

Article

Not peer-reviewed version

A Study on Tooth Wear Mechanisms During the Bandsawing of Cr12MoV with Bimetal Bandsaw Blade

[Yuzhen Jia](#) , [Jigang Wu](#) ^{*} , [Yugiang Chen](#) ^{*} , [Bing Chen](#) , Guoyue Liu , Zhiyong Ouyang

Posted Date: 19 September 2024

doi: 10.20944/preprints202409.1368.v1

Keywords: bimetal bandsaw blade; Cr12MoV; chipping; abrasive wear; adhesive wear; high-speed photography



Preprints.org is a free multidiscipline platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This is an open access article distributed under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Article

A Study on Tooth Wear Mechanisms During the Bandsawing of Cr12MoV with Bimetal Bandsaw Blade

Yuzhen Jia ^{1,2}, Jigang Wu ^{1,*}, Yuqiang Chen ^{1,*}, Bing Chen ^{1,2}, Guoyue Liu ^{1,2}
and Zhiyong Ouyang ²

¹ Hunan Provincial Key Laboratory of High Efficiency and Precision Machining of Difficult to Machine Material, Hunan University of Science and Technology, Xiangtan 411201, Hunan Province, China

² Bichamp Cutting Technology (Hunan) Co., Ltd., Changsha 410200, China

Abstract: Bandsaw blades are typical band-shaped cutting tools characterized by low stiffness and micro-level cutting depth, resulting in distinct wear mechanisms compared to rigid cutting tools. In this study, the wear curve and wear mechanisms of bandsaw tooth during the bandsawing of Cr12MoV cold-working steel was investigated. The tool life was divided into two stages: a rapid wear stage (Stage I) and a homogeneous wear stage (Stage II). In Stage I, the wear was dominated by chipping although multiple wear mechanisms were found due to the relatively poor manufacturing accuracy compared to rigid cutting tools, which results in remarkable differences among the cutting depths of individual teeth. In Stage II, abrasive and adhesive wear were the primary wear mechanisms instead of chipping, which was related to the microstructure of Cr12MoV. Furthermore, methods for increasing the bandsaw performance were proposed based on the tooth wear mechanisms.

Keywords: bimetal bandsaw blade; Cr12MoV; chipping; abrasive wear; adhesive wear; high-speed photography

1. Introduction

Since Luban made significant improvements to saws [1], sawing tools, including reciprocating saws, circular saws, chainsaws, wire saws, and bandsaws, have been developed for 2500 years. Owing to the thin kerf, excellent section quality and high cutting efficiency, bandsaw blades have been widely used in cutting-off procedures, especially for workpieces with large sizes [2].

The thickness of the bandsaw blade is between 0.5 mm and 1.6 mm. Thus, the bandsawing vibration is difficult to be avoided due to the lack of rigidity, which is distinguished from turning, milling and various rod tools [3–5]. Although several methods have been proposed to limit vibration during bandsawing, such as roll-tensioning [6,7], stretching [8], surface texture [9] and robust control [10], It is hard to completely eliminate vibration. The vibration makes the wear mechanisms of bandsaw teeth complicated. Sarwar et al. studied the wear modes of bandsaw teeth when cutting stainless steel [11], bearing steel [12] and Ni-Cr-Mo steel [13], found that flank wear was the main wear mode. Khan et al. [14] revealed that adhesive wear, frictional wear and diffusion wear were the main wear mechanisms during cutting Ti-17 by a TiAlSiN-coated bandsaw blade, and the TiAlSiN coating effectively improved the life of the bandsaw blade because coating decreased wear rate. Zhuo et al. [15] introduced acoustic emission technology to monitor the abnormal wear of bandsaw blade teeth to predict the occurrence of out-of-square phenomenon during bandsawing and reduce the losses of high-value materials. As mentioned above, recent studies on the wear of bandsaw blades have focused on blade wear when the blades were close to failure. Limited studies on the wear mechanisms throughout the whole life cycle of bandsaw blades, especially the alternation of wear

mode from early stage of tool life to failure, are reported. Meanwhile, the stimulations of different wear mechanisms are rarely investigated.

Cr12MoV is cold-work die steel widely used in stamping, die casting moulds, and extrusion dies. In addition, Cr12MoV is martensitic stainless steel with C content of 1%, Cr content of 12%, and high work-hardening rate, and the microstructure is composed by high-hardness metal carbides and low-hardness steel matrix, which is a typical difficult-to-machine materials [16]. Due to the complex and variable shape of the mould, industrial manufacturing requires the large die billet to be cut off to the target size before subsequent processing. Bandsawing is extensively adopted for cutting-off procedure in steel trading enterprises. In this study, Cr12MoV steel is used as the processing workpiece. High-speed photography, electron microscope observation and finite element modeling (FEM) are adopted to study the wear mechanism of saw teeth in the whole bandsaw blade life cycle and reveal the stimulations of different wear mechanisms. The methods to improve the bandsaw life are also discussed.

2. Experimental Procedure

2.1. Bandsaw Blade and Workpiece Material

The bimetal bandsaw blade (hereinafter referred to as bandsaw) tested in this study had a dimension of 41 mm × 1.3 mm and 2/3 teeth per inch (TPI), and its basic information is provided in Table 1. The tooth material of the bandsaw was M42 high-speed steel (HSS) with a hardness of 955 HV and its microstructure is shown in Figure 1a. The carbide was uniformly distributed in the tempered martensite matrix, and the maximum carbide size is <10 μm. The saw blade body was composed of X32CrMoV4-1 high-strength spring steel with a hardness of 505 HV, and its structure was mainly tempered sorbite (as shown in Figure 1b). The nominal compositions of the tooth and body materials are listed in Table 2.

