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A simple method for calibration of the rotational speed using PC sound card

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ABSTRACT

A thin film with a small thickness can be obtained when drops of liquid fall on a rotating surface. The thickness of the film can be controlled by the rotational speed of the disk. A very simple method for measuring the angular velocity which needs no additional equipment, but only microphone plugged into the sound card of a computer is proposed.

Keywords: *electric motor, rotational speed, calibration, sound card.*

INTRODUCTION

A small amount of liquid on a rotating horizontal disk forms a steady state of a thin film due to the centrifugal force and the surface tension. The film thickness depends on the rotational speed of the disk. The rotation is obtained by a usual electric motor which revolutions per minute (rmp) can be changed in order to get a needed angular velocity. The motor we used is an AC electric motor with nominal 10000 rpm at alternating voltage of 220 V. Its speed can be regulated through the voltage. We used a variable autotransformer with two windings, turned on a toroidal core, the primary connected to 220 V. The output voltage is obtained between one end of the secondary winding and a brush sliding over it. The construction of the autotransformer suggests that output voltage is proportional to the angle of the rotation of the axis of the brush.

The electric motor is connected to the autotransformer and by rotating its brush axis the output voltage can be varied smoothly from zero to the maximum, which leads to smooth change of the speed of the motor. The simplest suggestion is that the resulting motor's rmp are proportional to voltage, which is proportional to the angle of rotation of the axis of the autotransformer. The first suggestion can be checked very easily measuring the voltage at different angles. To check the second suggestion the rotational velocity needs to be measured. There are many commercial tachometers for this purpose and systems which allows accuracy better than 0.1 % [1], but we do not need such high precision that is why we decided to try to do this using a computer and a microphone only.

The sound card, present in every computer,

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has been used as a versatile tool to measure different physical quantities as the sound velocity in air [2] and other media, small time intervals [3] or even to measure [4] and create magnetic field [5]. The velocity of a fan is measured in [6] using photogates as in [3] and the same license free audio editor software Audacity [7]. In order to measure the rotational speed of the electric motor we used a straightforward method recording the motor sound on a computer by a microphone and analyzing its audio spectrum in the same manner as in [2].

EXPERIMENTAL

We divided the circle around the autotransformer's axis on 20 ticks, 18 degrees between two marks, and measure the voltage at each mark. The result of measurements is shown in Table 1 and from Fig. 1 it is clearly seen the linear dependence of the output voltage on the angle of rotation, so our first suggestion is fulfilled. Our second suggestion is that the rotational speed of the motor is proportional to the voltage i.e. to the angle of rotation of the autotransformer axis. The frequencies in the third column in Table 1 are calculated according this suggestion supposing 10000 rmp at 220 V.

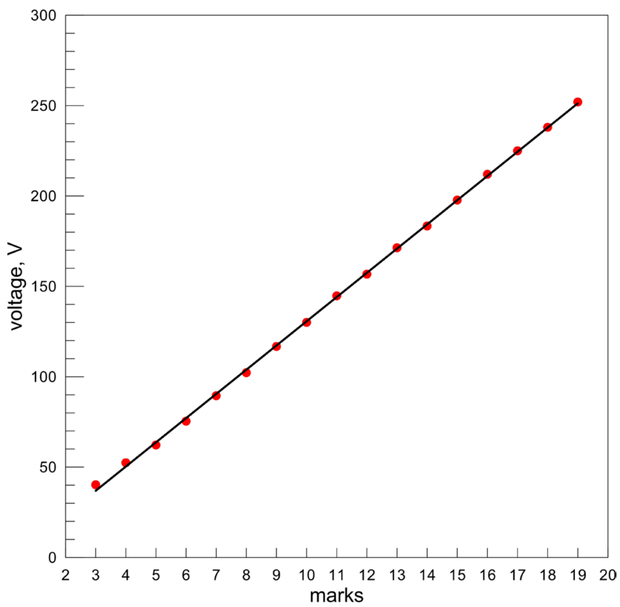

Fig. 1. Dependence of the voltage on the angle of rotation.

Additionally to the voltage measurements we record the sound of the motor at each mark and analyze it by the computer program Audacity [7].

