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THE LOADING TEST OF A MOTOR FOR EASY-MOVER

ABSTRACT *The machine – called "EasyMover", saves the drudgery, especially in companies producing heavy rollable things. The typical roll of paper weighs 5 tons, the reel of a cable up to 15 tons. To move such an object in the storage room or distribution shed using manpower is drudgery, being dangerous as well. Due to this fact, the workers use a simple mechanical device powered by compressed air to move heavy reels. However, the air pressure hose is the main disadvantage of this solution: The free movement is restricted. Our task is to develop the same device (EasyMover), powered by an electrical motor and supplied by accumulators.*

Keywords: *mover, rollable objects, rolls, reels, electrical motor, accumulators.*

1. INTRODUCTION

The machine – called "EasyMover", saves the drudgery, especially in companies producing heavy rollable things. Let us mention as an example paper mills, cable works, as well as other branches.

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The typical roll of paper weighs 5 tons, the reel of a cable up to 15 tons. To move such an object in the storage room or distribution shed using manpower is drudgery, being dangerous as well. If an unsuitable tool is used (for example lifting jack for a roll of paper), the object can be partially damaged.

Plants of this kind are usually equipped by some transporter, which connects all manufacturing operations along the production line. The production line is spread along the manufacturing hall. To move the commodity to the transporter, after one production step has been finished, and transport the object to the next position on the production line – this is a task for EasyMover.

Due to this fact, the workers use a simple mechanical device powered by compressed air to move heavy reels. However, the air pressure hose is the main disadvantage of this solution: The free movement is restricted. Our task is to develop the same device (EasyMover), powered by an electrical motor and supplied by accumulators.

2. THE PRINCIPLE OF OPERATION

The principle of the mechanism of the so called EasyMover is very simple. Its main part are two cylinders, connected to each other with tooth wells. The situation can be seen in Figure 1.

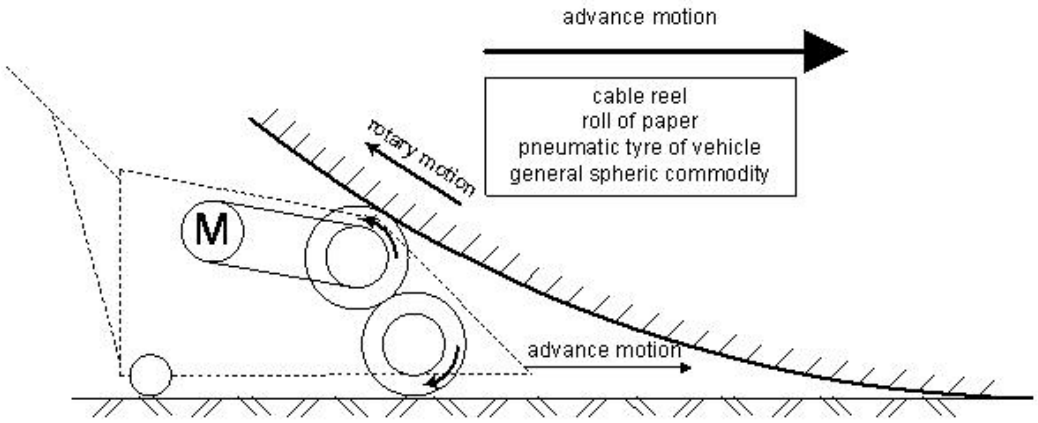

Fig. 1. EasyMover and the direction of rotation of cylinders

The bottom cylinder is in contact with the floor and its direction of rotation is given by moving forwards. Because the upper cylinder is connected to the bottom cylinder with the tooth wheel, its rotation has an opposite direction. In this way, the EasyMover is approaching to the object, for example the roll of paper.

Both cylinders surface is made from adhesive material. The bottom cylinder needs a high friction on the floor, the upper cylinder needs high friction with the roll of paper.

