

Measurement of Linear Parameters of Dielectric Filaments Based on the Corona Discharge

Aliya S. Tergeussizova, Shabden A. Bakhtaev, Waldemar Wojcik, Ryszard Romaniuk, Bekmurza H. Aitchanov, Gulzada D. Mussapirova, and Aynur Zh. Toygozhinova*

Abstract—On the basis of a unipolar corona discharge, a method of non-contact and continuous measurement of linear parameters of thin and ultra-thin dielectric fibres and optical fibres (10 to 125 microns) in the process of their manufacture was developed. The measurement method differs from the commonly known methods by high accuracy and reliability of measurement and resistance to changes in the electrical characteristics of the discharge gap and the state of ambient air.

Keywords—corona discharge, optical speed, optical fiber, measuring method, pulse signal, measuring accuracy, waiting mode

I. INTRODUCTION

THE unipolar corona discharge is base for a new method for contactless and continuous measurement of the pulling speed of thin and ultrathin dielectric filaments and optical fibers (10-125 microns) in the process of their manufacture. The measurement method differs from the known high accuracy and reliability of measurement and has noise immunity to changes in the electrical characteristics of the discharge gap and the state of the ambient atmospheric air. The main purpose of developing a device for measuring the speed of drawing dielectric threads is to ensure high accuracy and reliability of measurement when the indications of results are independent of changes in the electrical characteristics of the discharge gaps, the state of atmospheric air and the values of the geometric parameters of the dielectric filaments. The measurement of the speed of drawing dielectric threads is based on the principles of measuring velocities by the method of marks, which are preliminarily applied to moving objects, and then the speeds of their passage through various measuring instruments are determined. However, there are significant technical difficulties with marking when measuring the speed of movement of micro-objects, such as a dielectric thread or a microwire with enamel coating (10 to 100 microns). The proposed device for applying labels to a dielectric thread uses an outer corona discharge region that occurs when a sufficiently high voltage is applied between the corona wire and the outer plane-parallel electrode. In the outer corona discharge region, unipolar ions are usually present, which charge the surface of the dielectric filament. One

of the best ways to get a clear picture of electronic labels on the surface of a dielectric filament is to supply the discharge chamber with additional clock pulses of sufficient magnitude with a certain duration and frequency. In this case, the dielectric filament is located parallel to the corona wire and in the middle of the discharge gap between the wire and the flat electrode. Next, a dielectric filament with electronic marks passes through a second measuring electrode, located some distance from the first electrode. When the filament passes through the measuring electrode, there are processes of discharge of the filament and accordingly, electric signals with a clock frequency appear on the electrode load. Now, choosing the duration of the reference signals, in other words, choosing the counting time of the clock pulses during this time, the number of pulses determines the speed of thread pulling.

Equally important is the development of methods for measuring linear parameters (drawing speed and diameter) of moving dielectric filaments in the form of thin resistance wires with glass insulation of thin enamel wires and optical fibers. In this latter case, for example, one of the main stages of the process of manufacturing an optical fiber is pulling it on the drawing unit. It is established that oscillation of the diameter along the length of the fiber rod, in many respects, determines the optical and physical properties of the optical fiber (optical losses in the propagation of the signal, bandwidth, dispersion, etc.), and the scatter of the drawing velocities also significantly affect its strength and opto-physical properties [1].

A wide variety of electrode shapes and their location relative to each other, as well as the possibility of a corona discharge in atmospheric air, created the prerequisites for the development of a whole series of new methods and corona discharge transducers designed to measure the parameters of microwires and linear dimensions of various objects [2].

II. METHOD

Measurement of linear parameters of dielectric filaments. A method has been developed to control the inhomogeneity of moving dielectric filaments, which has high accuracy and reliability of measurements and is not affected by changes in the

Bakhtaev Shabden Abuovich is with Almaty University of Power Engineering and Telecommunications, Almaty, Kazakhstan (e-mail: b.shabden@aes.kz).

Waldemar Wójcik is with Lublin University of Technology, Lublin, Poland (e-mail: waldemar.wojcik@pollub.pl).

Ryszard Romaniuk is with Warsaw University of Technology, Poland (e-mail: r.romaniuk@ise.pw.edu.pl).

