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The Effect of LPG Pipe Temperature on Product Weight Variation in Portable Gas Production Process

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KEYWORDS
LPG pipe temperature; pipe insulation; portable gas; product weight; production process

ABSTRACT

This study aims to analyze the effect of LPG pipe temperature on product weight variation in the portable gas production process. Variations in product weight often occur due to temperature fluctuations in the pipes that transfer LPG from storage tanks to gas cartridges. High temperatures caused by direct sunlight exposure alter the liquid–gas phase ratio of LPG, thus affecting its volume and final product weight. The research employed an experimental method by measuring pipe temperature at six different points and five time intervals (08:00, 10:00, 12:00, 14:00, and 16:00). The results showed that the highest pipe temperature occurred at 12:00 with an average of 40.15°C, correlating with product weight deviation beyond the standard (330±3 grams). A corrective action was implemented by insulating (jacketing) the LPG pipes to reduce heat exposure. After insulation, all measured products met the standard weight requirement. In conclusion, thermal protection of LPG pipes plays a significant role in maintaining product weight stability and improving the efficiency of the portable gas production process.

INTRODUCTION

A portable gas stove is a portable cooking appliance that uses gas cartridge fuel or a canned gas cylinder (portable). Usually, portable stoves are widely used for outdoor cooking activities such as camping or picnics (Barbieri, Riva, & Colombo, 2017; Regattieri, Piana, Bortolini, Gamberi, & Ferrari, 2016). However, portable gas stoves are also widely used by boarding house residents or apartment dwellers who need practical and space-saving cooking utensils. Consequently, portable gas stoves are intrinsically related to the use of portable gas (canned gas) (Gao et al., 2023; Kashtan et al., 2023; Lebel, Finnegan, Ouyang, & Jackson, 2022).

LPG (Liquefied Petroleum Gas) is utilized by the Indonesian people as fuel for portable gas stoves and conventional gas stoves for cooking. Based on data from the Central Statistics Agency (BPS) in 2021, data were obtained showing that 82.78% of households in Indonesia use LPG gas for cooking. This percentage is higher than the use of other fuels, such as firewood, kerosene, electricity, and biogas (Dewan Energi Nasional, 2021).

Portable gas or canned gas as the main container of LPG certainly plays an important role in the use of gas stoves, especially portable gas stoves. Therefore, the quality of the portable gas will affect the function and role of the portable gas stove (Johnson & Chiang, 2015; Lai et al., 2020; McKercher, Salmond, & Vanos, 2017). One thing that is a requirement for portable gas is the weight measurement of the portable gas. The weight of portable gas is the sum of the can weight plus the weight of the LPG content inserted. In this case, it is necessary to maintain the volume or weight of the LPG that is put into the can. The weight of LPG put in cans during production is greatly influenced by the temperature of the pipes used to distribute LPG from LPG Storage to the filling process into cans. Temperature control in the LPG filling process is critically important for several key reasons (Ashok, Ashok, & Kumar, 2015; Ceviz, Kaleli, & Güner, 2015; Landucci, D'Aulisa, Tugnoli, Cozzani, & Birk, 2016; Sarvestani, Ahmadi, & Alenjareghi, 2021).

First, from a safety perspective, elevated temperatures increase the vapor pressure within the LPG system, potentially leading to overpressurization that poses explosion risks and compromises worker safety (Johnson & Williams, 2021). Second, production efficiency is directly affected by temperature variations, as inconsistent filling weights result in product rejection, material waste, and reduced throughput (Chen et al., 2022). Third, industry standardization requires that portable gas products meet strict weight specifications (typically 330±3 grams) to ensure consumer satisfaction, regulatory compliance, and brand reputation (International Organization for Standardization, 2021). Fourth, economic implications are substantial, as weight deviations lead to either product giveaway (overfilling) or customer complaints (underfilling), both of which impact profitability (Kumar & Singh, 2020). Finally, from a quality assurance standpoint, maintaining precise temperature control ensures consistent product quality, reduces batch variability, and minimizes the need for rework or disposal of non-conforming products (Lee et al., 2023). These temperature fluctuations cause changes in the LPG phase ratio between the liquid and gas phases.

