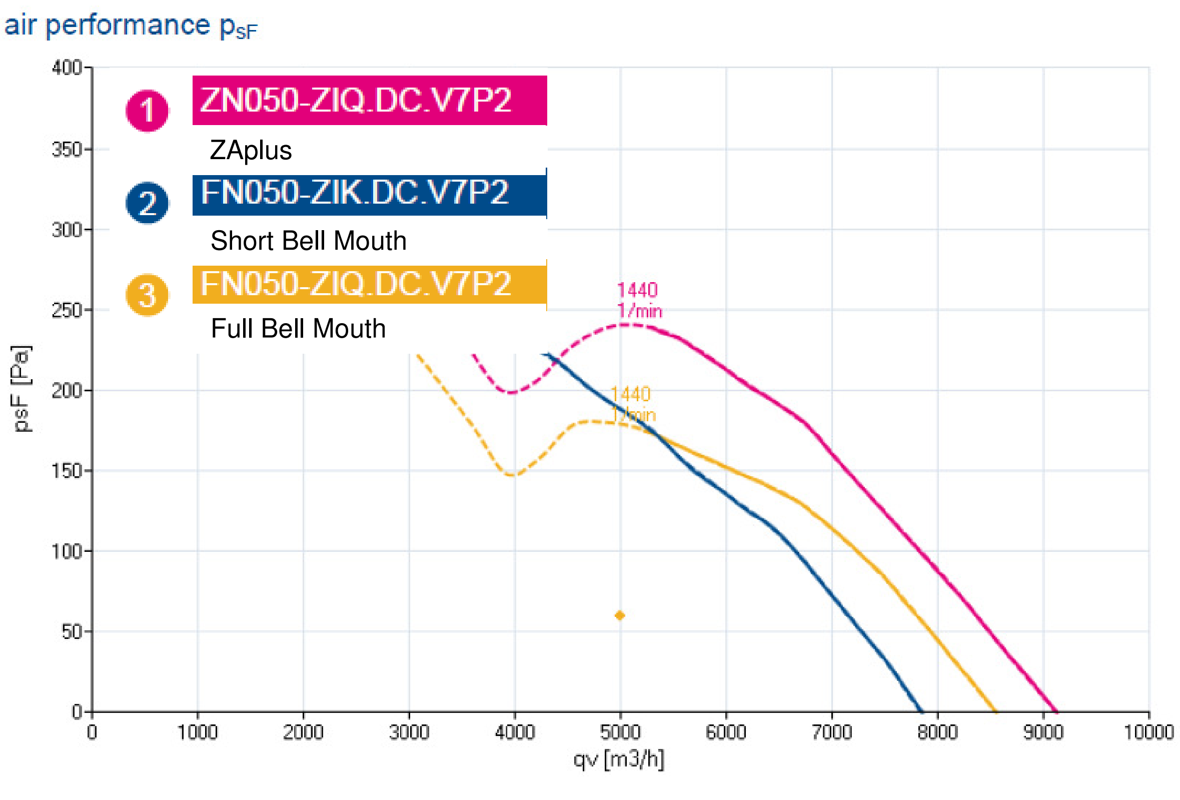


Figure 4: ZAplus improve air flow

Over the complete operating range the airflow is improved. The improvement depends on the originally used system and on the duty point. Higher pressure leads to more circulating flow components. In customer measurements, we often found more than 10% of more air flow. This improvement can be used to downscale the device or to increase the heating power. But in addition to the airflow, ZAplus also offers a higher pressure reserve, which is necessary for safe operation. That is important for icing conditions or when the heat pump is located inside a house and a ducting is required.

Improving efficiency

ZAplus change useless dynamic pressure into required static pressure. In doing so, the fan is unloaded and the efficiency will rise. Coming from a short bell mouth the power demand of the duty point in ZAplus is 215 W less, which is a reduction by 34%. The reduction compared with a full bell mouth is -142 W or 25%. That massive improvement makes inefficient fans with AC-motors compliant to ErP2015 (European directive for minimum efficiency of fans).