Aitchanov Bekmurza Husainovich is with Suleyman Demirel University, Almaty, Kazakhstan (e-mail: bekait@rambler.ru).

Tergeussizova Aliya Sovetzhonovna is with Kazakh National University named after al-Farabi, Almaty, Kazakhstan (e-mail: aliya55@mail.ru).

Mussapirova Gulzada Dauletbekovna is with Almaty University of Power Engineering and Telecommunications, Almaty, Kazakhstan (e-mail: mgulz1@yandex.kz).

Toygozhinova Aynur Zhumakhanovna is with Kazakh Academy of Transport and Communications named after M.Tynyspayev, Almaty, Kazakhstan (e-mail: aynur_t@mail.ru).



state of atmospheric air and the magnitude of the thread pulling speed [3,4]. When controlling the inhomogeneity of a moving dielectric filament, two series-connected corona discharge zones with oppositely space charges are used. The use of a common for two zones of a corona electrode in the form of wire ensures uniform distribution of space charges and their opposite polarity in two zones of measurement of the object. Due to the presence of the effect of stabilization of the discharge current when the two zones of the corona discharge are connected in series, the effects of changes in atmospheric air on the control accuracy of the object are also insignificant. To exclude the effect of a change in the speed of movement of the filament on the measurement accuracy, the density of the space charge in the corona discharge zone is established in accordance with Pauthenier's [5] theory of the "limit charge" of a dielectric object in the discharge zone, taking into account its dielectric constant and speed.

Figure 1 shows the functional diagram of the device. The device contains annular measuring electrodes 1 concentrically covering the common corona electrode in the form of a wire 2, a high-voltage power source with a constant stabilized output voltage 3, a load resistance 4 and a voltmeter 5. The controlled dielectric filament 6 is pulled through the outer corona discharge zones 7, where the highest uniform distribution of space charge.

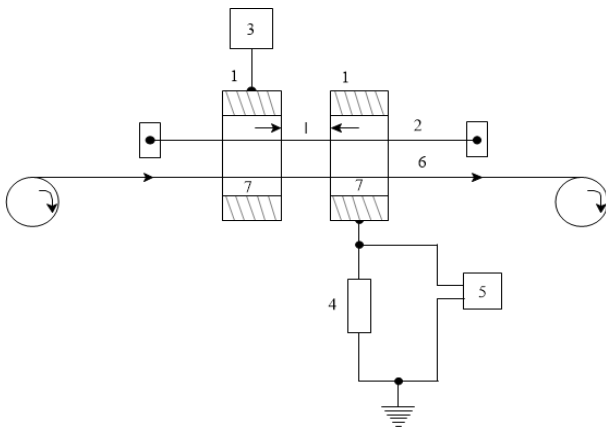


Fig.1. Functional diagram of the device for controlling the inhomogeneity of moving dielectric filaments

When a sufficiently high voltage 3 is applied to one of the measuring electrodes 1 between the corona wire 2 and the external electrode 1, a corona discharge arises with a space charge of the opposite sign of the polarity of the voltage of the power source 3. Subsequently, because the corona wire 2 is insulated, it begins to crown on the second measuring electrode 1, connected through the load resistance 4 to the ground bus, in which case the space charge has a reverse sign to the first one. The controlled dielectric filament, passing through the first zone of the discharge, is charged up to the "maximum charge", which leads to a decrease in the corona discharge current due to the carrying of charges from the zone. Next, the charged filament enters the second discharge zone, where there is a space charge of another sign and the charges on it are neutralized, reducing the corona discharge current. After neutralization of the charges on the dielectric filament, perhaps with sufficient time, charging it to the "ultimate charge", but now with the opposite sign. Thus, in the case of discharge processes according to the "charging (+

or -)" neutralization – charging (–or +) scheme, a generally repeated (threefold) increase in the accuracy of measuring the inhomogeneity (diameter) of a moving thread occurs, since the "ultimate charge" with a constant dielectric material permeability will, first of all, depend on the size, surface area of the thread, i.e. from its diameter.

The inner diameter of the ring measuring electrodes is 1.5cm, the working length is 1cm, the gap between them is $l = 0.25$ cm, the diameter of the discharge electrode is 100 microns, the load resistance is 10 k Ω , the high voltage is 8 kV, the operating current is 10 μ A. Copper wires with an enamel coating in the range of diameter 400–500 microns were tested as dielectric threads.

