Buried Pipe Detection Technology and In-pipe Traveling Robot Technology

September 17, 2014

Y. Higuchi, M. Tsunasaki, M. Yamagami
Osaka Gas Co., Ltd.

M. Konno, R. Sato
Tokyo Gas Co., Ltd.
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- In-pipe Traveling Robot Technology
  : Active Scope Camera for in-pipe delivery inspection
- Conclusion including Future Issues

Gyro Locator

Active Scope Camera
Technology Search - Two Promising Technologies

Five Needs for Gas Piping Safety

- Leakage detection
- In-pipe robot
- Location detection
- Tough pipe material
- Monitoring systems

In-pipe Traveling Robot

- UAV / Airship
- Infrared camera
- In-pipe camera
- Gas leakage
- Monitoring center

MEMS Gyroscope by JGA (2008 - 2010)

- GPS
- Vibration sensor
- Fiber optics

Drain pipe

- Gyroscopic Sensor
- New pipe material
- Vibration sensing by Fiber

Gas pipe

Image observation of methane gas

In-pipe robot

- Wheeled in-pipe robot
- DTG gyro sensor
- MEMS gyro sensor
- stainless steel inserted pipe

In-pipe Traveling Robot

- MEMS Gyroscope

DTG gyro sensor

Vibration sensing by Fiber

Technology Search - Two Promising Technologies

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In-pipe Traveling Robot

- MEMS Gyroscope
Gyroscope Technology - MEMS Gyro Sensor

Configurations of Gyro Sensor

Guide zig
Sensor pig

Φ = 40 mm

(Purpose)

Three-dimensional Pipeline Measurement

(Principle)

Gyro sensor carries through the pipeline, and gets the trace data.

(Measurement Items)

Gyro: Three axes
Acceleration: Three axes
Length: Encoder (ext.)

(Dimensions)

Diameter 40 mm × 61 mm

(Quality)

Prototype

(Application)

Construction field
# Gyro-Locator - Development

## Improvements

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Details</th>
</tr>
</thead>
</table>
| Gyro Sensor            | Rotation Speed: From 300 to 900 degrees/sec  
                        | Sensor Board: Compact in size 14 × 30 mm                              |
| Insertion & Collection | Adopting “Delivery Device” made of coiled metal wire                   |
| Software               | Adopting a formula that calculates Attitude Angles                     |

## Configurations of Gyro-Locator

- Gyro Sensor
- Rotary encoder
- Operation unit
- Operation soft
- “Delivery Device”
Gyro-Locator - Test Assessment

### Simulation Pipes

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Length</td>
<td>4 m (13 feet)</td>
</tr>
<tr>
<td>Bend Pipe</td>
<td>Eight curves</td>
</tr>
<tr>
<td>Diameter (2)</td>
<td>1 inch &amp; 1·1/4 inch</td>
</tr>
<tr>
<td>Shapes (5)</td>
<td>Five different patterns</td>
</tr>
</tbody>
</table>

\[ \Phi = 25 \, \text{A} / 32 \, \text{A} \]

\[ L = 4 \, \text{m} \]

### Assessment

<table>
<thead>
<tr>
<th>Number of Tests</th>
<th>[ 2 \times 5 \times 3 \text{ times} = 30 \text{ tests} ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-dimensional Measurement</td>
<td>All tests passed within a 10-cm (4-inch) margin of error.</td>
</tr>
</tbody>
</table>
Conclusion - Buried Pipe Detection Technology

MEMS Gyro Locator

- **Development**
  - A super-compact MEMS Gyro Sensor (14 × 30 mm)
  - “Delivery Device” installs the super-compact sensor.

- **Test Assessment**
  - Gyro-Locator can carry through pipe joints and pipe bends.
    (1 inch & 1·1/4 inch)
  - Accuracy of measurement is within 2.5 % margin of error.

- **Future Issues**
  - Reducing the amount of shock when passing through pipe joints
  - Correcting any margin of error in pipe measuring
In-pipe Traveling Robot–Active Scope Camera

Configurations of Active Scope Camera (ASC) by JGA (2008 - 2010)

(Demonstration)

(Specifications)

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Search robot for narrow space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principle</td>
<td>ASC moves forward autonomously when the fibers attached to the surface of the camera cable respond to vibrations caused by a motor.</td>
</tr>
<tr>
<td>Dimensions</td>
<td>Diameter 30mm</td>
</tr>
<tr>
<td>Quality</td>
<td>Prototype</td>
</tr>
<tr>
<td>Application</td>
<td>Construction field</td>
</tr>
</tbody>
</table>

The ASC tends to get stuck at the curves of continuous fitting.

ASC cannot insert 1-inch pipe.
Active Scope Camera - Development

Improvements

<table>
<thead>
<tr>
<th>Fundamental Structure</th>
<th>Fixed body part (including vibration motor inside) and flexible Tube</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tip Rotation Mechanism</td>
<td>Installing a tire with screw-like grooves</td>
</tr>
<tr>
<td>Easy to Retract Design</td>
<td>Tapering the metal in the back end and taking full advantage of the fiber location</td>
</tr>
</tbody>
</table>

Specifications

- Total length: 7m
- Diameter of the fixed body part without including the fibers: 12mm
- Diameter of the tube: 10mm
- Fiber length: 5mm

Configurations of ASC
Active Scope Camera - Test Assessment

Simulation Pipes

(Specification) Pattern A
- Total Length = 5.5 m (18 feet)
- Bend Pipe = Eight curves
- Diameter (2) = 1 inch & 1·1/4 inch
(Shapes (4)) = Four different patterns

Assessment

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Insertion</th>
<th>Retraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pattern A</td>
<td>All bends passed.</td>
<td>Up to four bends retracted.</td>
</tr>
<tr>
<td>Pattern B</td>
<td>All bends passed.</td>
<td>Up to five bends retracted.</td>
</tr>
<tr>
<td>Pattern C</td>
<td>All bends passed. (25A-3rd)</td>
<td>Up to four bends retracted.</td>
</tr>
<tr>
<td>Pattern D</td>
<td>Up to six bends passed.</td>
<td>Up to four bends retracted.</td>
</tr>
</tbody>
</table>
Conclusion – In-pipe Traveling Robot Technology

Active Scope Camera

• Development (for 1 inch & 1-1/4 inch diameter pipe)
  - Structural improvement of the body part and the tube
  - Installing a tip rotating mechanism
  - Easy-to-Retract design

• Test Assessment
  - Insertion: All bends passed (Pattern A,B,C).
  - Up to six bends passed (Pattern D).
  - Retraction: Up to four bends retracted.

• Future Issues
  - Improving the retraction method
  - Improving the mobility through pipes with various twists and turns
Conclusion including Future Issues

We developed these two technologies.

Gyro-Locator
For detecting three-dimensional pipe locations

Active Scope Camera
For in-pipe delivery inspection

We will develop a new technologies by combining these two technologies.

In the future,

We no longer have to dig out buried pipes to detect their location and shape.
It also allows extensive survey of the interior of the pipe.

This, in turn, contributes to safer gas pipeline maintenance.