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Study on hair dryer thermal vibration massage to make shaving more comfortable

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Abstract

When shaving, it is easy to suffer shaving burns, that is, facial burn irritation during shaving. The reason is that the razor blade irritates the skin. The current solution is to make the razor sharper and use a razor with a blade heating function. Although these ways can increase the comfort of shaving, they will also greatly increase shaving costs. This paper proposes using a hairdryer to massage the skin before shaving to reduce skin irritation during shaving. This is a simple, practical and low-cost method. The hair dryer's heat, sound, and wind energy have a massage effect, and they can make shaving easier and more comfortable. For analyzing shaving effect, two evaluation methods are used, which are sound spectrum analysis and mos. The sound spectrum analysis is used to analyze the working status of the razor objectively. The MOS test can reflect the subjective feelings of the subject on the shaving's comfort. The results show that the hairdryer thermal vibration massage can make the beard easier to cut, thereby reducing the irritation of the razor to the skin and improving shaving comfort.

Keywords: *Shaving, Hair Dryer, Thermal Vibration Massage, Sound Spectrum Analysis, MOS Test.*

1. INTRODUCTION

Shaving is a problem that every adult man needs to solve. People not only want to have smooth skin after shaving, but also want to be as comfortable as possible during the process of shaving. Shaving burn is a common problem. It refers to skin irritation caused by using blunt blades or failure to use appropriate techniques. It is manifested as a burning sensation on the skin, even if redness and swelling may occur in severe cases. Applying hot water to the face and using lubricants is one of the ways to relieve the symptoms of shaving burns. In addition, Multi-razor manufacturers want to improve comfort by improving razors. For example, they have developed a razor with a heating function. Its heating part can make the hair softer and easier to be cut. However, However, these razors are too expensive to be suitable for everyone. Therefore, it is necessary to study more effective and cheaper methods to make shaving more comfortable. This paper proposes using hot air to massage the face before shaving to relieve the irritation of shaving burns. [1] [2]

The hairdryer not only provides hot air but also provides the vibration effect of sound waves. The application of sonic vibration is extensive. It can be used for both cleaning and massage. For massage, such as a fascia gun, a massage chair is used for muscle relaxation, and a facial vibration massager is used for shrinking wrinkles. According to the research of the paper [3] [4], the oscillating mechanical stimulus applied on the skin surface can induce changes in the expression of some structural proteins, which has an anti-aging effect

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on the skin. According to Short et al., the mechanical organization of the skin is a large number of loose collagen fibers connected at randomly distributed nodes. [5] The sonic skin brush can generate upward-opening force to achieve a deep cleansing effect. [6] In a nutshell, all show that proper vibration is good for the skin. Vibration is the periodic work performed by applying mechanical force to the skin. Because the main body comprises water accounting for 70%, the human body will amplify the sound wave vibration. It can cause the resonance of cells and tissues. Resonance can cause the movement of substances in the tissues to achieve the massage effect in the cells. This massaging effect can change the permeability of the cell membrane, stimulate the diffusion process of the cell semipermeable membrane, and promote metabolism. It can promote the secretion of oil and water and make the hard connective tissue soft. When the mechanical energy of vibration is transmitted in human tissues, its energy is finally converted into heat. The heat energy generated by the friction between the massage equipment and the skin increases the temperature of the massaged part. Elevated temperature further increases blood circulation, dilation of capillaries and pores. That is to say, the mechanical energy of hairdryer vibrating massage can not only make the skin secrete water and oil and make the skin soft, smooth, and elastic. Moreover, the hot air from the hairdryer can also relax the pores and change the protein fiber structure of the hair to make the hair soft. So, the problem of skin friction and haircut resistance will be solved. [7]

The purpose of this paper is to study the use of the heating and sonic vibration of a hairdryer to perform thermal massage on the face to relieve the irritation of shaving burns and make shaving more comfortable and easier. Chapter 2 introduces the causes of skin irritation induced by manual razors. Chapter 3 introduces the evaluation methods of shaving effect. On the one hand, the objective evaluation is made by the sound spectrum analysis of the vibration sound when the razor is working. On the other hand, the MOS test is performed on all testers, and the shaving comfort is scored objectively. Chapter 4, Experiment, and discussion, perform sound spectrum analysis and MOS test and analyze the results. Chapter 5, Conclusion.

