

Design and Fabrication of Planetary Drive Pedal Power Hub-Dynamo

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Abstract— This paper presents a low speed permanent magnetic based generator which is suitable for supplying generating power from bicycle motion and application in providing energy for bicycle front and rear lights or electronics devices. The dynamo have a hub axel, a hub housing rotatable mounted around the hub axel with bearing, a planetary drive that increases the rotational speed of the permanent magnet, and the power generating mechanism with coil fitted to hub axel that has connected to the output connector. In such a hub dynamo, the magnet rotates faster than the bicycle wheel so that power output is high even at the normal bicycle speeds.

Key words: Pedal power, Hub-dynamo, planetary drive, Solid works, Creo 2.0

I. INTRODUCTION

The hub generators have been popular since the 1950s as bottle dynamo and stationary bicycle dynamo. Standard bottle generators running on the tire tread or rim suffer from frictional losses at the wheel/generator interface that also increases the heat at tire/generator interface. This type of generators are unreliable in wet weather (Khandewal et al, 2014). Bicycle hub generator offers a simple and reliable way to generate power for bicycle front and rear lights. But only in recent years have efficient generator hubs become available that generate about 2.4W power and moderate bicycle speed (N Brito et al, 2006). The device described in this paper integrates power higher than these dynamo and allowing the generation of environment-friendly electric power while keeping fit by pedaling. This contemplates both personal health and environmental issues (M N haji et al, 2010). With increasing concern about global warming, greenhouse gas emission & rising fuel prices, non-motorized modals, such as bicycle are gaining importance as viable mode in urban transportation worldwide (Majumdar et al, 2014). A dynamo is coupled to bicycle. This arrangement enables the lighting of front, rear light of bicycle and charging of mobile phone, if a cyclist pedals fast enough. The device is very suitable for the village and those areas where electricity is not available. Moreover, it can be a completely autonomous energy source without the need for maintenance. Taking in to account the available volume inside a bicycle hub and that the rotation due to bicycle movement are possibly the best energy source in this case, a multi polar magnet and armature was considered as the best way to harvest energy to power the bicycle electronic devices. In the last decade much research has been done in order to develop devices that harvest energy from applications environmental and it into electrical energy (A R mech. et al, 2012). This work is directed to bicycles and, more particularly, to the multi-pole dynamo having a stack that is formed by plate-shaped members. The stack of multi-pole dynamo is formed using pressed electrical steel sheet (Takahiro Endo et al, 2003). A dynamo has a multi stack armature with coil fixed to a hub axel and a magnet casing

that can rotate relatively higher speed than the bicycle wheel speed. The casing has transfer power by planetary drive to magnet holder. The armature stack that houses the coil comprises multiple laminated thin plate-shaped members to prevent the generation of eddy currents.

II. DESIGN CONCEPT AND PRINCIPLE OF OPERATION

A. Design of Hub Dynamo

A hub-dynamo is mounted to distal ends of right and left forks of a front wheel of a bicycle. A hub dynamo comprises a hub shaft structured to be mounted at the bottom end of front fork, a hub shell structured to rotate around hub shaft, a rotating member in the form of a driven body disposed radially inwardly of hub shell and structured to rotate around hub shaft, a planetary gear transmission that transmits rotation of hub shell to driven body. A power generating mechanism is disposed between driven body and hub shaft. Both end of the hub shaft are fixed to front fork. A portion of large diameter portion forms a sun gear of planetary gear transmission. Hub shell is a substantially cylindrical member formed in two pieces, and it is rotatable supported on hub shaft at both ends by bearing assemblies. Planetary gear transmission includes sun gear formed on hub shaft, ring gear formed on the inner peripheral surface of hub side cover, a planet gear carrier stationary supported by large-diameter portion of hub shaft, and a plurality of (e.g., three) planet gear supported by planet gear carrier. Planet gear carrier is very stable during operation and does not tilt. Planetary gear transmission communicates increased rotation of hub shell to driven body. The rotation of sun gear of planetary gear transmission can be expressed by the following expression-

