DETERMINATION OF COMFORT PRESSURE OF SHOES ON HUMAN FEET

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Abstract: *The need to wear comfortable shoes has always been a topical issue for the consumer, but in mass factory production it is not always possible to meet the criteria of shoe comfort for each user due to the individual structure and biomechanical characteristics of his foot. To preserve the natural anatomical structure of the foot in its satisfactory functioning, it is necessary to provide comfort and protect the foot from the environment during the operation of the shoe. On the basis of the comparative analysis of results of anthropometric researches of feet and subjective feelings of footwear comfort the expediency to perfect the footwear designing process by the individual order with the use of a universal shoe model-transformer is proved. These studies provide an opportunity to explore the subjective feelings of foot comfort in footwear, and ensure the production of high quality shoes to individual order using the universal shoe model transformer and a computer system based on an Arduino Uno microcontroller. The results of studies of individual sensations of pressure on the feet by shoes in the state of standing and walking are presented. A study of a two-factor experiment of the dependence of pressure parameters at anthropometric points of the rise and the heel of the foot is presented. The regression equation of the dependence of the shoe comfort level on pressure acting on the foot is obtained. The mathematical model of fitting the shoe model-transformer on the foot is presented.*

Keywords: *anthropometric parameters of the foot, materials, comfort, model-transformer, shoes, computer system, pressure, modulus of elasticity.*

1 INTRODUCTION

From the theory and practice of shoe production it is known that the manufacture of high quality shoes at the level of world trends is one of the main tasks of the fashion industry. The success of the manufacturer and its competitiveness largely depends on the quality of raw materials and components. However, it should be remembered that the rational design, comfort of the product and the microclimate of the foot inside the shoe are the main factors in shaping the requirements for shoes and they must meet international standards. The products are improved annually under the influence of fashion trends, changes in the designer's worldview, as well as according to the development of science and technology. But at each stage of production, raw materials, components and products, as the final product of production, must meet the needs, desires and professional requirements of the consumers at minimal cost.

The best material of shoe uppers is traditionally considered to be natural leather, which provides comfort and high reliability of the product during operation. However, the high cost of raw materials of natural origin gives rise to a significant cost of the resulting products. Today, in the world practice, synthetic leathers and knitted fabrics are widely used to make the uppers of shoes along with natural leather. One of the best knitted materials for making summer shoe uppers is CORDURA AFT® [1]. It is a knitted material made of high-strength polyester and polyamide threads with high resistance to abrasion, tearing and repeated bending. Microfiber leather is made of polyester and polyamide fiber and polyurethane. Microfiber is artificial leather developed by CLARINO [2] a division of Kuraray Co., Ltd., which is a world leader in the production of microfiber nonwovens and continues to be a leading innovator in the production of synthetic leather. CLARINO materials have a wide range of colors, properties and thicknesses. This artificial leather can be used to make the top of special, sports and casual shoes, and can also be used to make the lining. It is resistant to scratches and abrasion, has high adhesion, vapor permeability and resistance to chemicals.

In today's conditions, the topical issue is the production of exclusive products to individual order, which emphasize the status of the customer, his character and preferences. The task of modern small private shoe companies specializing in the production of custom-made shoes is to study the preparatory and basic processes of shoe production, namely: measuring the feet and layout of the product model of different materials, design or adjustment of shoe lasts, shaping the product while tightening shoes on lasts, etc. The solution of the problem of designing and manufacturing comfortable shoes is devoted in the fundamental works of researchers and scientists such as: Liba [3], Fukin [4], Zibin [5], Das [6], Goonetilleke [7], Nadopta [8], Chertenko [9] and others. Creating a comfortable and convenient form of product design is one of the main stages of shoe production, on quality and careful execution of which depends not only the shape stability and comfort of shoes at the stage of operation, but also the appearance of the product.

Quality and affordable footwear should be made by mass production technology, but take into account the individual characteristics of the consumer. A significant role in this sense is played by the process of designing shoes taking into account the anatomical points of the foot. At any, even insignificant deviations of foot from normal indicators the footwear made on the averaged form create a certain discomfort as the foot is an organ with very difficult anatomic structure [10, 11].