2. CAUSES OF SKIN IRRITATION INDUCED BY SHAVER

Shavers are mainly divided into manual shavers (wet shave) and electric shavers (Beard trimmer). Compared to electric shavers, wet shaving is a more traditional way. The manual shaver is mainly composed of a cutter head and a handle, and the cutter head is divided into single blade and multi-blade. When shaving, people drag the handle to make the head slide on the skin, the blade is at a certain angle with the skin, and the force of dragging the blade causes the blade to cut the hair. Then repeat this operation until the shaving is complete. The skin irritation caused by the razor comes from the contact between the blade and the skin. The blade's cutting mainly comes from the pressure and pulling force applied to the knife handle. The resistance of the razor is composed of skin friction and resistance to cutting the beard. In the end, the resistance to cutting the beard becomes the pulling force on the beard. As shown in Figure 1, for a multi-blade wet shaving, the pulling force of the front blade on the hair lifts a part of the hair and then cuts it off. The final cut hair will be hidden under the skin. The blade and skin friction and the pulling force of the blade on the hair are the main sources of irritation. The smoothness of the skin and the pressure applied determine the amount of friction. To reduce the resistance of the beard to the blade, the blade should be sharper, or the beard should be softer and easier to cut. [8]

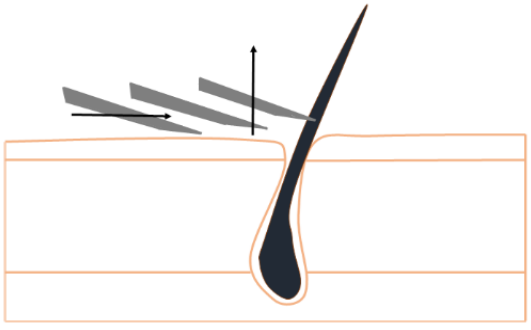

Figure 1. Schematic diagram of the working principle of shaver with multiple blade

The electric shaver uses the principle of rotating machinery to cut the hair. It uses electricity as the energy source to drive a micro-motor to rotate the blade at high speed. The rotating blade and grid form a scissors effect to cut the hair. The electric shaver is more difficult to cut the hair, result in the cut surface of the hair is rougher. The blade has a large pulling force on the hair, and no lubricant is used. The skin friction is large. Therefore, the comfort of electric shaving is lower than that of wet shaving. Figure 2 is the working principle of electric shaver schematic diagram. [9]

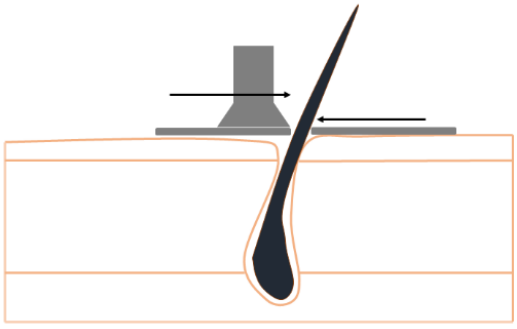

Figure 2. Schematic diagram of the working principle of an electric shaver

3. EVALUATION METHOD

3.1 Vibration and sound spectrum analysis method

The traditional evaluation methods for shaving effect mainly include sebum measurement, corneal measurement, epidermal water loss (TEWL), infrared thermal imaging, and high-frequency ultrasonic sound waves. These methods directly observe and analyze the material composition and content on the skin surface. However, sound spectrum analysis is an indirect method. It does not directly observe the skin but reflects the working status and effect of the razor by analyzing the sound components of the shaving sound. Vibration and sound spectrum analysis is often used in machine fault diagnosis, earthquake early warning, language signal analysis, and other fields. It can solve many problems that are difficult to observe directly. The structure of matter can be inferred by judging vibration and resonance because the frequency of matter is only related to its structure. Sound is a physical phenomenon, which is produced by the mechanical vibration of matter. The time-domain signal of sound is difficult to analyze, so it is necessary to perform time-frequency conversion to analyze in the frequency domain. The sound signal analysis methods include Fourier transform, short-time Fourier transform, discrete wavelet transform, continuous wavelet transform (CWT), Hill Bert transformation, Hilbert-Huang transformation. This paper uses the short-time Fourier transform (STFT) to construct the power spectral density of the sound signal. [13] [14]

The autocorrelation function (ACF) and the power spectral density function are a pair of Fourier transform. Thus, the autocorrelation function is calculated first, and then the power spectral density function can be obtained through the discrete Fourier transform.