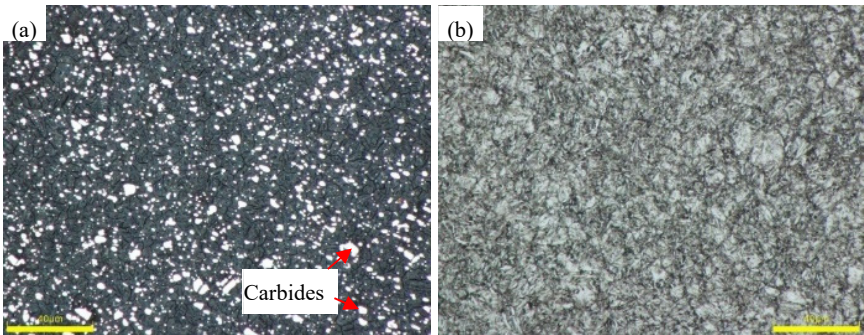


Figure 1. Microstructures of different parts of the bandsaw: (a) tooth (M42 high speed steel); (b) body (X32CrMoV4-1 high).

Table 1. Basic information regarding the bandsaw used in the experiment.

Item	Content
Section size (width × thickness)	41 mm × 1.3 mm
Pitch (TPI)	Variable pitch (2/3 TPI)
Rake angle/clearance angle	10°/30°
Setting sequence	Left—right—left—right—neutron
Kerf width	2.1 mm
Tooth material/hardness	M42/955 HV
Body material/hardness	X32CrMoV4-1/505 HV

Table 2. Chemical compositions of the tooth and body materials (mass fraction, %).

	C	W	Mo	Cr	V	Co	Ni	Fe
Tooth material	1.08	1.5	9.4	3.8	1.2	8.0	\	Bal.

Body material	0.32	\	1.0	4.0	0.3	\	0.5	Bal.
---------------	------	---	-----	-----	-----	---	-----	------

The workpiece material was a Cr12MoV cold-work die steel square with a size of 400 mm × 200 mm and an average hardness of 267 HV. The microstructure of workpiece is depicted in Figure 2, which shows an annealed structure, and the metal carbides are distributed in a pearlite matrix in the form of dots or strips.

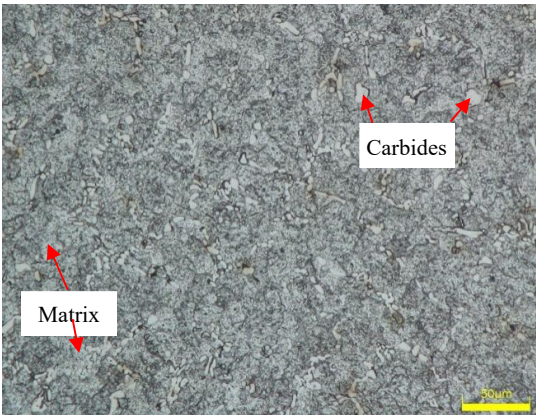


Figure 2. Microstructure of the Cr12MoV workpiece.

2.2. Experimental Method

Sawing test was conducted using an H-460HA horizontal bandsaw machine. Figure 3 shows the appearance of the bandsaw machine. The bandsaw did not undergo a break-in procedure, and band speed of 40 m/min and feed speed of 10 mm/min were used for the sawing test, obtaining the average cutting depth of 2.5 μm. Hispec high-speed camera was used to observe the chip formation of the first cut, and the image acquisition rate was 3500 frames/s. The bandsaw was removed off after every five cuts, and a VMS-3020H video measuring system was used to detect the flank wear of the saw teeth. Then, the bandsaw was reinstalled on the saw machine to continue the sawing test. This process was repeated until the bandsaw blade failed. When measuring the flank wear, the width of the wear platform at the left, middle, and right sides of each tooth was measured, and the maximum value was considered as the wear amount of the tooth [17]. In this test, the phenomenons such as body fractures, tooth breakage, or continued tooth stripping didn’t occur. The failure mode was out-of-square, in which the perpendicularity of the workpiece was too large due to severe tooth wear (criterion standard: perpendicularity of the workpiece section >1.5% × 200 mm). The material structure was observed by OLYMPUS DSX510 digital microscope. FEI Quanta200 scanning electron microscope (SEM) was used to observe the tooth morphology after failure in the secondary electron mode.



Figure 3. Bandsawing machine of the experiments.

3. Results and Discussion

3.1. Wear Curve of the Saw Tooth

Starting from the tool life of 0.08 m^2 (the first cut), the bandsaw was removed off after every five cuts for flank wear measurement. The wears of the neutron, left-set, and right-set teeth were measured individually, and the wear curves are shown in Figure 4a. The bandsaw employed in the sawing test finally fails after sawing 2.4 m^2 , and the failure mode is out-of-square due to the large wear of the teeth. The flank wears of the neutron, left-set, and right-set tooth reach 0.26 mm , 0.36 mm , and 0.37 mm , respectively.

