# Electronic Link Between the Needle Cylinder and the Dial of the Small Diameter Knitting Machine

**J. Skřivánek, M. Bílek, O. Baťka and M. Kašpárek**

**Abstract** The article is focused on verification of the applicability of individual drives in the design of small diameter knitting machines. The current arrangement of the drive ensures the mechanical transmission between the needle cylinder and the dial is via a central servomotor; this mechanical link raises limitations in terms of efficient utilisation of these elements of the machine. The new drive system eliminates the mechanical link and allows separate operation of the individual aggregates used in the knitting process. From the technical viewpoint, it is necessary to ensure compliance with the manufacturer's prescribed maximum deviation of rotation between the needle cylinder and dial during the working cycle. For this reason, the article discusses an experiment verifying the capability of the new drive system to achieve the above-stated rotation deviation.

**Keywords** Drive · Position · Knitting machine · Mechanical link · Knitting process

## 1 Introduction

Improvement of the mechanical structure of the machines is currently progressing far much more slowly and with much more difficulty than development in the areas of electronics, control and computer technology. This faster development of electronics creates an opportunity for deployment of electrical control drives on knitting

J. Skřivánek (✉) · M. Bílek · O. Baťka · M. Kašpárek
Technical University of Liberec, Liberec, Czech Republic
e-mail: josef.skrivanek@tul.cz

M. Bílek
e-mail: martin.bilek@tul.cz

O. Baťka
e-mail: ondrej.batka@tul.cz

M. Kašpárek
e-mail: michal.kasparek@tul.cz



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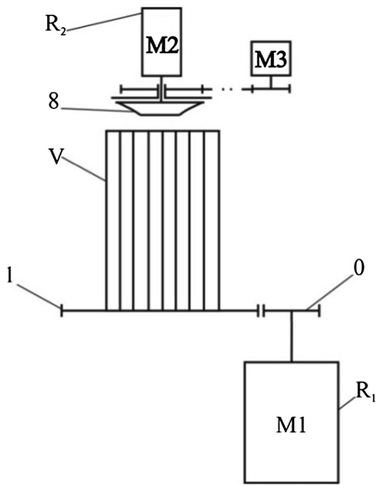
machines and hence elimination of mechanical transmissions. These transmissions are already at the limit of their possibilities and as compared to the past, they are becoming a limiting factor in the area of increase of dynamics and precision. Every small improvement of their properties is counterweighted by very high development costs and efforts, while in the electro-technical field, development is far much more dynamic. Further, when considering the trends to reduce not only the production, but also operating costs, the expansion of the electronic base of the machine pays off for many design applications since the use of long kinematic chains increases machine input while the power transmission efficiency declines. Further, the huge importance of the use of unit drives consists in the actual simplification of the design due to the reduction of mechanical transmissions [1, 2].

The article builds on the study solved in [3], where the first of the two basic knitting modes was examined, specifically, the return run of the already new knitting system in terms of the drive, resulting in the considerable simplification of the structure of the entire drive system, reduction of electric input and dynamic effects and achievement of higher efficiency in the use of the needle cylinder, dial and circular cutting blades. The cited modification of the system has a constraint consisting in the electronic replacement of the mechanical link since at present the transmission of power is, on standard basis, being realised through a system of gears and shaft, which ensure not only the transmission of the power to the needle cylinder and dial, but also their correct mutual setting, which is fundamental in the second basic knitting mode, specifically during synchronous rotation during the operation known as simultaneous transfer. The value of the maximum position deviation between the needle cylinder and the dial, in the relay of working speeds corresponding to the solved mode, should not reach more than 0.3° for this type of machine.

The arrangement of the drive in Fig. 1 shows the new structure of the small diameter knitting machines. From the viewpoint of the main drive, this drive can be

**Fig. 1** New drive system for small diameter knitting machines



divided into three basic driving aggregates. In the first aggregate, the needle cylinder (V) is driven by a servomotor (M1) and gears (0, 1). In the second, the servomotor (M2) drives the dial (8) and in the last, a stepped motor (M3) drives the circular cutting blade used to cut the ends of the threads. Since the article discusses only the motor synchronisation mode during the simultaneous transfer, the solved area is only focused on the drives (M1) and (M2) and the aggregates, which they drive. The replacement of the mechanical links with the electronic links was already solved in the past and described in articles [4, 5].

