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SOME ASPECTS OF LOADING SMALL HIGH-SPEED ELECTRIC MOTORS UNDER TEST

ABSTRACT *Following paper presents some considerations about modern small high-speed permanent magnet brushless direct current motors and possibilities of testing their mechanical characteristics. Usage of eddy current brake is described as well as a testbed and an experiment. Measured characteristic of tested motor is shown with some remarks about usage and design of eddy current brake intended to work with speed up to 50000 rpm.*

Keywords: *Eddy current brake, BLDC motor testing, high speed test brake*

1. INTRODUCTION

Small electric motors were always a point of interest of Institute of Micromechanics and Photonics. Mostly DC motors and stepper motors were tested and used in designed systems. Tests methods and equipment for those types of motors were successfully developed and used.

Recent years have brought a new challenge: usage of another type of small electric motors – brushless motors. Brushless direct current (BLDC)

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motors have been of course well known for a rather long time [1], but past few years have brought some "new blood" in this area – a small high-speed and lightweight BLDC motor (Fig.1, 2) used in radio control models. Those small motors are relatively cheap and are willingly used in design of small inspection robots or other small surveillance devices [2] (Fig. 3). But they are produced with "semi-industrial" methods, coils are winded manually, what is common in small volume fabrication, but also magnets are placed and glued manually. In this case it is common that an air gap between a stator and a rotor changes its size even by 50%.

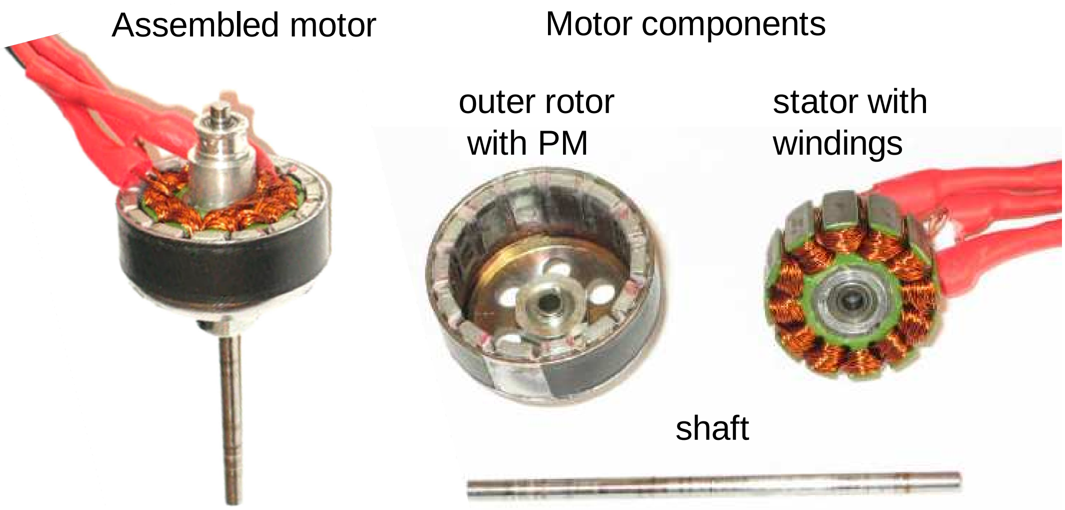

Fig. 1. Example of a permanent magnets brushless motor BA2410-09 with an outer rotor intended to use in small aerial vessels

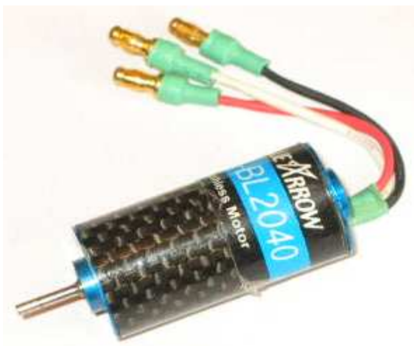

Fig. 2. Example of a permanent magnets brushless motor BA--BL2040 with an inner rotor used in small ground vessels

TABLE 1
BL-BA2040 technical data as provided by a supplier

KV: (reciprocal of back EMF constant)	**2400 rpm/V (0,416 V/1000 rpm)**
weight	57g (2.0 oz)
dimensions	Φ 20 x 40 mm
shaft diameter	Φ 2.0 mm
number of phases	3
number of poles	2
resistance	0.27 Ω
inductance	0.020 mH
no load current	0.4 A
load current	12 A
winding turns	15

