Progress of NIM's Smoke Stack Simulator and Field Measurement in Power Plants

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Need for Stack Gas Flowrate Measurement

- Industry plant efficiency test
- Air pollution emission monitoring
  - Chinese Environmental Protection Agency has clear demand for accurate flue gas flowrate measurement
- Carbon trading
  - In 2013, China has carried out pilot carbon trading in 7 provinces, and extended to the national carbon trading market in 2017
  - In 2013 NDRC issued first 10 industry sectors greenhouse gas emission accounting methods and reporting guidelines
Measurement and Calibration Scheme

- Industry plant efficiency test
  - S type pitot tube point by point measurement
  - Wind tunnel calibration at 0 pitch and 0 yaw angle

- Air pollution emission monitoring
  - On site velocity comparison using S type pitot tube.
  - Wind tunnel calibration at 0 pitch and 0 yaw angle

- Carbon trading
  - Fuel based calculation method
Overall Research Plan

- **Stack flowrate calibration**
  - Build calibration facilities to calibrate standard 3D pitot tubes in different flow conditions
  - Study the pitot tube integration method
  - Field calibration system

- **Stack ultrasonic flowmeter calibration**
  - Dry calibration
  - Real flow velocity calibration

- **Field tests**
01 Background

02 Smokestack Simulator of NIM China

03 Field Calibration System

04 Field Tests

05 Future Works
Smoke Stack Simulator of NIM

- Multi-Path USM
- Swirl and Turbulent Generator
- Expansion Turning Section
- Reference Section DN 800
- Wind Tunnel
- LDA Standard
- Working Standard

- Pitot Tube Transverse
- Axial Fan
- Test Section DN 1000, DN700, 0.7m*1m
Smoke Stack Simulator of NIM
- Velocity range of wind tunnel: 0.5~70 m/s
- Turbulence intensity: 0.75% @ 50 m/s
NIM’s Dual LDA Flowrate Standard

Standard Flowmeters
Nozzle and Turbine Flowmeters

Dual LDA Test Windows
(Downstream of Contraction)

Vacuum Pump
NIM’s Dual LDA Flowrate Standard

Dual LDA Test Windows (Downstream of Contraction)

Inlet

Nozzle Standard Flowmeter
NIM’s Dual LDA Flowrate Standard

- Boundary layer LDV
Reference Section & Wind Tunnel

- LDV primary standard of SMSS
Reference Section & Wind Tunnel

- LDV seeding
Reference Section & Wind Tunnel

- **Wind tunnel**
  - LDV Windows
  - Pitot Head Position Remains Unchanged
  - Yaw Angle
  - Pitch Angle
  - Pitot Tube Insert Slot
  - Automatic Calibration System

- PIV
Reference Section & Wind Tunnel

- 8-path USM working standard
Reference Section & Wind Tunnel

- USM lost signal
- Electromagnetic interference
Test Section

- Pitot Tube Automatic Transverse System
- USM Under Test
- Swirl Generator
- Frequency Conversion Fan
Test Section

- Contraction section and swirl generator
Test Section

- USM under test
  - Circular: 8-path (OWICS) + dual cross diametric path
  - Rectangular: 8-path (OWIRS) + dual cross diametric path
Test Section

- USM under test
Test Section

- Pitot tube automatic transverse system
Test Section

- Pitot tube automatic transverse system
Test Section

- Fans
Test Data

- Flow stability

![Graph showing flow stability over time](image)
## Test Data

### LDV calibrate USM

<table>
<thead>
<tr>
<th>Set flowrate (m³/h)</th>
<th>750</th>
<th>1700</th>
<th>3500</th>
<th>8500</th>
<th>17000</th>
<th>32000</th>
<th>50000</th>
<th>80000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity in the Center of the pipe (m/s)</td>
<td>0.5</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>LDV flowrate (Nm³/h)</td>
<td>755.467</td>
<td>1684.68</td>
<td>3494.48</td>
<td>8496.88</td>
<td>17375.7</td>
<td>32617.2</td>
<td>50932.2</td>
<td>84476.6</td>
</tr>
<tr>
<td>USM flowrate (Nm³/h)</td>
<td>745.971</td>
<td>1681.39</td>
<td>3517.49</td>
<td>8588.96</td>
<td>17542.3</td>
<td>32830.1</td>
<td>51358.4</td>
<td>84381.5</td>
</tr>
<tr>
<td>Indication error</td>
<td><strong>1.26%</strong></td>
<td><strong>0.19%</strong></td>
<td><strong>-0.66%</strong></td>
<td><strong>-1.08%</strong></td>
<td><strong>-0.96%</strong></td>
<td><strong>-0.65%</strong></td>
<td><strong>-0.84%</strong></td>
<td><strong>0.11%</strong></td>
</tr>
</tbody>
</table>
01. Background

02. Smokestack Simulator of NIM China

03. Field Calibration System

04. Field Tests

05. Future Works
Field Calibration System

- Standard 3D Pitot Tube
- Automatic positioning system
- Traceable
- Stack
- Flowmeter Under Test
- Flow
- Geometric Calibration
- Wind Tunnel
- Flow
Field Calibration System

- Geometric calibration device

1st Generation

2nd Generation

80mm
Field Calibration System

- Geometric calibration device

2nd Generation
Field Calibration System

- Automatic pitot tube positioning system
Field Tests

- Pitot tubes calibration in NIST wind tunnel
Field Tests

- Natural gas power plant

Install 6-Path Ultrasonic Flowmeter

Pitot Tube Test Platform
Field Tests

- Natural gas power plant
Field Tests

- Coal-fired power plant

Install 6-Path Ultrasonic Flowmeter

Pitot Tube Test Platform

Flow
Field Tests
Field Tests
Field Tests
Field Tests

- Coal-fired power plant – 3D laser scanner
Field Tests

- Coal-fired power plant – 3D laser scanner
Field Tests

- Coal-fired power plant – 3D laser scanner
Field Tests

- Coal-fired power plant – Flowrate Measurement

Graph: USM Path 1

Flowrate [m/s]

- 0
- 2
- 4
- 6
- 8
- 10
- 12
- 14

dates:
- 2016/11/7 9:36
- 2016/11/7 12:00
- 2016/11/7 14:24
Field Tests

- Coal-fired power plant – Flowrate Measurement

**USM Path 1**

- Flowrate [m/s]

- Graph shows variations in flowrate over time (1 to 57).

- USM Path 1 denotes the data series.
Field Tests

Coal-fired power plant – Flowrate Measurement by pitot tube @ 10Hz
Field Tests

- Coal-fired power plant – Flowrate Measurement

Differential Pressure 1-2

Differential Pressure [Pa]

2016/11/7 16:33

2016/11/7 16:36

P1-2
Field Tests

- Coal-fired power plant – Flowrate Measurement

![Graph of Differential Pressure 1-2](graph.png)
Background

Smokestack Simulator of NIM China

Field Calibration System

Field Tests

Future Works
Future Work

- Close loop wind tunnel which can change the gas composition (simulated flue gas) and temperature.
Future Work

- Dry calibration facility for flue gas USM
Future Work

- Other industry sectors (test 30 sites in 3 years)
  - Cement production
  - Glass production
  - Ceramic production
  - Chemical production
  - Non-ferrous metal production
  - Iron and steel production
Thank you for your attention

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