Ain Shams University
Faculty of Engineering
Mechanical Power Department

# Effect of an Impinging Jet on Horizontal Cylinder Cooling

A thesis submitted in fulfillment of the requirements for the degree of

MASTER OF SCIENCE
In
MECHANICAL ENGINEERING

By

**Eng. Ahmed Sayed Saber Sayed Mohamed**

B.Sc. Mechanical Engineering
Ain Shams University, 2010

Supervised by:

**Prof. Dr. Mahmoud Mohamed Abo El-Nasr**
Professor in the Mechanical Power Eng. Dept.
Faculty of Engineering - Ain Shams University

**Dr. Mahmoud Mohamed Kamal**
Associate Professor in the Mechanical Power Eng. Dept.
Faculty of Engineering - Ain Shams University

**Dr. Hamdy Ahmed Abotaleb**
Doctor in the Mechanical Power Eng. Dept.
Faculty of Engineering - Ain Shams University

Cairo, 2014

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

# Effect of an Impinging Jet on Horizontal Cylinder Cooling

By

**Ahmed Sayed Saber Sayed Mohamed**
B.Sc. Mechanical Engineering
Ain Shams University, 2010

**EXAMINERS COMMITTEE**

| **Name** | **Signature** |
|---|---|
| Prof. Dr. Mahmoud Abdel Fattah Elkady | …………………. |
| Prof. Dr. Adel Abdelmalek Alahwany | …………………. |
| Prof. Dr. Mahmoud Mohamed Abo El-Nasr | …………………. |
| Dr. Mahmoud Mohamed Kamal | …………………. |

Date: …. /...…/……

# STATEMENT

This thesis is submitted in the partial fulfillment of masters degree in Mechanical Engineering, Mechanical Power Engineering Major, Faculty of Engineering, Ain-Shams University.

The author carried out the work included in this thesis, and no part of this thesis has been submitted for a degree or qualification at any other university or institution.

Signature

Ahmed Sayed Saber Sayed Mohamed

# Researcher Data

| | |
|---|---|
| **Name of Researcher** | Ahmed Sayed Saber Sayed Mohamed |
| **Date of Birth** | January, 9th, 1989 |
| **Place of Birth** | Cairo, Egypt |
| **First University Degree** | B.Sc in Mechanical Engineering |
| **Department** | Mechanical Power Department |
| **University** | Ain Shams University |
| **Date of Degree** | June 2010 |
| **Current Job** | Teaching Assistant at the Mechanical Power Department |

# Acknowledgement

First of all, I am so grateful to Allah for giving me the guidance, strength, patience, and hope to finish my research. It is the mercy of God, and my trust in him that have made such a dream to become a reality.

I give many thanks for my advisor, **Prof. Mahmoud Mohamed Abo El-Nasr** for his advices along the research period, and for facilitating the work in our faculty.

I would like to thank my advisor, **Dr. Mahmoud Mohamed Kamal** for his valuable comments and advices throughout the research.

I wish to express my deep gratitude to my advisor, **Dr. Hamdy Ahmed Abotaleb,** for his inspiring guidance, valuable advice, and encouragement throughout the progress of this research. His suggestions, criticism, and patience have been great assets.

I express sincere thanks for **my family** for providing insightful opinions and recommendations as well as for their positive attitude, coaching, and encouragements that tremendously facilitate the progress of this work.

I would like to express my gratitude to **AVL Company** for supporting and providing me with the license and the technical support of the AVL-Fire package for the research purposes.

Finally, I would like to express my thanks to **my faculty** for their financial support and for the facilities that I used in my lab.

# Abstract

Investigating the quenching phenomena has an important impact on many applications such as steel hardening and cooling in nuclear power plants. Few studies investigated the usage of liquid slot jets. Experimental and numerical investigations have been conducted on the effect of quenching of hot horizontal stainless-steel cylinders by sub-cooled liquid slot jets. The temperatures, the cooling rates, heat flux, and the behavior of the maximum heat flux point have been experimentally investigated for changing different parameters, such as the cylinder initial temperature (between 400 and 600°C), the coolant temperature (with degrees of sub-cooling between 20 and 60°C), the coolant velocity (between 1.0 and 1.5 m/s), and the coolant type (including fresh water, and saline water 1%). The coolant was impinged from a slot of 1.3 mm width that covered the whole length of the cylinder. The slot was 5 cm above the cylinder in the vertical direction, so as to be parallel to the cylinder axis. A previous numerical model for circular jets using AVL-FIRE software was modified and validated for the slot jets as well.

The results of the present investigation indicate, for both the fresh water and saline water 1%, that increasing the initial temperature of the specimen caused the temperature at which the film boiling ended, the maximum rate of temperature decrease, and consequently the point of maximum heat flux to lag and increase in value. However, increasing the degree of sub-cooling led them to come earlier and with higher values, and increased the cooling rates. The jet velocity within the range under study had slight effect on the cooling curves. Using saline water 1% enhanced the cooling rates for the selected ranges. Up on going deep from the surface, more homogeneity in temperatures and slower cooling rates were achieved. The numerical model showed good agreement with the experimental values in most of the trials.

**Key Words:** Slot impinging Jet; cylinder quenching; liquid coolants; Steel heat treatment; quenchant type.

# TABLE OF CONTENTS