
PNEUMATIC ACTUATOR AS VERTICAL LOAD SIMULATOR WITH LIGHT WEIGHT VEHICLE WHEEL SUSPENSION

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ABSTRACT

Types of four or more wheeled vehicles that pass on the surface of the road surface at any time generate of fluctuating dynamic loads. This study aims to determine the vertical dynamic load which generated by the weight of the body and the weight of the axle of the vehicle and to determine the effect of the Shock Absorber and Spiral Spring on the vertical dynamic load. This research done at the pneumatic laboratory in Makassar state polytechnic. The method used in this study is to adjust the pressure of the compressor by the regulator starting from the pressure (P) from 1 bar to 6 bar. The amount of the pressure enters the cylinder while pushing the piston whose ends have been connected to a suspension system consisting of a spiral spring and a shock absorber. Force of the pneumatic cylinder push replaces the vehicle body weight (m_2) as 353,5 kg or (F_k) as 3535 N which burdening the suspension mechanism. The results showed that at a pressure (P) as 5 bar loading conditions were obtained which were equivalent to the actual load of the vehicle. The magnitude of the dynamic load of the light weight category vehicle at a pressure (P) as 5 bar is F_t as 16765 N. The reaction force given by the suspension mechanism to the action force of the cylinder is F_p as 8206 N. Thus, the magnitude of the dynamic force that is successfully suppressed by the suspension work is equal to ($F_t - F_p$) as 8559 N.

Keywords: Pneumatic suspensiaon

1 INTRODUCTION

A number of types of four-wheeled vehicles or more that pass over on the surface of the road at any time generate a number of dynamic loads that fluctuate. This fluctuating loading is not only obtained from dynamic load variations. This fluctuating loading, apart from being obtained from dynamic load variations, can also be caused by the presence of overloads and repetitive loads [4].

Effects of fluctuating load transfer of overloads and repetitive loads will reduce the ability or stability of the road structure in the form of surface deformation with holes or bumps. The ability of the road structure to accept the vertical dynamic load of the vehicle is dependent on the type of surface layer, elastic foundation layer and shear foundation layer. The study of dynamic loads that are transformed through the mechanism of suspension work on the vehicle's wheels against the road is aimed at knowing the magnitude of the vertical dynamic load generated by the weight of the body and the weight of the axle of the vehicle, to determine the effect of the Shock Absorber and Spiral Spring on the vertical dynamic load.

The weight of the vehicle body according to is a combination of empty weight (without passengers or load) and weight with passengers (Gross weight) [7]. The working direction of this body weight works in a vertical direction which gets direct resistance from the spiral spring and shock absorber. Based on these conditions, the body weight of this vehicle is defined as Sprung mass symbolized by m_2 . For vehicles with light weight categories, body weights range from 835 kg to 1394 kg. The weight of the axle which is centered on the wheels of this vehicle is a vertical dynamic load which is located under the center of the suspension mechanism. Because this vertical load is not directly affected by the action of the spiral spring and shock absorber, the weight of the axle is defined as unsprung mass, with the symbol m_1 . The average axle weight of this vehicle for the light weight category is 400 kg.

In general, the vehicle suspension system according, consists of a spring and a shock absorber arranged in parallel [1].

The arrangement of the suspension system is shown in Figure 1 (a), with sprung mass (m_2), unsprung mass (m_1), suspension spring constant (k_2), shock absorbers (c) and tire or wheel elastic constant (k_1). Shock Absorber according to reveals that the main function of a shock absorber is to dampen vibrations and reduce vertical loads acting on the road [5].

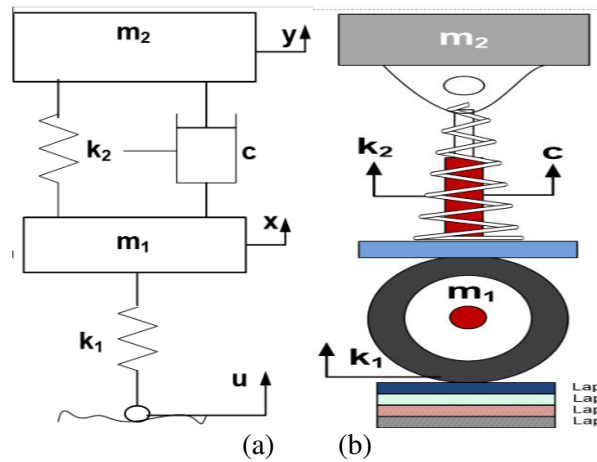


Figure 1. (a) Passive suspension model, (b) Suspension unit, shock absorber and axle

