Air Car

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Abstract

Nowadays energy conservation is widely recognized due to fuel crisis. Petroleum is one of the primary energy used in various aspects, especially by factories which consume energy at very high rate. Air pollution has been caused for this reason. Lots of industrial sectors have paid attention to this problem and have found out in different ways to manage it. The purpose of this work was to apply compressed air energy which is zero emission energy as an alternative energy instead of fossil energy. This energy was used in a prototype small three-wheeler powered by an impact wrench. The vehicle carried two tanks of 10 liters of air which pressure is 90 bars. The three-wheeler used chains and gears to transmit power to wheels. The gear increased torque ratio of the impact wrench. An air valve was controlled by a sling-controlling lever. On rear wheel hub, 3-speed gear was fitted to enable the car move conveniently according to speed of motor and road condition.

Test results showed that air car could move with the maximum speed of 21.4 km/hr and the farthest distance of 1,917 meters. The longest period of time which the car could move was about 5-6 minutes. The highest torque produced by impact wrench was 2.323 Nm at rotating speed of 3,400 rpm. It was also found that between the rotating speed of 2,000 and 4,000 rpm the impact wrench produced the best performance and this is a good condition to be chosen for further research and development for maximum efficiency.

Key words: Air Car, Air Econo Car, Zero Emission Vehicle

1. Introduction

Wind, water and solar are main important natures for human's life. Human knew how to use these natures before history. Since advanced technology had occurred, sustainable energy has been widely invented and used.

At present time, people are using much of energy, especially fossil fuels, to serve their comfortable life. These energies are used to push the world's economics forward. This causes very high rate of energy consumption and pollutions according to high population growth rate, high economics growth rate and abundant using of energy at low efficiency. This makes humans around the word facing 2 critical phenomena, global warming and high energy price crisis.

Understanding of these problems makes lots of people turn to use more sustainable energy instead of fossil fuels because the sustainable energy are friendly for natures. Wind is the one of alternative energy which causes no pollutions and has been widely used. Then the aim of this work was to study and build a small vehicle with produced zero emission by using compressed air as a source of propulsion energy.

2. Car developments and parts

Like normal vehicles, air car has power train. The heart of its power train is power plant, which is engine in car. This work used impact wrench to do this function due to its characteristics that it can produce high torque at relatively low revolution speed. However, it has also a disadvantage that the impact wrench could not withstand longtime used because some part of it could breakdown. Method to overcome this problem will be described later in this paper.

2.1 Impact wrench

Impact wrench or air gun is a socket wrench power tool powered by compressed air as shown in figure 1. It is widely used in many industries in order to tighten or release nuts and bolts. Figure 2 shows housing inside view and figure 3 shows parts of impact wrench.

Fig. 1 Impact wrench [1]

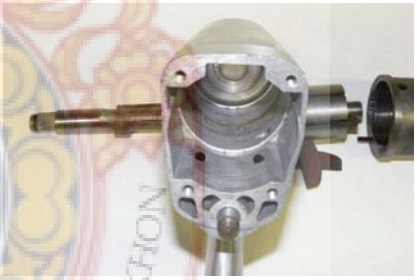


Fig. 2 Housing inside view [1]

Principle of impact wrench can be described as follows [1], first air is forced in the adapter and up through the handle. There are 2 holes inside on the bottom. Air is forced through one of the 2 holes which controlled by forward/reverse control valve. This control valve determines direction of anvil. Air is then passes through a hole in the mechanism to the rear plate. The rear plate

channels the air into the rotor cylinder which connecting with the rotor blades. Rotor blades received forces from pressure of air and start to turn in the same direction force from air. When rotor turns, torque occurs and torque will be transmitted to hammer cage, hammer and anvil. The hammer function is to increase torque sending to anvil. Technical specifications of impact wrench used in this work are shown in table 1.

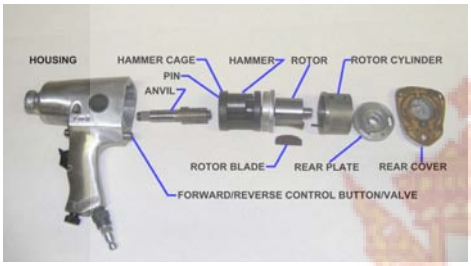


Fig. 3 Parts of impact wrench [1]

Table 1 Technical specifications of impact wrench "KUANI" type KI-850 Square drive1/2" General duty

Square drive (inch)	1/2"
For bolt size) (inch/mm)	(9/16)/M14
Free revolution speed (rpm)	7000
Maximum torque (ft.lb/N.m)	230/312
Overall length (inch/mm)	7/178
Air inlet(pt)	1/4
Air hose(ID)	3/8
Avg.Air consumption(cfm/l/min)	4/113
Net weight (lbs/kg)	5.2/2.36

2.2 Power plant modification

Since impact wrench had been chosen as power plant of the air car. It was modified in some part to drive the car smoothly and overcome the long term breakdown problem. Impact kid of the impact wrench was removed and then anvil and rotor were welded together to be a long shaft as shown in figure 4.