As the upper roll touches the roll of paper, its direction of rotation is trying to slide the EasyMover under the roll of paper. Due to this fact, the pressure force is increasing and the EasyMover slides under the roll. However, the roll of paper has no roadblock and starts moving forward itself. The resistance of the roll against the movement is given by the squash of the roll.

3. THE ELECTRIC MOTOR FOR EASY-MOVER

Due to the fact that the energy is stored in the accumulators, the first possibility is a DC motor. However, also the DC motor has several possibilities from which to choose. These possibilities are given by the connection of the excitation winding, or we can use a permanent magnet machine. When we use a serial excitation machine, we obtain a high starting torque. Unpleasant seems the no-load state where the enormous speed is dangerous not only for the motor, but also for the gear box.

Due to this fact the motor with permanent magnet excitation is used almost exclusively. The working cycle of the Easy Mover contains working breaks, and consequently, the motor can not be used to a much greater extent.

4. THE WORKING CYCLE

Based on industry experiences with the air-powered EasyMover, the following type of working cycle was determined by the would-be producer of EasyMover.

Starting current for 2 seconds 172,5 A. The resting time to one minute is the current 57,5 A. This loading is expected 20 times per one working day, i.e. for 8 hours. The time-distribution of this loading is expected as uniform.

As a follows from the first simulation of the determined working cycle, the temperature of the winding exceeds the allowed temperature already during the first period of the working cycle. After a few periods of the working cycle, the temperature is stabilized and therefore we can induce that a motor should optimally be 5 times bigger than it is.

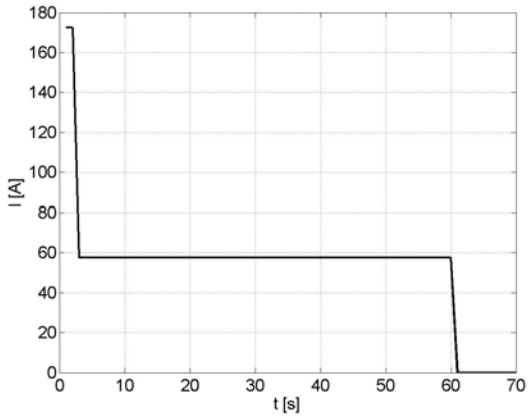

Fig. 2a. The detail of the current during one period of a working cycle

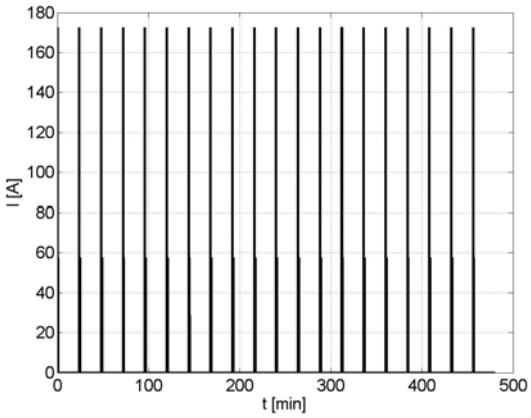

Fig. 2b. The current during 8 hours of working day

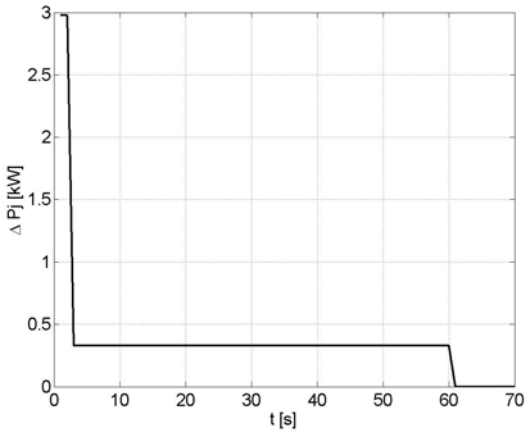

Fig. 3a. The power losses in the motor winding which mainly increase the motor temperature