The calculation of the value of the spring constant, k_2 by [3] in the book " Machinery's Handbook, 29th Edition is formulated as follows:

$$k_2 = \frac{Gd^4}{8n_a D^3} \tag{1}$$

Explanation:

- G = Stiffness modulus (N/cm^2),
- d = Wire diameter (cm),
- n_a = Number of active coils (pieces)
- D = Average coil diameter (cm)

The magnitude of the effective force generated by the cylinder piston according to is equal to[2] :

$$F_{p2} = F_{ef} = F_k - R_f \tag{2}$$

$$F_k - 0.1F_k = 0.9F_k \tag{3}$$

Explanation:

$F_{p2} = F_{ef} = F_k - R_f$: Effective piston force (N)

R_f : frictional force the seal and the cylinder wall 10%.

The magnitude of the theoretical thrust of the piston on a pneumatic cylinder is shown in equation[6]:

$$F_k = \frac{\pi}{4} D^2 P_2 \tag{4}$$

If the piston diameter $D = 100$ mm can be selected according to the planning needs, while P_2 (bar) is the amount of air pressure from the compressor and is a variable that can be changed, then based on equation the compressive force on the suspension mechanism is obtained by

$$F_k = 785 \times P_2 \text{ dan } F_{p2} \tag{5}$$

$$706.5 P_2 = 707 P_2$$

The basic equation about the dynamic load that covers the road surface after going through the suspension mechanism can be explained in equations formulated as follows[8]:

$$F_{p2} = F_k = 1.1(k_2 + c/t)x_2 \quad (N) \tag{6}$$

The equation for the vertical dynamic load on the road surface is obtained by:

$$F_{t1} = 707 P_2 + 10. m_1 \tag{7}$$

The spring constant k_2 , damping coefficient c and m_1 are constant numbers, while x_2 is the displacement of the suspension system.

5 METHODOLOGY

Experimentally, the loading on the road foundation structure was carried out by equivalence the total weight of the vehicle body m_1 (kg) and the weight of the wheel axle m_2 (kg), with a pneumatic cylinder piston thrust, F_{ef} (N) as an actuator working at a working pressure of $P_2 = 1$ to 6 (bar).

Research oriented to the simulation of the pneumatic cylinder piston force which is identified as the real dynamic load of the vehicle.

Based on the loading simulation, the experimental data collection was carried out by reading the scale (11) the designation of the needle / dial displacement indicator, x (mm) when compression occurred in the spring (10).

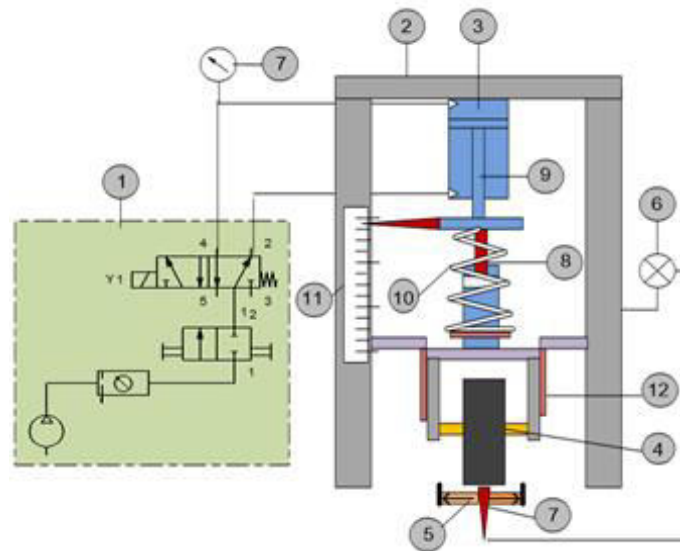


Figure 2. Loading simulation with pneumatic actuator

6 RESULT AND DISCUSSION

The results of the calculation of the cylinder piston thrust against the vehicle suspension and the weight of light vehicles parts can be seen in Table 1.