The temperature of the pipe is affected by the solar radiation because the position or path of the pipe is in an open area. This phenomenon has been documented in previous research where elevated pipe temperatures significantly affect industrial processes involving LPG. Manurung (2019) investigated the influence of air temperature in LPG pipes on fuel consumption rates during paddy drying processes, demonstrating that temperature increases of 10-15°C resulted in 18% higher LPG consumption due to altered vaporization rates. Similarly, Purnomo (2022) examined production time efficiency in tofu processing industries using LPG, finding that uncontrolled pipe temperatures caused by environmental heat exposure led to inconsistent heating patterns and reduced overall process efficiency by up to 23%. These studies established that external thermal influences on LPG distribution systems create operational challenges across various industries. However, both studies focused primarily on consumption patterns and process timing rather than direct effects on product weight in filling operations.

The novelty of this research lies in several distinct aspects that differentiate it from previous studies. First, this study specifically measures real-time temperature variations at multiple points along the LPG distribution pipeline (six measurement locations) correlated directly with instantaneous product weight outcomes during the filling process, providing spatiotemporal resolution not examined in prior work. Second, the research analyzes the diurnal temperature cycle effects across five specific time intervals (08:00, 10:00, 12:00, 14:00, and 16:00) to establish precise relationships between solar radiation intensity, pipe temperature, and product weight deviation patterns. Third, this study develops a practical intervention methodology by implementing and evaluating pipe insulation as a corrective measure, then quantitatively assessing its effectiveness through before-and-after weight measurements—an applied solution not documented in existing literature on LPG filling operations. Fourth, the research establishes a mathematical correlation between specific temperature thresholds (particularly at 40.15°C) and standard weight deviation in portable gas production, providing actionable quality control parameters for industry practitioners. These novel contributions address a significant gap in understanding how thermal management of LPG distribution infrastructure directly impacts finished product specifications in cartridge filling operations.

The objective of this research is to systematically investigate and quantify the relationship between LPG pipe temperature fluctuations and product weight variations in portable gas manufacturing, and to develop and validate an effective thermal management solution to ensure consistent product quality. The benefits of this study include: (1) providing empirical data that establishes temperature thresholds for quality control in portable gas production; (2) offering a cost-effective engineering solution through pipe insulation that can be readily implemented in existing production facilities; (3) reducing product waste and economic losses associated with weight deviations; (4) enhancing production efficiency by minimizing the number of non-conforming products; and (5) contributing to improved workplace safety by better controlling LPG phase behavior during filling operations. The implications of this research extend beyond the immediate production context, as the findings can inform industry standards for LPG handling infrastructure design, support development of thermal management protocols in similar liquid-gas systems, and provide a replicable methodology for quality improvement initiatives in portable gas manufacturing across different operational environments.

METHOD

This research was carried out using an experimental method conducted at a portable gas manufacturing company. The steps or stages taken were to observe the temperature measurement of LPG pipes which were divided into several points. The temperature measurement was carried out at several variations of time intervals to observe the differences in pipe temperature and their correlation with product weight outcomes.

Tools and Materials

The tools used in this study include 1 unit of pipe temperature measuring device (thermo trace), 50 pcs portable gas samples, and 1 unit of digital scale to measure the weight of the portable gas product.

Figure 1. Thermo trace tool

Figure 2. Digital Scales

Research Procedure

Determination of temperature measurement points or locations on pipelines.

Of the total length of the existing LPG pipeline, it is divided into 6 (six) points. Where each distance between points is about 15 meters.

Procedure Pipe temperature data capture

To obtain data on the temperature of the pipes in each, measurements were made using thermo trace and directed to the outer surface of the iron pipe with a distance of about 30 cm. Measurements are carried out at 5 different times, namely 08.00, 10.00, 12.00, 14.00 and 16.00.

Data analysis

The results of temperature measurement observations are then processed in the form of tables. The data is described using quantitative descriptive techniques.