$$F_n(K) \overset{DFT}{\Longleftrightarrow} R_n(k) \qquad (1)$$

The following is the short-term autocorrelation function. The short-term refers to multiplying by a window function to intercept the signal and perform autocorrelation calculation at the same time.

$$R_n(k) = \sum_{m=-\infty}^{\infty} x(m)W(n-m)x(m+k)W(n-m+k) \qquad (2)$$

It can be defined as:

$$h_k = W(n)W(n+k) \qquad (3)$$

So, the short-term autocorrelation function can be rewritten as a convolutional expression.

$$R_n(k) = \sum_{m=-\infty}^{\infty} x(m)x(m-k)h_k(n-m)$$

$$= [x(m)x(m-k)] * h_k \qquad (4)$$

Therefore, the short-term autocorrelation function can be regarded as the output of the sequence $x(m)x(m-k)$ through the h_k filter. Where the W(n) is FFT windows.

Finally, the short-time autocorrelation function is subjected to discrete Fourier transform to obtain the power spectral density.

$$F_n(K) = \sum_{n=0}^{N-1} R_n(k)e^{-j\frac{2\pi}{N}Kn} \qquad (5)$$

Using a fast Fourier transform (FFT) algorithm can reduce the calculation time. From the power density spectrum, the sound intensity of each frequency domain component can be observed, and the frequency composition of the sound signal can be understood. By observing the change of the spectrum component, the change of the working state of the machine can be inferred. [12]

3.2 MOS test

MOS (mean opinion score) is used to evaluate the compressed voice quality received by the system. It is also widely used in human objective evaluation tests for an event. The final score is the average opinion score of all testers. It is generally a 5-point system, with 1 to 5 representing five different evaluation levels from low to high. In this paper, Mos is used for subjective evaluation of shaving comfort, and the comfort is divided into five levels. 1: terrible, 2: uncomfortable, 3: normal, 4: comfortable, 5: excellent. Each tester gives a score based on his true feelings and finally gets an average score, representing the subjective average opinion of most people. [13]

4. EXPERIMENT AND DISCUSSION

The experiment subjects were 30 adult males with beards, ranging in age from 20 to 63 years old. The experimental device has three-blade wet shaving, hair dryer, shaving soap, and sound recording equipment. The experimental site is a quiet laboratory. The experiment is divided into two parts: the normal shaving process and the other part is the massage shaving process. The experiment divided the tester's face into two experimental areas to control the variables. Half of the face was required to shave normally, and the other side was shaved after vibration massage. During the experiment, the microphone recording device was fixed 5 cm in front of the subject's face, and the collected shaving sound source was sampled at 48khz and quantized to 16 bits. The analysis software was Audition CS6. Use this software to perform 256-point FFT on the sound source. The obtained analysis spectrum is filtered by the Hanning window. Then all subjects scored the comfort of normal shaving and vibration massage shaving and got the MOS test result. Figure 3 is the experimental process.

Figure 3. Experimental process

Figure 4 is the sound power spectrum analysis of the sound analysis of the general wet shaving process and the wet shaving process after the hairdryer massage. X-axis means frequency (kHz), y-axis means sound intensity (dB). The solid yellow line is the spectral density curve for normal shaving, and the yellow dashed line is the spectral density curve for predicting environmental background sounds. Similarly, the solid blue line represents the spectral density curve of the shaving sound after vibration massage, and the blue dashed line represents the spectral density curve of the corresponding predicted environmental background sound. Environmental background noise is white noise. The shaving process caused sound resonance to gain the spectrum amplitude. A total of three resonance peaks appeared. The first resonance peak was the natural frequency of the razor, and the second resonance peak was the resonance frequency component generated by the friction between the razor blade and the skin. The three resonance peaks are the resonance frequency components generated by the friction between the razor blade and the beard when it cuts the beard. The third formant is related to razor and beard cutting. At the third resonance peak, the blue solid line resonance peak (Bw2) is greater than that of the yellow solid line resonance peak (Bw1). In other words, when the skin is vibrated and massaged, the blade and the beard will resonate. The spread spectrum appears. According to the experimental results, the average Bw1 is 5944HZ, and the average Bw2 is 9886HZ. The bandwidth of the frequency band has been expanded by more than 50%.