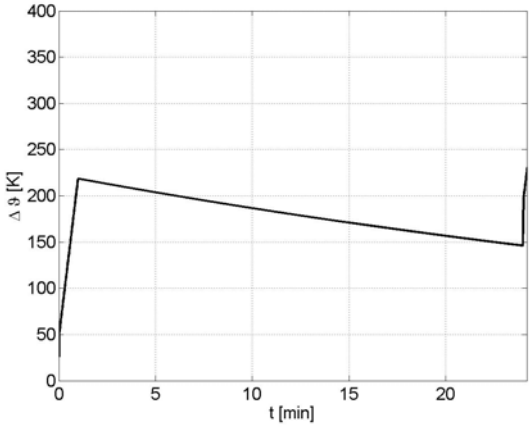

Fig. 3b. Warming of the winding. During this first period of the working cycle the machine would be destroyed!

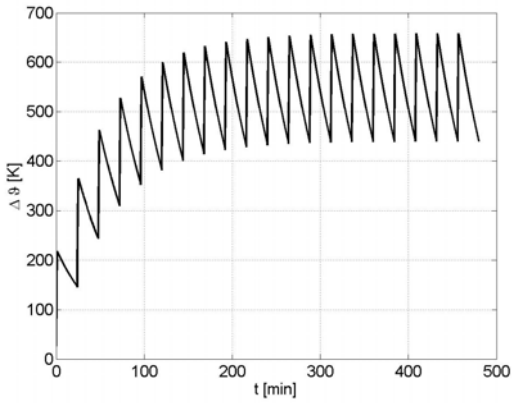

Fig. 4a. The temperature during complete period of working cycle. When the motor is stopped, the temperature decreases, however the next period of running starts too early. The temperature reaches up to 650 K

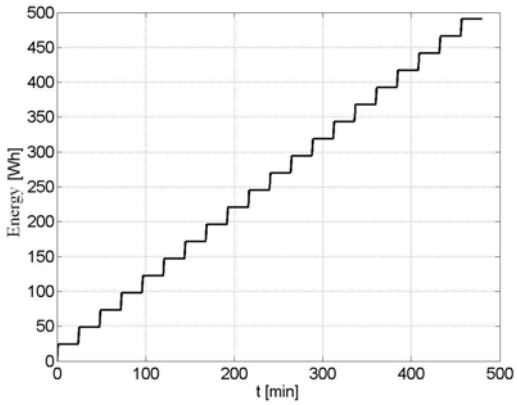

Fig. 4b. The energy demand to accumulators during 8 hours of working day

5. THE SOURCE OF ENERGY

The energy demand putting on accumulators is enormous, around 0,5 kWh. In addition, the starting current of the machine is approximately 200 A. Due to this fact the backup accumulators are not suitable for this purpose. After few months we discovered the special new industrial LiFePO accumulators.

a)

Fig. 5a. The industry accumulator contains in the one package 4 peaces of cells in serial connection.

b)

Fig. 5b. The cells can operate at any possition

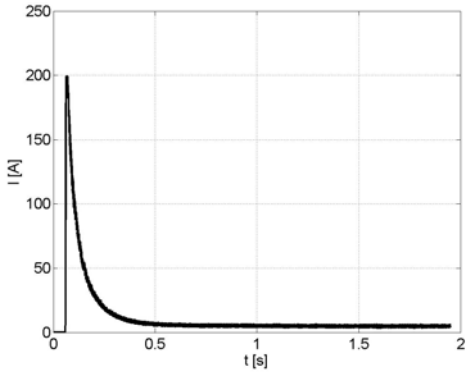

Fig. 6a. The motor starting current is up to 200 A

There are Lithium-Iron-Phospate industrial accumulators. Their capacity is up to 20 Ah and when we used 2 accumulators in serial connection, we reach the energy up to 0,48 kWh. Little-bit unpleasant is a nominal voltage, which is slightly higher with respect of lead accumulators in cars. The charger needs the voltage up to 16 V. Because we cannot use a conventional chargers, we developed our own charger.

