The Quality Detection Technology and Characterization Marking of Knife Edge

Zhonghua Su*, Taizhong Huang, Lichang Fan, Haipeng Mi, Xiong Deng and Xiaodong Deng
Chongqing Academy of Metrology and Quality Inspection, Chongqing 401123, China
*Email: Su_water@163.com

Abstract. The quality and detection of kitchen knives at home and abroad were introduced in this paper. The knife edge toughness index was proposed to measure the comprehensive ability of the blade to resist chipping and curling, and the testing method and testing equipment for the cutter and the chopper were developed. Besides, aiming at the sharpness, durability and toughness which are the key indicators of the knife edge quality, the corresponding detection and identification methods were given.

1. The Industry and Testing Situation of The Kitchen Knife
The kitchen knife product is one of the key products in the daily hardware industry. It is an indispensable kitchen tool in people's life. The production process includes more than forty production processes such as material selection, cutting, forging, quenching heat treatment, grinding and polishing, balance point positioning, tool holder preparation, cutting, and opening. Each step requires extremely strict quality control [1]. Compared with foreign kitchen knife production technology, domestic manufacturers have yet to improve in terms of design, surface treatment, processing precision, heat treatment technology and raw material use. As far as kitchen knives are concerned, the most widely recognized kitchen knives in the world are German and Japanese kitchen knives. The German knives are characterized by precision and durability. And the Japanese knives are characterized by lightness and sharpness. There are thousands of kitchen knife production enterprises in China, and the output of products has increased year by year. Most of them are private enterprises, mainly distributed in coastal provinces such as Guangdong and Zhejiang, and Longshui Town in Dazu, Chongqing. Due to the large scale and advanced equipment, the market share of Guangdong and Zhejiang kitchen knives has increased year by year, and some well-known kitchen knives have emerged, such as Yangjiang 18, Zhang Xiaooquan, and Qiao Fu [2], but the quality of kitchen knives is still not as good as Europe, America and Japan.

Standardization is the key to improving the quality of Chinese kitchen knives. The standards for the quality and testing methods of kitchen knives at home and abroad are mainly DIN EN ISO 8442-5-2005 “Materials and products with food contact and cutlery. Part 5: knives sharpness and blade maintenance test”, QB/T 1924-1993 “Chopper”, DB50/T 261-2014 “Chopper” [3-4]. And the corresponding testing items include material (component), surface defects, blade thickness, resistance corrosion performance, tool strength, handle firmness, hardness, sharpness, durability, drop resistance, resistance to deformation of non-metallic handles in hot water, sanitary requirements, surface roughness, metallographic structure, quenching width, and steel, etc [5-8]. However, the blade toughness which consumers are most concerned about is only clearly required by the foreign tool associations, and this index is not clearly required in the relevant standards at home and abroad, let alone in the classification of grades. The blade toughness index is easy to understand for non-
professionals and can directly reflect the quality and durability of cutting tools. Therefore, establishing the evaluation index in the knife standard and characterizing the knife quality are beneficial to the control of the tool quality by the kitchen knife manufacturer, and it is easy for consumers to understand and consume. In this paper, the testing method, testing equipment and quality characterization of knife edge toughness were systematically studied.

2. The Toughness Detection Technology of Kitchen Knife

Common failure modes of household kitchen knives are chipping, curling and blunting. The failure problem of blunting can be solved by re-grinding, however, the other two kinds of failure problems, such as chipping and curling, are difficult to solve by grinding them again. Therefore, the ability of the blade to resist the chipping and the curling is the key index to evaluate the quality of the kitchen knife. The chipping and the curling edge are mainly affected by the hardness of the blade edge. When the hardness is high, the chipping is easy, and while the hardness is low, which is easy to roll. The scientific value of the hardness value is not conclusive, because the reasonable hardness value also needs to consider the shape and the material of the knife edge and the heat treatment process. In order to provide guidance for the scientific production of the kitchen knife production enterprise and make the purchaser of kitchen knives consume clearly, the toughness of the kitchen knife edge is proposed and studied in this paper. The toughness index of the knife edge is mainly to characterize the ability of the knife edge to resist the chipping and curling when it meets a hard object during use, and it is also a key indicator for evaluating the quality of the kitchen knife. But it is necessary to study the scientific and reasonable testing methods and equipment before making a reasonable evaluation of the index. Since the kitchen knife usually includes a cutter and a machete, this paper will separately explain the detection method and testing equipment for the toughness of the cutter and the chopper.

