THE VELOCITY DISTRIBUTION AROUND CHICKEN CARCASSES

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SUMMARY

The work presented here concerns airflow patterns around chickencarcasses. It contains experimental work done in a windtunnel. The first section after the introduction is a short introduction in fluid mechanics and heat and masstransfer. These are followed by a description of methods used in the experiment and a discussion of (some of) the results. Finally the conclusions and ideas for future research are discussed.

Introduction.

The research efforts at Stork Bronswerk B.V. are aimed at fully understanding and quantifying the processes involved in the cooling of carcasses. This work includes airflow patterns in cooling tunnels, heat and masstransfer from carcasses and heat and masstransfer inside carcasses. Up to this stage all of the work was experimental but, due to increasingly powerful and available hard and software, at present efforts are being made to do part of the work numerically. The results from the experiments presented here will be used in engineering and to validate the numerical calculations.

Fluid flow, heat- and masstransfer.

The relation between fluid motion and heattransfer is something all of us will have experienced on a windy day. This effect is due to the influence of the flow on the boundarylayer. The boundarylayer is a thin layer of slow moving fluid near the wall of an object in a flow. The boundarylayer presents a barrier for heat- and masstransfer. This can easily be understood when we consider that heat- and masstransfer very near the wall depends entirely on diffusion. When the distance from the wall increases the contribution of (turbulent) convective transport increases until all the (large scale) transport is due to (turbulent) convection.

Analyses of the Navier-Stokes, energy and concentration equations yield the parameters governing the transportprocesses. It is beyond the scope of this paper to go into these analyses in detail, therefore only the most important parameters and their physical interpretation will be discussed shortly.

- The Reynolds number ($Re=V*d/\upsilon$) is the ratio between convective and viscous forces. For a given geometry the Re-number characterizes the flow regime.
- The Nusselt number ($Nu=\alpha*d/\lambda$) is the dimensionless heattransfercoefficient.
- The Prandtl number ($Pr=a/\upsilon$) is the ratio between the diffusion of momentum and heat, this parameter brings into account the properties of the fluid with regard to heattransfer.

These three parameters describe the heattransferprocess, from dimensional analysis we conclude:

Nu=F(Re,Pr)

Analogous reasoning will yield the following expression for masstransfer:

Sh=F(Re,Sc)

Sh stands for the Sherwood number and Sc for the Schmidt number. Because of the analogy between heat- and masstransfer the same relations can be used for a given geometry substituting Sh and Sc for Nu and Pr respectively.

Methods.

The experiments were performed in a windtunnel which was specially build for this experiment. It has open measuringsection of 800x800 mm cross section, air velocities between 0 and 2.5 m/s can be selected. Fig. 1 (Schouten and Groen 1993) shows a part of the windtunnel, with the measuring section, the anemometers and their supports. The arrow denotes the flow direction. In the measuring section plaster carcassmodels of chickens were positioned to investigate the airflow patterns.

Both qualitative and quantitative measurements of the flow patterns were made. The qualitative measurements were made using smoketubes which release a small stream of smoke. This smokestream is ideal for flow visualization. The visualized flowpatterns were recorded by drawings and photographs.

The quantitative measurements were made with TNO-IG thermal anemometers. The probe operates by means of two equally sized spheres (approx. 4 mm diameter) of which one is electrically heated. The temperature difference between spheres depends on the heatloss of the heated sphere only and is measured by thermocopples. The heatloss is linked with the flow velocity: Nu=F(Re,Pr). Hence after calibration the temperature difference is a measure for the air velocity.

Combining both flow visualization and velocity measurements a good insight in the relevant features of the flow is obtained.

Investigated cases.

A total of 10 different flow situations were investigated with velocities ranging from 0.5 to 2 m/s. In 6 cases a single carcass model was positioned in the airflow, in 4 cases 2 or 3 carcass models were used. Fig. 2 (Schouten and Groen 1993) shows the positions of the carcassmodels relative to the flow direction. The positions B1-1, B1-2 and B1-3 are referred to as 'crossflow', '45°' and 'parallelflow' respectively. The single model was positioned as the second (middle) model shown in fig. 3, B1-1,2,3 and was investigated with and without the suspension hook.

