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Research Article

Observation of Wear Characteristics on Razor Blades with Different Materials and Lubricants

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A B S T R A C T

The wear of razor blades often occurs when a man shaves his facial hair. In this paper, the observation of wear characteristics with different types of material and lubricants is investigated. The experiment was conducted on six students of the Mechanical Engineering study program with uniform beards and mustaches for six weeks. Each week, the wear from the surface of each blade was observed using an optical microscope. Two types of razors were investigated with different materials based on the price, which consisted of cheap razors (type A) and expensive razors (type B), each of which has three blades. There were three types of lubricants used, namely: water, liquid soap, and foam. The result shows that a type B razor is better than a type A razor because the material has a high carbon content based on chemical content from testing with Energy Dispersive X-ray (EDX). Foam lubricant can slow down the wear on razor blades. The 1st blade razor wears out faster than the 2nd and 3rd blades, respectively.

1. INTRODUCTION

Shaving facial hair is a routine activity carried out by men. The size of male facial hair has an average diameter of about 0.1 mm and a distance of about 3 mm from the root to the skin surface [1]. So we need a razor that has the ability to cut hair on the face. The type of razor used for shaving has varied greatly from time to time. Currently, the most widely used type of razor is the disposable razor because it is easier to obtain, easily recognized, and available in mini-markets and supermarkets at cheap and affordable prices [2].

Shaving men's facial hair is done on average 4 to 5 times a week. If you want a clean shave and a neat appearance, you usually shave 1-2 times a day [2]. Many factors affect how often a person shaves facial hair. The quality of the shaving depends on the sharpness of the razor. Razors can lose their sharpness with time and use. Even though razors are about 50 times harder than hair, they eventually become dull after shaving. Factors that affect blade durability are hair type, growth rate, shaving surface area, blade, shaving technique, and blade storage [2].

According to the American Academy of Dermatologists, disposable razors should be thrown away after 5 to 7 uses, depending on the quality of the razor. For razors at a lower price, the wear of the blade will be faster than that of an expensive one.

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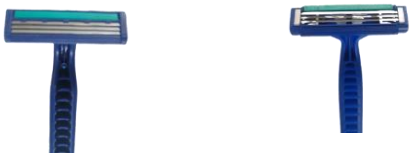
Besides the quality of the razor, razor replacement is also influenced by the thickness of the hair on the face. The right time to replace a razor is if there is skin irritation, uneven shave, rough skin after shaving, dull razor, and excessive blade friction on the skin [2].

The razor deforms its edges gradually after shaving. This is because the strength of the edge of the razor is not able to withstand the stress that occurs when shaving. So cracks occur on the edge of the razor. Cracks are caused by a combination of bending loads, heterogeneous microstructures, and asperities-microscopic chips along edges. The crack originates at the asperity of razor edges and creates chipping, which dulls the blade more rapidly than any other process [3].

Research on razor wear has not been carried out by many researchers. Most of the research has focused on razor material, which causes razor blades to dull and crack [3, 4]. This research was conducted to observe how the wear mechanism occurs on disposable razors. Based on the wear that occurred on the blade, it can be estimated how long the razor blade can be used and must be replaced. Two different types of blades, namely expensive and cheap razors, were used in this study. In addition to the type of razor material, the factor that greatly influences the ease of cutting facial hair is the lubrication used. Three types of lubricants were used in this study, namely water, liquid soap, and foam.

2. METODOLOGI

2.1. Razor Type



(a) (b)

Figure 1. Razors, (a) cheap razors (type A) and (b) expensive razors (type B)

This study used disposable razors, which can be purchased at convenience stores. The type of disposable razor used has three blades with two types of razors at different prices, namely cheap razor (type A) and expensive razor (type B), as shown in Fig.1.

2.2. Testing the Chemical Content of Razor Blades

Two types of razors used in this study were observed for their chemical content. Testing the chemical content of the razor used an energy-dispersive X-ray (EDX) tool. EDX is one of the analytical techniques to analyze the elements or chemical characteristics of the material from the used razor material specimens.