The ability of the feet to freely perform full-fledged movements when walking in shoes is one of the main requirements for comfort and quality of footwear. Ideally comfortable shoes can be called ones in which the biomechanical performance of the feet when moving will be identical to those when running without shoes. Creating comfortable shoes is a complex engineering task, because when designing you need to take into account not only the parameters of the foot in statics, but also in the dynamics. The foot is a complex static-dynamic system, the mathematical description of which requires taking into account many factors and individual features in order to ensure a sufficient level of shoe comfort. The effect of the same factor on different feet is completely different. The human foot is one of the important elements of the musculoskeletal system and has a complex structure. It consists of 28 bones, 56 ligaments that hold the bone structures in the correct position and 38 muscles that support the foot. The foot makes contact with the support, redistributes the reaction force of the support to the higher segments and performs an important spring function, provides stability of the lower limb and adhesion to the support surface. The ability of the foot to withstand the load is due not only to biomechanical perfection, but also the properties of its constituent tissues.

2 ANALYSIS OF PREVIOUS RESEARCHES AND SOURCES OF INVESTIGATION

As shown by the analysis of works on the problem of shoe comfort [12-15], we can conclude that the authors considered the comfort of shoes from the standpoint of mass production. Today, more and more consumers are turning to individual tailoring due to factors such as: environmental friendliness, small or large foot size, consumer segment, varieties of exotic leathers, activities (working in show business, celebrity), etc. which require a certain design of shoes. Due to the pursuit of fashion and aesthetic appearance of shoes, most manufacturers generally miss the most important task: to make shoes for consumers that protect the foot from external influences and are comfortable to use.

The force interaction between the foot and the shoe is a very complex process. At the upper of the shoe there are active pressure forces of the back of the foot, and at the bottom of the shoe there are reactive forces of pressure of the plantar part of the foot and active forces of support pressure of the foot [16-19].

The physiological effect of dynamic foot loading depends on many factors: size; places of application and directions of forces acting on the foot; the general scheme of the tense state of the foot, etc. The magnitude, direction and location of the application of force factors acting on the foot, change dramatically during walking and running. The manufacture of individual footwear begins with measurements of the basic anthropometric parameters of the feet, which are taken into account when designing the shoe last. But to create comfortable shoes, it is necessary to take into account the subjective consumer’s feeling of pressure on the foot.

Knowledge of footwear as an object of study in terms of actual comfort can be assessed on the basis of sensation and perception by direct consumers. That is, the consumer's perception of shoes can be considered as an integrated image or objective-subjective assessment of shoes, which contains a set of properties that an individual receives through the sensory organs. By its nature, perception, like sensation, is reflexive.

The elasticity of the foot due to individual anatomical and functional features is determined by genetic, age, gender and other multiple factors. Many authors have studied the modulus of elasticity and other physico-mechanical properties of foot tissues. Previously it was established that the normal bone density is 2.4 kg/m^3, Young's modulus is E=2000 MPa, tensile strength is σ=100 MPa, relative deformation reaches 1%. Young's modulus of the tendon is 160 MPa. Collagen material is characterized by a Young's modulus value of 10-100 MPa, and elastin -0.5 MPa [20].

Wright and Rennels [21] first determined the modulus of elasticity of plantar aponeurosis, which was 342-822 MPa. For comparison, these values are in the range of 50-500 MPa, given for connective tissue of other localizations studied in vitro; and exceed the modulus of elasticity of fascial and ligament structures of the foot and leg [22-24].

Adipose tissue of the supporting surface of the foot has a unique structure, which is due to the load that the foot experiences when walking. The amortization capacity of the fat layer in this part of the human body is due to its thickness, size and shape of fat particles, the development of fibroelastic skeleton, which strongly connects the dermis with plantar aponeurosis and periosteum of the overlying bones [25]. The main mechanical characteristic of adipose tissue of the plantar surface of the foot is the modulus of elasticity (Young's modulus), which is normally 1.076-1.364 kg/cm^2 [26]. Researchers Perepelkin, Mandrikov, Krayushkin and Atroshchenko [27] studied the mechanical properties of healthy feet of boys and girls. In this paper, the elastic deformation of the foot in the vertical plane was considered. Normally, the modulus of elasticity of the foot in boys is 616.9 kPa; in girls the modulus of elasticity is 6012 kPa. The authors Hashemi, Chandrashekar and Mansouri [28] found that the increase in tissue rigidity in males is due to increased collagen synthesis, and the decrease in elasticity in women is determined by the smaller number of fibers, their diameter and the relative amount of collagen in each ligament fiber of their foot.

