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INVESTIGATION OF THE EFFECTS OF HYDRAULIC SYSTEM ON LOADING SPEED AND FUEL CONSUMPTION IN FORKLIFTS

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Abstract: -

In this study, the effects of hydraulic systems on lift speeds and fuel consumption of diesel forklifts were investigated. Well-known forklift models produced on the subject were examined.Literature review was done on the subject. Forklifts usually with the help of a single pump, the driver steering and lift hydraulic system is working.In our project, as the original value, two separate pumps are used for steering and elevator.In this way, during the operation, the steering is not consumed power. This extra power, which is not used for steering, increases the lifting capacity of the fork in the lift during load lifting. The hydraulic working system of our model is shown in mathematics and physics. Also with solidworks, we found the capacity values for fork lifting. The load lifting capacity values of the hydraulic system of our prototype model and the other hydraulic systems of the equivalent models were explained. The performance of our model seems to be quite good in terms of its load-bearing capacity, among other models that do not apply a dual hydraulic system. The design and construction of our model was completed and performance tests were performed. It is also possible to apply the tandem hydraulic system to other forklift models.

Keywords: - *Hydraulic pump, Double pump, Tandem pump, Lifting system, Steering system*

INTRODUCTION

In our prototype model, steering and lift load lifting hydraulic systems are separated from each other. TUBITAK (Turkish Scientific and Research Council) 7170507 project work is one of the results of this unique study, the driver steering system and hydraulic lift systems are fed by two different pumps or double output tandem pump. Related to the subject, as a result of literature review, hydraulic systems Andreas et al.,(2016); Christoph et al.,(2014); LIN et al.,(2012) and equivalent double hydraulic KOMATSU Ltd., (2018); TOYOTO Material Handling.,(2017); diesel models and other single hydraulic models *Çukurova Forklift.*,(2006); *Dolphin Lift.,(*2018); Hangcha Forklift.,(2014) Ceylift Forklift neo.,(2017); TAİLİFT; Jungheınrıch; CLARK the Forklift.,(2011); Crown Pneumatic Forklift Trucks,(2016); *EP Forklift.;* HELI Forklift.,(2015); *CAT;* NISSAN Forklift; were examined. In single-pump hydraulic systems, the lift and steering movement is provided by a single pump. This results in additional fuel consumption to the engine and overloads the hydraulic pump during any maneuver with the steering wheel during load lifting. In order to reduce fuel consumption and prevent excessive hydraulic pressure to the pump, dual pump hydraulic systems were used as the original value.

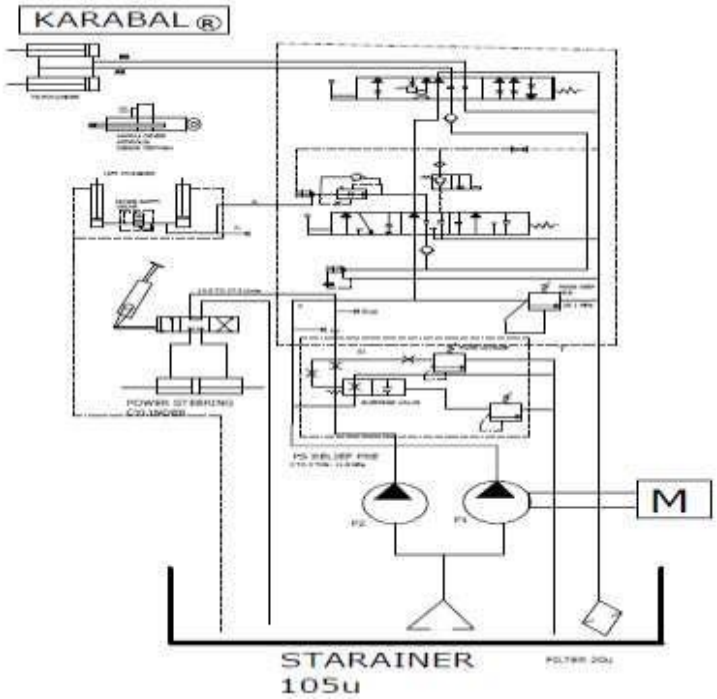

Figure 1. Tandem hydraulic system diagram

Hydraulic System Operation

The hydraulic feeding systems of our designed model are given schematically in Fig.1. The diagram shows the working principle of the tandem hydraulic system. Accordingly, the driver turns the steering wheel during load lifting using a separate hydraulic pump circuit.