Results.

During the experiments a large amount of data was generated because of the many different flow situations investigated. To restrict the total amount of information presented here a selection of the available data has been made and grouped into three cases.

In the figures the velocities are given on the symmetry-axis of the carcass. To prevent loss of data the positions of the velocitymeasurements at the carcass follow the contour of the carcass, the values thus taken are underlined. The direction of the main flow is from left to right in all cases.

1: The influence of the suspension hook.

To investigate the influence of the suspensionhook a single carcass in the B1-3 parallelflow position is investigated. Measurementdata of the flow is shown in fig 3 and 4. The suspension-hook, trolley and T-iron cause a large amount of disturbance and turbulence. The velocitymeasurements show a decrease in average velocity of more then 50% upstream of the carcass (1.8 to 0.8 m/s). This means that the cooling effect of the airstream is reduced significantly. The flow inside the cavity will also reduce causing an extra loss of heattransfer.

2: The influence of the flowdirection.

The influence of the flowdirection is investigated for a single carcass with the suspensionhook. The measurementdata is presented in fig. 3 and 5. In the 45° position the suspensionhook accelerates that part of the upstream velocityfield which collides with the carcass. Due to the fact that velocity larger than 2.5 m/s could not be measured the exact magnitude could not be established, but in the vicinity of the cavity-opening velocities of around 2.3 m/s were measured. This acceleration will have a positive effect on the heattransfer.

3: The influence of neighbouring carcasses.

The influence of neighbouring carcasses on the flow was investigated in cross, 45 ° and parallelflow position. The data in fig. 6 shows the velocities for the crossflow situation. As expected a large reduction in velocity is observed in the crossflow position. The upstream velocity of 2.1 m/s is reduced to 0.8 m/s after the first carcass and to 0.5 m/s after the second carcass. No further reduction in velocity occurs after the second carcass.

In fig. 7 the measurementdata for the 45 ° situation can be seen. In the vicinity of the suspensionhook the velocities are accelerated in the same manner as in the single carcass situation. The wake area of the upstream carcass causes a reduced velocity at the chest of the second carcass.

The data in fig. 8 shows the airflowpattern in the parallelflow case. Due to the reduced crossection area for the flow to pass the velocity between the carcasses increases.

Conclusions.

The presence of obstructions in the flow, such as the T-iron, trolley and suspensionhook, have a significant influence on the flowpatterns-and velocities. This effect can be a reduced velocity (parallelflow) or an increased velocity (45°).

The results from multiple carcass disposition are as expected: reducing velocities after the first and second carcass for the crossflow position and an increase in velocity between the carcasses for the position.

Future work.

Regarding this investigation the future work will be modelling a chickencarcass to calculate the airflow patterns and heattransfer with the numerical computercode PHOENICS.

Regarding the research the future work will be exporting the results from this work as boundary conditions to the BERTEM computer code from TNO-IMET. The BERTEM code is especially designed to calculate heat and moistertransfer (both vapour and liquid) in carcasses. With the BERTEM code the transient solution of the cooling process of a carcass can be calculated accurately.

The next phase will be the extension of this technique to other products and the calculation of airflow patterns in coolingtunnels using numerical techniques.

References.

Schouten M.J., Groen S., (1993) Vorminvloeden op Luchtsnelheden rondom Slachtkuikens. Bachelor Thesis, Hogeschool Utrecht.

Captions.

Fig. 1 and 2: The measuring section of the windtunnel. Carcass positions in the windtunnel, flow direction from left to right.

Fig. 3 and 4: Velocity measurements parallelflow, with and without the suspensionhook. Velocity in cm/s, flowdirection from left to right.

Fig. 5 and 6: Velocitymeasurments single and multiple carcass. Velocity in cm/s, flowdirection from left to right.

fig. 7 and 8: Velocity measurements multiple carcasses. Velocity in cm/s, flowdirection from left to right.