Experimental measurements have shown that changes in atmospheric air pressure within ± 10 kPa and wire pulling speeds up to 100 m/min do not significantly affect the accuracy of measuring the diameter of the wire, which is approximately 1–2% of the measured diameter of the wire. The obtained accuracy of measuring the diameter of a moving wire corresponds to a calibration curve constructed from the values of wire diameters in the range of 400–500 microns, measured in stationary conditions.

Close to the technical essence, the proposed device is a known device for controlling the inhomogeneity of moving dielectric threads [3], containing two ring electrodes concentrically surrounding the common corona wire electrode, high voltage power supplies with a constant stabilized output voltage, a load resistance and a voltmeter constant current, the controlled dielectric filament being pulled through the outer corona discharge zone, where the uniformity of the distribution volume charge is the highest. In this device, due to the presence of the discharge current stabilization effect when the two corona discharge zones are connected in series, the effect of the change in the state of atmospheric air on the accuracy of the object control will be negligible. In fact, the effects of the change in the state of atmospheric air on the discharge currents in the two electrodes can differ substantially. Since, at identical voltages on the electrodes, the negative corona discharge proceeds more efficiently and besides, it is established that when the microelectrodes of negative polarity are corrupted there is always a pulsed discharge regime [2]. The proposed device also does not take into account the effect of the difference in the edge effects of the two electrodes. All this can greatly reduce the accuracy of measuring the device.

The main distinguishing feature of the proposed device is that in all three electrodes, the initial portion of the volt-ampere characteristic of the positive corona discharge is used when the corona discharge is in the "waiting" mode, and the charging by ions of the surface of the moving dielectric filament occurs when additional pulses of negative polarity are fed to the middle electrode the form of half-waves of sinusoidal voltage. In this case, the middle electrode is covered on both sides by electrodes of similar shape and size, which excludes the effect of edge effects on this electrode when pulsed charging of the thread.

Figure 2 shows the functional diagram of another device for measuring the diameter of a dielectric filament in the process of pulling it [5]. The device contains three plane-parallel electrodes 1, 2, 3 identical in shape and size and located at predetermined

distances, corona wire 4, controlled dielectric thread 5, a high-voltage power source with negative polarity at the output 6, source of unipolar pulses 7, the amplitude detector 8 and a DC voltmeter 9. 10 denotes the rewind unit. The supply of pulse signals to high-voltage points of the measuring circuit is carried out by high-voltage capacitors C_1 and C_2 , and they are also removed through capacitor C_3 . The stabilization of the electrical characteristics of the corona discharge in the electrodes and the creation of the condition of the “waiting” mode are ensured by the means of high-resistance resistances R_1 , R_2 , R_3 and selection of high voltage values. 4 shows a diagram of a source of unipolar pulses, consisting of a step-up transformer Tr with a midpoint in the second winding and two amplitude converters (D_1 R_4 and D_2 R_5). It produces two types of unipolar pulses for additional power supply of electrodes 1 and 2.

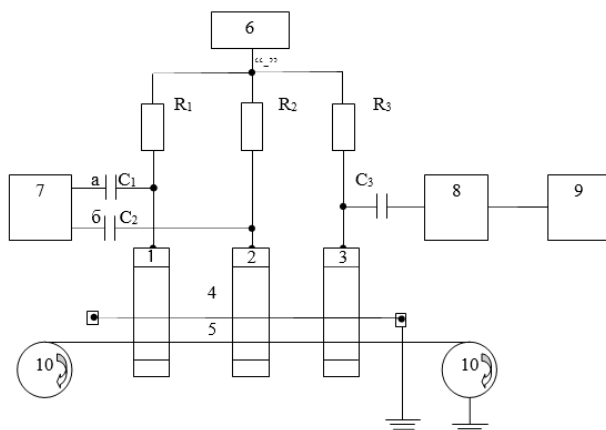


Fig.2. Functional diagram of the device for measuring the diameter of the dielectric filament