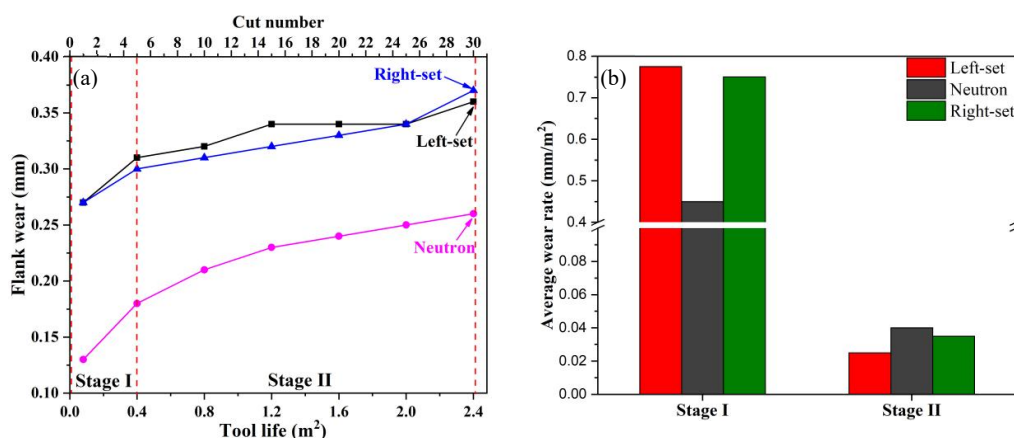


Figure 4. Wear of tooth of bandsaw in tool life: (a) wear curves; (b) average wear rate.

As shown in Figure 4a, the flank wear of the neutron tooth is less than that of the set tooth due to the shape characteristics of different teeth. The wears of both the neutron and set teeth are divided into two stages: Stage I—sawn area below 0.4 m^2 , and Stage II—sawn area over 0.4 m^2 . When the sawn area reaches 0.4 m^2 , the flank wears of the neutron, left-set, and right-set tooth are 0.18 mm , 0.31 mm , and 0.30 mm , respectively, which are 69.2%, 86.1%, and 81.1% of those of the failed bandsaw, while the tool life percentage at this time is only 16.7% ($= 0.4/2.4 \times 100\%$). After the sawn area exceeds 0.4 m^2 , the tooth wear enters into Stage II, when the wear rate decreases significantly. The average wear rates of the neutron, left-set, and right-set teeth at Stage II are $0.04 \text{ mm}/\text{m}^2$, $0.025 \text{ mm}/\text{m}^2$, and $0.035 \text{ mm}/\text{m}^2$, respectively, which are largely lower than those at Stage I (as shown in Figure 4b).

Common tool wear curves are characterized by three stages: rapid wear in the first stage, uniform wear in the second stage, and severe wear in the later stages [18,19]. However, in this study, the bandsaw teeth does not exhibit severe wear in Stage III. Bandsaw blades are flexible cutting tools and fail mainly because of out-of-square or body fracture. When teeth are severely worn, the feed force increases, forcing saw blade body to bend. When the bending reaches a critical value, out-of-square wear will occur. At this time, the tooth wear has not entered into Stage III (severe wear stage). If out-of-square wear did not occur, the saw teeth would be violently worn (the third stage of wear), called as “domino stripping of teeth” phenomenon, which does not happen in this study.

3.2. Saw Tooth Wear Mechanism in Stage I

To explore the mechanism of tooth wear in Stage I, the bandsaw was removed after the first cut, and a total of 200 teeth were randomly selected for morphological observation, and significant differences were found in the wear modes of the different teeth. For the purpose of discussion, the wear modes of teeth at this stage are divided into four types.

The first type is mild wear without chipping, as shown in Figure 5a. The vast majority of teeth are characterized by a small amount of saw tooth wear (usually flank wear below 0.1 mm), and no

wear is found on a few saw teeth, indicating that they are not hurt by the workpiece. The saw teeth are relatively intact without chipping. Eleven of the 200 teeth are found to be with such characteristics, accounting for 5.5%.

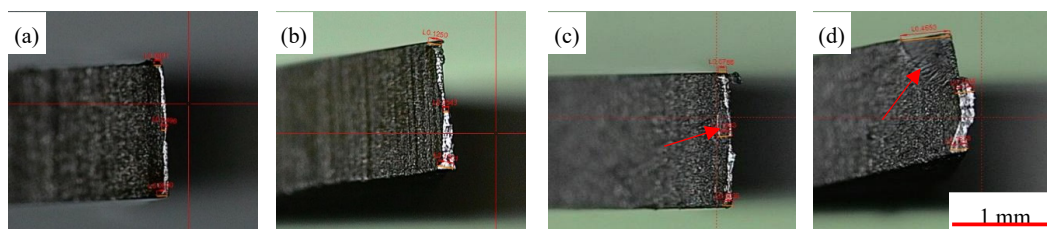


Figure 5. Different wear modes in Stage I: (a) mild wear, no chipping; (b) significant wear, no chipping; (c) chipping; (d) tooth breakage.

The second type is significant wear without chipping, as shown in Figure 5b. Compared with the first type, the wear of this type is larger, generally over 0.1 mm, and the built-up edge (BUE) can be observed on several teeth. However, the integrity of the teeth is good, and no chipping is found. A total of 64 teeth with these characteristics are identified, accounting for 32% of the total.