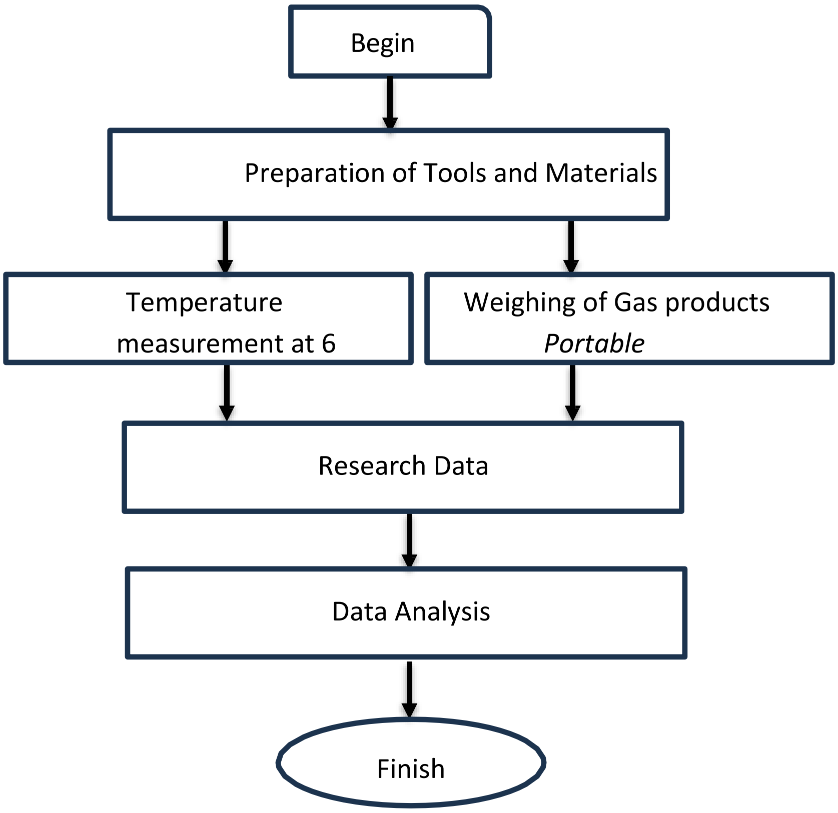


Figure 3. Research Flowchart

RESULTS AND DISCUSSION

The primary activity involved data collection at the portable gas company, specifically the collection of pipe temperature data at each point using thermo trace directed at the outer surface of the iron pipe at a distance of approximately 30 cm. Measurements were carried out at 5 different times, namely 08:00, 10:00, 12:00, 14:00, and 16:00. As previously described, the total length of the existing LPG pipeline was divided into 6 (six) points, where each distance between points was approximately 15 meters. Subsequently, the next dataset comprised weight measurements of portable gas products.

Temperature Measurement Data on LPG Gas Pipelines

The steps taken are as follows:

- Determination of 6 (six) temperature measurement location points on LPG pipes

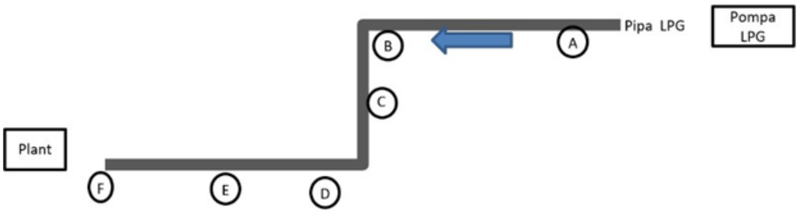


Figure 4. Temperature Measurement Point (location)

- Implementation of temperature measurements in 5 different times. Namely 08.00, 10.00, 12.00, 14.00 and 16.00

From the results of temperature measurements on LPG gas pipes are as follows:

Table 1. LPG Pipe Temperature

Time	Measurement Results ($^{0C)}$						Weather	Information
	A	B	C	D	And	F		
08.00	30,90	31,20	31,70	32,30	34,60	34,60	Bright	
10.00	34,20	36,10	35,40	36,30	35,60	37,20	Bright	
12.00	40,90	40,70	41,30	39,70	39,20	39,10	Bright	
14.00	37,10	41,10	43,20	39,10	38,00	37,70	Overcast	
16.00	35,90	34,70	36,40	35,90	35,70	35,70	Overcast	

From Table 1 above, it is found that the data that:

a. The highest temperature in the LPG gas pipeline occurred at 12.00 with an average temperature of 40.150C
b. The highest temperature occurs at point C with an average temperature of 37,600C

Portable Gas Product Weighing Data

Another data taken is data from product weighing results at the same hour when measuring pipe temperature. Namely at 08.00, 10.00, 12.00, 14.00 and 16.00.