When a sufficiently high voltage of negative polarity is applied to external electrodes, conditions are created for the occurrence of a positive corona discharge between them and wire 4. Then, by adjusting the values of high voltage 6 and using high-resistance $R_1 - R_3$, they achieve a “waiting” mode in all bit intervals. After that, from the source of unipolar pulses, pulses of negative polarity are fed through C_1 to the middle electrode 2 in the form of a half-wave of sinusoidal voltage. In this case, in the discharge gap of the electrode 2, a pulsed corona discharge arises, which charges the surface of the dielectric filament 5 in the outer zone of the discharge with positive ions. Due to the transience of the transition of the discharge gap ions ($20 - 30\mu s$) during the half-wave of the sinusoidal voltage, the dielectric thread has time to be charged to the “maximum charge” in accordance with the Pauthenier theory [5]. According to this theory, it has been established that the “ultimate charge” of a moving thread with a constant dielectric constant of the material will, first of all, depend on the size of the surface area of the thread, i.e. from its diameter. Charged dielectric filament enters the electrode 3, which is in the “standby” mode and is discharged there. When the filament is discharged at the load R_3 of the electrode 3, pulsed signals proportional to the “limit charge” of the filament appear.

The pulse signals are converted in the amplitude detector to a constant voltage, which is measured by a DC voltmeter. The

graduation of the scale of the voltmeter is made in advance by the known standard diameters of the dielectric filament. One of the differences of the device is that simultaneously with the half-wave negative polarity of the sinusoidal voltage applied to the electrode 2, a half-wave of positive polarity is applied to the electrode 1, while the discharge gap of the electrode 1 is closed and the charging of the filament by the “dark” current of the corona discharge that is “Standby” mode.

The device has the following parameters: plane-parallel electrodes have a width of 1.5 cm, the working length is 1 cm, the gap between them is 0.1 cm, the diameter of the corona wire of tungsten is 100 microns, the controlled filament is located at a distance of 0.3 cm from the outer surface electrode, ballast resistances R_1 , R_2 , R_3 were equal 0.1Ω and capacitors C_1 , C_2 , C_3 of $1\mu F$. The VS-22 type was used as the high-voltage power supply.

Experimental measurements have shown that changes in the state of ambient atmospheric air and the speed of a moving thread do not have a significant effect on the accuracy of measuring the diameter of the thread, which was about 1 – 2% of the measured diameter. The obtained accuracy of measuring the diameter of the thread corresponds to a calibration curve constructed from known standard diameters in the range of 20 to 100 microns.

The main distinguishing feature of the proposed device is that in all three electrodes, the initial portion of the volt-ampere characteristic of the positive corona discharge is used when the corona discharge is in the “waiting” mode, and the charging by ions of the surface of the moving dielectric filament occurs when additional pulses of negative polarity are fed to the middle electrode the form of half-waves of sinusoidal voltage. In this case, the middle electrode is covered on both sides by electrodes of similar shape and size, which excludes the effect of edge effects on this electrode when pulsed charging of the thread.

The basis of measuring the speed of pulling dielectric threads based on the principles of measuring speeds using the method of labels, which are applied to moving objects in advance, and then determine the speed of their passage with the help of various measuring devices. However, there are significant technical difficulties with applying labels when measuring the speed of movement of micro-objects, such as a dielectric filament or microwire with an enamel coating (10–100 microns).

The developed device for applying labels to a dielectric filament uses the external area of a corona discharge that occurs when a sufficiently high voltage is applied between the corona wire and the external plane-parallel electrode. In the outer corona discharge region, unipolar ions are usually present, which charge the surface of the dielectric filament. One of the best ways to obtain a clear picture of electronic marks on the surface of a dielectric filament is to feed additional discharge pulses to the discharge chamber of sufficient magnitude with a certain duration and frequency. At the same time, the dielectric filament is located parallel to the corona wire and in the middle of the discharge gap between the wire and the flat electrode. Then, the dielectric filament with electronic tags passes through the second measuring electrode, located at some distance from the first electrode. As the filament passes through the measuring

electrode, the processes of filament discharge occur and, accordingly, electrical signals with a frequency of clock pulses appear on the electrode load. Now, choosing the duration of the reference signals, in other words, choosing the counting time of the clock pulses during this time, the speed of the thread pulling is determined by the number of pulses.