The third type is chipping, as indicated by the red arrow in Figure 5c. In this type of wear, the chipping positions can be on the middle or corner of the teeth. The chipping width is less than 1/2 of the tooth width, usually being between 1/5 and 1/3 whatever the chipping positions are. This type of wear accounted for the largest proportion of the saw teeth (107 saw teeth, or 53.5% of the total).

The fourth type is tooth breakage, as the position indicated by the red arrow in Figure 5d. In this type the saw tooth is seriously damaged. Both sides of the corner have large breakage, and the size is more than 1/2 of the width of the saw tooth, and in extreme cases, a complete broken saw tooth can be seen. A total of 18 teeth with the wear type are found, accounting for 9%.

The phenomenon is probably due to the different cutting depths, resulting in the cutting force alternations of different teeth. When a saw tooth is subjected to a large force, the third and fourth wear types are inclined to occur, and when a saw tooth is subjected to a small force, the first and second wear types are more likely to occur. To verify the assumption above, high-speed photography was used to obtain a real-time picture for in situ observation during bandsawing by a new saw blade, as shown in Figure 6. Large differences were found in the cutting depths of different teeth. Some of the teeth had larger cutting depths and formed thicker chips, as shown in Figure 6a. In this case, the cutting force of the teeth was high, causing significant wear or chipping, and in extreme cases, tooth breakage could occur. The cutting depth of some of the teeth was relatively small, and the formed chip was fine and thin, as shown in Figure 6b. In this case, the cutting force was relatively small, the corresponding wear was mild, and the saw teeth were only slightly worn, as shown in Figure 5a. In the high-speed photographic observations, a few teeth were found not to be in contact with the workpiece, as shown in Figure 6c, and thus did not cut the workpiece; consequently, tooth wear did not occur.

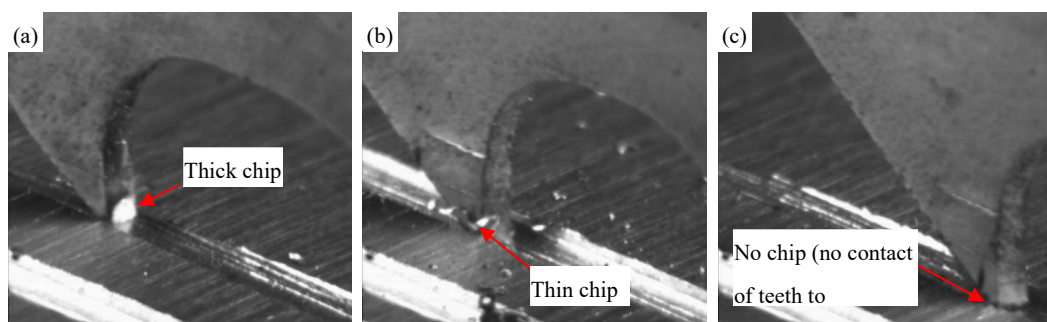


Figure 6. High speed photographs of the first cut: (a) large cutting depth; (b) small cutting depth; (c) tooth not touching workpiece.

This phenomenon is probably due to the bandsaw processing accuracy. For bimetal bandsaws, the teeth are usually shaped by a milling cutter followed by a setting process to form neutron teeth, left-set teeth, and right-set teeth. In the case of milling, production is stroke by stroke rather than continuous, where the stroke length is determined by the length of the milling cutter, and a joint is formed between two adjacent strokes [20]. The accuracy of the joint will affect the accuracy of the bandsaw. Meanwhile, the milling cutter will also experience wear during use, and as the milling cutter edge becomes worn, the width of the bandsaw during formation processing will change (usually, the width will gradually increase). The milling cutter needs resharpener when worn to a certain extent, and the width before and after resharpener is likely to alter. All these factors will affect the accuracy of the bandsaws. Similarly, tooth setting processing is affected by several factors, such as equipment rigidity, operator experience, and wear of the setting tool. To determine the deviation of the width of the bandsaw (distance from the tooth tips to the bottom edge) and the actual accuracy of tooth setting magnitude, the widths of 89 consecutive teeth of the new saw blade, setting magnitude of 40 consecutive left-set teeth and 40 consecutive right-set teeth were measured, which are shown in Figure 7. The width of the bandsaw fluctuates from 40.83 mm to 40.93 mm, i.e., within a tolerance of 0.1 mm (as shown in Figure 7a), and the setting magnitude varied from 0.37 mm to 0.43 mm, i.e., within a tolerance of 0.06 mm (as shown in Figure 7b). The average cutting depth per tooth is usually small [21] and is only 0.0025 mm in this study, which is only 1/40 of the width fluctuation range and 1/28 of the setting fluctuation range. Fluctuations in the width and setting magnitude are inclined to result in different cutting depths of different teeth. The tooth with a relatively small width and small setting magnitude withstands a small cutting depth, and in contrast, a large cutting depth occurs on the tooth with a relatively large width and small setting magnitude, which is easily chipped or broken.