## 2 Test Equipment for Simulation of the Drive of a Small Diameter Knitting Machine

Figure 2 shows the test equipment, which consists of three main parts. Part one (1) is the power part and contains the drives on which the flywheels are installed (2 and 3). The second part (4) contains the power supply and control of the drives by means of frequency converters. The last part (5) is the controller, where the essential input parameters are entered via PC.

The test equipment in Fig. 2 is used to simulate two motion regimes, in which the knitting process runs. The first regime is the return run of the system based on the assumption of the required motion of the flywheel (2) according to the applied stroke dependence based on the entered position of the needle cylinder. In the second regime, i.e. steady rotational motion (synchronous run of the needle cylinder and dial), which is represented by the flywheel (3), the monitored parameter at the moment of deployment of the dial is compliance with the maximum position deviation at the constant rotation speed of both flywheels.

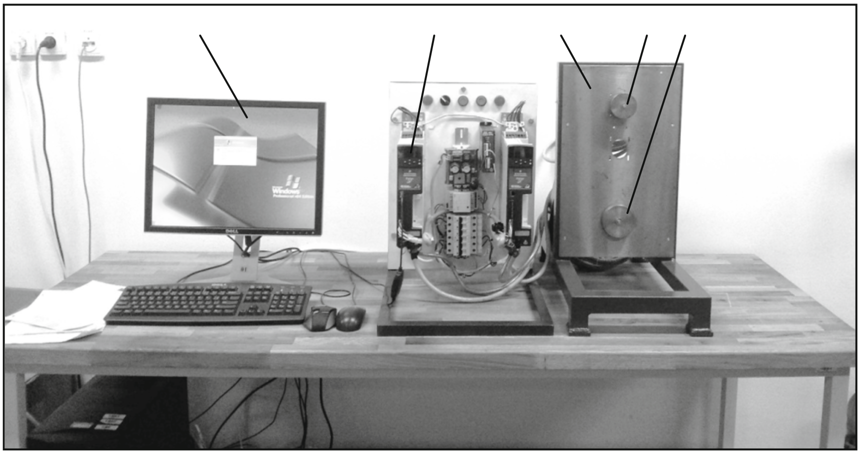


**Fig. 2** The apparatus used during the measurement—measurement workstation

The measuring equipment, unlike the real machine, does not have any gears. In order to affect this gear between the needle cylinder and the dial, flywheel (2) representing the needle cylinder rotates at six-fold the angular speed of the flywheel (3) representing the dial. The results obtained from the following measurements shall be related to the needle cylinder as the main working element using the gear between the needle cylinder and dial.

## 3 Measurement in Synchronous System Regime

Verification of the use of unit drives within the framework of modification of the drive of the small diameter knitting machine was done by measurement of the mutual position deviation between the needle cylinder and the dial at constant rotation speed of both components. During the measurements, various simultaneous transfer speeds typical for these machines were tested, i.e. from 100 to 220 rpm in steps of 20 rpm; for experimental reasons, the speeds of 300 and 400 rpm were tested. In the real case, the standard speeds are in the range of 160–200 rpm, where the specific speed is derived from the mechanical properties of the material used for knitting. The stepped build-up of machine speed was chosen for experimental reasons as an extreme state for the system and subsequent possibility to assess the stabilisation of the position deviations.

A demonstration of the behaviour of the position of the needle cylinder for a simultaneous transfer speed of 180 rpm is given in Fig. 3, which shows the overall measured behaviour and detailed part of the behaviour of the synchronisation of motion between the needle cylinder and the dial. The visualisation already includes the gears between these working elements.

