Study on the Compression and Rebounding of the Zoom Air in Sport-Shoes

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Abstract: Today, the zoom air was widely used in top grade sport-shoes. Firstly, the function of zoom air, including shock absorption, energy return, light quantization and ornament results were introduced. Secondly, the problems of using the zoom air nowadays were brought forward, through testing the compression and rebounding of the zoom air in sport-shoes, the shock absorption and the energy return of it were researched. The factors of influencing the compression and rebounding of the zoom air were discussed from speed of the athletics and the aging of the zoom air. The speed has effect on the shock absorption performance and energy return performance. The faster the speed is, the smaller the protection the zoom air can offer and the energy feedback are. Ageing will not make the material of the zoom air produce essential change, but may cause the reduction of the gas in the zoom air. All performances of the zoom air are improve after ageing, which means the zoom air in the market is not optimum at present, all this contributes to the lack of united standard. Finally, the method of testing and the standard of evaluation were put forward, which did some early work for the standard of zoom air in producing and testing.

Key words: sport-shoe; zoom air; compression and rebounding; shock absorption; energy return

1 Introduction

In China the zoom air is fresh. At present, there aren't the relevant standards about the zoom air and the inspection of it. Abroad, the research about the zoom air is kept as "trade secret", which discourages the dissemination of the standard about the zoom air. But the application of the zoom air is more and more extensive at present, so need unified standards to standardize the trade of zoom air badly, which makes the protection function of the air cushion be realized. Some work in the earlier stage of the standard about zoom air has been done in this thesis by testing the compression and rebounding of it, seeking the shock absorption and the energy return how to be influenced by the speed of the athletics and the aging of the zoom air.

2 Functions of the zoom air

2.1 Shock absorption functions

The definition of the shock absorption of the zoom air in sport-shoes made by the ASTM (American Society for Testing Materials) is: By means of the growth of time which external force works on the zoom air, make the energy of the peak value of shock power reduce. That is to say, the bump time lasts longer, the zoom air deforms greater, the better the shock absorption function is. Vice-president of the shoes marketing department of NIKE Company Tom Clarke emphasizes: "The zoom air has a most important characteristic, it can reply the original state immediately when the pressure is cleared up, this shows that

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it still can provide the next step the shock absorption, then every of users' run movement can get the shock absorption protection of the zoom air." So shock absorption function is primary performance of a zoom air. Among the sport, by pressing the shape of the zoom air the gas of zoom air is pinched, it makes the shock power that the human body receives in sports reduce to produce certain obstruction, thus shield the human body.

2.2 Energy return function

Energy return is the procedure that some of the energy is feed backed to body in the course of sport. The zoom air absorbed some energy when produced obstruction in the course of pushing. Once the pressure is dismissed from, the zoom air will release this part of energy, some energy among them has been feed backed to body, which is used in sports. This kind of performance that the zoom air has is energy returns function. Regard jumping as the example, when jumper falls the zoom air is compressed and it absorbs energy at this moment, when the jumper leave the ground, the zoom air release energy, some of which is used for doing sports of jumping partly. This economizes physical stamina for the player. The shock absorption and energy return of the zoom air can been judged by testing its compression and rebounding.

2.3 Light quantization

In sports, the weight of shoes is an important factor which influences the movement comfortableness; it has obvious influence on the consumption of physical stamina. Studies have shown that once the weight of shoes increases by 1%, the consumption of people's physical stamina increased by 3%- 10%. Because the mid-sole is replaced by the zoom air, the zoom air shoes are lighter than the ordinary sports shoes, can meet the requirement of light quantization even more.

2.4 Ornament results

Now, the zoom air made by every producer vies with each other for glamour, and is designed with different exposure, in order to cooperate with the design of the shoes' upper. Among them the most common ones are change the table of exposed zoom air and add printing stamp in exposed zoom air.

2.5 As a selling point

The zoom air shoes of NIKE may be the sign of NIKE, and today about seventy percent of the NIKE sport shoes all have zoom air. And now zoom air shoes permeate through people's life as a kind of fashion, a pair of zoom air shoes nearly become each sport teenager's initial dream of "the leap ".

3 Problems and analyzing of zoom air shoes

The analyzing of the quality problems of the zoom air which are reflected on the market, tells the critical matter of the zoom air shoes is concentrated on: The contradiction of the stability, the shock absorption and the energy return.

The contradiction of the stability and the shock absorption mainly display on the disagreement of the comfortableness and thickness of the zoom air. There are two reasons for the zoom air to be unstable: First, the zoom air is too thick; and second, because the gas in the zoom air can be compressed and has mobility. But these two points are why the zoom air can has the shock absorption function exactly. The gas in the zoom air can be compressed, just absorbs the excessive energy, and prevents both feet from the sport injury. And the thicker the zoom air is, the heavier it can be compressed, the more energy can be absorbed, and the more obvious protect of the shock absorption is.