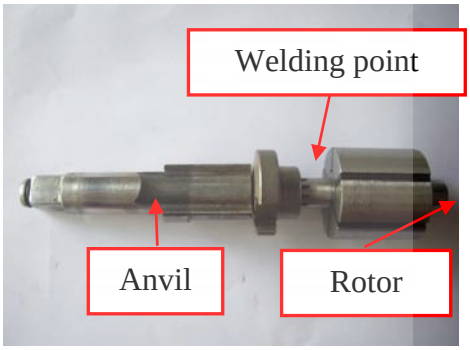


Fig. 4 Impact wrench parts before welding

2.3 Impact wrench performance test

After modified the impact wrench, it was necessary to do its performance test by making a pony brake which had load cell to measure force acting on cable in order to know output torque of impact wrench. Air pressure entering the impact wrench was controlled as 7 bars. Figure 5 shows the performance test of the impact wrench.

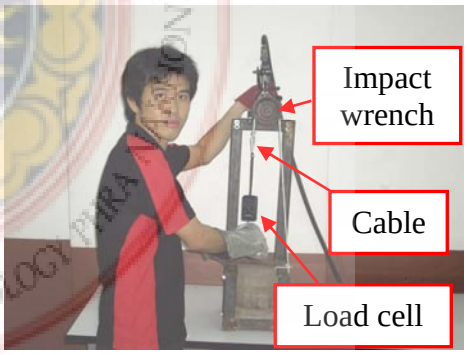


Fig. 5 Impact wrench performance test

Performance test result of the impact wrench is shown in figure 6. The maximum brake torque was 2.323 Nm at revolution speed of 3,400 rpm and the maximum output power was 1 kW at revolution speed of 5,444 rpm. It was found that in the rage between 2,000 and 4,000 rpm the impact wrench produced the best performance and could use this range to change the position of driving gear.

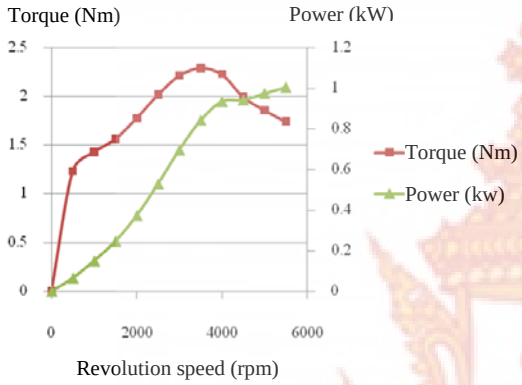


Fig. 6 Impact wrench performance

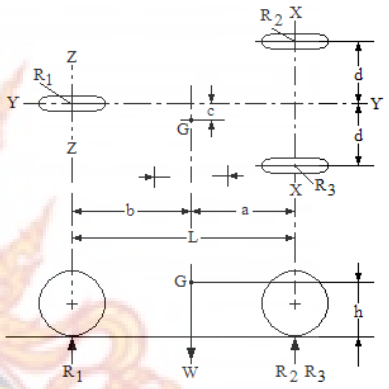
Moreover, the maximum flow rate of air was also measured by Air flow meter. Air pressure entering the impact wrench was controlled as 7 bars and impact wrench valve position was set to maximum value. At this condition, the impact wrench consumed air 17.0 cfm or 481.38 l/min.

2.4 Car design

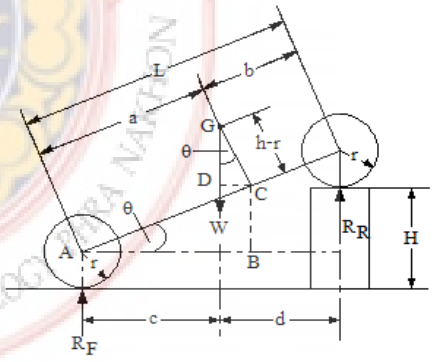
When the performance of the impact wrench had been known, next step was to design and construct the air car. The concept was a small and low weight car which could carry 1 person. The three-wheeler using chains and gears power to transmit power to wheels has been selected. The weight of air car should not be more than 50 kg. Center of gravity of the body should be low as possible for good stability. Two 10 liter air tank which had maximum pressure of 90 bars had been installed at lower part along the car on each side (on the left and right side).

2.4.1 Center of gravity

Center of gravity is important for car's stability. It should be in good position for stability and energy consumption of the car. Figure 7 shows dimensions of car and reaction forces on wheels (a) general condition (b) finding center of gravity



(a)



(b)

Fig. 7 Dimensions of car and reaction forces on wheels

when W = weight of the car

a,b,c,d,h,H = dimension

R_1,R_2,R_3 = reaction force

Force acting of front wheel R_1 was calculated by

$$R_1 = \frac{Wa}{L} \quad (1)$$

Force acting of rear wheel R_3 was calculated by

$$R_3 = \frac{W}{2}\left(\frac{b}{L}+\frac{c}{d}\right) \quad (2)$$

Distance h was calculated by

$$h = \frac{(wa - R_R L)\sqrt{L^2 - H^2}}{HW} + r \quad (3)$$

2.4.2 Transmission

Transmission design is important because good transmission system will give good drive performance of a car. The air car used chain and gear to transmit power from impact wrench to wheels. It used 2 set of gears and chain as shown in figure 8. On rear wheel hub, 3-speed gear was fitted to enable the car move conveniently according to speed of motor and road condition.