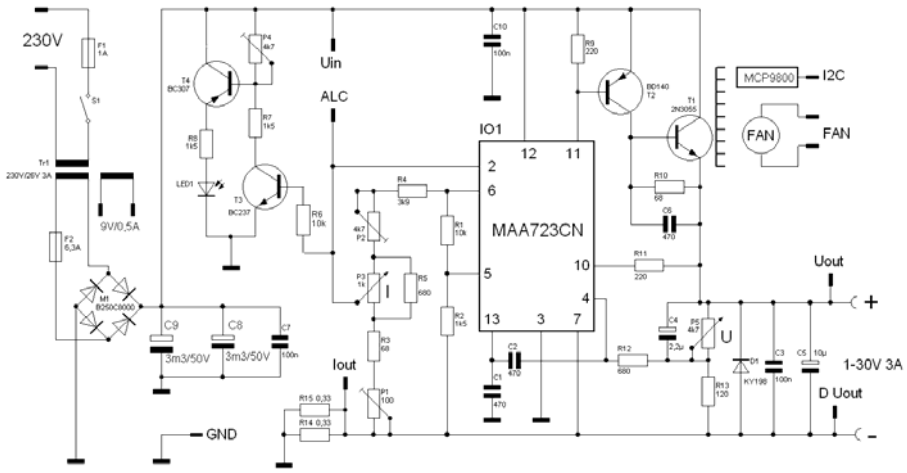

Fig. 6b. Scheme of connection of our charger

6. SOME ACCUMULATOR PARAMETERS

Nominal voltage	13 V
Operating voltage	11,5-14,8 V
Deep discharge voltage	11 V
Maximal charge voltage	16 V
Optimal / maximal / peak discharged current	10/60/200 A
Optimal / maximal / charged current	10/20 A
Weight	3,4 kg
Number of working cycles	2000

7. CONCLUSION

Should the simulated machine work in the factory, the working cycle would have to be changed. There are many possibilities, the following is one of them. Starting current for 2 seconds is the same – 172,5 A. For resting time (58 seconds), the current must be decreased to approximately 50%, i.e. 27,5 A. The working break for cooling has to be 2 times longer, i.e. 47 minutes. This can be arranged e.g. by using two pieces of EasyMover and their alternation. In any case, it should be considered as a disadvantage.

a)

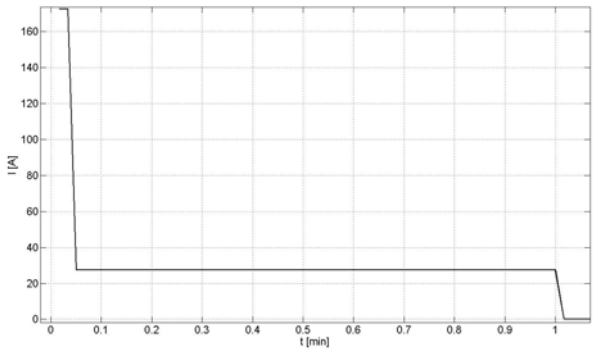

Fig. 7a. The detail of the changed current of the working cycle

b)

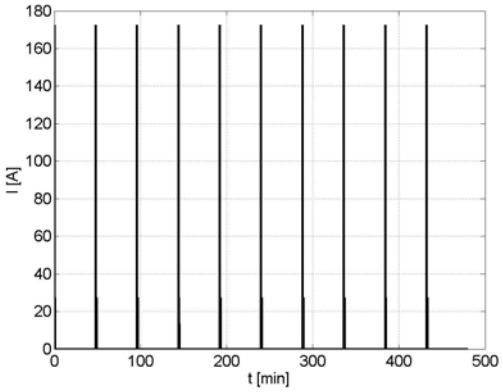

Fig. 7b. The changing current during 8 hours of working day

The EasyMover was designed for speed of free movement 0,6 $m.s^{-1}$. The motor has a power about 1 kW with the switch-on ratio 10%.