The contradiction between the shock absorption and the energy return of the zoom air is more obvious. Shock absorption is to absorb energy, but energy return is to release some energy back to the

human body. To have good shock absorption, the zoom air must possess performance that it is early to be pressed into deformation, by which it can absorb the shock wave that the step produces while striking the ground; in the other hand to meet the athletes' need——making them run faster or jump higher, the zoom air would have a good energy return performance. If the zoom air is very soft and has a good shock absorption performance, it is unable to make the athlete run faster or jump higher, which would influence the improvement of the sport achievement.

4 Methods and results of the testing the compression and rebounding for the zoom air

4.1 Principles and purposes of the experiment

Most people land first with the heel position while running, and while transient landing a reacting force of the earth's surface is produced; but the centre of the force moves to half sole position from the heel position rapidly, at this moment the force reaches the peak and would sustain until the toe leaving the ground. At the last stage of the whole landing, the first half of the foot is compressed first and then rebounded, the whole body is moderated first (compressed) and then accelerate (Rebound). The whole course of zoom air in that process is as follows: When the foot lands, the effort is downward, the gasbag is pressed at this moment, receiving energy; after the foot lands, a part of the energy absorbed in the gasbag input, playing a shock absorption role; when the foot leaving, the remaining energy in the gasbag (zoom air) Lose again the foot, the direction of force is forward, playing a run-up function.

In order to imitate the above course, the zoom air is exerted pressure and under certain speed in this experiment. The pressure begin from zero, when it is added to the value set up firstly, removes the pressure, testing machine of multi-functional material (TS2000-S) joined with the computer records automatically the value of the rebounding force of the zoom air in this course, as the value is zero, the machine stops, and then exports the greatest displacement, compressing work and redounding work in that course. The shock absorption is reflected by the greatest displacement and compressing work, as the energy by percentage of the energy returns (namely the ratio of the rebounding work than the compressing work). By combining the shock absorption performance and energy return performance can analyze the quality of a zoom air.

This test is divided into two parts, in the first part the selected zoom air (Fig. 1 - a) is tested in the same greatest pressure and some varied speeds, this part of test is mainly to consider the influence of the compressing speed on the zoom air. In the second part some sample (Fig. 1 - b) is tested twice --before and after wearing out, to analyze the influence of the aging on these two kinds of performance.

(a) Sample 1 **(b) Sample 2**

Fig. 1 Sample picture

4.2 First part of the test

First put the selected sample 1level on the testing machine of multi-functional material (TS2000- S). Then set up the parameter on the computer -- biggest pressure 400N, the pressing speed 5mm/min, 10mm/min, 20 mm/min, 30 mm/min, 40 mm/min, 50 mm/min separately. Finally, begin this test, and the results of the test are outputted by the computer.

The result of first part experiment: (Table 1)

Tab. 1 The Results of the Same Sample under Different Speed

Sample Name	Compressing Speed (mm/min)	Maximum Rebounding Force (N)	Greatest Displacement (mm)	Compressing Work (N.mm)	Rebounding Work (N.mm)	Percentage of Energy Returns
Sample 1	50	439.46	5.67	376.16	356.67	94.81%
Sample 1	40	429.70	5.77	378.76	346.38	91.45%
Sample 1	30	422.36	4.72	380.60	335.54	88.16%
Sample1	20	415.57	4.69	379.02	322.71	85.14%
Sample 1	10	407.52	4.75	382.86	314.85	82.24%
Sample 1	5	403.64	4.75	386.04	312.93	81.06%

The analyses of the results of test one:

The faster the speed is, the maximum rebounding force value is greater. But the growth of the maximum value, can not state the reduction of the shock absorption, because the faster the speed is, the bigger the kinetic energy produced by it is, the rebounding force increases naturally. In the same way the growth of the compressing maximum displacement can not prove the change of the shock absorption either. But it can be proved that the bigger injury to the human body caused by the addition of the maximum rebounding force value, because the runner must bear more rebounding shock than the low one. This also can be found out from the compressing work, because if the speed increases the kinetic energy raises, but the compressing work shown here is reduced gradually, which proves that in this course, much energy is consumed, that is just the shock received by human body in sport.

The test indicates compressing work reduces as the speed increases, while the rebounding work and the percentage of the energy return increases as the speed increases. That is to say, for athlete, their speed is bigger, more energy is returned by the zoom air, but at the same time, greater physical stamina is consumed and the chance they would injure himself is bigger.

4.3 Part two of the test

Elect six zoom air A, B, C, D, E, F in samples 2 at first, choose three points separately on the six zoom air, measure their thickness. Then test the compression and rebounding of them, in which this parameter should be set up -- pressure 400N, pressing speed 5mm/min. After finishing testing, wear out the zoom air by adding the pressure board to the zoom air, pressing the zoom air to certain thickness, then putting it to oven with temperature in 60 degrees Centigrade, taking out after baking for 4 hours, unloading the pressure board, finally putting for 24 hours. You can insure it by measuring the three points again, if the thickness of them change that means the zoom air aging. At last measure the compression and rebounding again under the original condition, compare the result of this two times.