Operation of Hydraulic System and İts Effects on Fuel Economy:

In single-pump hydraulic systems that provide lift and steering movement of the forklifts, the steer-ing shaft and lift system are driven by a single pump connected to the crankshaft. This affects the steering movement during loading. There are significant differences in fuel consumption between the two-stage hydraulic pumps and the single pumps.

a. Operation of Hydraulic System

In the lift systems of diesel forklifts with 3000 kg lifting capacity, single or double hydraulic pumps with a flow rate of 30 lt / min are generally used. In our model, with the help of a gear connected to the crankshaft, the two pumps operate independently of each other. Fig. 2 and Fig.
3 show respectively mono-center and bi-center hydraulic pistons that provide steering movement.

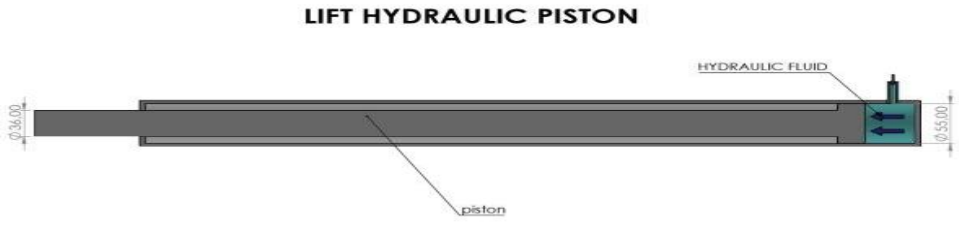

Figure 2. Lift pump hydraulic piston.

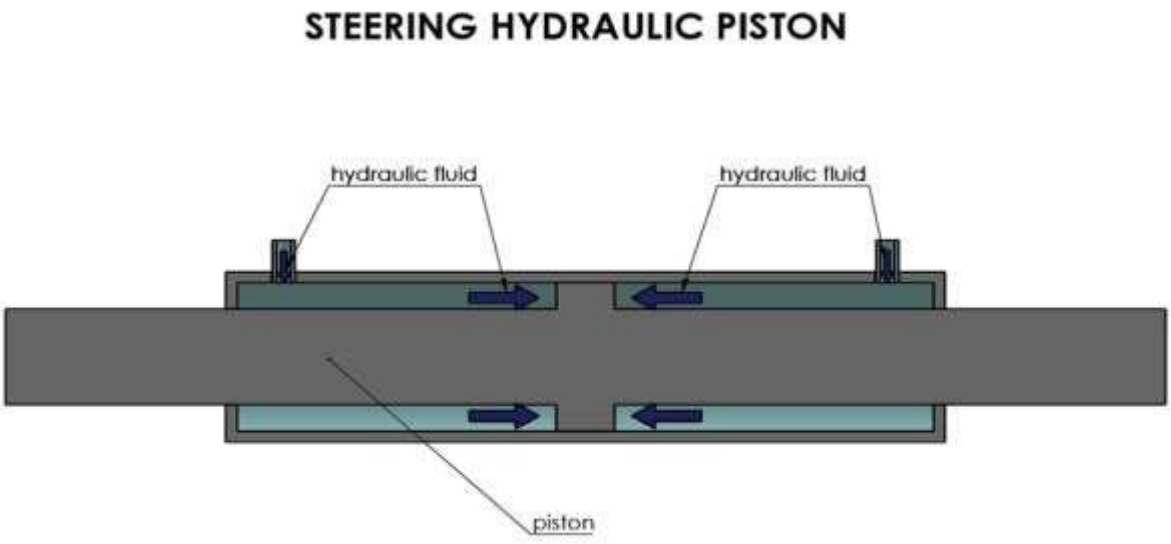

Figure 3. Steering pump hydraulic piston

In dual-stage pump systems, the hydraulic flow channel is gradually separated from each other for lift and steering movement. The steering and lift lifting mechanism is provided with the help of the double output step pump as shown in fig. 4. Pump lift and steering movement is made by different hydraulic channels. In order to better understand the differences between the pumps, a single hydraulic pump is shown in fig.5 and a double and tandem hydraulic pump is shown in fig. 6.

Figure 4. PXK Double stage hydraulic pump

Figure 5. PX1 single hydraulic pump

Figure 6. PX2 Double hydraulic pump

These pumps differ in terms of their power and operating principles. The pumps are powered by the main forklift engine. The power the truck draws during load lifting directly affects the fuel consumption. Most of the forklifts used in the industrial area work with single hydraulic pumps. A very small number of forklifts operate with a double hydraulic pump or a dual stage hydraulic pump.. Most of the forklifts used in the industrial area work with a single hydraulic pump. A very small number of forklifts operate with a double hydraulic pump or a dual stage hydraulic pump. As can be seen from Fig.7 below, it is seen that the load lifting speeds of the 3000kg capacity diesel pumps vary slightly according to the pump power. This shows us that during the operation, the sides-lift and other- lift movements should be within safe speed limits.