2.1. The Toughness Detection Method of Cutting Knife Blade

In daily life, the main reason of cutting and curling edge is to cut meat food containing bone. Therefore, the method of measuring the toughness of cutting edge will be used to cut the specimen containing hard material. In order to ensure the consistency of the test conditions, the pencils with different hardness of the same brand were selected and the hardness range was 9B-9H.

A soft pencil was selected at the beginning of the experiment, and then put into the pen tray, immediately afterwards the pencil was cut vertically at a speed of Vmm/s at the position 10 mm from the end of the pencil. After repeating the operation N times, a magnifying glass was used to magnify the cutting edge of the pencil by X times to measure the size of the chipping and curling in the image. Chipping and curling edges are effective defects only when the size of the blade direction or perpendicular to the edge direction is \( \geq L \) micron. If there is no effective defect in the knife edge, then choose a pencil with a larger hardness value to repeat the previous experiment, and the test is stopped until a \( \geq L \) micron chipping or curling occurs on the edge of the knife. The toughness of the knife edge is the pencil hardness value used before the effective defect is generated. Figure 1 shows the magnification of the cutter before and after the toughness test.

![Figure 1. The micrograph of knife edge before and after the toughness testing](image-url)
2.2. The Toughness Testing Equipment of the Cutting Knife Edge

The cutter edge toughness detecting device comprises a base, a sample pusher, a magnifying glass, a bracket, a cutter vertical cutting drive, a cutter holding device, a pencil cutting board, and a cutting board fine adjustment device, corresponding to the numbers 1 to 10 in Figure 2. The base in figure 2 is mainly used to support the whole equipment to ensure the smoothness of the equipment placement; the sample pusher is fixedly mounted on the base for pushing the pencil sample, and when the pencil is cut, the pusher automatically pushes the pencil forward by 10mm for the next cutting; the magnifying glass is fixedly mounted on the base for magnifying and observing the size of the chipping and curling in the cutting position of the blade; the bracket is vertically fixed on the base, and is mainly used for supporting the cutter vertical cutting drive and the cutter clamping device; the fixed height of the cutter vertical cutting drive could be adjusted, and the cutter clamping device is fixed on the drive shaft at the lower end of the drive, besides, the cutter clamping device and the cutter move vertically up and down with the drive shaft, and the moving speed or the maximum vertical shear force can be adjusted as needed; the cutter clamping device is mainly used to fix the cutter, and the cutting board fine adjustment device is set because the thickness of the cutter sample is inconsistent and the cutter edge is not necessarily aligned with the blade protection seam on the cutting board after the cutter is fixed; the lower end of the cutting block is fixed on the upper surface of the cutting board fine adjustment device, and the surface of the cutting board is crisscrossed with a sample slot and a blade protection joint, the sample slot is used for placing a pencil sample, and the blade protection joint is used for protecting the blade edge, thereby to avoid unexpected damage to the blade.

![Figure 2. Cutter blade toughness testing equipment](image)

2.3. The Toughness Detection Method of the Hacking Knife Edge

The main reason for the chopper's chipping and curling is the cutting of thick and hard bones. Therefore, when testing the toughness of the knife edge, it is necessary to select a sample whose hardness value is close to the bone. In order to ensure the consistency of the test conditions, a pencil of different hardness of a certain brand was selected before the experiment, and the hardness range of which includes 9B-9H. At the beginning of the experiment, a pencil was chosen with a hardness lower than that of the bone, then pencil was placed in the pen tray, and cut at a speed of Vmm/s at a position 10 mm from the end of the pencil. After repeating the operation N times, a magnifying glass was used to magnify the cutting edge of the pencil by X times to measure the size of the chipping and curling in the image. Chipping and curling edges are effective defects when the size of the blade direction or perpendicular to the edge direction is ≥ L micron. If there is no effective defect in the knife edge, then choose a pencil with a larger hardness value to repeat the previous experiment, and the test is stopped until a ≥ L micron chipping or curling occurs on the edge of the knife. The toughness of the knife edge is the pencil hardness value used before the effective defect is generated.
2.4. The Toughness Testing Equipment of the Chopper Knife Blage