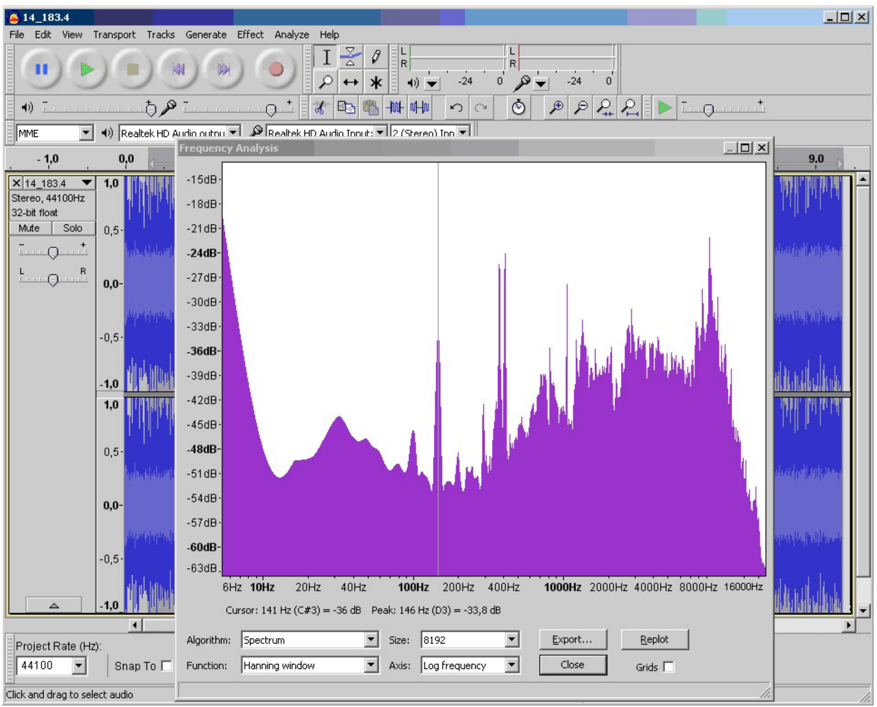

Fig. 2. Audacity output: spectrum of the recorded sound. The marked peak at 146 Hz corresponds to the rotational speed of the motor.

Table 1.Voltage, calculated and measured frequencies at different angels.

Marks	Voltage	Freq., Hz	Freq., Hz	RMP
18° each	V	calculated	measured	fitted
3	40	30	30	1800
4	52	40	49	2550
5	62	47	49	3280
6	75	57	61	4000
7	89	68	81	4680
8	102	77	87	5340
9	117	88	103	5980
10	130	99	109	6600
11	145	110	121	7190
12	157	119	128	7760
13	171	130	141	8310
14	183	139	146	8840
15	198	150	157	9340
16	212	161	163	9820
17	225	170	172	10280
18	238	180	177	10720
19	252	191	186	11120

When operating, the motor and the mechanism driven, make noise in a wide spectral range. The angular velocity of the motor must present in this sound spectrum. The program Audacity has a tool to do a Fourier analysis and to plot the audio spectrum obtained. A typical result is shown in Fig. 2, where the file analyzed is recorded at 14-th mark at 184 V, and from Table 1 follows that the expected frequency is 139 Hz. Many peaks are seen on the spectrum plot and the closest peak

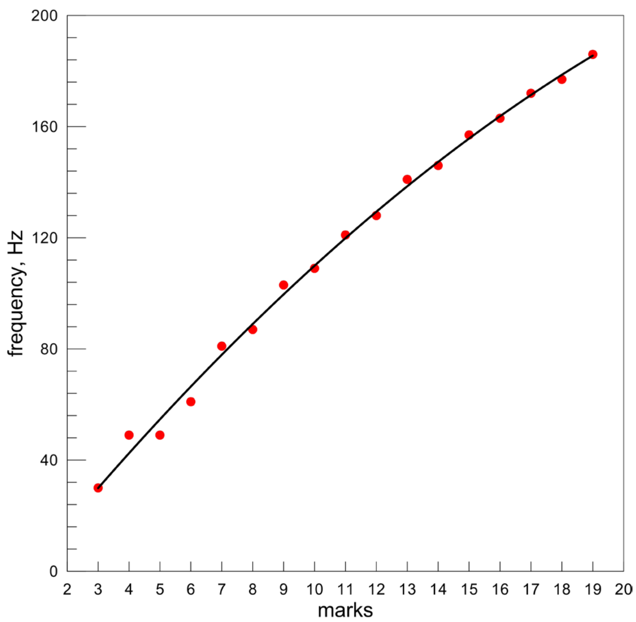

Fig. 3. Measured frequencies versus angle of rotation of the autotransformer's axis.

is found at 146 Hz. All frequencies measured in such a manner are written in the fourth column of Table 1.

The dependence of the frequency on the angle of rotation of the autotransformer axis is given in Fig. 3. It is seen that our second suggestion, that this dependence is linear, is fulfilled with not so good accuracy as the first one, but if we fit the experimental points by second order polynomial as in Fig. 2, the difference is less than 5 Hz. The three parameters of this curve are used to calculate the frequencies and the revolutions per minute given in the last column in Table 1. The calculated rmp, given in Table 1 with the correspondent marks, were printed on a paper disk, glued on the autotransformer, and used as a scale to adjust the motor rotational speed.

CONCLUSIONS

A simple method for a calibration of the rotational speed of an electric motor is developed. It is measured as a frequency in the audio spectrum recorded on a PC trough its sound card. It is possible to identify the correspondent frequency among all peaks of the spectrum because of our knowledge of the nominal rotational speed of the motor at 220 V. This method uses no other equipment, but microphone and sound card available at every personal computer and license free audio editor software.

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