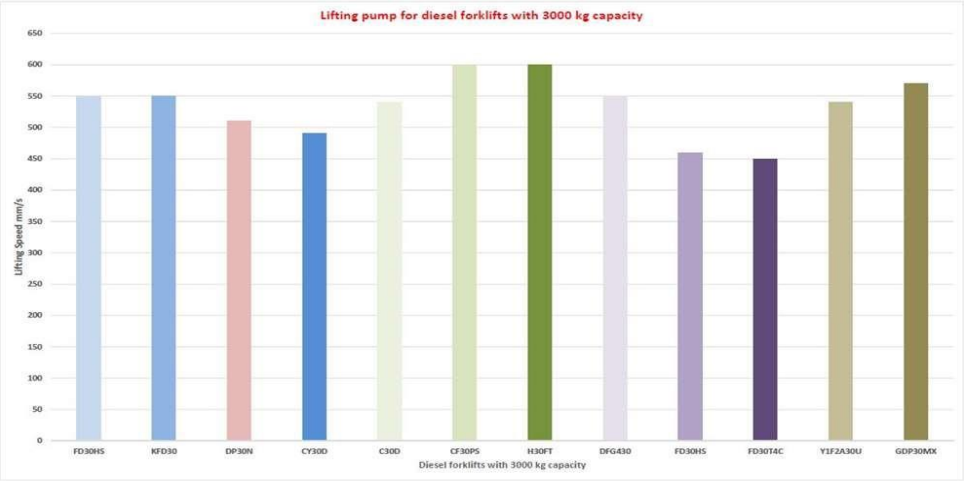

Figure 7. Lifting pumps for diesel forklifts with 3000kg capacit

In double-pump or multistage super hydraulic systems, while the diesel engine is operating at low speed with no load, the lift has the ability to move about twice as fast as single pump hydraulic systems at lift speeds below 150 mm / s.[9]. This ensures a stronger lifting of the load, independent of steering movement. Fig. 8 shows the speed of the lifts in single and tandem pumps with no load. while the diesel engines are operating at low speed.

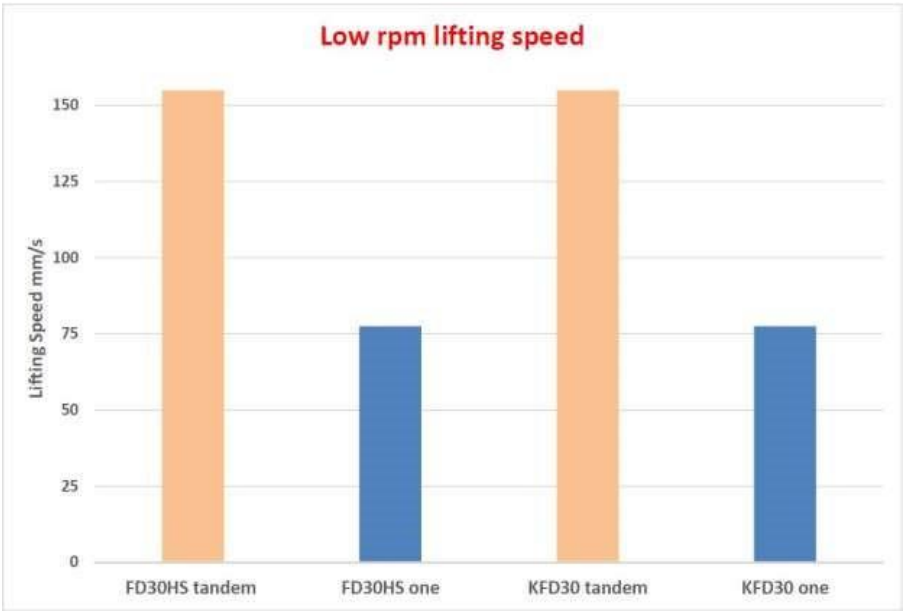

Figure 8. shows the speed of the lifts in single and tandem pump type models

b. Effect of Pumps on Fuel Consumption:

The power the truck draws during load lifting directly affects the fuel consumption. Most of the forklifts used in the industrial area work with single hydraulic pumps. A very small number of forklifts operate with a double hydraulic pump or a dual stage hydraulic pump. In the single-pump hydraulic systems that provide lift and steering movement in forklifts, the movement to the steering shaft and lift system is provided by a single pump operating in connection with the crankshaft. This affects the steering movement during loading. Steering must not be performed while the forklift lift is operating. To overcome this drawback, the driver is often forced to supply more fuel to the engine in order to meet the power drawn by the pump. This significantly increases the fuel consumption of the engine. It is possible to explain this consumption as follows. Let's express the power that the tandem pump used in our prototype model draws from the engine crankshaft as belo

$$N = \frac{Q \times P}{600 \times \eta}(kW) \quad [1]$$

N … Pump-drawn power (kW)