Figure 4 shows the details of the behaviour of the position deviation at standard speed range during simultaneous transfer. It is possible to state that the servomotors are capable of maintaining the mutual position settings in relation to the maximum

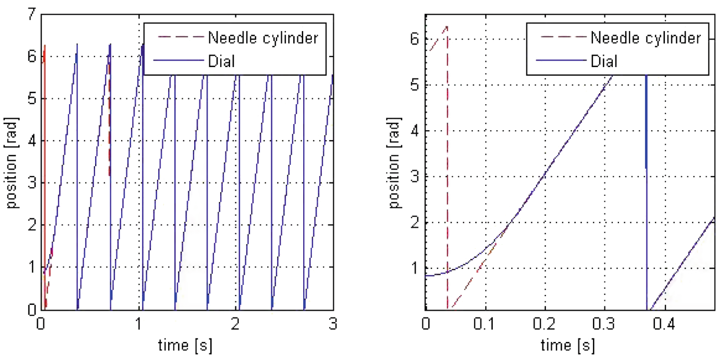



**Fig. 3** Behaviour of the position of the needle cylinder and dial at a speed of 180 rpm

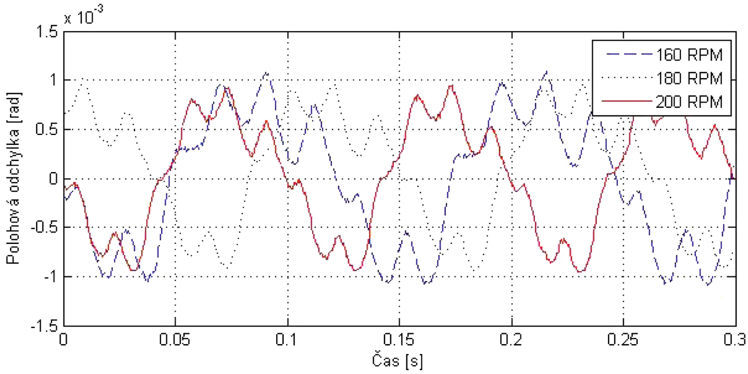



**Fig. 4** The behaviour of the position deviation of the needle cylinder and dial for the applied speeds

permissible deviation. In the real knitting machine system, a component of the drive is an in-line gear from the servomotor on the needle cylinder, thanks to which the resultant value is expanded by the value of tooth play in the gear.

# 4 Conclusions

Within the framework of the verification of the possibilities of application of virtual electronic cams to the new knitting machine structure, the possibility of precision synchronisation of two electronically linked drives with embedded virtual gearbox was experimentally verified. Precision was tested both in terms of the range of the normally used rotation speeds as well as at higher rotation speeds of the needle

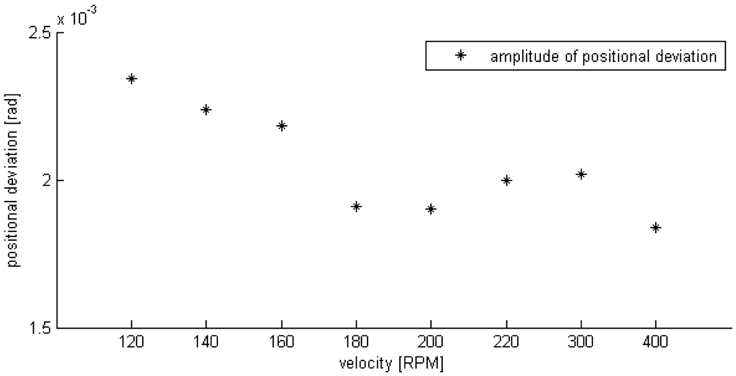



**Fig. 5** Dependence of the amplitude of the position deviation on a speed of 120–400 rpm, during simultaneous transfer, after settling of the transition phenomenon

cylinder (up to 400 rpm). With regard to the drives used with a working speed range of 4000 rpm, their suitability for use in low-speed applications with a requirement for high precision and uniformity of speed was proven. With increasing working drive rotations, the synchronisation deviation dropped and at the used speeds and higher speeds, the requirement for the maximum permissible deviation was fulfilled.

The graph in Fig. 5 clearly shows that the position deviation declined with increasing speed up to a speed of 180 rpm. This phenomenon can also be attributed to the more suitable operating conditions of the drives, particularly for the drive of the dial, which rotates at six-fold the speed of the drive of the needle cylinder.

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