07 - 10 September 2009

PROCEEDINGS

# 54. IWK

Internationales Wissenschaftliches Kolloquium

International Scientific Colloquium

# Information Technology and Electrical Engineering - Devices and Systems, Materials and Technologies for the Future

Faculty of Electrical Engineering and Information Technology

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=14089

TECHNISCHE UNIVERSITÄT
ILMENAU

**Impressum**

Herausgeber: Der Rektor der Technischen Universität Ilmenau
Univ.-Prof. Dr. rer. nat. habil. Dr. h. c. Prof. h. c.
Peter Scharff

Redaktion: Referat Marketing
Andrea Schneider

Fakultät für Elektrotechnik und Informationstechnik
Univ.-Prof. Dr.-Ing. Frank Berger

Redaktionsschluss: 17. August 2009

Technische Realisierung (USB-Flash-Ausgabe):
Institut für Medientechnik an der TU Ilmenau
Dipl.-Ing. Christian Weigel
Dipl.-Ing. Helge Drumm

Technische Realisierung (Online-Ausgabe):
Universitätsbibliothek Ilmenau
ilmedia
Postfach 10 05 65
98684 Ilmenau

Verlag: isle
Verlag ISLE, Betriebsstätte des ISLE e.V.
Werner-von-Siemens-Str. 16
98693 Ilmenau



ISBN (USB-Flash-Ausgabe): 978-3-938843-45-1
ISBN (Druckausgabe der Kurzfassungen): 978-3-938843-44-4

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=14089

# DEVELOPMENT OF AN AIR-AIR-HEAT EXCHANGER FOR LACQUER DRYING FURNACES

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## ABSTRACT

In this paper we show results of numerical simulation and experimental studies concerning the deposition of a lacquer mixture on the surfaces of an air-to-air heat exchanger. Upon hydro dynamically increasing the shear stress at the surfaces, the resulting shear forces increase, raising the rate of mass removed from the already deposited layer of lacquer particles. This leads to the reduction of the overall deposition rate. We discuss how the surface shear stress can be maximizes and present a new experimental method to demonstrate the effectiveness of this hydrodynamic measure.

***Index Terms*** **–** Heat Exchanger, lacquer drying furnaces, deposition, rate of deposition and removal, deposit growth

## 1. INTRODUCTION

The rate of deposit growth $dm/dt$ of a particle layer at a surface is given by the difference between the rate of deposition $\phi_D$ and the rate of removal $\phi_R$, i.e.

$$\frac{dm}{dt} = \phi_D - \phi_R \, .$$

The rate of removal depends on the already deposited mass and the removal rate parameter $E$ :

$$\phi_R = E \cdot m_d \, .$$

The parameter $E$ itself depends on the viscosity of the streaming fluid $\mu_f$, the shear stress $\tau$ acting on the heat exchange surface, and the so-called turbulent burst coefficient $\alpha$ :

$$E = -\frac{\ln\left(1 - \frac{\alpha}{270}\right)}{75 \cdot \mu_f} \cdot \tau \, .$$

While the fluid viscosity is a purely thermo-physical parameter, the turbulent burst coefficient is a heat exchanger specific value which is experimentally determined. The simplest way to minimize the rate of deposit growth is to raise the shear stress at the surface.

This can easily be realized by using structured surfaces instead of smooth flat sheets and by means of increase the flow velocity

## 2. NUMERICAL SIMULATION

Using the CFD program FLUENT different geometries (Figure 1) will be examined by comparing the resulting shear stress under the side condition that the hydraulic pressure loss does not increase drastically. Also the turbulent intensity of the flow should not increase so that particles can be carried from the turbulent flow through the laminar sub-layer to the heat exchange surface.
The results show that the geometry HKV, consisting of staggered semicircles, produces a maximum of shear stress, an acceptable pressure drop, and a relatively low production of turbulence.

## 3. EXPERIMENTS

To examine experimentally the effect of the increase of the flow velocity on the surface shear stress we use the test plant shown in figure 2. We vary the Reynolds number to cover both the laminar and the turbulent fluid-flow range. Figure 3 shows that the increase of the velocity increases the shear stress. As a result, the overall dimensionless rate of deposit growth decreases.

Unfortunately, the proposed method of increasing the Reynolds number shows two short-comings. First, a higher pressure is required to push the fluid through the heat exchanger. Secondly, the higher velocity results in a higher noise level. In application, stronger fans and an effective s that could be noise isolation must be installed.

