Abstract: As an experiment for the doctoral thesis the idea of creating a mechanical model for the simulation of gait with which could be to measure the movements of the various parts of a person's legs while walking could be measured is proposed. In fact, the installation of sensors on the man's leg in many places cannot provide accurate measurements of displacements (accelerometer mounted on the muscle contractions because it's contractions do not give accurate results) [1]. So, one of the most logical way to provide measurements is creation of mechanical model (stand) - a prototype imitating walking human leg. Displacements of moving parts of stand can be measured by sensors – accelerometers [2]. Certainly, obtained accelerations using sensors must be made in accordance with accelerations of human leg parts.

Key words: stand, gait simulation, accelerometer

1. INTRODUCTION

Despite the accelerating pace of development of medicine and science in general, many problems still remain relevant and unresolved. One of these problems - a complex of numerous diseases associated with man locomotion apparatus (LA). There are 75% of Europeans and 85-90% of Russians suffer from diseases of LA [3]. It is noteworthy that there is no social, gender or age group of people which could be considered out of risk of such diseases. The main causes of diseases ODA considered sedentary life or work, lack of time and energy to do physical exercises, overweight, mechanical traumas, excessive exercise, hypothermia, wearing trainings with high heels or even without them. However, despite the high prevalence of such diseases in the world there is no satisfactory ways of diagnosis, treatment and recovery of locomotion function. The disadvantages of the existing solutions are no satisfactory automatic diagnostic systems of a particular disease (visual diagnosis determines the existence of the human factor the means the increase of the possibility of making mistakes in diagnosis), and the high cost of the technological equipment, absence of guarantee of full recovery, insufficient accounting for individual characteristics of human limbs and so on. The aim of this work is to create a prototype of mechanical legs and hip, with which it will be possible to explore the human gait.

2. MAIN TASKS OF THE STAND

Before making design of the stand, you must determine what constructive tasks you put before them and what types of movements it should perform. Structurally, the geometric shape of the stand should be possible to match the shape of the human pelvis and legs. Functionally, the mechanical components of the stand must make movements similar to those that make a person's legs and pelvis while walking. Constructive part is clear – we find an average statistical length of leg and width between hips of an adult male with a coefficient 0.5 (divided on 2). The functional point of view of human gait can be divided into several movements, as shown in (Fig. 1).
Mechanical components located between points A and B, F and G correspond to the feet of man. The legs can be raised and lowered vertically during simulate walking through 4 adjustable spring receiving vibrations from the wheel 19. Joints at points B and F indicate some deviations from the vertical axis of the leg movements that occur when walking. Connecting links 6 are used to adjust the central abnormalities of the upper plate 10 (pelvis) in relation to the feet. Deviations from any leg axis is going due to the plate 10 rolling around a central point D of the joint 9 (lifting - lowering the hips) and rotation of the entire plate - pelvis about a central point O of the support joint 12. Scrolling plate around the point D and movement of the plate 10 around the point O provide planar motion - wagging the hips. Elastic elements - springs 8 installed inside the round dampers and attached to the corresponding joints to transmit the movement and dampen vibrations of the entire system. Moreover, springs reduce the dependences between legs.

3. CONSTRUCTION AND PRINCIPLES OF WORK

The main technological assemblies of its mechanical design for definition of operating principle of stand are separately shown (Fig. 2).

To begin we launch synchronized stepper motors 2 mounted on the frames 1. Using controller and adjusting the required number of motor rotations per minute (25-60 rpm), the torque is being transmitted to bicycle wheel 3 set on frame 25. The usage of frame 25 is necessary to reduce the rotation moment which has influence on the type and characteristics of motors. The plywood profiles 18 are glued on the outer edge of the rim on both sides of wheel 3. Basically, the shape of profiles 18 plays very important role because it responds not only for character of vibrations but for the causing of movements of mechanical system of stand at all. The shape of plywood profiles is calculated from
experiments with accelerometers installed on the heel and instep of walking adult men. After we found the average length of the step (1.35 seconds and 135 measurements) and having in attention the initial conditions (at least 4 profiles (90 degrees for each profile) should be glued on the one side of rim of every wheel), we get a good coefficient for building the shape of accelerations 0.67 degrees for 1 measurement. As example the profile of heel accelerations is shown (fig. 3).