The main purpose of developing a device for measuring the speed of drawing dielectric threads is to ensure high accuracy and reliability of measurement when the indications of results are independent of changes in the electrical characteristics of the discharge gaps, the state of atmospheric air and the values of the geometric parameters of the dielectric filaments.

Previously, a method has been developed for measuring the speed of pulling a microwire [6,7], which contains two additional ring electrodes identical in shape and size located coaxially on both sides of the main electrode, and the balance circuit with an output device, containing the main ring electrode surrounding the monitored wire. In this device, due to the appearance of an electro-gas dynamic effect near the surface of a moving wire, processes of entrainment and the introduction of space charges into the discharge zones of additional electrodes arise, which ultimately allows us to judge the values of the speed of wire drawing. In this device, it is noted that the use of a balanced measurement scheme significantly reduces the errors in measuring the speed of wire drawing with changes in electrical characteristics of discharges and geometric parameters of the corona wire. Meanwhile, due to the different location of the additional electrodes, which are essentially measuring, the changes in temperature and pressure of the ambient air can have a significant effect on the accuracy of the measurement. In addition, the proposed device also does not take into account the effect of the difference in edge effects in two additional electrodes. In addition, because of the impossibility of replacing the corona wire with a dielectric thread, this device is not suitable for our purposes.

The measurement of the speed of drawing dielectric threads is based on the principles of measuring velocities by the method of marks, which are preliminarily applied to moving objects, and then the speeds of their passage through various measuring instruments are determined [2]. However, there are significant technical difficulties with marking when measuring the speed of movement of micro-objects, such as a dielectric thread or a microwire with enamel coating (10 - 100 microns).

The proposed device for applying labels to a dielectric thread uses an outer corona discharge region that occurs when a sufficiently high voltage is applied between the corona wire and the outer plane-parallel electrode. In the outer corona discharge region, unipolar ions are usually present, which charge the surface of the dielectric filament. One of the best ways to get a clear picture of electronic labels on the surface of a dielectric filament is to supply the discharge chamber with additional clock pulses of sufficient magnitude with a certain duration and frequency. In this case, the dielectric filament is located parallel to the corona wire and in the middle of the discharge gap between the wire and the flat electrode. Next, a dielectric filament with electronic marks passes through a second measuring electrode, located some distance from the first electrode. When the filament passes through the measuring

electrode, there are processes of discharge of the filament and accordingly, electric signals with a clock frequency appear on the electrode load. Now, choosing the duration of the reference signals, in other words, choosing the counting time of the clock pulses during this time, the number of pulses determines the speed of thread pulling.

To improve the accuracy of measurement and reliability of results, as well as to increase the noise immunity of the measurement to changes in the characteristics of the corona discharge and the geometric parameters of the measured dielectric filament, a positive corona discharge is used in both electrodes, its initial section of the current-voltage characteristic when the corona discharge is in "standby" mode or a small discharge current flows (not more than $1 \mu\text{A}$). The choice of positive corona discharge is due to the fact that it has high stability of the characteristic and there are no electron avalanche processes that form the random pulses of Trichel [8, 9]. As clock pulses for the application of electronic tags, rectangular pulses in the form of a "meander" shape are chosen for the filament, which close the discharge gap with a positive half-wave, and in the other half-wave create pulsed discharges that charge the moving dielectric filament.

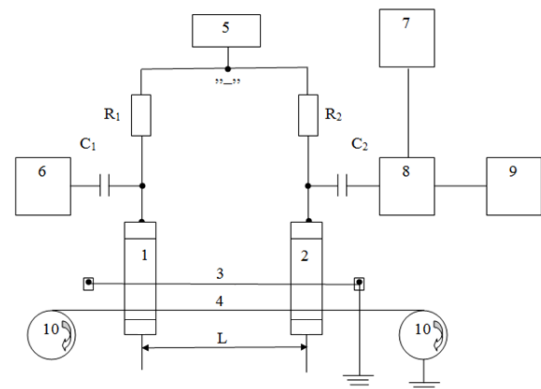


Fig.3. Functional diagram of the device for measuring the speed of pulling the dielectric thread