The authors would like to acknowledge financial support by the Deutsche Bundesstiftung Umwelt DBU and technical support by Eliog Kelvitherm, Roemhild, Germany

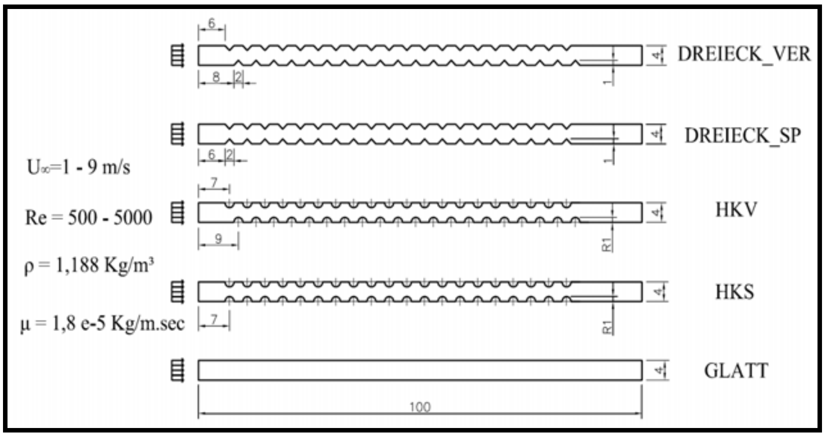

Figure 1: Structure surfaces examined during the simulations

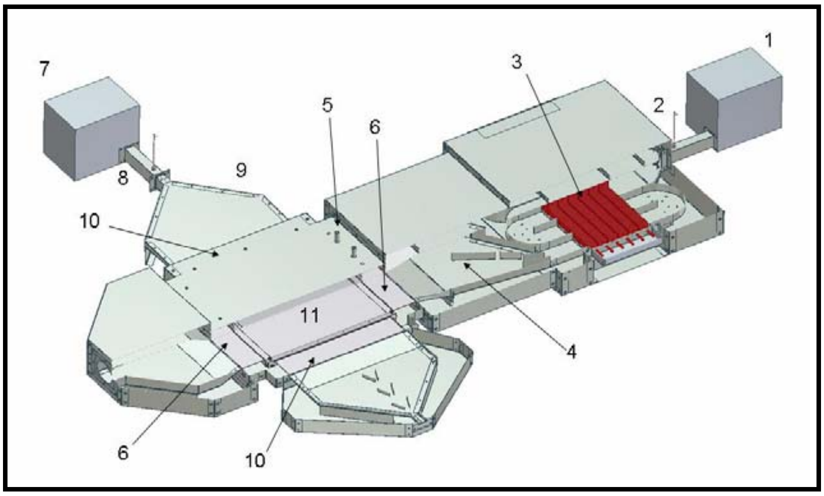
Figure 2: Test plant - 1 Hot air fan, 2 Prandtl tube (hot side), 3 Heating segment, 4 Hot air channel, 5 Paint and solvent injection channel, 6 Hot air supply and removal channels, 7. Cold air fan, 8 Prandtl tube (cold side), 9 Cold air channel, 10 Cold air supply and removal channels, 11 Test sector

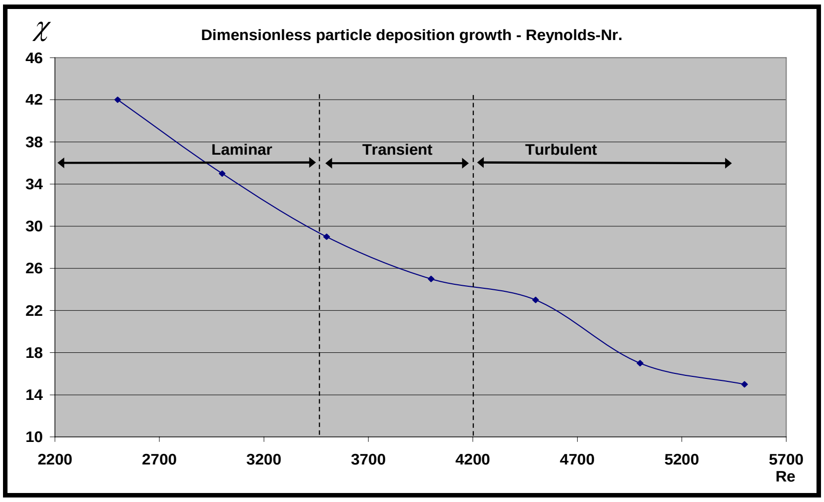

Figure 3: The change the dimensionless rate of deposit growth along the change of Reynolds number

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