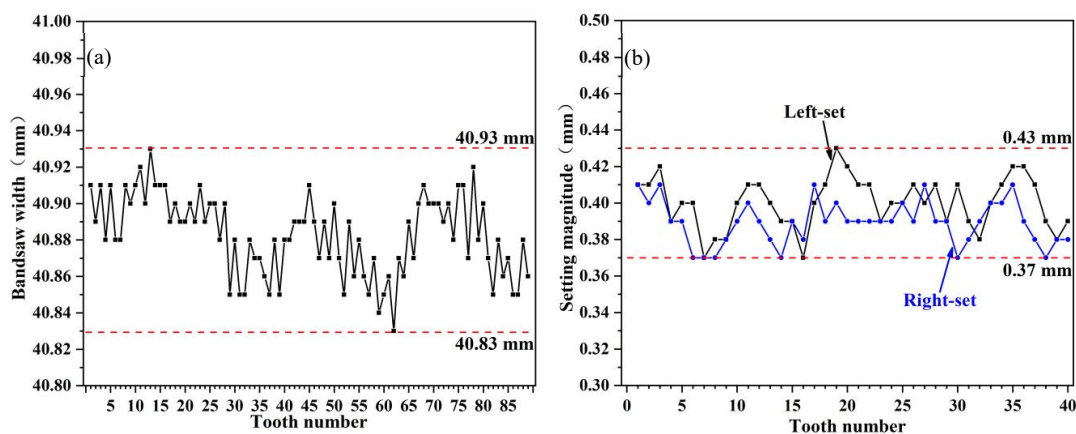


Figure 7. Variations of dimensions of new bandsaw: (a) bandsaw width; (b) setting magnitude.

As a multi-point cutting tool, the cutting depths and forces on different teeth of a new bandsaw should ideally be uniform. However, the actual cutting depths and forces of different teeth varied due to the processing accuracy of the bandsaw. Thus, the saw teeth were worn in different types. For most of the saw teeth, because of the relatively large cutting depth, the cutting resistance was large, so the saw teeth wore quickly, and chipping or breaking tended to occur. Chipping is the main wear type, and it is the main reason for the rapid wear of the bandsaw blade in Stage I. After Stage I (rapid wear), the wear of saw teeth entered Stage II (stable wear) due to the relatively even saw teeth after worn in Stage I.

3.3. Saw Tooth Wear Mechanism in Stage II

When the saw tooth wear enters Stage II, the different saw teeth become even until the bandsaw blade fails. Except for seriously damaged saw teeth (the fourth type) in Stage I, most of the remaining saw teeth eventually present uniform wear, as shown in Figure 8a–c. However, because of the specificity of the distribution of the bandsaw blade teeth, the wear characteristics of different teeth are distinguished. For neutron tooth, both sides of tooth are worn more severely than the central part of tooth, forming an arc shape after uniform wear, as shown in Figure 8a. For the set tooth, the major part that withstands wear is the outside of the saw tooth, that is, the left side of the left-set tooth and the right side of the right-set tooth. Therefore, wear mode of the set tooth is mainly unilateral wear, as shown in Figure 8b,c, which meets the results of research by Söderberg et al. [22]. Figure 8d–f show the stress fields of different saw teeth obtained by finite element method. The main loading positions of the neutron tooth are on both sides of the cutting edge, and the stress fields on both sides are basically the same. The main loading position of left-set tooth is on the left side of the cutting edge, and the loading area on right side of the tooth is relatively small. Accordingly, the main loading position of right-set tooth is on the right side of the cutting edge, and the loading area on the left side of left-set tooth is relatively small. By comparing Figure 8a–c and Figure 8d–f, it can be seen that the severe worn areas of the tooth match those with relatively concentrated stress fields.

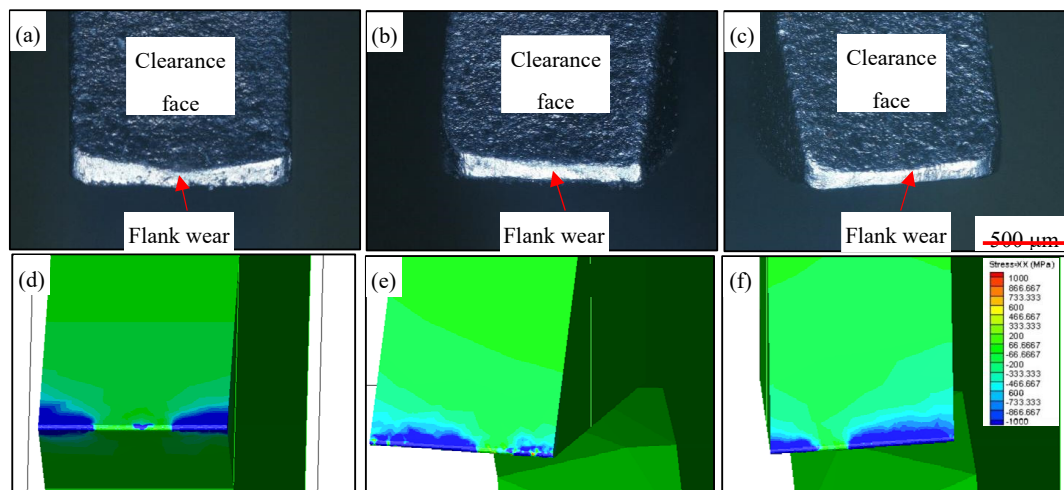


Figure 8. Typical worn teeth morphologies (a–c) and simulated stress field (d–f) of bandsaw teeth: (a)&(d) neutron tooth; (b)&(e) left-set tooth; (c)&(f) right-set tooth.

