E-VESPA: THE ELECTRICAL CRANK SHAFT

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ABSTRACT

The aim of this project is to convert a historic Vespa 50 special into an electric vehicle with original, manual gearbox. Due to this fact it is necessary to find a way to implement the electric machine into the original power train. Hence the crank shaft converts the combustion engines power into rotational movement it is replaced by the electric motor directly. The primary gear transmission between motor shaft and clutch is the defined mechanical interface. This modular design makes the conversion process fast and easy.

1. INTRODUCTION

In times of rising fuel prices, a real hype has erupted around electric vehicles. The conversion of old vehicles into electric vehicles includes a cost and resource effective alternative compared to acquire new electric vehicles. In the special case of this project the conversion of a Piaggio Vespa 50 from the 1970s is a challenge because the manual gear shift should be retained for testing and esthetical reasons. The behaviour of the electric motor in combination with a manual gear shift is of interest in terms of hill climbing capabilities and driving performance. [2]

2. METHOD

The first step was to disassemble the vehicle and to rehabilitate the original parts. All parts which were missing or defective have been replaced by new ones. The original power train comprises a one cylinder, two-stroke combustion engine, a clutch, a gearbox with 4 gears and the wheel. All these modules (except the wheel) are located in the same housing. To exchange the crank shaft by the electric motor, only the cylinder has to be dismounted and the housing has to be deconstructed into two pieces. Now the crank shaft with piston can be extracted from the crankcase.

The electric motor has to have a smaller diameter than the crankcase, to fit into it. It is a brushless DC motor (BLDC) with external rotor architecture. This architecture gives the motor a shaft torque of 8Nm at a rotor diameter of 83mm. To make the BLDC-motor work

with the original gear, the clutch sided crank shaft end has to be manufactured to mount on the motor's rotor and to fit the original gear pinion. Fig 1 shows the CAD designed part.

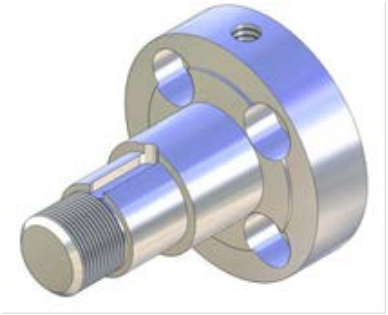

Figure 1: precise copy of original crank shaft end for driving the gear pinion [1]

This crank shaft end is the most important part in the whole project work. It is the interface where the fuel powered engine is replaced by the electric powered motor. This part together with the motor describes the electrical crank shaft.

In Fig.2, Fig.3 and Fig.4 the built in electric motor with the parts described before are pictured. The main difference to other bike/scooter conversion is the integration of the electrical machine. Fig.1 shows the drawing of the BLDC-machine[8], the crank shaft end[7], the oil seal[5], the ball bearing[4], the gear pinion[3], the lock washer[2] and the nut[1]. This set is designed to substitute the crank shaft.

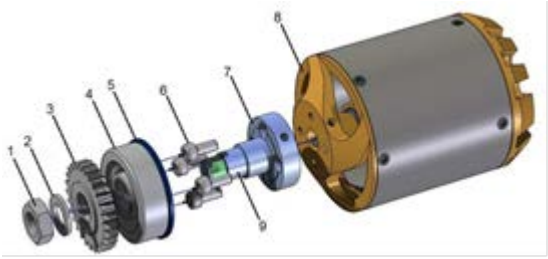

Fig.2: electric motor with crank shaft end and gear pinion [1]

Fig.3: electric motor mounted in crank case with original gear pinion at clutch side

Fig.4: original drive train viewed from clutch side

Fig.4 discovers the original drive train. The gear transmission is adapted and a stronger clutch is used. The drive system includes also the drive inverter, the accumulator and the throttle. These parts were assembled to the Vespa to make the vehicle run with electric power.

3. RESULTS

The implementation of the electric drive train into the original power train recovered difficulties. The original clutch is not able to transfer the torque of the electric motor. Therefore a high-end racing clutch with carbon clutch linings and six springs is used. But this also is not able to deal with the maximum torque of the BLDC motor. To prevent early abrasion of the clutch the maximum torque of the motor is minimized by limiting the main current.

During driving the gears can be switched by the driver in the same way how it was possible before the conversion. The drive chains performance has now improved due the higher nominal power of the electric motor compared to the original combustion engine. The BLDC motor is able to deliver a maximum of 7 kilowatts. The original motor delivered a power of 1.5 kilowatts.

The sound of the vehicle changed completely. The sound of the gear transmission is the only thing you hear now. This was one of the improvements which wanted to be achieved. Now this Vespa is a historic vehicle which can be moved in areas were no combustion engine powered vehicles without catalytic converter are allowed to drive. The style factor of the vehicle is crucial. People want to have nice looking, in vogue scooters instead of bad looking ones. That's the market for such scooter conversion.

Fig.5 shows the finished e-Vespa. The look has not changed at first glance.

Fig.5: Finished e-Vespa

Figure 6: e-Vespa motor department

When the motor department door is open, the difference is visible. Fig.6 shows the motor department of the converted scooter. The motor controller is located above the drive train for short wiring distances and cooling reasons.

4. CONCLUSION

To convert a Vespa 50 special with 4 gear shift transmission into an electric vehicle with four gear shift transmission brings many advantages and also difficulties. The implementation of the BLDC into the original drive is possible and works with one limitation. This limitation is the maximum torque the clutch can transmit. An electric motor in combination with a gear shift has losses, which has to be seen as a disadvantage, the advantage is a raise in driving performance. The advantage is that hill climbing ability rises by the use of a gear shift. Compared to drive on a flat road, the same velocity by driving up hill can be achieved. The reliability of the electric power train can also be prolonged due to the smaller start-up currents the motor draws when starting up with the clutch closing slowly, as it is done with the combustion engine driven vehicle.

5. REFERENCES

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[2] Alexander Elbe, „e-Vespa, Entwurf eines Hochstromwechselrichters für bürstenlose Gleichstrommotoren“, Carinthia University of Applied Sciences, 2011

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