Chopper knife toughness testing equipment includes base, cutting board fine adjustment device, pencil cutting board, chopper clamping device, bracket, cutting drive, connecting rod, rocker arm, rocker arm limiting device, for details, see numbers 1 to 3 and 6 to 11 in figure 3. The base in the figure is mainly used to support the whole equipment to ensure the smoothness of the equipment placement; the cutting board fine adjustment device is mainly used for adjusting the position of the pencil cutting board fixed on the surface, and ensuring that the cutting edge does not directly contact the cutting board after the chopper cuts the pencil, but enters the protection seam of the cutting edge, thereby avoiding unintended damage of the cutting edge; the cutting board is used to place the pencil sample, the upper surface is crisscrossed with the sample slot and the blade protection joint; the chopper clamping device is mainly used to fix the machete; the bracket is vertically fixed on the base, and is mainly used for supporting the cutting drive and the chopper clamping device; the cutting drive provides driving force for the cutting motion of the chopper, and the driving force is transmitted to the rocker arm through the connecting rod, and the rocking arm drives the clamping device and the chopper to cut, thereby realizing the movement mode of simulating the artificial cutting of the bone. To avoid damage to the blade due to excessive cutting of the chopper, the rocker limit device is specially designed to limit the upper and lower limits of the chopper. In addition, a sample pusher and a cutting edge magnifier are also provided in the apparatus.

![Figure 3. Chopper blade toughness testing equipment.](image)

3. The Characterization and Identification Method of Knife Edge Quality

Good steel used on the blade is the key method to improve the quality of the knife, which fully shows that the quality of the knife edge is very important to the whole knife. Therefore, we should focus on evaluating the quality of a kitchen knife when we evaluate the quality of the knife. This paper will expound the methods of characterizing and identification for the sharpness, durability and toughness which are the key elements of the knife edge quality.

The sharpness and durability of the knife mainly depend on the geometric angle and material properties of the blade. The properties of the material include material size, compactness, wear resistance, hardness, elasticity and forming texture. In this paper, the method used to characterize the sharpness and durability of the kitchen knife is DB50/T 261-2014 “Chopper”. And the sharpness value is the sum of the cutting depths of the first three cutting weeks, and the durability value is the sum of the cutting depths of 30 weeks during the test process. The toughness of the kitchen knife mainly depends on the geometric angle, hardness, elasticity, grain size and compactness of the cutting edge. The characterization method uses the previously proposed blade toughness detection method.

In the case where the sharpness, durability and toughness characterization methods are determined, this paper will present a clear identification method for identifying the edge quality. The kitchen knife manufacturing company usually adopts mechanization in the production process, and the sharpness, durability and toughness of the kitchen knife are relatively consistent. Therefore, it is only necessary
to sample and characterize the continuous batch product before characterizing the knife edge quality. If the test results are as follows, sharpness is 60mm, durability is 260mm, and toughness is 3H, then the mechanical printing mark F60N260J3H is printed near the trademark position of the kitchen knife, and the quality of the knife edge can be understood by the consumer through the mark.

4. Conclusions

In view of the technical requirements, testing methods and testing equipments of domestic kitchen knives without anti-fracture and curling edge, this paper proposed a blade toughness testing project and developed corresponding testing techniques, including the testing method and equipment of the cutting tool and the detection method and equipment of the chopper.

Based on the criticality of sharpness, durability and toughness on the quality of the knife edge, the methods of detecting and characterizing the key indicators were given, which would increase the market driving force for the quality improvement of the kitchen knife product.

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