# Performance Test of Temperature Compensated Type Pressure Transmitter

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## 1. Introduction

A temperature compensated type pressure transmitter for liquid metal is being developed at Korea Atomic Research Institute (KAERI). Liquid metal such as sodium can be used as a coolant for heat transport system [1]. For pressure measurement in high temperature liquid metal system, NaK-filled type pressure transmitter which uses NaK as a pressure transfer material has been used [2]. However, thermal expansion of pressure transfer material in high temperature, a kind of distortion affects pressure measurement and temperature compensation of NaK-filled transmitter over a wide range of temperature is limited. Furthermore, there is few pressure transmitter for liquid metal in high temperature and low pressure range.

In this paper, we have investigated performance of a prototype of newly developed temperature compensated type pressure transmitter in comparison with a reference pressure transmitter.

## 2. Performance Test of Temperature Compensated Type Pressure Transmitter

### *2.1 Overview of a Prototype of Temperature Compensated Type Pressure Transmitter*

The prototype of newly developed temperature compensated type pressure transmitter is composed of two pressure measurement elements as shown in Fig. 1. The first element is for measuring system pressure including pressure from diaphragm deformation caused by thermal expansion of pressure transfer material. The second element is only for measuring pressure from diaphragm deformation caused by thermal expansion of pressure transfer material. Thus, the pressure without the effect of thermal expansion of pressure transfer material can be calculated from the pressure measurements from two pressure measurement elements. The specification of the pressure transmitter set is shown in Table I. Silicon oil has been chosen as a pressure transfer material for reducing thermal expansion with its low coefficient of thermal expansion and reducing delay in pressure transfer with its incompressibility.

Fig. 1. The prototype of newly developed temperature compensated type pressure transmitter set: For system pressure measurement (up), for temperature compensation (down)

Table I: The Specification of the Developed Pressure Transmitter Set

| | Specification |
|---|---|
| Calibrated Operation Pressure Range of Transmitter | Max. 186.5 kPa |
| Operation Temperature | Max. 300 ℃ |
| Pressure Transfer Material | Silicon Oil |
| Diaphragm Material | SS316L |
| Output Signal Range of Transmitter | 4~20 mA |

### *2.2 Setup of Performance Test*

Performance test equipment for the pressure transmitter set is shown in Fig. 2. The test equipment is composed of a chamber, an Ar gas cylinder, a ceramic mold type heater, a heater controller, thermocouples, a set of temperature compensated type pressure transmitters, a reference pressure transmitter, and Data Acquisition System (DAS).

The set of temperature compensated type pressure transmitters as well as the reference pressure transmitter can measure pressure of Ar gas in the chamber. The reference pressure transmitter is not affected by the thermal expansion of pressure transfer material because it is installed through sufficiently long impulse line from the chamber. The temperature of Ar gas is controlled by the ceramic mold type heater, thermocouple, and the heater controller. The performance test has been carried

Fig. 2. Performance Test Equipment for the Developed Pressure Transmitter Set

Table II: Performance Test Matrix

| Temp. (℃) \ Pressure(kPa) | 0 | 25 | 50 | 75 | 100 |
|---|---|---|---|---|---|
| 130 | O | O | O | O | O |
| 180 | O | O | O | O | O |
| 230 | O | O | O | O | O |
| 270 | O | O | O | O | O |

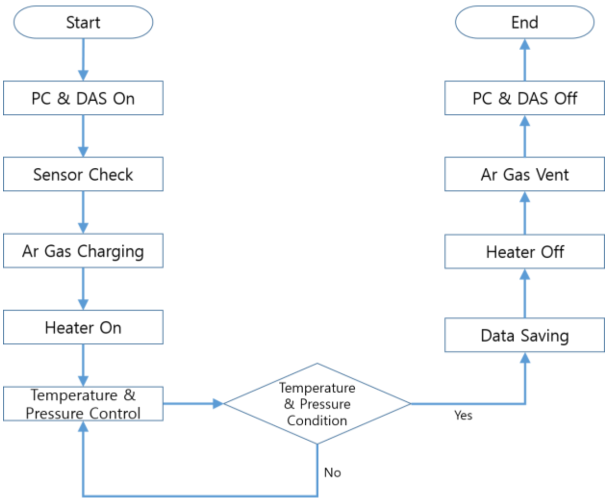


Fig. 3. Performance Test Procedure

out for various pressure and temperature conditions given by the performance test matrix as shown in Table II. We have carried out performance test for five pressure conditions (0 kPa, 25 kPa, 50 kPa, 75 kPa, and 100 kPa) and four temperature conditions (130℃, 180℃, 230℃, and 270℃). Fig. 3 describes test procedure for performance test of the developed pressure transmitter set.

### *2.3 Performance Test Results*

Fig. 4 shows the linearity of the developed pressure transmitter set at different four temperature conditions and five pressure conditions.