The thin blue line shows the real shape of obtained curve, the bold green line means the borders of profile cutting. Another one initial condition is necessity to use 3 different profiles of accelerations for heel, instep and combined profile. The last one profile we get after analyzing and calculating of experimental measurements for heel and instep matching their peak accelerations. Because it is possible to use only the same acceleration profile during the experiment, 3 is the minimal number of different using wheels. According to calculations the maximal difference between the heights of small wheels (minimal and maximal point) is 8.05 cm.

Fig. 3. The profile of heel averaged accelerations

Torque transmission is provided with using coupling 14. On one side of coupling 14, a hole corresponding to the shape of the motor shaft (with a key) and on the opposite side an inner thread are cut. In thread of coupling 14 a pin 16 is screwed up. Tightening the screw in the key 15, inserting the pin 16 into the hub of a bicycle wheel and installing locknut 17 (fig. 4), we have a strong mechanical junction. Next, going by plywood profiles 18 glued to the rotating bicycle wheel, a carriage wheel 19 causes the mechanical system of the stand to make plane vibrations, imitating human leg lifting during the process of walking. Since the profiles 18 are situated in relation to each other at 45°, the system with increasing angular velocity of rotation of bicycle wheels becoming more and more "swinging". Figure 1 shows the maximum phase of the system "swing" of the system. When a carriage wheel 19 is going to the peak of the plywood profile 18 (fig. 6c), the right leg lifts up.
Then the spring 4 is compressed with subsequent transmission of force to the round pipe 5, moving within a wider stationary pipe 21 playing a role of a guide. The parameters on spring 4 is easy to find knowing the shape of profiles, maximal difference between the height of lengths in relation to the floor and the minimal force enough for pressure on wheel 19 to avoid jumping it. The pipe 21 is attached to bracket of wheel 19 at bottom and restricted radially with frame 26. Since the spring 4 is selected with the reserve, it is possible to install the simplest limiter 20 consisting of standard plates and threaded connections. Pipe 5 working as a piston transfers force to the intermediate joint 6, which puts pressure on the axle 8 (hip joint) (fig. 6b).

The right axle 8, in turn, causes compression of the upper and left springs 7, resulting in movement of the joining plate 10 (pelvis) compressing left axle 8 and causing its horizontal and vertical displacements on left springs 7. Joining plate 10 performs composite plane motion two: on the one hand it rotates around the central point of joint 9. On the other hand it moves to the left together with the pipe 11 (i.e., performs motion around a central point of joint 12) pressing the springs 23 and seal 24. To limit the displacement angle of pipe 11 with the plate 10, the pipe 13 (supporting all the construction) has projections on its edges, restricting the fall of elements 11 and 10. Pipes 11 and 13 are connected with axle 12 (supporting joint) which is passed through those pipes. Since plywood profiles 18 should be set oppositely (for example with in relation to each other by 45 degrees) the profile peaks do not match. This provides the possibility of movement of the components of the left "leg" in the opposite direction in comparison with the components of the right leg (fig. 6a). The left leg goes down by the similar way. Firstly, left hip joint 8 presses on the lower left spring 7 and makes the intermediate joint 6 to move pipe 5 down. Left pipe 5 moves down and compresses spring 4, pulling a carriage wheel 19 to plywood profile 18. Passage of each profile peak corresponds to one human step.

The most likely place in a stand for installation of accelerometers is pipe 5. It is planned to use accelerometer with Bluetooth module. Measuring the accelerations causing with vibrations of plywood profiles, it will be possible to find the speeds and displacements of pipe 5. By that we can practically find the upper part of leg what we couldn’t do before because of impossibility to install accelerometers directly on muscle.
4. ADVANTAGES OF DESIGNED STAND

The stand for imitation of man path was introduced in this paper. The main advantage of such mechanical system is very simple construction and big number of things to measure. For example launching stepper motors with different rotation speeds will allow us to simulate lameness.

5. CONCLUSION

Describing the stand, the good and simple mechanical model for making experiments was designed. It is possible to use that for measuring parameters we couldn’t practically measure before. After all, the analytical model for making theoretical calculations on the base of shown stand can consist from 3 basic steps:

1) Finding the degrees of freedom of moving elements of the stand
2) Finding the general equations of the kinetic (T) and potential (V) energies, applicable to the experimental stand
3) Finding the Lagrange equations of the second kind (L=V-T).

6. REFERENCES

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