In Stage II, the saw teeth gradually become even, so chipping of the saw teeth infrequently occurs, and the wear of the saw teeth presents a wear mechanism different from that in Stage I. The SEM images of the bandsaw blade teeth after failure are shown in Figure 9, which exhibits two different tooth wear mechanisms in Stage II. Obvious adhered workpieces are observed, and most of them are tightly adhered to the saw teeth. However, cracks can be found between some adhered workpieces and the saw teeth, indicating that they are about to peel off. The parts show the characteristics of adhesive wear. Meanwhile, small scratches exist on the worn surface of the saw tooth, and the direction of the scratches is consistent with the cutting direction, which presents abrasive wear.

Mostly, abrasive wear is caused by the scraping of hard particles. The workpiece material (Cr12MoV cold-work die steel) used in this study is high-Cr martensitic stainless steel with a high C content of ~1%. There are amounts of carbides with high hardness distributing on the matrix (as shown in Figure 2). These hard carbides abrade the saw teeth during bandsawing, which is the original of abrasive wear.

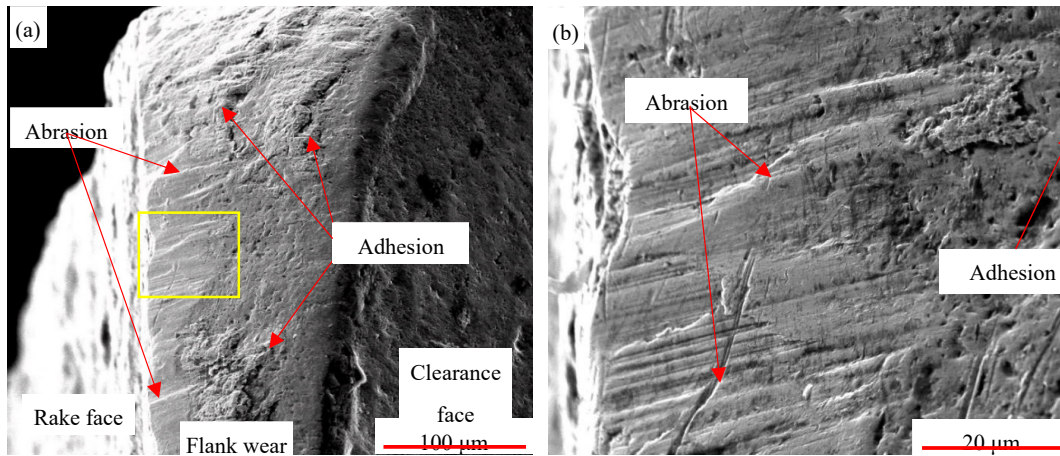


Figure 9. SEM morphologies of the teeth of a failed bandsaw. (b) shows the details of yellow area in (a).

Figure 10a is the photo of a typical chip formed in Stage II, and Figure 10b is the picture showing details of the chip in Figure 10a. The chip thickness is about 80 μm , which is 32 times of the average cutting depth. One side of the chip is irregularly serrated, with the space between two adjacent serration of about 11 μm , as shown in Figure 10c. The serrated side is the curved surface of the chip and does not contact with the saw edge. The other side of the chip is a smooth surface, which is in contact with the saw tooth and forms a secondary deformation zone during the sawing process, which is subjected to great shear stress due to the friction between chip and tooth. Small grooves can be seen on the smooth surface, which are formed by the scraping of the fine carbides in the high speed steel. In Figure 10b,d, obvious tearings can be seen on the smooth surface, and their length and spacing are not significantly regular, suggesting that the tear on the chip surface is formed randomly. The workpiece Cr12MoV adopted in the test was annealed to a hardness of about 267 HV, composed of hard carbide and soft steel matrix. Cutting temperature can reach 300~400 $^{\circ}\text{C}$ due to the heat generation during bandsawing. The heat makes the soft steel matrix of the workpiece very adhesive and a part of the matrix adheres on the tooth. The adhered chip may be peeled off from the tooth under the large shear stress. By the action of the adhering-peeling cycle, the chips will form irregular tearings on the smooth surface, as well as adhesive wear on the saw teeth.

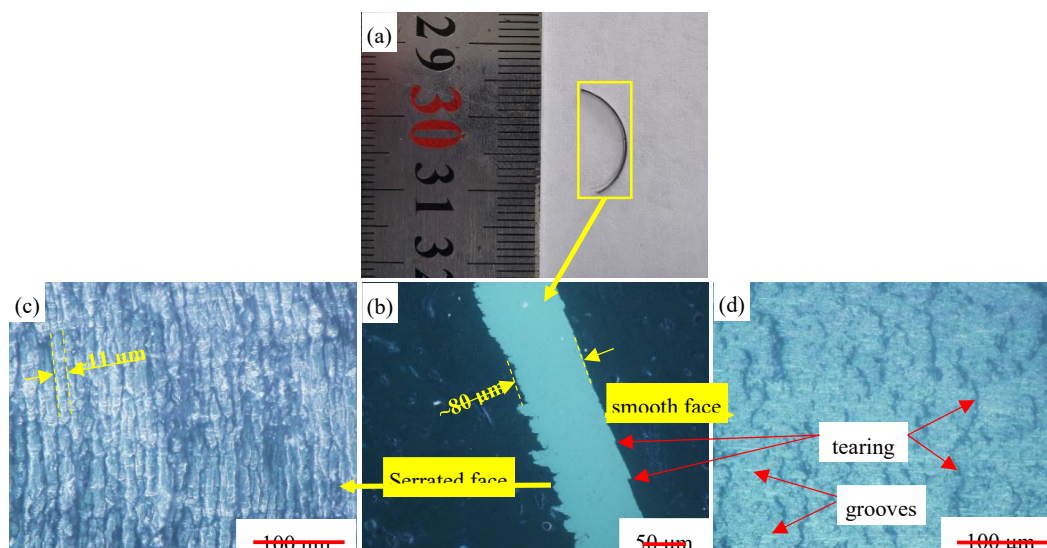


Figure 10. Typical morphology of a chip formed in Stage II: (a) photo of the chip; (b) micro-picture showing section of the chip; (c) serrated face of the chip; (d) smooth face of the chip.