2.3. Razor Blade Wear Test

Wear tests of razor blades were carried out on six volunteers, consisting of students of the Mechanical Engineering study program who have beards and mustaches aged between 20-22 years. Each volunteer used the same razor for two different types of razor (type A and type B) six times in 6 weeks. In this study, each volunteer who had finished shaving took a photo of the razor blade to see the wear that occurred on each of the blades by using a stereo microscope with 20x magnification.

2.4. Type of Lubricant

The shaving process usually uses foam, liquid soap, or water to make it easier to shave because it is more comfortable. There is a layer that separates between the razor and the skin as a lubricant to minimize friction between the skin and the razor blade. Each type of razor used by the volunteers used a different type of lubricant. The types of lubricants used were water, commercial liquid soap, and commercial razor foam, which were purchased at mini-markets around the city of Padang.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Chemical Content of Razor Blades

Razor blades are made of a variety of steels that have certain compounds, usually martensitic stainless steel. Stainless steel, for example, is a mixture of iron, carbon, and chromium. This material is ideal for making razor blades because it is resistant to corrosion. Since razors are regularly exposed to damp conditions, there is a tendency to rust. Modern razors are made of semi-stainless steel, which contains 0.65-0.70% carbon and 12-14% chromium [1]. Today, most quality razors are made from a steel compound called carbide steel. These are metals in which other elements are used which do not have a fixed quantity. In varying amounts, chromium, manganese, silicon, and molybdenum are added to the mixture of iron and carbon to make the malleable steel blade as thin as possible and corrosion-resistant and sharp. An Energy Dispersive X-ray (EDX) was used to determine the chemical content of razor blades. The results of the examination show that there were three main chemical ingredients in razors, namely Fe, C, and Cr. Table 1 shows a comparison of the chemical content of razor blades with different types of razors. Type B razor blades have a higher carbon content compared to type A razor blades, which have a carbon content of 23.48 to 23.95% and a chromium content of 12.99 to 13.78%.

Table 1. Chemical content analysis of two types of razor blades

Chemical content	Blade Type A			Blade Type B		
	1st blade	2nd blade	3rd blade	1st blade	2nd blade	3rd blade
Fe (%)	66.73	66.41	65.96	63.47	63.05	62.13
C (%)	20.76	20.43	20.41	23.48	23.95	23.83
Cr (%)	12.97	13.36	13.23	13.05	12.99	13.78

3.1.2. Surface Texture of the Blades

New razors usually have an edge radius of less than 0.1 microns [1], an angle of $17^{0,}$ and a blade tip radius of 40 nm [3]. The surface texture of the razor blade before use is shown in Fig.2. There is no difference in surface texture between the 1st, 2nd, and 3rd blades for either type A or type B blades. The radius of the razor blade is different between type A and type B razors. The slope of the edge of the blade of the type A razor is firmer when compared to the edge of the edge of the type B razor. On the type B razor, the edge tip of the slope limit of a razor blade is almost invisible for all three blades.

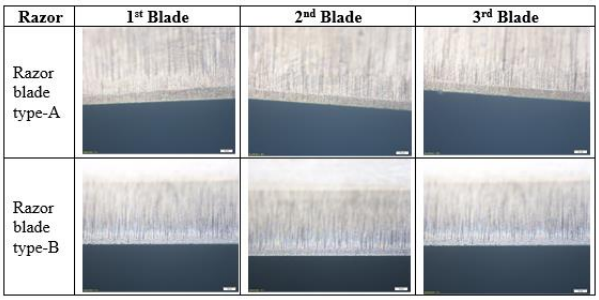


Figure 2. Comparison of surface texture for both types of razor blades before use.

3.1.3. The Effect of Using Lubricant on Surface Wear of Razor Blade

3.1.3.1 Water Lubricant

The wear of the two types of blades (type A and type B) for water lubricant can be seen in Fig.3 and Fig.4. Razor type A (Fig.3) In the first week, wear has not occurred on the blades for the three blades, but fracture has occurred on the surface of 1st blade. Likewise, in 2nd week, wear has not occurred on the blades for the three blades, but fractures are visible on 1st and 2nd blades. In the 3rd week, wear appeared on 1st blade, and the surface of 3rd blade was fractured. In 4th week, 1st blade caused massive wear and tear on 2nd blade, while on 3rd blade, wear on the blade had started to occur. Starting from the 5th week onwards, the three blades have caused massive wear.