Figure 3 shows the functional diagram of the device for measuring the speed of pulling a dielectric filament during its manufacture. The device contains two identical electrodes of a plane-parallel form, which coaxially cover the corona wire and are located at a given distance from each other. The controlled dielectric filament passes through the discharge zone of the corona discharge. In our case, a high-voltage power supply with negative polarity at the output is used, which allows obtaining a positive corona discharge in the discharge gap between the electrodes and the wire. The stabilization of the characteristics of the corona discharge in two discharge chambers and the creation of conditions of the "standby" mode are achieved with the help of high-resistance ballast resistances. In addition, the device contains two pulse signal generators: one high-frequency clock and the reference pulses. The supply and removal of pulse signals to high-voltage points of the circuit are carried out by high-voltage capacitors. The output signal from the measuring electrode enters the electronic unit 8 and after conversion is transmitted to the pulse counter. The electronic unit consists of a pulse shaper and an electronic key.

Where 1,2 is two identical planar-parallel electrodes, 3 is the corona wire, 4 is the dielectric thread, 5 is the power source, 6 is the high-frequency clock generator, 7 is the low-frequency reference pulse generator, 8 is the electronic unit, 9 is the pulse counter, 10 – the rewind unit.

When a sufficiently high voltage of negative polarity is applied to the plane-parallel electrodes 1 and 2, the conditions for the occurrence of a positive corona discharge between them and the wire 3 are established. and 2. Then, on the electrode 1 from the clock pulse generator 6, rectangular pulses are fed through C1 in the form of a “meander” and, with a negative half-wave, flows through the discharge gap imp pulse corona discharge, which provides charging of the dielectric filament 4, located in the discharge zone. With the “standby” discharge mode, the operating point is located at the initial part of the current-voltage characteristic of the corona discharge and therefore, a positive half-wave of clock pulses closes the discharge gap, which allows cleaning the discharge zone and the surface of the dielectric filament from extraneous charged particles. When pulling the dielectric thread with electronic labels enters the second measuring electrode 2, where it is discharged and at the same time on the load of the electrode R2 appear pulse signals with a frequency of clock pulses. These pulses through C2 are fed to the input of the electronic unit 8, consisting of a pulse shaper 1 and an electronic key 2 (Figure 4 (b)). They in the pulse shaper 1 are converted into a convenient form for the pulse counter and enter the electronic key 2. The electronic key 2 only passes them when the reference signal from generator 7 is applied to it and in time equal to the duration of the reference signal. The pulse counter 9 shows the number of pulses transmitted through the electronic key, which will be proportional to the speed of the thread pulling. Thus, it becomes possible to carry out the calibration of the pulse counter from the previously known values of the pulling speed of the dielectric filament, measured in stationary conditions with control devices with higher measurement accuracy.

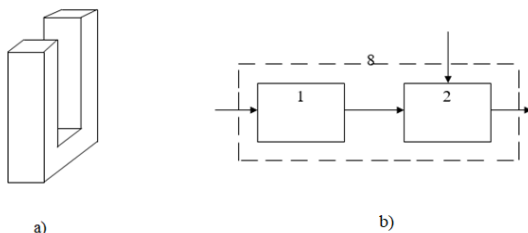


Fig.4. The shape of the electrodes a) and the electronic unit b), where 1 is a pulse shaper, 2 is an electronic key

When a sufficiently high voltage of negative polarity is applied to the plane-parallel electrodes, conditions are created for the occurrence of a positive corona discharge between them and the wire. If there are two high-resistance ballast resistances and adjusting the high voltage values, the “standby” mode is set in two discharge gaps. Then, on the first electrode from the clock pulse generator, rectangular pulses are sent in the form of a “meander” through a high-voltage capacitor and, with a negative half-wave, a pulsed corona discharge flows through the discharge gap, which ensures charging of the dielectric filament in the discharge zone. In the “standby” discharge mode, the

operating point is located at the initial part of the current-voltage characteristic of the corona discharge and therefore, a positive half-wave of clock pulses closes the discharge gap, which allows cleaning the discharge zone and the surface of the dielectric filament from extraneous charged particles. When pulling the dielectric thread with electronic labels enters the second measuring electrode, where it is discharged and at the same time, pulse signals with a frequency of clock pulses appear on the electrode load. These pulses through a high-voltage capacitor are fed to the input of the electronic unit, consisting of a pulse shaper and an electronic key. They are converted into a convenient form for a pulse counter in the pulse shaper and fed into an electronic key. The electronic key skips them only when the reference signal from the generator is fed to it and in a time equal to the duration of the reference signal. The pulse counter shows the number of pulses transmitted through the electronic key, which will be proportional to the speed of the thread pulling. Thus, it becomes possible to carry out the calibration of the pulse counter by the previously known values of the pulling speed of the dielectric filament, measured in stationary conditions with control devices with higher measurement accuracy.

