Flow Calculation Using Flow Paddle Data

WHITE PAPER

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1. Introduction

Flow out measurement is a critical component in mudlogging operations, as it enables precise monitoring of mud circulation throughout the drilling process.

The accuracy of flow measurement directly impacts the detection of anomalies such as fluid losses or gains, ensuring drilling safety and efficiency.

One commonly used device for flow measurement is the **paddle-type flow meter**.

This document presents an analysis of the challenges faced in using paddle-type flow meters and proposes a standardized solution to improve flow rate calculation using polynomial regression techniques.

2. Overview of Paddle-Type Flow Meters

Figure 1: Flowmeter paddle type

The paddle-type flow meter is widely employed in mudlogging units.

The device functions as a rotary potentiometer, where the rise and fall of the paddle arm driven by the force of mud flow controls an electrical voltage signal, this signal is then converted into a percentage value, which is displayed on the mudlogging unit,

The percentage value corresponds to the flow rate. **(1)**

2.1 Working Principle

- **Paddle Motion**: The paddle is moved by the force of mud flow in the flow line.
- **Electrical Signal**: A rotary potentiometer reacts to the paddle's angular displacement and controls the voltage passing through in a range of 4 mV to 20 mV, where a 0-degree angle of the paddle corresponds to 4 mV and a 90-degree angle corresponds to 20 mV.
- **Percentage Output**: The voltage variation is processed and displayed as a percentage according to a preset calibration, the lowest position of paddle arm means 0% and the highest level of paddle arm means 100%, which can then be used to approximate the flow rate variation. **(2)**

Despite its simplicity and widespread use, paddle-type flow meters present significant limitations in accurately determining the mud flow rate.

3. Challenges in Flow Measurement

The following challenges limit the precision of flow rate calculation using paddle-type flow meters:

1. **Variability in Flow Line Section Surface**
   - Flow lines often differ in dimensions and shapes depending on rig design and configuration.
2. **Flow Line Inclination (Dipping)**
   - The angle of the flow line impacts the paddle's displacement, leading to inconsistent readings.
3. **Differences in Paddle Design**
   - Variations in paddle size, shape, and position affect its sensitivity to mud flow.
4. **Paddle Spring Wear**
   - Over time, the spring supporting the paddle weakens, reducing accuracy.
5. **Manufacturer Disparity**
   - Different flow paddle brands and models exhibit complexity of calibration due to varying construction standards.

These limitations make it difficult to rely on paddle percentage readings alone for accurate flow rate measurements.

To address these issues, a **calibration-based approach** is proposed in this white paper.

4. Proposed Solution

The solution involves implementing a calibration procedure specific to each **paddle-flow line combination** in a rig.

By performing controlled mud flow tests, it is possible to generate a unique polynomial function that correlates paddle percentage readings with actual flow rates.

4.1 Methodology

The procedure consists of the following steps:

1. **Close the Blowout Preventer (BOP):**
   - This isolates the mud circulation system, ensuring a controlled environment for calibration.

2. **Perform Controlled Flow Tests:**
   - Conduct mud circulation at two different pump rates (e.g., a slow rate, mid rate and a high rate) to generate calibration data.
     - **Step 1:** Perform a slow pump rate, such as 200 L/min, and record the corresponding paddle percentage.
     - **Step 2:** Perform a medium pump rate, such as 600 L/min, and record the corresponding paddle percentage.
     - **Step 3:** Perform a high pump rate, such as 1200 L/min, and record the paddle percentage.
3. **Polynomial Regression Analysis:**
   - Use the recorded flow rates and paddle percentages to derive a polynomial function that defines the relationship between paddle percentage and flow rate.

The general form of the quadratic polynomial equation is:

$$y = a * x^2 + b * x + c \qquad [1]$$

Where:

y = Flow rate (L/min)
x = Paddle percentage
a, b, c = Polynomial coefficients determined through regression analysis.

4.2 Example Calibration Data:

Table 1: Calibration Data

Calibration DATA	
Paddle %	**flow rate l/min**
20	200
50	600
80	1200

From this data, polynomial regression can be applied to generate coefficients of polynomial function a, b, c using a Microsoft Excel formula “LINEST”. **(3)**

Table 2: Polynomial coefficients

Polynomial confessions		
a	b	c
0.11111111	5.555556	44.44444

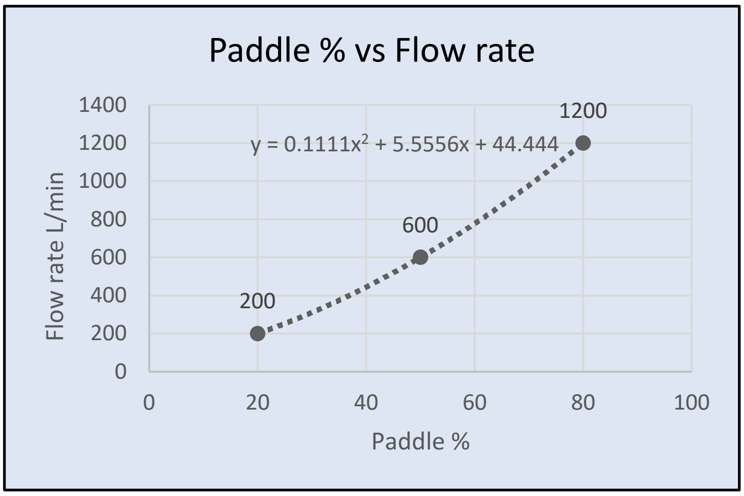

Figure 2: Paddle % vs Flow Rate

4.3 Flow Rate Calculation

Once the polynomial function is derived, it can be used to calculate the flow rate based on real-time paddle percentage readings.

This can be automated using spreadsheet software (e.g., Microsoft Excel)

5. Results and Benefits

The proposed calibration method offers several key benefits:

1. **Improved Accuracy**
    - By generating a site-specific polynomial function, flow rate calculations become more reliable and accurate.
2. **Adaptability to Different Rigs**
    - The method can be applied to any combination of paddle-type flow meters and flow lines, regardless of rig configuration.
3. **Simplified Data Interpretation**
    - The polynomial function allows for quick and easy flow rate calculation from paddle percentage readings.
4. **Cost-Effectiveness**
    - The solution leverages existing equipment and requires minimal additional resources for calibration.

6. Conclusion

Paddle-type flow meters, while widely used in mudlogging, face challenges that limit their accuracy in flow rate measurement.

The proposed calibration procedure addresses these challenges by deriving a unique polynomial function specific to each rig's paddle-flow line combination.

This approach enhances flow rate accuracy, improves operational efficiency, and provides a cost-effective solution for mudlogging applications and associate calculations.

Future work may include automating of associated calculations related to flow meter and integrating machine learning algorithms to further refine predictions based on paddle percentage readings and gas data.

References:

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Hacene Abayahia is a mudlogger at Sonatrach with expertise in geological identification and real-time drilling monitoring. Holding a master's degree from the University of Kasdi Merbah, in the field of petroleum geology, he is dedicated to advancing mudlogging solutions, including the development of a calcimetry interpreter application for faster and more accurate carbonate rock identification.

His work focuses on integrating automation into geosciences to enhance mudlogging data interpretation and improve decision-making in drilling operations, bridging the gap between traditional mudlogging methods and modern technology.