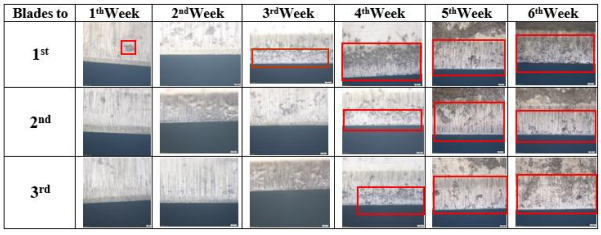


Figure 3. Wear comparison from 1st week to 6th week with water lubricant for razor type A.

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For razor type B (Fig.4) with water lubricant, blade wear occurs in week 3 for both the 1st and 2nd blades. Blade wear for 3rd blade only begins in 4th week where the wear is at certain locations.

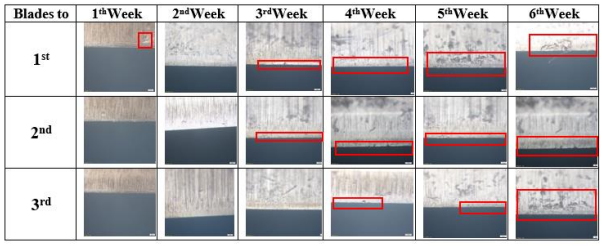

Figure 4. Wear comparison from 1st week to 6th week with water lubricant for razor type B.

3.1.3.2 Liquid Soap Lubricant

The effect of liquid soap lubricant for both types of razors can be seen in Fig.5 and Fig.6. From Fig.5 for liquid soap lubricant for razor type A, the wear of the blade starts in the 4th week for the 1st and 2nd blades. On the 1st blade, the wear of the blade is wider than that of the 2nd blade. The wear of 3rd blade is just starting to cause wear in 5th week.

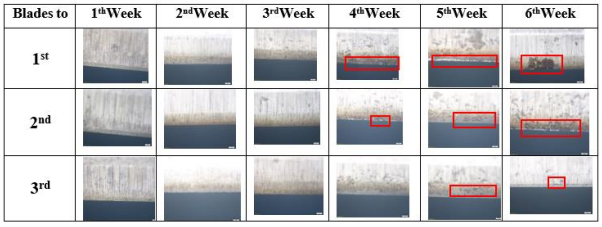

Figure 5. Wear comparison from 1st week to 6th week with liquid soap lubricant for razor type A.

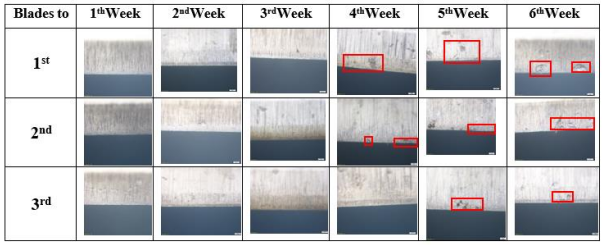

Figure 6. Wear comparison from 1st week to 6th week with liquid soap lubricant for razor type B

Type B razor lubricated with soap can be seen in Fig.6. The wear on the blade started in the 4th week for the 1st and 2nd blades, where the wear was not evenly distributed for all blades. The 3rd blade's new wear is visible in the 5th week, in the middle of the 3rd blade.

3.1.3.3 Foam Lubricant

The effect of foam lubricants on the wear of razor types A and B can be seen in Fig.7 and Fig.8. Fig. 7 shows wear on razor type A with foam lubricant. The wear of the 1st blade was visible in the 3rd week. The 2nd and 3rd blade wear was only seen in the 4th week, where the 3rd blade was worn on the blade in a certain spot area.

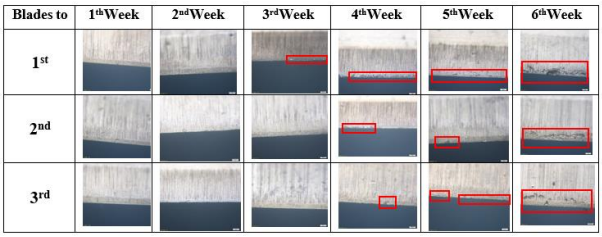

Figure 7. Wear comparison from 1st week to 6th week with foam lubricant for razor type A.