3 MATHEMATICAL MODELLING

The analysis of orders for individual tailoring of shoes showed that when adjusting the parameters of the shoe last on the individual parameters of the foot and fitting the prototype of the shoe, customers often experience certain feelings of discomfort in the area of the rise of the foot. For individual tailoring of comfortable shoes you need to more meticulously determine the parameters of the human foot and based on them, satisfy the wishes of a particular customer. After all, the comfort and safety of the lower limbs during walking and physical activity depend on the right shoes.

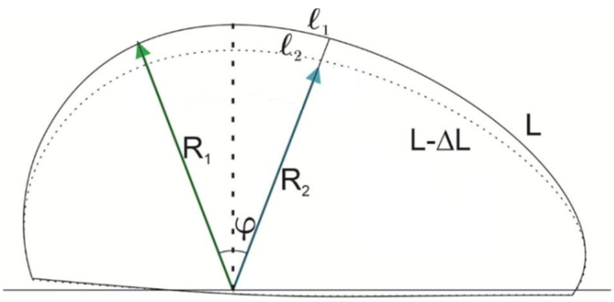

Figure 1 Cross section of the foot at the point of rise: R_1 and R_2 - the outer radius of the deformation zone of the foot before - and after compression, respectively; L - the length of the cross section of the shoe; φ - the central angle of the cross-sectional segment of the foot in the deformation zone; l_1 and l_2 - the length of the shoe upper segment before - and after compression, respectively;

To assess the level of shoe comfort, it is important to analyze the influence of various factors on the pressure exerted by the upper of the shoe on a person's foot in the area of rise. The calculation scheme for determining this pressure is shown in Figure 1.

Assume that the pressure between the foot and the shoe upper at the contact area is equal to the compressive stress in the surface layers of the foot. Then the magnitude of the pressure, according to Hooke's Law:

$$P = k_1 E_1 \varepsilon \tag{1}$$

where: E_1 - modulus of elasticity of the foot; k_1 - coefficient that takes into account the individual elastic properties of the foot; ε - relative deformation of the foot.

The relative compression deformation of the foot in the rise zone can be represented as:

$$\varepsilon = \frac{R_1 - R_2}{R_1} \tag{2}$$

where: R_1 and R_2 - the outer radius of the deformation zone of the foot before - and after compression, respectively.

According to the properties of the circle segment:

$$R_1 \varphi = l_1 \tag{3}$$

$$R_2 \varphi = l_2 \tag{4}$$

where: φ - the central angle of the cross-sectional segment of the foot in the deformation zone; the length of the shoe upper segment before - and after compression, respectively.

Taking into account (2), (3) and (4), the relative compression deformation will be:

$$\varepsilon = \frac{l_1 - l_2}{l_1} \tag{5}$$

The length of the shoe upper segment after tightening the shoe on the foot, taking into account the shortening of the segment will be:

$$l_2' = l_2 + \Delta l_2 \tag{6}$$

where: Δl_2 - the elongation of the segment.

The shortening of the segment will be determined by the ratio:

$$\frac{\Delta l_2}{l_2} = \frac{\sigma}{E_2} \tag{7}$$

where: σ - tensile stresses acting in the segment; E_2 - modulus of elasticity of the segment.

From expression (7) we have:

$$\Delta l_2 = l_2 \frac{\sigma}{E_2} \tag{8}$$

Substituting (7) into (8), after the transformations we obtain:

$$l_2{}' = l_2\left(1+\frac{\sigma}{E_2}\right) \tag{9}$$

Substituting (9) into (5), we obtain:

$$\varepsilon = 1-\frac{l_2}{l_1}\left(1+\frac{\sigma}{E_2}\right) \tag{10}$$

Substituting (10) in (1) we have:

$$P = k_1 E_1\left[1-\frac{l_2}{l_1}\left(1+\frac{\sigma}{E_2}\right)\right] \tag{11}$$

We will express tensile stresses in the segment by means of the formula for definition of circular stresses in a cylindrical shell which for our case will be:

$$\sigma = \frac{k_2 P R_1}{h} \tag{12}$$

where: k_2 - a coefficient that takes into account the uneven distribution of pressure on the surface of the foot; h - thickness of the segment.

