Toughness Detection and Gradation for Kitchen knife Edge

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Abstract. Breakage, curling edge and bluntness are the common failure forms of kitchen knife edge. A comprehensive characterization index, knife edge toughness, has been proposed, which including sharpness, durability and roll/breakage edge resistance indexes. The definition, testing method and testing equipment for each index have been described. Gradation for each index has been taken by market sampling and testing. The grade marking method for kitchen knife edge toughness has been demonstrated by image case.

1. Introduction

The key method to improve kitchen knife quality is putting good steel into blade. It fully shows that edge quality is very important for the whole kitchen knife. So, we should take edge quality to evaluate the quality of kitchen knife. Breakage, rolling edge and bluntness are common failure forms in kitchen knife using. When kitchen knife blunting, grinding again is used to repair its performance. Durability is the index to characterize anti-wear ability of kitchen knives. It is difficult to recover kitchen knives performance by grinding again after breakage, rolling edge. In domestic and international standards, there is no index to characterize breakage and rolling edge resist ability of kitchen knife, and no index to characterize comprehensive quality of knife edge. The definition, detection method, testing equipment and gradation for knife edge quality indexes will be describe in this paper. Definition of durability is the ability of kitchen knife edge to resist cutting wear.

Knife edge quality indexes have been defined as follows. Definition of knife edge toughness is the performance between cutting edge and first grinding, or between two grinding, which including sharpness, durability and roll/breakage resistance. The index is used to characterize the comprehensive quality of knife edge, and its representation is gradation. Definition of sharpness is the cutting ability of kitchen knife edge. The sharpness value is cutting depth sum in first three weeks. The corresponding symbol(unit) is F (mm), which refers to DB50/T 261-2014 <Kitchen Knife>. Definition of durability is the ability to resist cutting wear of kitchen knife edge. The durability value is cutting depth sum in first 30 weeks. The corresponding symbol(unit) is N(mm), which refers to DB50/T 261-2014 <Kitchen Knife>. Definition of roll/breakage edge resistance is the curling and breakage degree of knife edge when encounter hard objects during cutting. The smaller damage, the better roll/breakage edge resistance. Corresponding symbol(unit) is K(mm²).

2. Testing equipment and methods

Edge toughness of kitchen knives, as a comprehensive index, includes three sub-indexes. They are sharpness, durability and roll/breakage edge resistance. Therefore, three sub-indexes must be tested
before determining the edge toughness of kitchen knives. Testing equipment and methods for each sub-index are as follows.

2.1. Testing Equipment and Method for Sharpness
Testing equipment is Tool Sharpness and Durability/Abrasion Detector. Testing method refer to DB50/T 261-2014, 6.4.

2.2. Testing Equipment and Method for Durability
Testing equipment is Tool Sharpness and Durability/Abrasion Detector. Testing method refer to DB50/T 261-2014 6.4.

2.3. Testing equipments, materials and methods for roll/breakage edge resistance
Breakage equipment for roll/breakage edge resistance should have kitchen knife fixing device, which can fix kitchen knife vertically with knife edge facing down. The fixing device can vertical lift up and down, move in 50 mm/s, and stop when maximum pressure over 500 N in descent process. A horizontal placement sample table is right below the edge of knife, which has a protective groove parallel to knife edge. The protective groove is width 1 mm - 2 mm, depth > 10 mm. The fixing device for kitchen knife should stop declining after standard sample cutting off and entering protective groove. The index is not covered by existing standards, therefore, there is no corresponding testing equipment. The test equipment designed in this paper is shown in Fig1.

Breakage cut wire for roll/breakage resistance adopt galvanized wire tie wire, which was made in Yue Qing Quantum Electric Co Ltd. Its brand name ELECALL, model Ф1.5mm, implementation standard YB/T 5294-2009. Sample information is shown in Fig 2.

VHX-5000 3D microscope with super depth scene have been used for roll/breakage resistance quantitative detection. The equipment is shown in Figure 3.