Figure 5. Product Weighing

Where at every hour a sample of @5 pcs. portable gas is taken. The data is as follows:

Table 2. Weight of Portable Gas Products Scales

Time	**Sample to (gram)**					
	1 (g)	**2 (g)**	**3 (g)**	**4 (g)**	**5 (g)**	**Average**
08.00	331,21	331,15	330,92	330,87	330,74	330,92
10.00	331,26	330,11	329,98	329,88	328,87	329,71
12.00	**327,30**	**326,78**	325,87	326,66	326,98	326,72
14.00	327,11	327,05	328,11	327,84	329,07	327,84
16.00	328,22	327,99	329,83	330,11	330,88	319,41

From Table 2 above, data is obtained that the weight of the product in Portable Gas decreases or is outside the standard, namely 330±3 0C at 12.00. From the two observations, namely the observation of the amount of LPG pipe temperature with the weight of *Portable Gas*, there is a correlation, which occurred at the observation at 12.00.

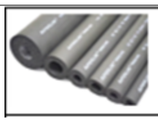
Corrective actions

From the existing data, especially related to the temperature of LPG pipes, the actions taken are: modifying the existing LPG pipes with the aim of minimizing the temperature of LPG pipes which are indirectly expected to improve the weight of the portable gas product. The modifications made are to reduce the heat generated in LPG pipes due to exposure to the sun's heat. The work carried out is the process of LPG Pipe Insulation or Jacketing Pipe on LPG pipes.

Components and Materials

In LPG pipe insulation, it is carried out by using the following components and materials:

Table 3. LPG Pipe Insulation Process Components and Materials

COMPONENT	SPECIFICATION	PHOTO	FUNCTION (USE)
Insulator Fleksibel (Armaflex Superlon)	Thickness 1/2 " / Dia. 2 "		Prevents condensation and reduces energy loss in piping and ducting systems.
Duct Tape	Width 45 mm		Helps prevent leaks, protects pipes from hot and cold, and maintains neatness of installation.
Cover Pipa BJLS (Baja Lapis Seng / Galvanized Steel Sheet)	Thickness 0.4 mm		Protects pipes from corrosion and damage due to environmental factors, and improves the efficiency of the piping system.
Cover Pipa LPG (box)	$0.25 \times 4 \times 69$ m2	-	Support
Rangka Besi (Iron Frame)	Thickness 0.9 mm, Screw	-	Support
ACP (Aluminium Composite Panel) Lapisan Aluminium Foil Silent	Thickness 3 mm (bubble finish silent)		Additional layer for thermal insulation.
Pipa Galvanis (Galvanized Pipe)	Dia. 50 mm		As a channel for various fluids, both liquid and gas.

The form or model of LPG pipe insulation is as follows:

Figure 6. Shape or model of LPG pipe insulation

For the LPG pipe installation process, it is done as shown in the pictures or photos below:

Figure 7. LPG pipe insulation installation

Weight Measurement of Portable Gas Products After LPG Pipeline Modification

As the next step after the installation of LPG pipe insulation, it is necessary to measure the effectiveness of the repair action. The measurement is weighing the weight of Gas Portable products. Meanwhile, the temperature measurement of LPG pipes is not carried out because LPG pipes are already wrapped in insulation. The collection of data from product weight measurement adjusts the clock to the time before LPG pipe insulation is carried out. And here is a table of the measurement results:

Table 4. Weight of Portable Gas Products Scales after LPG pipe insulation

Time	Sample to (gram)					
	1 (g)	2 (g)	3 (g)	4 (g)	5 (g)	Average
08.00	332,12	332,87	331,25	331,97	332,16	332,07
10.00	331,26	332,03	332,64	331,88	330,99	331,89
12.00	331,03	331,67	331,43	330,96	331,32	331,28
14.00	330,77	331,04	331,05	331,54	330,88	331,10
16.00	331,65	332,09	332,16	331,93	332,02	331,97

From Table 4 above, data is obtained that the product weight in Portable Gas is standard, which is 330±3 ^{0C} at all sampling times. From the two observations, namely the observation of the amount of LPG pipe temperature with the weight of Portable Gas, there is a correlation, which occurred at the observation at 12.00.

CONCLUSION

This study concludes that LPG pipe temperature significantly affects the weight stability of portable gas products, as direct sun exposure raises pipe temperatures above 40°C, altering the LPG's liquid-to-gas phase ratio and causing product weight deviations from the 330±3 grams standard. Insulating the pipes effectively lowers temperatures, stabilizes the phase ratio, and ensures product weight meets quality standards, while enhancing production efficiency. Future research could explore the long-term durability and cost-effectiveness of different insulation materials under varying environmental conditions to optimize sustainable temperature control in LPG production.

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