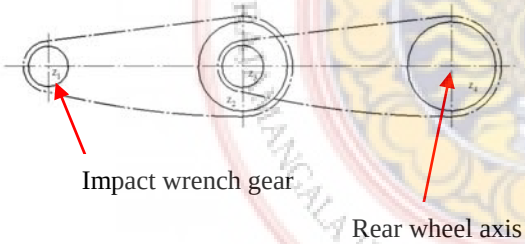


Fig. 8 Transmission chain and gears

Gear ratio can be calculate by

$$i = \frac{Z_1}{Z_2} \quad (4)$$

when i = gear ratio

Z_1 = number of 1st gear teeth

Z_2 = number of 2nd gear teeth

2.4.3 Moving resistance and driving power

Moving resistance of car contains rolling resistance at wheels, aerodynamic resistance from winds, gradient resistance and accelerating resistance. If a car moving on flat road, there is no gradient resistance. The resistance can be described in equation form as follows

$$R_t = R_r + R_a + R_g + R_f \quad (5)$$

when R_t = total resistance

R_r = rolling resistance

R_a = aerodynamic resistance

R_g = gradient resistance

R_f = accelerating resistance

According to the first law of Newton, driving force (P_r) which need to drive a car with constant speed (v) should be the same as total resistance. The power which needs to drive the car (P_w) can be calculate by

$$P_w = P_r v \quad (6)$$

3. Air car assembly

After all of necessary data had been prepared according to theory, the air car had been built, tested run, improved and lastly, filled with impact wrench. Figure 9 to 13 show the air car assembly.

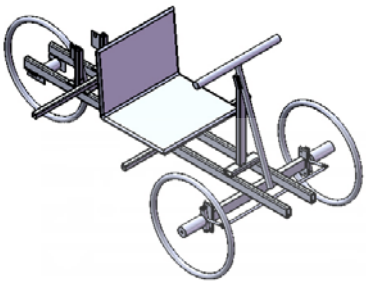


Fig. 9 Air car structure

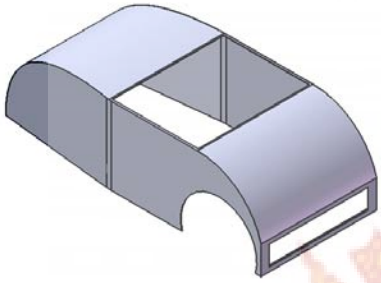


Fig. 10 Air car body design

Fig. 11 Air car assembly

Fig. 12 Air car power train

Fig. 13 Complete Air car

4. Performance test and result

The Performance test of air car could be divided into 3 parts, 3 time tests for every part. Air pressure entering the impact wrench was controlled as 7 bars.

Part 1 tested maximum time used, distance and speed that air car could run from stop with full tanks compressed air until the tanks were empty. Table 2 shows part 1 test results.

Table 2 Test results: Part 1

Test No.	Time used (min)	Max. distance (m)	Max. speed (km/hr)
1	6.08	1,930	21.2
2	5.47	1,880	22.0
3	6.15	1,950	20.9
Average	5.90	1,917	21.4

Part 2 tested maximum speed that air car could reach from stop until it reached 30 m. distance. Air control valve was fully opened for maximum air flow and thus maximum power output. Table 3 shows part 2 test results.

Part 3 tested constant speed of air car when using 3 different gear positions (or ratios). Table 4 shows part 3 test results.

Table 3 Test results: Part 2

Test No.	Max. speed at 30 m distance (km/hr)
1	12.2
2	12.5
3	12.4
Average	12.37

Table 4 Test results: Part 3

Test No.	Speed Gear 1 (km/hr)	Speed Gear 2 (km/hr)	Speed Gear 3 (km/hr)
1	16.5	19.1	21.2
2	17.0	19.0	21.5
3	16.8	18.9	20.9
Average	16.77	19.0	21.2

Test results of part 1 showed that air car could run with maximum distance of 1,950 m. Part 2 showed maximum speed at 30 m distance was 12.3 km/hr and Part 3 showed the velocity of each gear position. At gear 3 position which was the highest gear ratio, air car could run at maximum speed of 21.2 km/hr.

5. Conclusions

A small size air car had been researched and developed in order to have a zero emission vehicle. A three-wheeler using chains and gears to transmit power to wheels had been built. A modified impact wrench or air gun had been introduced as engine of the car which using compressed air as energy.

The highest torque produced by impact wrench was 2.323 Nm at rotating speed of 3,400 rpm. Between the rotating speed of 2,000 and 4,000 rpm the impact wrench produced the best performance and this is a good condition to be chosen for further research and development for maximum efficiency.

Performance test results of the air car showed that air car could run with maximum distance of 1,950 m in about 6 minutes and had maximum speed of 21.2 km/hr.

6. Acknowledgements

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