The test methods for roll/ breakage edge resistance are as follows. First we fix kitchen knife on the breakage equipment for roll/breakage resistance, and keep middle knife edge parallel to the sample table as far as possible. Cutting wire should be placed and fixed on the sample table below middle knife edge. Make sure the length of cut off wire is not less than 10 mm, and the kitchen knife cuts vertically at 50 mm/s speed. We should repeat above operation twice, and keep cutting point spacing of kitchen knife edge more than 10mm. The edge broken kitchen knife is placed horizontally on the loading platform of VHX-5000 3D microscope. Microscopic lens is aligned with break or roll edge point (The rolled up side should be upward). We should choose 100 times lens and focus to ensure the clarity of blade. Curves are used to select the area of breakage or rolling edge. During selection process, the curves should not be less than 20 segments, and each segment should close to the boundary of breakage or rolling edge (at the junction of light and shade in the image) as far as possible. After selection, we can close curves and calculate the area of breakage or rolling edge. The calculation and marking for the area are finished by the system of VHX-5000 3D microscope, which are shown in Fig 4. The average area of three breakage or rolling edge is taken as the result of knife roll/ breakage edge resistance.
3. Gradation and identification
Before toughness gradation, each sub-index should be gradated. Test kitchen knives, which have different brands and prices, were purchased in markets. The sharpness, durability and roll/breakage resistance of kitchen knives have been tested according to the detection methods above-mentioned. The test results have been sorted and plotted separately. The sorts are shown in Fig 5-7.
According to the trend of curves, sharpness, durability and roll/breakage resistance have been classified into four grades (A B C D). The edge toughness of kitchen knives have been classified into four grades (A B C D) corresponding. The parameters for each index are shown in Table 1. The toughness grade is determined by the lowest grade of sharpness, durability and roll/breakage resistance. For example, the sharpness and durability are all grade A, while the roll/breakage resistance is only grade B, then the toughness of kitchen knife is grade B.

Kitchen knives should be marked with toughness grade and sub-indexes data to show their edge quality. The marking method is shown in Figure 8. Marking content in Figure 8 can be interpreted as toughness grade B, sharpness 55 mm, durability 220 mm, roll/breakage resistance 0.4 mm². The bigger sharpness value, the stronger cutting ability. The bigger durability value, the stronger keeping cutting ability. The smaller roll/breakage resistance value, the stronger resistance to hard damage, and the better hardness and plasticity comprehensive performance.

| Tab 1. Sort for knife edge toughness |
|-----------------------------------|
| Toughness Gradation | A | B | C | D |
| Sharpness. F(mm) | \(F > 60\) | 50 < \(F \leq 60\) | 40 < \(F \leq 50\) | \(F \leq 40\) |
| Durability. N(mm) | \(N > 250\) | 200 < \(N \leq 250\) | 150 < \(N \leq 200\) | \(N \leq 150\) |
| Roll/Breakage Resistance. K(mm²) | \(K < 0.1\) | 0.1 ≤ \(K < 0.5\) | 0.5 ≤ \(K < 1.5\) | \(K \geq 1.5\) |

4. Conclusion
Aiming at the common failure modes of kitchen knives such as breakage, roll edge and grinding bluntness, a comprehensive characterization index for knife edge toughness has been proposed, including sharpness, durability and roll/breakage resistance. The definition, detection method, testing equipment and gradation for knife edge quality indexes have been expounded respectively. A breakage
equipment for roll/breakage edge resistance has been developed. Combining with VHX-5000 3D microscope, the roll/breakage edge resistance can be tested. Sub-indexes of knife edge toughness have been classified into four grades (A B C D) by market sampling and detection. The marking method has been demonstrated by image case. Improvement of enterprise technical level, standardization of market competition, explicitness of product quality, and convenience of consumption choice will be promoted with the popularization and application of this technology.

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