3.4. Suggestions for Improving the Sawing Performance of Bandsaws

As mentioned above, the wear of bandsaw teeth when sawing Cr12MoV was divided into two stages: Stage I-rapid wear stage, during which the dominant wear mechanism was chipping with flank wear and tooth breakage coexisted; and Stage II-homogeneous wear, during which adhesive and abrasive wear were the main wear mechanisms. Therefore, suppressing chipping in Stage I and adhesive and abrasive wear in Stage II are the main strategies for improving the sawing performance of bandsaws.

Edge preparation of saw teeth by sandblasting was previously proposed to reduce the previous chipping of bandsaw teeth [23,24]. Since bandsawing features a small cutting depth of a single tooth (the average cutting depth of a single tooth in this study was 2.5 μm , while the cutting depths of other methods such as turning, drilling, and milling were usually more than 100 μm [25–27]). The edge radius of bandsaws shall not be too large, which is distinguished from other cutting tools. The main reason for chipping in Stage I is the large tolerance of the processing accuracy of the bandsaw blade (greater than the cutting depth of a single tooth); thus, improving the processing accuracy of the bandsaw blade is an effective way to reduce chipping. A method to manufacture a bimetal bandsaw blade by CNC grinding instead of milling was proposed to improve the width accuracy of the bimetal bandsaw blade from 0.1 mm (as shown in Figure 6a) to ≤ 0.05 mm [28]. Break-in procedures are widely used in bandsawing, especially for hard-to-machine materials with work-hardening rate, such as stainless steel and superalloys. When executing the break-in procedure, the operator needs to decrease the feed rate to reduce the average cutting depth per tooth to reduce the cutting force. Then, the feed rate is increased gradually to the normal value after break-in. However, there are many factors that will influence the break-in procedure, such as the bandsaw's quality, stability of the bandsaw machine and workpiece. Operators generally perform the break-in procedure based on their own experience.

Adhesive and abrasive wear are the main wear mechanisms of Stage II, so improving the wear resistance of the saw teeth is beneficial for reducing the wear during Stage II. The application of powder metallurgy HSS instead of traditional HSS is effective. For example, ASP2042 [29] and ASP2051 [30] are better options for saw tooth materials. PVD technology has been broadly used for various tools, such as lathing tools, milling cutters, drills, and circular saws. Researchers have tried to apply PVD technology to improve the sawing performance of bandsaws, and the life of bandsaws has been obviously improved [14]. However, unlike other tools, PVD coating is not widely utilized in bandsaws at present due to its high cost and the special shape of bandsaws.

4. Conclusions

In this study, bimetal bandsaw blade was adopted for cutting-off Cr12MoV, and the evolution of wear mechanisms during different wear stages were investigated. Proposes to improve the sawing performance were given. Results are as follows:

(1) The saw tooth wear mechanism when Cr12MoV was machined by a bimetal bandsaw blade varied during tool life and showed two stages of characteristics: rapid wear stage (Stage I) and uniform wear stage (Stage II).

(2) The wear mechanisms of the saw teeth in the two stages were different. In Stage I, chipping was the dominant wear mechanism while flank wear and tooth breakage were also occurred. These mechanisms were related to the processing accuracy of the bandsaw blade, where deviations in the width and setting magnitude were the main effects.

(3) Less chipping occurred, and adhesion and abrasive wear dominated the tooth wear mechanism in Stage II. The abrasive wear was caused by the scrapping of hard carbides of workpiece. The heat generated during bandsawing made the soft steel matrix adhesive, which was the reason of adhesive wear.

(4) Reducing the chipping in Stage I and adhesive and abrasive wear in Stage II were conducive to elongating tool life of the bandsaw. Tooth edge preparation, processing accuracy improvement, and break-in procedures could reduce chipping in Stage I. The use of powder metallurgy high-speed steel as the tooth material and application of PVD technology could suppress adhesion and abrasive wear in Stage II.

Acknowledgements: This research was financially supported by the Hunan High-Tech Industry Scientific and Technological Innovation Leading Program of Hunan Province (Grant No. 2022GK4049) and the Science and Technology Innovation Program of Hunan Province (Grant No. 2022RC1050). Mr. Robert C. Hayden is appreciated for providing consultation.