Substituting (12) in (11), we have:

$$P = k_1 E_1\left[1-\frac{l_2}{l_1}\left(1+\frac{k_2 P R_1}{E_2 h}\right)\right] \tag{13}$$

Solving equation (13) with respect to P, we obtain:

$$P = \frac{1-\dfrac{l_2}{l_1}}{\dfrac{1}{k_1 E_1}+\dfrac{l_2}{l_1}\dfrac{k_2 R_1}{E_2 h}} \tag{14}$$

When tightening the length of the cross section of the shoe upper decreases by the value of ΔL. Assume that the length of the cross section of the shoe upper segment adjacent to the deformation zone of the foot will decrease by the value of $l_1 - l_2$ according to the proportion:

$$\frac{l_1 - l_2}{l_1} = \frac{\Delta L}{L} \tag{15}$$

From (15) follows:

$$\frac{l_2}{l_1} = 1-\frac{\Delta L}{L} \tag{16}$$

Substituting (16) in (14), we obtain:

$$P = \frac{\Delta L}{\dfrac{L}{k_1 E_1}+\dfrac{k_2 R_1}{E_2 h}\left(L-\Delta L\right)} \tag{17}$$

Expression (17) allows you to determine the amount of pressure on the foot at the point of the rise, which affects the feeling of comfort level of shoes.

4 EXPERIMENTAL

According to the results of theoretical and analytical, marketing and experimental research, the paper presents a shoe model-transformer (Figure 1) using a computer system based on the Arduino Uno microcontroller to measure the costumer's level of subjective comfort.

An analog signal will appear on the output terminal when a load is applied to the resistive pressure sensor. The Analogue to Digital Convertor converts this signal into a digital value of the pressure applied to the sensor and displays it on the monitor display.

The model is a blank of the top of the closed leather shoes, with a leather lining, tightened on a men's shoe last, to which is glued a thin, flat sole with a heel, size 275 mm. The shoe model-transformer consists of 7 fasteners on which the scale from 70-100 mm in length is marked, each of which is placed in the corresponding places: 1 - zone of the resistive sensor at the point of direct rise of the foot, 2 - zone of the resistive sensor at the point of the outer bundle of the foot, 3 - zone of the resistive sensor at the point of the inner bundle of the foot, 4 - zone of the resistive sensor at the point of height of the heel of the foot; 5 - the highest point of height of an ankle of a half-shoe (from point C + 70 mm upwards in the center of a crest); 6 - on a direct rise (0.55 foot length); 7 - point of the calcate point C (center of the line of the inner and outer bundles (calcate)); 8 - the middle of the foot on the outside (0.5 foot length); 9 - point of the outer bundles(0.68 foot length); 10 - the middle of the foot on the inside (0.5 foot length); 11 - point of the inner bundle (0.72 foot length), 12 - Arduino UNO microcontroller.

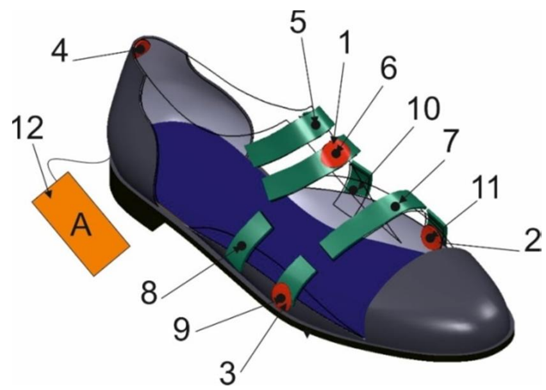

Figure 1 Shoe model-transformer

The computer system consists of the following elements: Arduino UNO microcontroller, 3.3 kΩ resistor, resistive pressure sensor FSR402. The pressure power sensor and voltage divider are connected to the output of the Arduino Uno microcontroller. The supply voltage is 5 V.

Resistive pressure sensors are essentially resistors that change the value of their resistance (in ohms) depending on the force of pressure on the sensitive element.

The principle of operation of the device is as follows. When the pressure applied to the sensor is zero, its resistance will be almost infinite, respectively, the signal from the sensor is also zero.

To evaluate the feeling of comfortable pressure on the foot, the proposed answer options (ranging from minor to significant findings in accordance with the lower to upper thresholds of sensitivity (Table 1), the customer was asked to evaluate in points by direct scaling.

The perception of shoes should always be considered as an integral, objective and complex phenomenon, because it combines human feelings coming from a number of analyzers. Therefore, the actual comfort of the shoes can be established by the results of fitting the experimental shoe model-transformer on the basis of the analysis of the customer's feelings. The following scale of sensations was offered: unsatisfactory condition, severe discomfort, moderate discomfort, perfect comfort.