$$N_s = (Z_r/Z_s) \times N_r$$

Where N_r and Z_r is the rotation and number of teeth on ring gear and N_s and Z_s is the rotation number of teeth on sun gear. When the number of teeth Z_s of sun gear is set at 32T, and the number of teeth Z_r of ring gear is set at 66T, then

$$N_s = (66/32) \times N_r = 2.0625 N_r$$

Power generating mechanism comprises a magnet and a fixed unit, wherein magnet is fitted to the inner peripheral surface of driven body for rotation there with, and fixed unit is fixed to hub shaft. In this design, a ring-shaped magnet comprises 13 set of alternating N-poles and S-poles spaced apart in the circumferential direction of driven body. The interior fixed armature has a ring-shaped coil and a stack assembly that is disposed such that it surrounds the coil. The stack assembly and coil are secured to the hub shaft such that they are sandwiched by a pair of nuts and are fastened to screw members formed on the outer circumferential surface of the hub shaft.

The complete specification of the generator is given in Table 1

Parameters	
Voltage	6V
Output	3W
Brake Type	Disc Brake
Hub shell Material	6061 Aluminum
Bearing type	Sealed cartridge
Hub Axle Diameter	10 mm
Hub axle length	140 mm
Over locknut dimension	100 mm
Spokes holes	36
Pitch circle diameter	72 mm
Flange width	57 mm
Weight	800 grams

Table 1. Hub-Dynamo Specifications

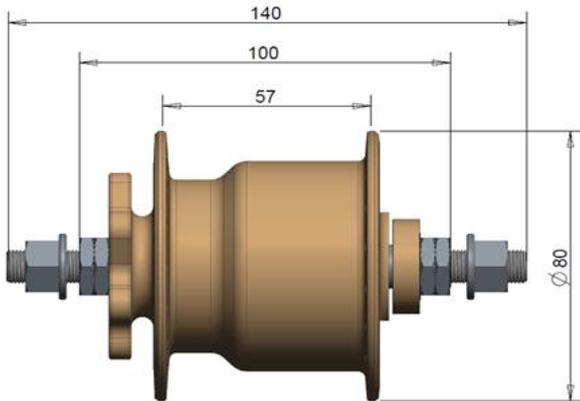


Fig. 1: Hub dynamo

B. Principal Operation of Hub Dynamo

When the front wheel, i.e. the hub casing, rotates relative to the hub axel as the bicycle travels forward, the planetary drive rotates the permanent multi pole magnet around the coil. When the vertical outer portions of the plate shaped pieces forming the first stack arm receive N-pole magnetic flux from the multi pole permanent magnet, then the radially outer portion of the plate-shaped pieces forming the second stack receive S-pole magnetic flux. Conversely, when the radially outer portion of the plate-shaped pieces forming the stack receive S-pole magnetic flux from the permanent magnet, then the radially outer portion of the plate-shaped pieces forming the second stack receive N-pole magnetic flux. By virtue of the rotation of the permanent magnet around the radially outer portions of the plate-shaped pieces forming the first and second stack the hub dynamo repeated alternates between a first state in which the first stack comprise the N-pole and the second stack comprise the S-pole. As a result, alternating magnetic flux occurs in the radially inner portion of the magnetically linked stack of plate-shaped pieces. The alternating magnetic flux produces inside the coil and current flow through the coil. The generated power transfer by the wire to the connector and connector connect the all electrical devices of the bicycle.

III. RESULTS AND DISCUSSION

As per the standard JIS.c.9502, the electrical output is monitored with 12 ohm and 15 ohm resistances, science that's how it's always been done, as bulbs are also resistors. As per report of vintage bicycle press and technical editor Chris Juden, all hub dynamo gives 3-4 volts at normal bicycle speed but this power is not sufficient to charge

electrical devices, so increase the hub dynamo speed without increasing the bicycle speed, we can get sufficient power. To increase the hub dynamo speed at armature end we insert a planetary gear derive to hub assembly. Planetary gear drive increase the hub speed by 2.07 times. The hub dynamo rotation also depend upon the wheel diameter, if the wheel diameter is less it takes more turn for a specific speed then the large diameter bicycle wheel. It can be seen that planetary gear transmission should be preferred for low bicycle speed and the power output of hub dynamo is about 3-4 watt at normal bicycle speed (8-12 km/h).