Q … Flow rate of pump $(lt / dak.)$

In this formula, the characteristics of our pump; put in place $Q = 30 lt\ dak/.$, $P = 260 bar$, η= 0.85 is $N_{max.} = 15.3 kW$ found. However, during operation, P=180bar for the lifting, 80 bar steering is separated by the current divider. In a single pump system; The total power drawn from the engine during lift lifting and steering:

$N = N_{lift} + N_{dir.}\ (kW)$ olacaktır. [2]

N_{lift} … Pump power spent in elevator movement (kW)

$N_{lift\ ...}$. Pump power to steering movement (kW)

In a single pump, since the elevator movement and steering movement are provided from the output of the same pump, it will be necessary to multiply the pump power spent by the elevator movement by 2 to find the total pump power. So in 3−3.5 *ton* diesel forklift, 180 $2x = 360 kW$ power will be required. If the required pump power for the tandem system is compared with the pump power consumed by models using a single pump, it is possible to write the following relation.

$$\frac{W_{tandem}}{W_{tekli}} = \frac{260(kW)}{360(kW)} = 0.70 \quad [3]$$

will be. Fuel consumption rates between diesel forklifts using a single pump and diesel forklifts using a tandem pump can be written as follows.

$$M_{tandem} = 0.70 \times M_{tekli}\left(cm^3 / s\right) \quad [4]$$

On models using a single pump, the additional power drawn from the engine for steering movement will increase the fuel consumption of the truck by approximately 0.70. On the other hand, during the movement of the lift, the steering movement forces the pump, causing hydraulic fluid leakage and other mechanical failures. These disadvantages are eliminated by using double or step pump instead of single pump which is the original value in our project works. As you can see from table 1 below, unit fuel consumption values are given for our KFD30 model, FD30-16 model and other forklift models. This table 9 shows that for diesel forklifts with a capacity of 3000 kg, fuel consumption in double hydraulic systems is less. Hydraulic pumps, which are connected to the crankshaft of the engine, directly affect the fuel consumption. For this reason, the selection of hydraulic pumps in forklifts is important. As a result of our studies, it has been shown that it has superior features compared to single pumps in terms of ease of use and fuel economy in double stage and double inlet pumps.

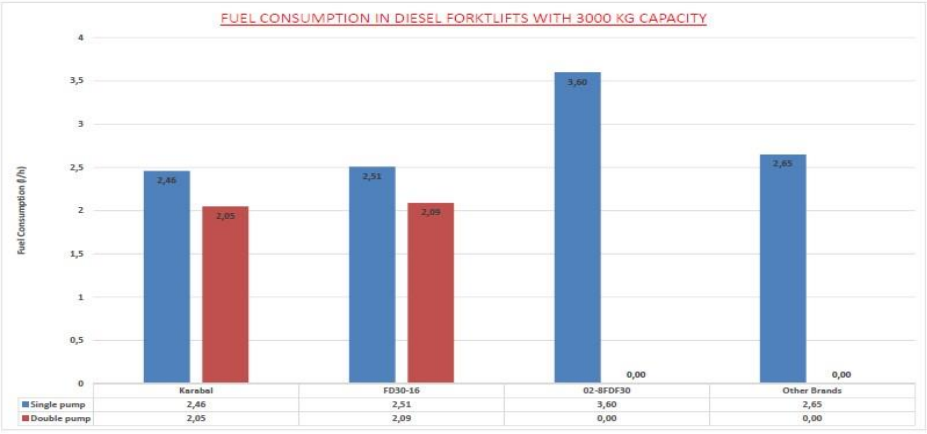

Figure 9 Fuel consumption in diesel forklifts with 3000kg capacity

When the results in fig. 9 are examined, it is seen that the effects of single pumps on fuel consumption are quite high. Most of the forklift models are models using single pump. As can be seen from the table above, very few models included in our model use dual stage or double pump.

Conclusions

The results of the project and one of our original work, elevator movement, steering movement instead of a single pump, instead of the elevator movement and steering maneuvering movement of the two-stage pump related to the use of forklift and pump design studies were done. At the same time, the lift lift and steering movement difficulties seen in single pumps were eliminated in our model and unlike other equivalent forklifts, the most suitable dual stage pump was selected for

our prototype model. In our model, two-stage pump was designed by eliminating the problems seen in other equivalent forklifts. On the other hand, there were significant differences between the fuel consumption of single pumps and double and double stage pumps. As a result of our studies on these differences, it was seen that the fuel consumption of forklifts using double pumps was lower. After the design studies, it was observed that the fuel consumption of our manufactured prototype model was very economical.

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