Due to the fact that the electronic tagging method usually works using the “0 or 1” algorithm, which means there is a signal or not, in principle, it is possible to eliminate the influence on the measurement accuracy of changes in a number of parameters of a measuring device, for example, changes in the electrical characteristics of a corona discharge, the state of the ambient air and the geometric dimensions of the controlled filament. If in this way the methodological error of measurement is minimized, then the rest of the measurement error will be determined by the instrumental error of the measuring devices used in the device. Somewhat easier is the fact that the measurement accuracy of the standard equipment used is known in advance or there is a possibility of their choice.

The device has the following parameters: plane-parallel electrodes are 1.5 cm wide, the working length is 1 cm, the gap between them is $L = 2$ cm, the diameter of the corona wire from tungsten is 100 microns. The controlled filament is located at a distance of 0.3 cm from the surface of the external electrode. The ballast resistance was 1 m Ω , high-voltage capacitors of 1 microfarad each. A high voltage source of the VS-22 type was used to power the discharge chambers. Sources of pulse signals were generators. $\Gamma 5-88$ ($f = 1$ kHz, $U = 100$ V) and $\Gamma 5-72$ ($f = 1$ Hz, $U = 10$ V).

Experimental tests of the device were carried out on a rewinding unit with a limit of change of the rewind speed up to 30 m/min. Copper wires with an enamel coating in the range of diameters of 20–100 microns were tested as dielectric threads. Experimental measurements showed that changes in atmospheric air pressure within ± 20 kPa and wire diameter of ± 10 microns do not affect the accuracy of measuring the speed of pulling a dielectric thread, which was about 1–2% of the measured speed. The obtained measurement accuracy of the pulling speed of the dielectric filament corresponds to a calibration curve constructed from the values of pulling speeds in the range of 1–30m/min, measured in stationary conditions.

III. CONCLUSIONS

Based on the impulse characteristics of a unipolar corona discharge, a method and device have been developed for contactless and continuous measurement of the linear parameters of dielectric optical fiber filaments, the use of which provides automatic control and management of the optical fiber manufacturing process.

Based on the pulse characteristics of a unipolar corona discharge, a device has been developed for contactless and continuous measurement of the diameter of moving dielectric filaments, including optical fibers (10 to 125 microns) in the process of their manufacture. To develop the device, the initial part of the current-voltage characteristic of the positive corona discharge in the electrodes was used, when the corona discharge was in the "waiting" mode, and the surface ions of the moving dielectric filament were charged by applying additional pulses of negative polarity to the electrodes. The main distinguishing feature of the proposed device is that in all three electrodes, the initial portion of the volt-ampere characteristic of the positive corona discharge is used when the corona discharge is in the "waiting" mode, and the charging by ions of the surface of the moving dielectric filament occurs when additional pulses of negative polarity are fed to the middle electrode the form of half-waves of sinusoidal voltage. In this case, the middle electrode is covered on both sides by electrodes of similar shape and size, which excludes the effect of edge effects on this electrode when pulsed charging of the thread. Experimental measurements have shown that changes in the state of the ambient air and the speed of the moving filament do not significantly affect the accuracy of measuring the diameter of the filament, which amounted to about 1 - 2% of the measured diameter. The resulting accuracy in measuring the diameter of the filament corresponds to a calibration curve constructed from known standard diameters in the range 20-100 microns. Methods and devices for contactless and continuous measurement of linear parameters (diameter) of dielectric threads of optical fiber are developed, the application of which provides automatic control and control of the technological process of manufacturing of optic fiber.