Table 1 Rating scale for the shoe comfort evaluation

Rating	Feeling of comfort
90-100	Perfect comfort
60-80	Moderate discomfort
30-50	Severe discomfort
1-20	Unsatisfactory condition

Obtaining information on the basis of the measurement of the pressure of the inner surface of the shoe in different parts on the foot taking into account basic anatomical parameters of the foot with the use of shoe model-transformer according to the method [11, 12] involves the following steps:

1. Installation of pressure sensors from the inner space of the shoe in these anthropometric zones, which are attached to the layout with PVC tape;
2. Connection of sensors to the block diagram of the prototype;
3. Fixation of the shoe model-transformer on the customer's foot with the help of "Velcro" fasteners and evaluation of the comfort level of pressure in points 1 to 4 (Figure 1) according to the rating scale (Table 1) at different fixed tightening states of the fasteners;
4. Registration of pressure in points 1 to 4 (Figure 1) and corresponding comfort levels of the shoe model-transformer in the different tightening states of the fasteners in statics and dynamics;
5. Getting results - saving information.
6. Implementation of the necessary automated measurements by comparative, calculation and graphical procedures.

Fixing sensors on the inner surface of the shoe model-transformer allows you to measure the pressure of the inner surface of the shoe upper on the foot in both static and dynamic conditions.

5 RESEARCH RESULTS

When measuring the pressure of the inner surface of the shoe on the foot in areas, where the sensors are installed, the readings of the device are translated into the values of pressure. In the interior of the shoe model-transformer there are 4 resistive pressure sensors FSR402 in the marked areas (Figure 1 (1-4)). On pressing the sensor depending on the resistance value, software uses one of several formulas to calculate the force applied to the sensor and displays its digital value to the monitor.

The values of pressure at different fixed tightening states of the fasteners were estimated by the customer in terms of the feeling of comfort of the foot. Fixed subjective consumer`s scores of comfort levels of pressure when fitting the shoe model-transformer and corresponding pressure values in points 1 to 4 (Figure 1) are given in Table 2.

From Table 2 it follows that the highest estimation of comfort in the conditions of standing the customer feels at tightly fitted fasteners of the shoe to the foot. Fixed pressure on the foot at different points with such tightening is in the range from 8209.1 to 10491.2 Pa.

The next task of the experiment was to determine the comfort level of pressure applied to the foot by the shoe model-transformer when walking (Table 3).

Table 2 Comfort levels of pressure of the shoe model-transformer on the foot while stand

Tightening states of the fasteners:	Detached	Very loosely fitted	Loosely fitted	Fitted	Tightly fitted	Very tightly fitted	Squeezed
Subjective feeling of comfort [mark]	30	70	80	90	100	60	22
The pressure at the measuring point 1 [Pa]	-	688.4	2944.4	8269.5	10491.2	16227.9	16952.8
The pressure at the measuring point 2 [Pa]	-	614.1	2540.7	7475.3	8869.9	14544.8	16090.1
The pressure at the measuring point 3 [Pa]	-	628.0	2221.8	7224.5	9645.0	15070.2	16952.8
The pressure at the measuring point 4 [Pa]	-	628.0	1861.1	4964.3	8209.1	13259.7	15831.8

Table 3 Comfort levels of pressure of the shoe model-transformer on the foot while walking

Tightening states of the fasteners:	Detached	Very loosely fitted	Loosely fitted	Fitted	Tightly fitted	Very tightly fitted	Squeezed
Subjective feeling of comfort [mark]	10	52	79	100	81	61	12
The pressure at the measuring point 1 [Pa]	-	4065.8	8869.9	11039.1	14146.0	16664.9	18860.9
The pressure at the measuring point 2 [Pa]	-	3856.3	8209.1	9367.7	10647.5	13691.0	17818.5
The pressure at the measuring point 3 [Pa]	-	3961.0	8759.5	9922.8	11263.3	14430.8	16090.1
The pressure at the measuring point 4 [Pa]	-	2923.8	7224.5	8209.1	8869.9	11656.4	16377.3