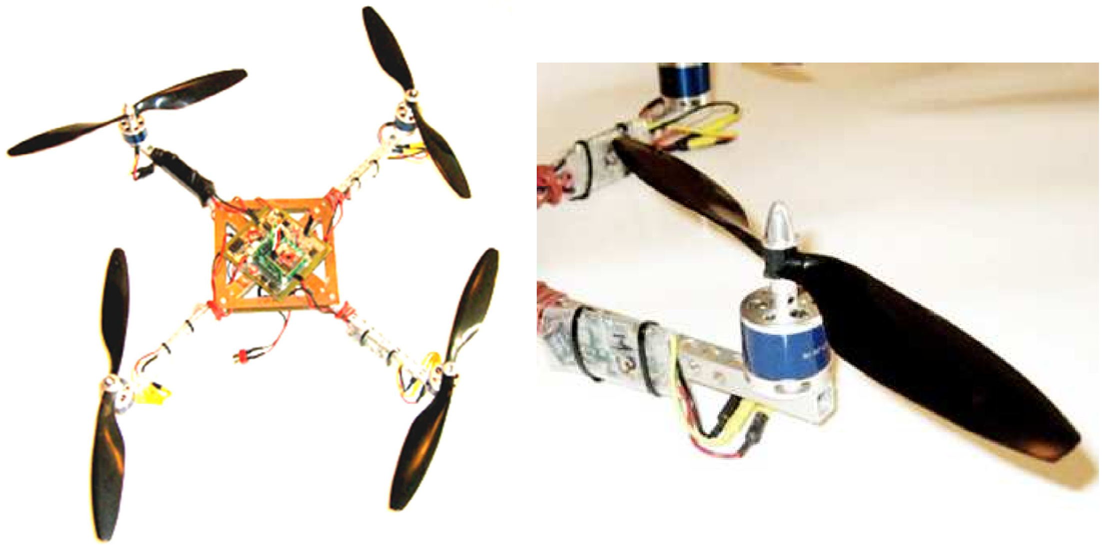

Fig. 3.Surviliance quadrocopter designed and build [2] by P. Skałowski, M.Sc. Eng. graduate of micromechanics, left general view shows cross type frame with 4 motor-propeller units, the right one – single motor close-up, on a bar motor controller labeled M3 can be seen

Usage of presented motors in manner that engineers are used to is almost impossible due to lack of data. For instance catalog data of BL-BA2040 motor is shown.

As it can be seen, those data are insufficient to design a drive unit properly, first of all there is no information about a torque nor mechanical power that motor can give. According to such conditions, an idea to build a testbed to measure mechanical characteristics has been taken.

2. TESTBED CONCEPT AND REQUIREMENTS

An examination of existing testbeds and equipment has ended with a conclusion that none of possessed brakes and loading devices can be used for speeds higher than 5000 rpm. Mass moments of inertia of powder brakes are few orders of magnitude larger than motors ones. It was decided to find out which of known low inertia brake will be useful to test high-speed small BLDC motors. De Prony brake, disc type friction brake and eddy current brake were considered. Known features of the first two types of brakes were confronted to speeds and mounts of energy needed to be dispersed (Table 2 shows maximum speed and output power of selected motors). In this case an eddy current brake was selected to use in the testbed as predestined to be use with high speeds.

TABLE 2
Comparison of maximum speed and power of selected motors

Motor type	Max. speed at 8.4 V	Max. speed at 12.6 V	Max output power (12.6 V)
BA BL2040 (KV = 2400 rpm/V)	20160 rpm	30240 rpm	120 W*
BM2410-9 (KV = 840 rpm/V)	7056 rpm	10584 rpm	104 W
HK540 8.5T (KV = 4000 rpm/V)	33600 rpm	50400 rpm	500 W

* calculated for 80% efficiency

Testbed (Fig. 4) has been assembled from the following components:

- static torque meter with piezoelectric transducer and Kiestler 5011 amplifier;
- tested motor BM2410-9 mounted in special cage holder;
- additional sleeve bearing used to support motor shaft;
- eddy current disc made of aluminum 1.5 mm thick;
- PM disc equipped with two N38 NbFeB magnets (50x25x12 mm);
- PM disc mount.

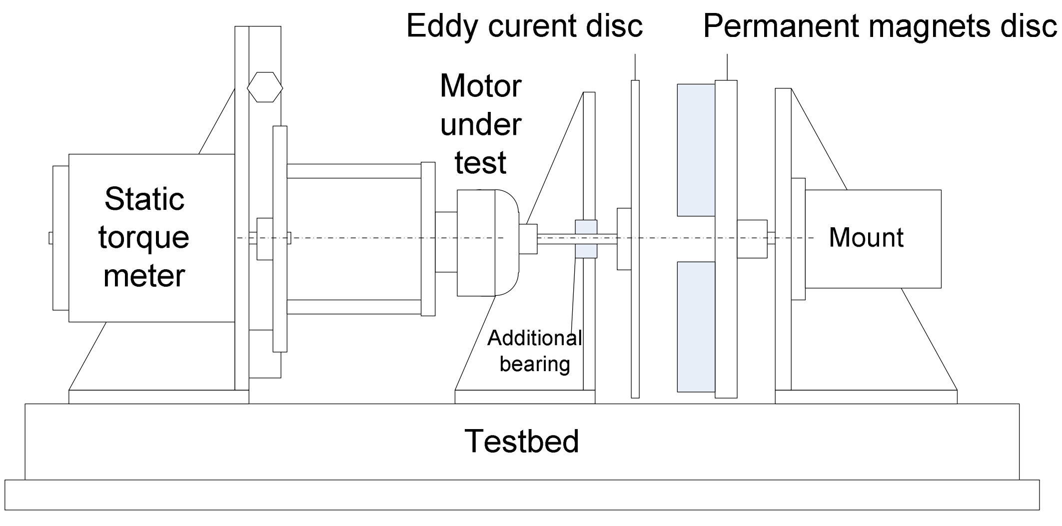

Fig. 4. Testbed configuration

3. EXPERIMENT

Motor BM2410-9 has been selected for the first test of a new brake as the slowest motor possessed. Tests have been made in quasi-static manner, a BLDC motor has been set to run at full speed, then PM disc has been placed to achieve desired size of an air gap. No interactions have been observed for a gap larger than 80 mm.

