Experimental Study on Energy Consumption Distribution of Electric Forklift

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Abstract. In this paper, the energy consumption and its distribution of forklift in various working conditions are analyzed through experiments, and the main factors of energy consumption are found, which can find a breakthrough for system energy saving and provide theoretical basis for subsequent research. According to the measured battery output voltage and current of the electric forklift, the walking system accounts for about 42.7% of the overall energy consumption of the hydraulic system, the steering system accounts for about 13% of the overall energy consumption of the hydraulic system, the pitch system accounts for about 0.3% of the overall energy consumption of the hydraulic system, and the lifting system accounts for the largest proportion of the overall energy consumption of the hydraulic system, reaching about 44%.

1 Introduction

The most common working process of electric forklift is walking, turning and lifting goods. Due to the limitation of the capacity of the battery carried by the electric forklift, the forklift cannot work for a long time. The analysis of the energy consumption and its distribution of the existing electric forklift is an important prerequisite for the study of forklift energy-saving technology. In this chapter, the energy consumption and its distribution of forklift in various working conditions are analyzed through experiments, and the main factors of energy consumption are found, which can find a breakthrough for system energy saving and provide theoretical basis for subsequent research.

2 Energy consumption analysis of hydraulic pipeline and multi way valve

Because of the viscosity of the actual liquid, it is necessary to consume some energy to overcome the viscous resistance when the liquid flows in the pipeline. The energy consumed is called pressure loss. This kind of pressure loss also exists in the working process of electric forklift. The pressure loss caused by liquid flow includes pressure loss along the path and local pressure loss.

The pressure loss along the pipeline refers to the pressure loss caused by friction when the liquid flows in the straight pipe with equal diameter. The calculation formula is:
\[ \Delta p_\lambda = \frac{64 \lambda \rho v^2}{Re \ d \ 2} \]

where: \( \rho \) — Density of liquid;
\( \lambda \) — Resistance coefficient along the way, theoretical value \( \lambda = \frac{64}{Re} \).

In consideration of the fact that there are also temperature changes and other factors in the actual flow, the liquid flow in the metal pipe is taken as \( \lambda = \frac{75}{Re} \), or flow in rubber hose is taken as \( \lambda = \frac{80}{Re} \).

The local pressure loss is directly related to the kinetic energy of liquid flow.
Multi way valve is the hub of conveying and transferring hydraulic fluid, and its pressure loss is often greater than that of pipeline. The pressure loss of multi way valve can be obtained by the test method of JB / t8729.2-1998.

### 3 Experimental method

Taking Liu Gong cpd30 forklift as the test platform, a standard working cycle was run. The operation process is shown in Figure 1. After the forklift moves from point a to point B, it turns to point C. after the lifting of the fork is completed, the forklift retreats to point B. after the turning, it continues to move to point D, and then turns to point e to complete the lifting of the fork. Finally, the forklift returns to point a at the original position. As shown in Figure 2, flow sensor I and pressure sensor I detect the output flow and pressure of the hydraulic pump, and flow sensor II and pressure sensor II detect the flow and pressure in the tilt and steering hydraulic oil circuit.

![Figure 1. Forklift standard working cycle.](image-url)
When the forklift is running, the voltage and current signals of the whole working process of the forklift are collected by the data acquisition instrument. Analyze the data. The operating power curve of forklift is obtained, and the energy consumption ratio of each working condition is analyzed.

4 Experimental data analysis

In the process of the above-mentioned standard working conditions, the forklift has completed the actions of walking, turning, lifting and pitching. As the pitching action time is short and the energy consumption is small, no separate data acquisition is required. The power curve of walking, lifting and turning is shown in the figure below.

Figure 3. Walking power curve under standard working condition.

Figure 4. Lifting power curve under standard working condition.
5 Conclusion

In a complete standard working cycle, the forklift consumes more energy in lifting, walking and turning. According to the measured battery output voltage and current of the electric forklift, the walking system accounts for about 42.7% of the overall energy consumption of the hydraulic system, the steering system accounts for about 13% of the overall energy consumption of the hydraulic system, the pitch system accounts for about 0.3% of the overall energy consumption of the hydraulic system, and the lifting system accounts for the largest proportion of the overall energy consumption of the hydraulic system, reaching about 44%.

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