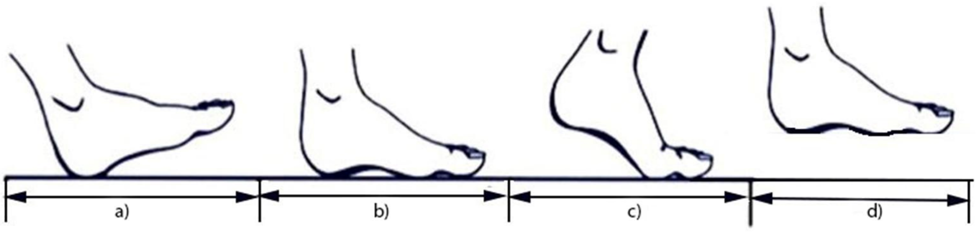

Figure 2 Phases of the step

Walking is a complex cyclic movement involving interaction of the body with the support surface and its change in space. Characteristic of walking is the constant preservation of support on the one or the other foot. The movement of the human body is the result of the interaction of external and internal forces. The external forces are: the force of gravity of the body; support reactions; resistance of the environment. The external forces are generated inside the human body as a result of the interaction of its individual parts [16].

Based on the mechanism of movement when walking the following phases of the step are distinguished [17] (Figure 2):

a. roll around the heel;
b. support on the whole foot;
c. roll around the front section;
d. the transfer period.

To determine the comfortable pressure while walking the same tightening states of the fasteners were ensured as in case of standing.

The results of measurements of subjective comfort level of pressure exerted by the shoe model-transformer on the foot while walking are given in Table 3.

Analyzing data in Tables 2 and 3, we observe a difference in customer's perception of the comfort level of pressure exerted by the shoe model-transformer on the foot while standing and walking. In the state of standing, the highest level of comfort is with the tightly fitted fasteners, and in the state of walking with the fitted fasteners.

Figure 3 shows the results of measuring the pressure of the shoe model-transformer on the foot in selected points while walking with the fitted fasteners.

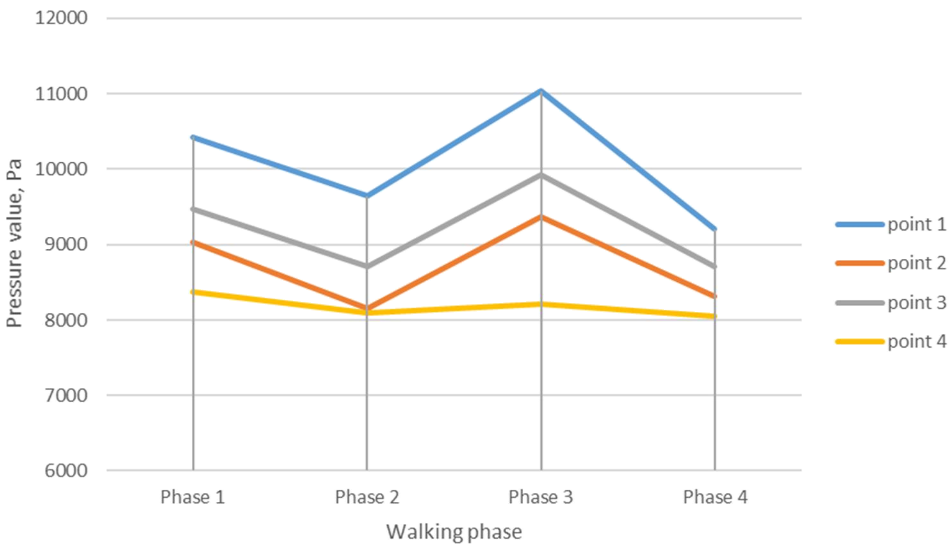

Figure 3 Pressure of the shoe model-transformer on the foot while walking

As a result, it can be noted that the most comfortable pressure in the standing position reaches 10491.2 Pa, and when walking the value increases to 11039.0 Pa. The difference between these values is 547.8 Pa. In order for the customer to feel comfort not only while standing, but also when walking, it is necessary to reduce the pressure on the foot by a difference of 547.8 Pa when adjusting the fasteners in fitted state during standing. Thus the pressure in the statics conditions should be: 10491.2 - 547.8 = 9943.4 Pa. Then, given the magnitude of the increase in pressure when walking, a person will feel comfortable pressure on the foot, equal to that determined in standing conditions.

To study the parameters of the pressure of the inner surface of the shoe on the foot, a two-factor experiment was planned and performed [29]. To identify the dependence of the feeling of subjective comfort C on pressure P_1 and P_4 in points 1 and 4 respectively (Figure 2) in the third most representative phase of walking according to the previous experiment (Figure 3) the method of multifactorial experiment was performed.