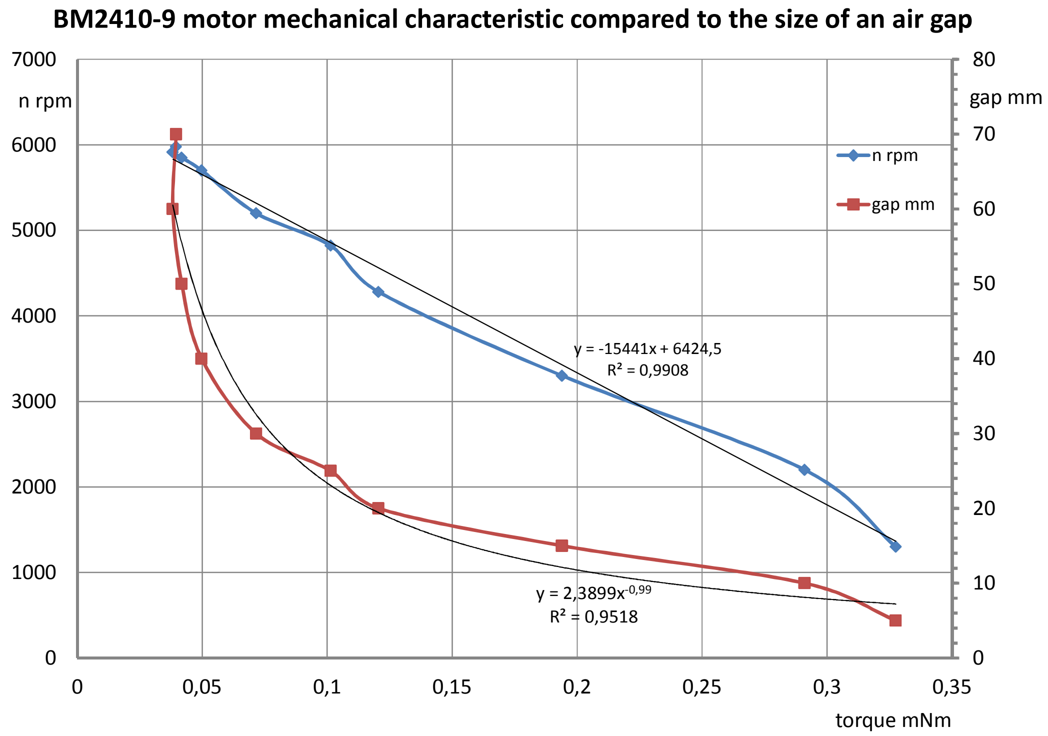

Fig. 5 Experiments results – BM2410-9 motor mechanical characteristic curve

During the test motor has been driven by an 18 amper motor controler and 2s LiPo battery supplying 7,5 Volts and 11.5 Ampers under load. In those conditions mechanical output power reached its maximum at 67 Watts. Compared to the catalog value 104 W at 12,6 V it seems to be proportional.

4. CONCLUSION

An eddy current brake was succesfully used to measure mechanical characteristic of BLDC motor. For further experiments it is neccesary to desing special, precise bearings for an eddy currents disc. Also fine balancing of a disc is a need, the most notice should be placed to reduce radial play of a disc. During the tests itinitial axial play of 0.2 mm was reduced by an interaction with a PM disc.

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Manuscript submitted 06.12.2011

WYBRANE PROBLEMY ZADAWANIA OBCIĄŻENIA W TRAKCIE BADAŃ SILNIKÓW BEZSZCZOTKOWYCH O DUŻYCH PRĘDKOŚCIACH OBROTOWYCH

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STRESZCZENIE *Artykuł przestawia rozważania dotyczące możliwości badania charakterystyk miniaturowych silników bezszczotkowych. Przeanalizowano możliwości zadawania obciążenia w czasie takich badań. Analizy te doprowadziły do zaprojektowania stanowiska testowego wykorzystującego hamulec wiroprądowy z magnesami trwałymi. Wyniki badań ilustrują przykładowe charakterystyki jednego z badanych silników. W podsumowaniu podano spostrzeżenia i wnioski na temat wykorzystania hamulców wiroprądowych z magnesami trwałymi do badania silników o prędkościach obrotowych do 50000 obr/min.*

Słowa kluczowe: *hamownica wiroprądowa, badanie silników bezszczotkowych, hamownica o dużej prędkości obrotowej*