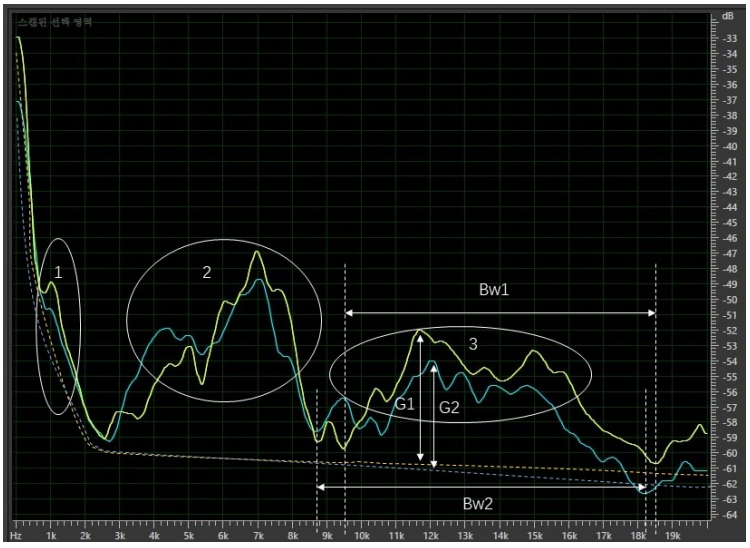

Figure 4. The sound spectrum of normal wet shave (yellow line) and the sound spectrum of wet shaved after the Hairdryer hot sound wind vibration massage (blue line)

For the amplitude gain of the third formant, G1 represents the amplitude gain of normal wet shaving, and G2 represents the amplitude gain of shaving after vibration massage. Table 1 shows the average amplitude gain results of the third formant of all testers. The benchmark amplitude before the massage is 68.37dB, the shaving amplitude is 75.34, and the resultant average gain is +6.97. The amplitude gain of shaving after vibration massage is +4.54dB. After vibration massage, the amplitude gain is reduced by -2.43dB. The sound pressure level is reduced by approximately two times. That is, the resonance caused by the friction between the razor blade and the beard is reduced. It means that the resistance of the beard to the blade is reduced. Therefore, the beard becomes easier to be cut. Massage makes shaving easier.

Table 1. Amplitude gain effect

	Massage before	Massage after
Shaving	75.34 dB	64.32 dB
Normal	68.37 dB	59.78 dB
Gain	+6.97 dB	+4.54 dB
Bias（after- before）	-2.43 dB	

Table 2 is about the MOS test of shaving comfort. It shows the scores and average scores of some testers on the comfort of the two shaving methods. The average score of shave comfort before the massage was 1.89, which means that most of the testers thought shaving before the massage was uncomfortable. On the contrary, the score for shaving after the massage is relatively high, with an average score of 3.77. The results of the MOS test can be found that the comfort evaluations before and after the massage were very different. In addition to massage that makes shaving easier, it can be guessed that the temperature of thermal massage and vibration massage reduces the skin's sensitivity, relax the nerves, and enhances the autonomic regulation, result in reducing the degree of response to razor stimulation.

Table 2. MOS test result

	Massage before	Massage after
1	2	3
2	2	3
3	2	5
4	3	3
5	3	4
6	1	5
7	1	4
…	…	…
30	3	4
Average	1.89	3.77

5. CONCLUSION

Human beings require not only more cleanliness but also more comfortable in shaving. Most always feel uncomfortable during shaving. This paper proposes the use of a hairdryer thermal vibration massage method before shaving. It is aimed at making shaving easier and more comfortable. For the evaluation of the ease of

shaving, the acoustic spectrum analysis method is used. Moreover, use the MOS test to evaluate the comfort of shaving.

The results of sound spectrum analysis show that the third formant is related to beard-cutting. After vibration massage, the bandwidth of the third formant is increased by 1.5 times. The amplitude gain is reduced by 2.43dB. It means that the frictional resistance between the blade and the beard is reduced. That is, the pulling force of the blade on the beard is reduced. Therefore, massage reduces skin irritation and improves the comfort of shaving. According to the MOS test's result, most of the subjects felt uncomfortable during normal shaving. On the contrary, the shave comfort was significantly improved after the hairdryer thermal massage. The improvement in comfort is related to the thermo-acoustic vibration massage, which can relax skin protein fibers and reduce skin sensitivity.

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