The result of second part: (Table 2)

The analyses of the results of test two:

(1)The factors making the weight of the same sample different are that: a. the thickness of the zoom air wall is uneven; b. the weight of the gas in the zoom air differs. Here, suppose it is caused only by the

amount of the gas, then the less (within the specific limits) the gas in the zoom air is ,the softer the zoom air is, the greater the compressing work is, the better the shock absorption function is. Suppose it is caused just by the thickness of material, then the thinner the inboard wall is, the softer the physical property of the material is, which makes the zoom air more easily to be compressed, the bigger the greatest maximum displacement value and compressing work value are in the same pressure, that is to say the better the shock absorption function of the zoom air is.

Tab. 2 The Result of the Samples before and after Worn Out

Sample Name	Compressing Speed (mm/min)	Maximum Rebounding Force (N)	Greatest Displacement (mm)	Compressing Work (N.mm)	Rebounding Work (N.mm)
Sample 2 - A before Wear Out	401.37	8.17	1014.46	863.66	85.13%
Sample 2 - A after Wear Out	401.22	8.58	1154.68	965.02	83.57%
Sample 2 - B before Wear Out	401.14	8.80	1132.76	970.27	85.66%
Sample 2 - B after Wear Out	401.31	9.17	1220.14	1021.45	83.72%
Sample 2 - C before Wear Out	401.33	7.13	924.05	776.30	84.01%
Sample 2 - C after Wear out	401.22	8.70	1165.30	944.30	81.03%
Sample 2 - D before Wear Out	401.46	7.43	946.87	784.23	82.82%
Sample 2 - D after Wear out	401.33	8.75	1143.20	931.81	81.51%
Sample 2 - before Wear Out	401.40	6.95	902.66	743.47	82.36%
Sample 2 - E after Wear Out	401.45	7.57	965.15	789.66	81.82%
Sample 2 - F before Wear Out	401.26	8.29	1036.23	863.41	83.32%
Sample 2 - F after Wear Out	401.20	8.85	1124.29	934.63	83.13%
Average before Wearing Out	401.33	7.80	992.84	833.56	83.96%
Average after Wearing Out	401.29	8.60	1128.79	931.15	82.49%

(2) No matter before or after worn out, the tendency of the curves of the compression and rebounding is unanimous, having few changes, which states that ageing has no essence change on the material of the zoom air, Because the material of the zoom air have great influence on the tendency of the curves of the compression and rebounding.

(3) The greatest displacement and the compressing work of the zoom air after ageing are bigger than them before ageing. This proves energy stored in the course of compressing is more after ageing, namely after the zoom air worn out the energy return function is stronger and energy loss is smaller, in real sports, the chance that the human body is injured is little. The change of the percentage of the energy returns is: the percentage after ageing obviously reduces, which means the energy return function has been weakened after the zoom air worn out. As we all know the ageing can be divided into two pacts, one is to the material of the zoom air, and the other is to the gas in the zoom air.

(4) Although the ability of the energy return of the zoom air has been reduced after ageing, the rebounding work has increased in the test. This indicates, after the zoom air worn out, not only the shock absorption performance is strengthened, but also the work rebounded increases, though the energy return performance weakens. It demonstrates the zoom air after worn out is more excellent than the new one. But why? According to the analysis of this text, it is because lacking the standard in the zoom air trade, the new zoom air produced by the manufacturer is not the one with the best design of good stability, excellent energy return and shock absorption performance.

4.4 Experiments explaining

In above test, the settlement pressures are all 400N, and the speeds are all small. But in the real movement, the pressure and speed are all much larger than this. Using such small value to do the experiment is because of limitation of the experimental condition, the sensor of the laboratory apparatus can not bear too great shock and impact. The force received is about 2 times of the human body according to generally walking. And also because of the limitation of the condition, the frequency of the step is considered in this text, the step when people walk is generally four hertz, namely take four steps in one second.

5 Conclusions

In this paper, a set of methods was put forward about testing the performance of various fields of the zoom air; hope to provide some reference for norm of the zoom air trade:

(1) Test the inside atmospheric pressure of the zoom air. The atmospheric pressure has very great influence on the performance of various fields of the zoom air. If the atmospheric pressure is too big, the zoom air would be too tough, and would influence the shock absorption and the comfortableness of the shoes of the zoom air.

(2) Measure the ability of the zoom air on bearing bending. Put the zoom air under the environment that it should use (Below zero 20 to 50 degrees Centigrade), and let it bend needed times (Such as 60,000 times). If there is no quality problem of leaking gas etc., it is qualified.

(3) Test the eternal deformation of the zoom air made by compressing under the hot air, measure the ageing-resistant intensity of the zoom air.

(4) Test the compression and rebounding of the zoom air, which can measure the shock absorption and energy return.

There are two extra experiments for the explored zoom air:

(1) Survey the ability to bear the yellow changes, which is just for the zoom air with transparent appearance.

(2) Survey the ability to bear being pierced through.

It can measure the quality of a zoom air basically by testing all the above-mentioned methods. But to above-mentioned tests, there are quite a lot lacking standards, they need to be perfected by doing a large number of work. Now call upon every zoom air manufacturer to pay more attention to the standardization of the zoom air while producing them, make the zoom air not only commercial gag, but really bring the sport person protection.

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