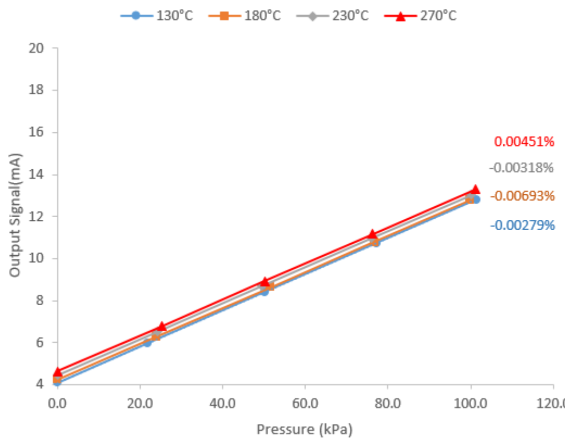


Fig. 4. Linearity of the developed pressure transmitter

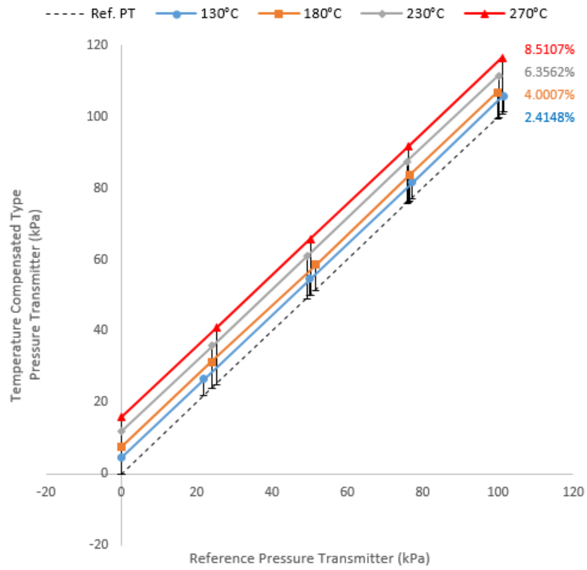


Fig. 5. The percentage of full scale accuracy of the developed pressure transmitter versus the reference pressure transmitter without temperature compensation

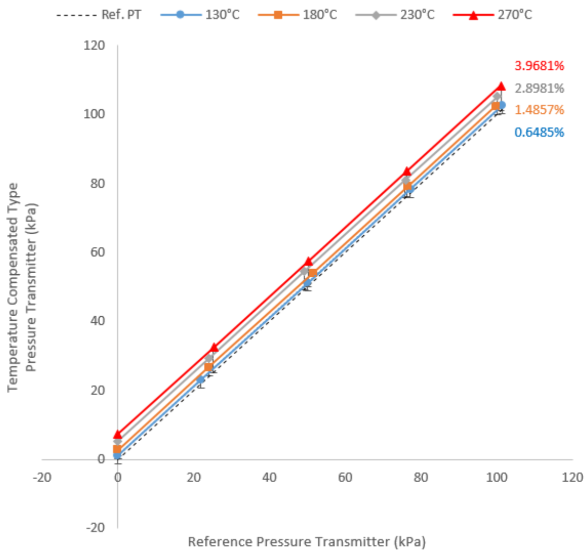


Fig. 6. The percentage of full scale accuracy of the developed pressure transmitter versus the reference pressure transmitter with temperature compensation

The maximum linearity error of the developed pressure transmitter set is -0.00693% at 180℃. Thus, it can be considered that the linearity error of the developed pressure transmitter is sufficiently small.

On the other hand, the full scale accuracy of a sensor can be represented as follows:

$$\%\text{ of full scale} = \frac{\text{Sensor output - Ref. sensor output}}{\text{Full scale span}} \times 100\ (\%) \qquad (1)$$

The performance of the developed pressure transmitter versus reference transmitter without temperature compensation based on percentage of full scale at different four temperature conditions and five pressure conditions is shown in Fig. 5. Fig. 6 shows the performance of the developed pressure transmitter versus reference transmitter with temperature compensation. As shown in the Fig. 5 and Fig. 6, the temperature effect on pressure is reduced from 8.5107% to 3.9681%. We believe that the concept of temperature compensation has been verified throughout the performance test and performance can be improved by optimization in the next step based on the results.

## 3. Conclusions

Performance of a prototype of newly developed temperature compensated type pressure transmitter in comparison with a reference pressure transmitter has been investigated in this paper. We have carried out performance test of the developed pressure transmitter for five pressure conditions (0 kPa, 25 kPa, 50 kPa, 75 kPa, and 100 kPa) and four temperature conditions (130℃, 180℃, 230℃, and 270℃). The maximum linearity error of the developed pressure transmitter set is -0.00693% at 180℃, and the accuracy of the developed pressure transmitter set is improved from 8.5107% to 3.9681% at 270℃ through the temperature compensation. The results can be used for performance improvement of the developed pressure transmitter for further works.

## ACKNOWLEDGEMENT

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