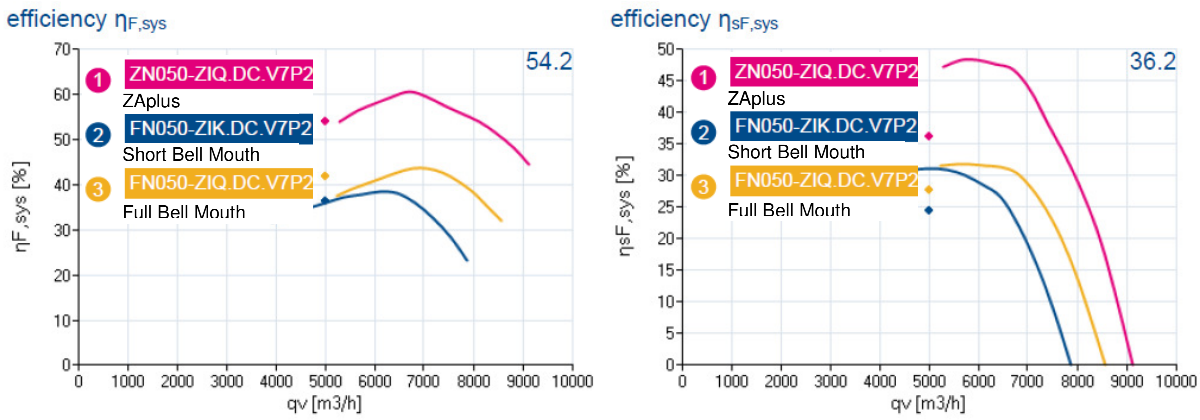


Figure 5: ZAplus improve efficiency

Improve sound power

Easily spoken, reducing air velocity means reducing turbulences which will decrease the sound power of the heat pump. Although ZAplus offers more airflow it is at the same times more silent than using a full bell mouth and even using a short bell mouth. In ZAplus and equal duty point we measured a reduction of 6 dB(A) coming from a short bell mouth and 4 dB(A) compared to the full bell mouth.

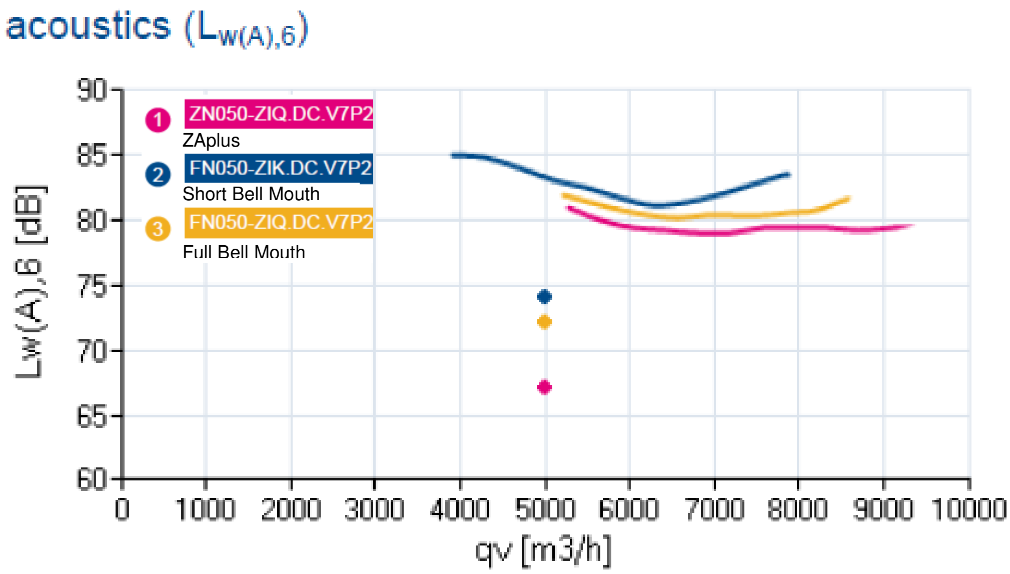


Figure 6: ZAplus reduce sound power

5 CONCLUSION

Air source heat pumps can be easily improved by using modern innovative fan systems like ZAplus. The optimization can be used to get more heating capacity or to reduce power demand and therefore increase the COP of the heat pump. Additionally a noise reduction will occur.

6 REFERENCES

Lukas Gasser, dipl. Ing. FH, Ivan Wyssen, BSc Maschinentechnik, Maik Albert, dipl. Ing. FH, Marc Häusermann, BSc Maschinentechnik, Mirko Kleingries, Dr.-Ing., Beat Wellig, Prof. Dr. sc. techn. ETH Hochschule Luzern HSLU T&A, December 2011, „Effiziente Luft/Wasserwärmepumpen durch kontinuierliche Leistungsregelung“

Lukas Gasser, dipl. Ing. FH, Beat Wellig, Prof., Dr. sc. Techn. ETH Hochschule Luzern, „Effiziente Heizsysteme mit leistungsgeregelten Luft/Wasserwärmepumpen“, 18. Tagung des BFE-Forschungsprogramms «Wärmepumpen und Kälte» 27. Juni 2012, HTI Burgdorf

Joachim Dietle Dipl.Ing.(FH) Ziehl-Abegg SE, „From components to system approach Optimization of air-water heat pumps“, European Heat Pump Summit 2013

ZIEHL-ABEGG product documentation ZAplus www.ziehl-abegg.com

ZIEHL-ABEGG selection program FANselect www.fanselect.info