Table 1. Calculation Results of Cylinder Thrust and Vehicle Weight Part To Suspension

No	Pressure (bar)	Cylinder Push (Fk =707.P)	Weight of Cehicle
1	1	707	70,7
2	2	1414	141,4
3	3	2121	212,1
4	4	2828	282,8
5	5	3535	353,5
6	6	4242	424,2

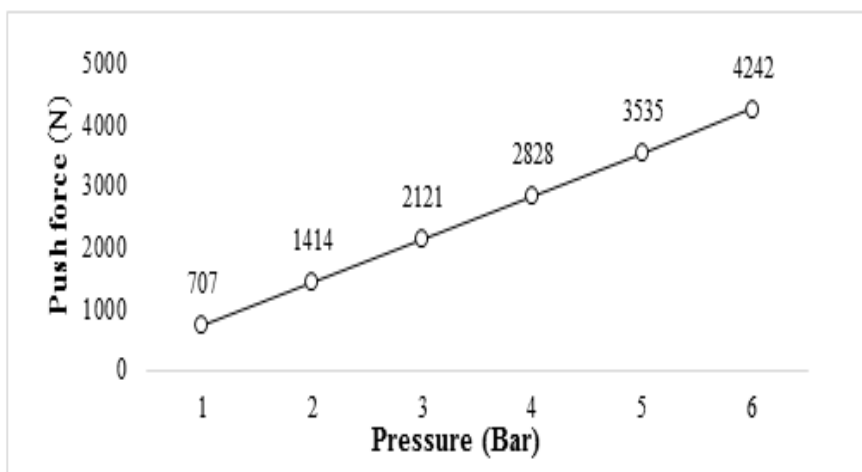


Figure 3. The Result of Cylindrical Thrust to Pressure.

Intermediate characteristics, spring stiffness, and absorber damping coefficient against vertical dynamic forces.

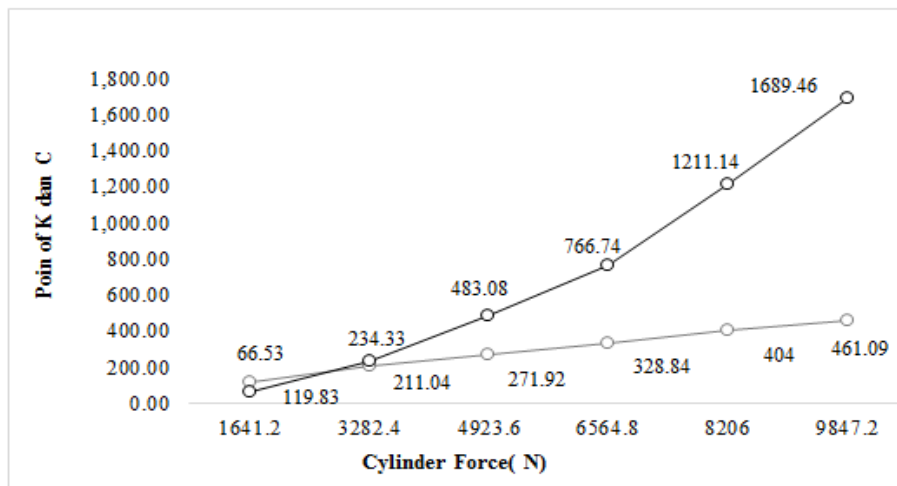


Figure 4. Relationship between spring stiffness, absorber damping coefficient and cylinder pressure force.

7 CONCLUSION

The vertical dynamic load generated by the weight of the vehicle body is proportional to the thrust generated by the pneumatic cylinder piston at a pressure of 5 bar, which is 3535 (N). The characteristics of the vertical dynamic force indicate that there is a condition that, the greater the value of the pressure force (Fp) on the cylinder, the greater the value of the Spring Stiffness, (k) the Absorber Damping Coefficient (c).

The effect of a shock absorber of $k=1211.14$ N/m and a spiral spring of $c= 404$ Ns/m, contained in the suspension mechanism is that it can reduce the force that comes from the vertical dynamic load of the vehicle, so that the vertical load that burdens the road is not to large.

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