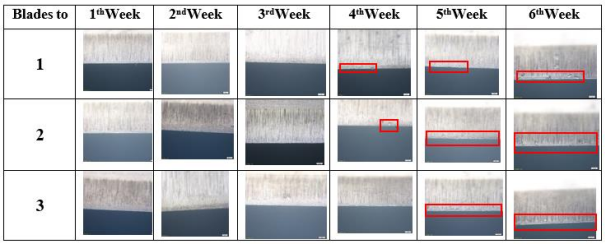

Figure 8. Wear comparison from 1st week to 6th week with foam lubricant for razor type B.

3.2. Discussion

The hair will bend away from the blade when a razor cuts hair attached to the skin. This causes the cutting angle to change [3, 4]. When the angle of the cutting edge is perpendicular to the surface of the blade, the blade will cause very large shear stress, which causes abrasive wear on the blade. This is because steel has a major weakness caused by the process of making razor blades made of brittle martensitic steel. When the razor blade is moved across rough hair surfaces, it causes micro-cracks formed on the razor blade. Microcrack nucleation takes place from asperities during hair cutting, and only a small fraction of asperities proceed to form microcracks. These microcracks initially propagate orthogonally to the edge [3]. Because the load on the blade is repeated when a hair meets the razor blade in one of

these micro-cracks, the crack spreads, and chips are formed, which will peel off due to fatigue and abrasive wear on the surface of the razor blade.

The second thing that affects the process of blunting razor blades is the variation of the microstructure along the edge of the razor [3, 4]. Steel blades are made of tiny microstructures, some of which are brittle and some of which are tough. As a rule, this composition is advantageous in that it prevents the spread of cracks. However, the material of the razor can be damaged if the blade does the heaviest hair.

Besides that, the material of the razor greatly affects the wear of the razor blades. The research shows that type A (cheap) and type B (expensive) razor materials cause different blade wear. B-type razors are rich in high carbon content, which causes the surface of the blade to become hard, so they have high shear strength, and they take a long time to wear out.

The wear of blades is not only influenced by the material of the razor but also affected by the type of lubrication used when shaving. The use of soap and foam lubricants is better than using water lubricants. Water has a low viscosity, so the layer separating the blade from the skin's surface is very thin. So, the friction that occurs on the surface of the blade is very high. Foam lubricant is better compared to soap lubricant. This can be seen in the wear that occurred on the surface of the blade, especially in the 6th week. The use of foam lubricant when shaving hair provides lubrication on the surface of the face when in contact with the blade and provides a softening process for the hair [1]. The position of the blade will also affect the wear that occurs, where 1st blade wears out earlier compared to 2nd and 3rd blades. This is because when cutting, 1st blade comes into contact with the first hair so that the load received by 1st blade is greater compared to 2nd and 3rd blade. The cutting angle of the 1st blade, 2nd blade, and 3rd blade, respectively, is different. The first hair-cutting process is carried out by 1st blade where there is still hair left, and the next hair-cutting execution is carried out by 2nd and 3rd blade so that the hair is not remaining. The best hair-cutting style is if the cutting force is perpendicular to the hair surface or if there is a pure shearing force [3].

4. CONCLUSIONS

The results of research on razor wear have been carried out by varying the type of blade material and the type of lubrication used. The following conclusions can be drawn:

1. The wear mechanism of the razor blade was fatigue abrasive wear due to repeated loads when it cut the facial hair.
2. The material blade with a high carbon content (type B) has high shear strength. So when it encounters a rough hair surface, it is good compared to type A material.
3. This type of foam and liquid soap lubricant can reduce the wear that occurs on razor blades compared to water lubricant. Foam lubricant can provide good lubrication when it is in contact between the blade and the surface of the skin so that wear on the surface of the razor blade can be reduced.
4. 1st blade has a large load, so that the wear of 1st blade is higher than 2nd and 3rd blade.

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