S.NO.	Bicycle speed (Km/h)	Existing Bicycle Hub Dynamo		With Planetary Gear Assembly	
		Hub Speed (rpm)	Power Output (W)	Hub Speed (rpm)	Power Output (W)
1	0	0		0	
2	2.5	19	0.2	39	0.4
3	5.0	38	0.5	78	1.0
4	7.5	57	1.2	117	2.4
5	10.0	76	1.8	156	3.6
6	12.5	95	2.2	196	4.4
7	15.0	114	2.6	235	5.2
8	17.5	133	3.0	274	6.0
9	20.0	152	3.2	313	6.4

Table 2. Hub dynamo speed and Power output with Existing Hub Dynamo and Planetary Gear Drive Hub Dynamo

The results showed from the numerical analysis are presented in graphical forms. It is evident that there is an appreciate variation between the gear assembly dynamo and existing bicycle dynamo. With the increase in speed this difference increases. Figure 2 shows the Bicycle speed over Hub Speed according to existing hub dynamo and Planetary Gear Assembly Hub Dynamo and figure 3 shows the calculated Power output versus bicycle speed for Existing hub dynamo and Planetary Gear Assembly Hub Dynamo. It has seen that the power output of geared hub dynamo generate sufficient Power for lightening the bicycle at normal speed (8-12km/h).

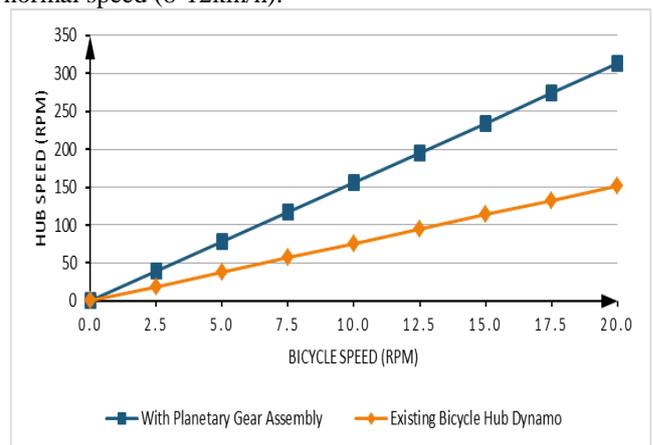


Fig. 2: Bicycle speed over Hub Speed according to Existing hub dynamo and Planetary Gear Assembly Hub Dynamo

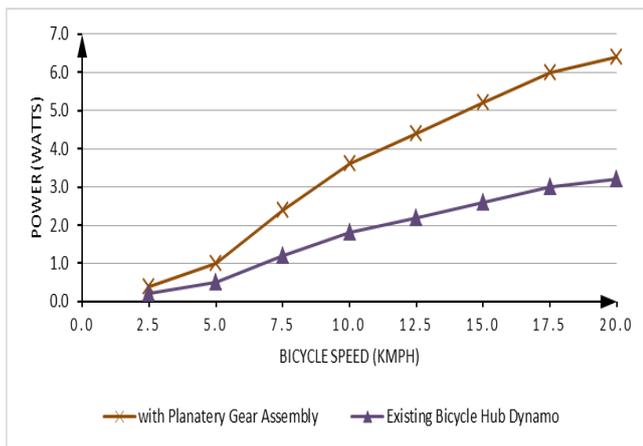


Fig. 3: Power output over Bicycle speed according to Existing hub dynamo and Planetary Gear Drive Hub Dynamo

IV. CONCLUSION

Planetary gear train is one of the key component of the Hub dynamo to increase the rotation at armature end. This paper presented a new design for a low speed permanent magnetic generator. The idea behind this study was to develop a suitable electricity generator for bicycle, which could power supply to bicycle lights and other electronic devices. This paper introduce the structure of a permanent magnet hub dynamo which could beneficial over the bottle dynamo and other type of bicycle dynamo. The prototype generators generated 3-4W power at the normal bicycle speed. These results indicates that the generated power by the bicycle hub generator is sufficient amount for lightening 3-4 watts load from the bicycle motion.

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