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The effects of multiple storages on performance of hydro-pneumatic hybrid driveline

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ABSTRACT – The study emphasis on the effect of multiple storages on the performance of hydro-pneumatic hybrid driveline. Passenger’s car space is very limited. Therefore, the initial solution suggested to use smaller storage, but more in numbers. Its small size allows it to be placed several locations in the car while the number increases the storage capacity. An experiment was carried out to see the system behaviour. It was found that the multiple storages produced better power. However, the torque and efficiency had an adverse effect because of the increase of motor speed, pressure drop, and flow limitation.

1. INTRODUCTION

Hybrid technology advancement has ended up become dominant in the automotive business. The innovation demonstrated to enhance the vehicle efficiency, economical in fuel consumption and greener technology [1]. One of the hybrid vehicle types is a hydro-pneumatic hybrid. The hydro-pneumatic hybrid car is a compounding of two or more types of propulsion subsystems work in a vehicle. The concept utilizes energy losses in braking and recovers into useful energy [2]. The hydro-pneumatic system usually applied by the heavy hybrid vehicle as secondary propulsion [3-5]. It is also widely used in the suspension system [6]. PSA Peugeot-Citroën claimed that the hybrid system is using the current existing hydraulic and pneumatic component, therefore, this system is worth for money as well. Compared to the electric hybrid system, this hydro-pneumatic system is lighter, and the company also claimed that it is cheaper [7]. The system requires lower maintenance than hybrid electric. The use of accumulator also does not involve energy degrading like a hybrid electric battery. Due to the low energy density and capacity faced by this technology, the authors would like to propose the new approach to overcoming them. The system to be introduced is called multiple storage systems. The energy storages are arranged in parallel orders. This scheme delivers a smaller storage size, and it is easy to fit space in the passenger car. Therefore, the more storage number can be set up. Based on the study, it is clearly shown that the technology is still in the research and development phase. Most of the research focused on simulation rather than experimental work [8-9]. So, there are many rooms to be explored.

2. METHODOLOGY

The procedure starts by designing the schematic diagram. Then, the functional simulation was conducted by using Automation Studio software. The next process is preparing the experiment setup. It involves the process of installation and fabrication based on the schematic diagram that has been made. Once finished, the experiment was carried out to obtain the dependence data such as time, revolution per minutes, and flow rate while the storage pressure is independence variable. The collected data was referred to the component specification to ensure they are within the range and reasonable. The Rexpower fix displacement vane pump is used to charge the accumulator with the volume displacement of 8 cm^3/revolution. The Rexroth safety block is used to protect the accumulator from overpressure and embedded in the accumulator block. The experiment was conducted by using 0.75 L Hydac accumulator with a permissible pressure ratio of 8:1 which is 30 bar and maximum operating pressure is 210 bar. The flow rate specification for the accumulator is 95 L/min. The propulsion Sauer-Danfoss OMM8 used as a rotary actuator, but there is no load given to the output. The hydraulic motor has 8.2 cm^3 displacement and a maximum speed of 2450 rpm. The experiment assumed that the flow rate at any point in the system is constant as shown in Figure 1.

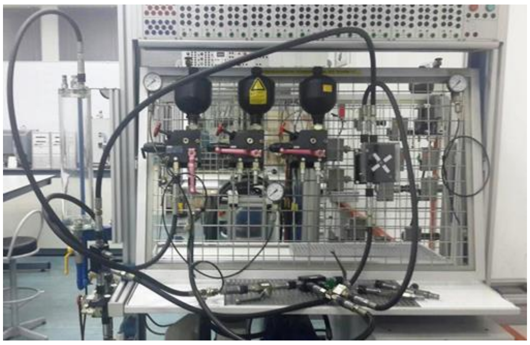

Figure 1 Experimental layout.

3. RESULTS AND DISCUSSION

3.1 Power

Figure 2 shows that the power generated by the hydraulic motor was proportional to the pressure change. The highest power generated at 55 bar by the three accumulators in parallel. Meanwhile, the lowest power generated at 35 bar by the one accumulator. It has shown that the power correlates with the capacity of the accumulator. The higher the accumulator capacity will produce more power in return [10]. The only restriction for the two and three accumulators is the flow limitation and pressure drop across the branch. This was confirmed by the similarity of the power generated and flow profile in the system. Since the branch orifice and flow conflict has disrupted the flow rate, and affecting the power generated. The profile also has shown that the power keeps increasing from 35 to 55 bar. There is a tendency that the profile will remain increase if higher pressure is given. A standard error is representing the uncertainty in the experiment. Small standard error means the estimation is precise while it is the opposite if the value is large.

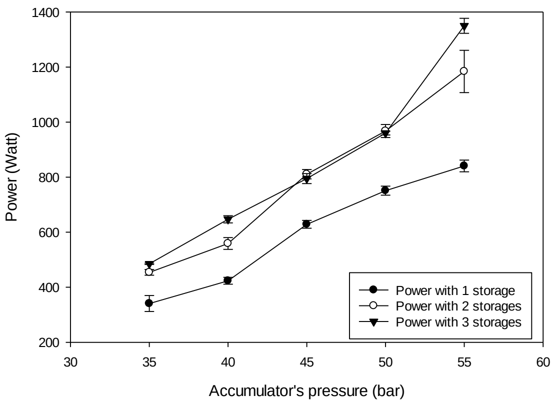

Figure 2 Effect of pressure change to the power.

3.2 Torque

The effects of torque to the pressure change for one, two and three accumulators were shown in Figure 3. The starting torque is high, and it is very usable to be applied in a vehicle application. When the valve is open, the discharge pressure is extremely high, and forming pressure spike causes the torque to increase. These usually happen in the low speed because lower speed swept more volume displacement per revolution. The "intermediate" small accumulator can be used to dampened the high pressure and avoid the spiking. The highest torque was produced by single accumulator. It clearly shows that the more accumulators added to the system, the lower torque it may produce due to higher flowrate and rpm.

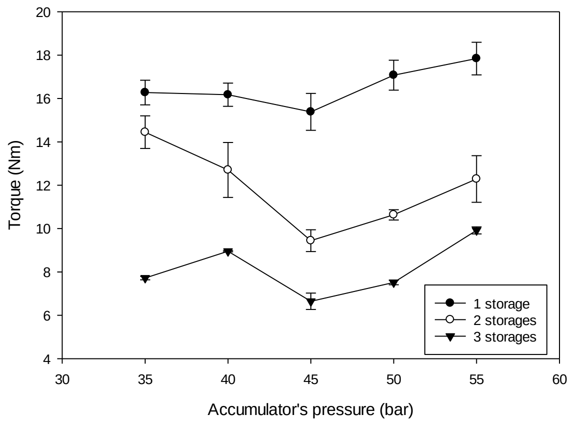

Figure 3 Effect of pressure changes to the torque.

4. CONCLUSION

In conclusion, the study has shown that by adding more accumulator to the driveline of the hydro-pneumatic system does not increase the whole system performance. It is only affected the power and discharges time, but for torque and efficiency at a particular pressure, it shows the opposite results. The high number of accumulator source in the system causes disturbance and orifice effect on the flow rate and has resulted in torque and efficiency to drop. The lowest efficiency recorded by the experiment was 40%, and the highest was 55%. The efficiency is still low and not optimum. In the future, the focus should be given to finding the optimum operating pressure, improve the orifice effect and reduce the leaking in the motor to improve efficiency.

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