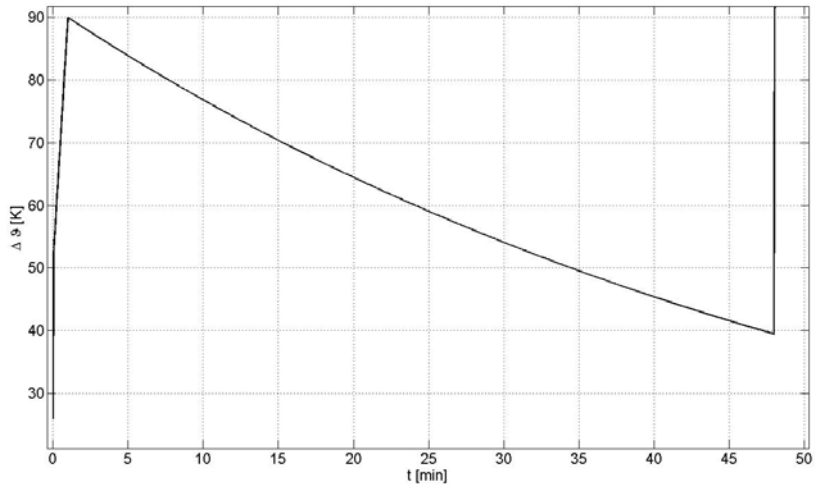

Fig. 8a. The warming up during the first period of the new working cycle

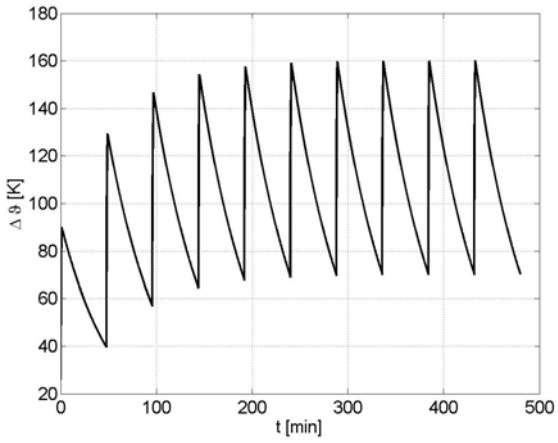

Fig. 8b. The warming up during 8 hours of a working day with the new working cycle

Acknowledgement

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LITERATURE

1. Skala B.: Study of the suitable machine for a EasyMover, Research work, Pilsen 2010.
2. Skala B.: Measurement on the EasyMover, Technical report, Pilsen 2010.
3. http://www.i4wifi.cz/lithium-high-power-battery-lifepo4-12v-20ah-packed-_d2099.html, valid April 1st, 2011.

4. Rafajdus P., Braciník P., Hrabovcová V.: The Current Transformer Parameters Investigation and Simulation, Journal of Electronics and Electrical Engineering, 4(100), Litva, 2010, 04, p. 29-32.

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PRÓBA OBCIĄŻENIA SILNIKA URZĄDZENIA DO PRZEMIESZCZANIA PRZEZ PRZETACZANIE (EASY MOVER)

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STRESZCZENIE *Maszyna nazwana „Easy Mover" oszczędza pracę, zwłaszcza w firmach produkujących ciężkie przedmioty, które można poruszać, tocząc je. Typowa rolka papieru waży 5 ton, zwój kabla 15 ton. Przemieszczanie takich obiektów w magazynach lub składach dystrybucyjnych siłami pracowników jest bardzo pracochłonne oraz niebezpieczne. W związku z tym robotnicy używają prostego urządzenia mechanicznego napędzanego sprężonym powietrzem, służącego do przemieszczania ciężkich krążków. Główną wadą tego rozwiązania jest przewód (wąż) wysokiego ciśnienia, który ogranicza swobodę ruchu. Naszym zadaniem jest opracowanie takiego urządzenia, które będzie napędzane silnikiem elektrycznym i zasilane prądem z akumulatora („Easy Mover").*