The minimum and maximum values of pressure in the points of the rise and the heel are determined by the satisfactory values of measurements of the previous experiment.

Therefore, the maximum values of factors P_1 and P_4 are the following: $16×10^3$ Pa and $11×10^3$ Pa. The minimum value of the factor P_1 is determined from a previous experiment and is equal to $8×10^3$ Pa. The minimum value of the factor P_4 is $5×10^3$ Pa.

The experiment was planned using a rotatable Box plan [29] for a two-factor experiment. As a result of processing of the experimental data the function of dependence of level of comfort of footwear on pressure in the point of the rise (P_1) and on pressure in the point of the heel (P_4) of the foot is received:

$$C=-98.6209+4.3473P_1+1.1909P_4+ \\ +0.9375P_1P_4-5.2616P_1^2-6.6987P_4^2 \tag{18}$$

Figure 4 shows the graphical dependence of the foot comfort level on pressure in the points of the rise and of the heel of the foot.

To find the optimal pressure parameters of the comfortable fit of the model to the foot, the relaxation method was used [17]. Thus, it was found that the optimal values of the technological parameters of the process of fitting the template to the foot are the pressure in the point of the rise of 13165 Pa and in the point of the heel of 8251 Pa. At these values of technological parameters the maximum value of level of comfort of footwear 99.611 is reached.

The comfort indicator has a dualistic nature due to the presence of two components - objective, which is determined by the criteria of shoe quality and depends on environmental conditions, and subjective, which is determined by direct organoleptic sensations of the consumer, which dominate in determining the ergonomic properties of shoes.

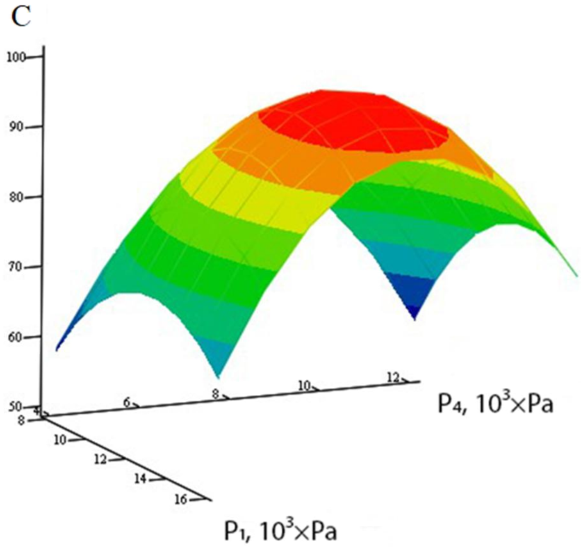

Figure 4 Dependence of the comfort level on pressure in the points of the rise and of the heel of the foot

The aim of the work was to investigate the subjective comfort of the inside shape of shoes on the foot, on the example of an individual consumer by experimental prototyping of shoes.

Given the defined subjective comfort values of pressure at different anthropometric points for the consumer, men's ankle boots were made to order Figure 5.

Figure 5 Men's ankle boots by individual order

6 CONCLUSIONS

Based on a computer system with an Arduino Uno microcontroller and resistive pressure sensors FSR402, a device for determining the pressure between the foot and the inside surface of the shoe has been developed. As a result of the calibration of the device the unambiguous dependence between indications of the device and the values of the measured pressure is established that allows defining pressure of the inside surface of footwear on the foot both in the state of standing, and in the course of walking.

The proposed method of measuring the pressure of the inside surface of the shoe on the foot, taking into account its basic anatomical parameters using the shoe model-transformer of the prototype allows you to design and manufacture comfortable individual shoes for the customer.

The optimal values of technological parameters of the process of fitting the model-transformer to the foot were experimentally determined, as well as recommendations for comfortable tightening of working fasteners on the shoe model were given and the peak comfort pressure was adjusted to ensure comfortable walking in different walking conditions.

The mathematical model of fitting of a template in a separate zone of foot by means of the Shoe model-transformer is developed.

As a result of measuring the pressure in the standing position and walking position, fixed values of comfortable pressure on the foot at different points and at different phases of walking are given. The results of the study of the influence of pressure parameters in anthropometric points of the rise and the heel of the foot are presented. Given the satisfactory pressure values for the customer, a pair of men's shoes was made to order.

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