On the basis of the unipolar corona discharge, a method has been developed for contactless and continuous measurement of the pulling speed of thin and ultrathin dielectric filaments and optical fibers (10-125 microns) in the process of their manufacture. The measurement method differs from the known high accuracy and reliability of measurement and has noise immunity to changes in the electrical characteristics of the discharge gap and the state of the ambient atmospheric air. The main purpose of developing a device for measuring the speed of drawing dielectric threads is to ensure high accuracy and reliability of measurement when the indications of results are independent of changes in the electrical characteristics of the discharge gaps, the state of atmospheric air and the values of the geometric parameters of the dielectric filaments. The

measurement of the speed of drawing dielectric threads is based on the principles of measuring velocities by the method of marks, which are preliminarily applied to moving objects, and then the speeds of their passage through various measuring instruments are determined [3]. However, there are significant technical difficulties with marking when measuring the speed of movement of micro-objects, such as a dielectric thread or a microwire with enamel coating (10 to 100 microns). The proposed device for applying labels to a dielectric thread uses an outer corona discharge region that occurs when a sufficiently high voltage is applied between the corona wire and the outer plane-parallel electrode. In the outer corona discharge region, unipolar ions are usually present, which charge the surface of the dielectric filament. One of the best ways to get a clear picture of electronic labels on the surface of a dielectric filament is to supply the discharge chamber with additional clock pulses of sufficient magnitude with a certain duration and frequency. In this case, the dielectric filament is located parallel to the corona wire and in the middle of the discharge gap between the wire and the flat electrode. Next, a dielectric filament with electronic marks passes through a second measuring electrode, located some distance from the first electrode. When the filament passes through the measuring electrode, there are processes of discharge of the filament and accordingly, electric signals with a clock frequency appear on the electrode load. Now, choosing the duration of the reference signals, in other words, choosing the counting time of the clock pulses during this time, the number of pulses determines the speed of thread pulling.

REFERENCES

- [1] G.M. Kondratiev, G.N. Dulnev, E.S. Platunov, N.A. Yaryshev, "Applied physics: Heat transfer in instrument engineering." St. Petersburg: St. Petersburg State University of Information Technologies, Mechanics and Optics. IVA, 2003.
- [2] Sh.A. Bakhtaev, A.A. Bokanova, G.V. Bochkareva, G.K. Sydykova, "Physics and technology of corona discharge devices," Almaty, 2007.
- [3] M.A. Abishev, Sh.A. Bakhtaev, G.V. Bochkareva, Z.A. Baymakanova, T.S. Titova, "Method for controlling the inhomogeneities of moving dielectric filaments," *Provisional patent of the Republic of Kazakhstan* №12030, Published on 16.09.2002, IPC G01 B7/12.
- [4] T. Abiru, F. Mitsugi, T. Ikegami, K. Ebihara, S. Ichi Aouki, K. Nagahama, "Environmental application of electrical discharge for ozone treatment of soil," *Informatyka, Automatyka, Pomiar w Gospodarce i Ochronie Środowiska*, vol. 5, no. 4, pp. 42-44, 2015, <https://doi.org/10.5604/20830157.1176573>.
- [5] K. Adamiak, "Rate of charging of spherical particles by monopolar ions in electric fields," *IEEE Transactions on Industry Applications*, vol. 38, no. 4, pp. 1001-1008, July-Aug. 2002, doi: 10.1109/TIA.2002.800562.
- [6] Sh.A. Bahtaev et al., "Ustrojstvo dlja izmerenija skorosti protjazhki dijelektricheskijh nitej," *Patent na poleznuju model'* № 2018/0174.2, Published Bull. №44, 23.11.2018.
- [7] Sh.A. Bahtaev et al., "Ustrojstvo dlja izmerenija diametra dvizhushhihsja dijelektricheskijh nitej," *Patent na poleznuju model'* № 2018/0175.2, Published Bull. №46, 17.12.2018.
- [8] Y. Zhang, Q. Xia, Z. Jiang, et al., "Trichel pulse in various gases and the key factor for its formation," *Sci Rep* 7, 10135, 2017. <https://doi.org/10.1038/s41598-017-10118-2>
- [9] V.M. Ilinskiy, "Non-contact measurement of consumption," *Moscow: Energia*, 1970, pp. 5-28.