References

1. Jones, P. A.; Simons, E. N., The story of the saw. Spear and Jackson Limited: Sheffield, 1961.
2. Wang, Y.; Zhang, Y.; Tan, D.; Zhang, Y., Key Technologies and Development Trends in Advanced Intelligent Sawing Equipments. Chinese Journal of Mechanical Engineering 2021, 34, (1), 30.
3. Lengoc, L.; McCallion, H., Wide bandsaw blade under cutting conditions: Part I: Vibration of a plate moving in its plane while subjected to tangential edge loading. Journal of Sound and Vibration 1995, 186, (1), 125-142.
4. Lengoc, L.; McCallion, H., Wide bandsaw blade under cutting conditions: Part II: Stability of a plate moving in its plane while subjected to parametric excitation. Journal of Sound and Vibration 1995, 186, (1), 143-162.
5. Lengoc, L.; McCallion, H., Wide bandsaw blade under cutting conditions: Part III: Stability of a plate moving in its plane while subjected to non-conservative cutting forces. Journal of Sound and Vibration 1995, 186, (1), 163-179.
6. Fujiwara, K., Experimental verification of bandsaw roll-tensioning theory. Journal of Wood Science 2002, 48, (5), 359-364.
7. Fujiwara, K., Theoretical analysis of bandsaw roll-tensioning. Journal of Wood Science 2002, 48, (4), 277-282.
8. Gendraud, P.; Roux, J. C.; Bergheau, J. M., Vibrations and stresses in band saws: A review of literature for application to the case of aluminium-cutting high-speed band saws. Journal of Materials Processing Technology 2003, 135, (1), 109-116.
9. Ni, J.; Lang, J.; Wu, C., Effect of surface texture on the transverse vibration for sawing. The International Journal of Advanced Manufacturing Technology 2017, 92, (9), 4543-4551.
10. Christopher, J. D.; Le-Ngoc, L., Robust Active Vibration Control of a Bandsaw Blade. Journal of Vibration and Acoustics 1999, 122, (1), 69-76.
11. Sarwar, M.; Persson, M.; Hellbergh, H., Wear of the cutting edge in the bandsawing operation when cutting austenitic 17-7 stainless steel. Wear 2007, 263, (7), 1438-1441.
12. Sarwar, M.; Persson, M.; Hellbergh, H., Wear and failure modes in the bandsawing operation when cutting ball-bearing steel. Wear 2005, 259, (7), 1144-1150.
13. Sarwar, M.; Persson, M.; Hellbergh, H.; Haider, J. In Forces, wear modes, and mechanisms in bandsawing steel workpieces, Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 2010/11/01, 2010; IMECHE: pp 1655-1662.
14. Khan, F. N.; Daadbin, A.; Persson, M.; Haider, J.; Hellbergh, H., Assessing the performance of TiAlSiN coating on bandsaw tooth when cutting Ti-17 alloy. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture 2012, 226, (5), 870-877.
15. Zhuo, R.; Deng, Z.; Chen, B.; Liu, G.; Bi, S., Overview on development of acoustic emission monitoring technology in sawing. The International Journal of Advanced Manufacturing Technology 2021, 116, (5), 1411-1427.
16. Li, W.; Zhang, L.; Wu, C.; Cui, Z.; Niu, C., Influence of Tool and Workpiece Properties on the Wear of the Counterparts in Contact Sliding. Journal of Tribology 2022, 144, (2), 021702.
17. Zhuo, R.; Deng, Z.; Chen, B.; Liu, T.; Ge, J.; Liu, G.; Bi, S., Research on online intelligent monitoring system of band saw blade wear status based on multi-feature fusion of acoustic emission signals. The International Journal of Advanced Manufacturing Technology 2022, 121, (7), 4533-4548.
18. Shaw, M. C., Metal Cutting Principles. Oxford University Press: Oxford, 2005.
19. Bhushan, B., Introduction to Tribology. John Wiley & Sons, Ltd.: New York, 2013.
20. Sarwar, M.; Haider, J., Aspects of burr formation in bandsaw teeth manufactured by milling operation. Robotics and Computer-Integrated Manufacturing 2010, 26, (6), 596-601.
21. Sarwar, M.; Haider, J.; Persson, M. In Scientific evaluation of cutting-off process in bandsawing, Scientific Proceedings VIII International Congress—Machines, Technologies, Materials, Bulgarien, 2011; Bulgarien, pp 29-32.

22. Söderberg, S.; Åhman, L.; Svenzon, M., A metallurgical study of the wear of band-saw blades. *Wear* 1983, 85, (1), 11-27.
23. Jia, Y.; Wu, Y.; Ouyang, W.; Liu, G.; Peng, D.; Chen, G.; Effects of Shot Peening on Cutting Life and Fatigue Resistance of Bi-metal Bandsaw Blade. *Tool Engineering* 2017, 51, 37-40. (in Chinese)
24. Fleming, M. G. Investigation of the wear and failure modes of surface engineered multipoint cutting tools. Dublin City University, Ireland, 1992.
25. Karmiris-Obratański, P.; Karkalos, N. E.; Kudelski, R.; Markopoulos, A. P., Experimental study on the effect of the cooling method on surface topography and workpiece integrity during trochoidal end milling of Incoloy 800. *Tribology International* 2022, 176, 107899.
26. Yu, Z.; Zeng, D.; Hu, S.; Zhou, X.; Lu, W.; Luo, J.; Fan, Y.; Meng, K., The failure patterns and analysis process of drill pipes in oil and gas well: A case study of fracture S135 drill pipe. *Engineering Failure Analysis* 2022, 138, 106171.
27. Shoja, S.; Norgren, S.; Andrén, H. O.; Bäcke, O.; Halvarsson, M., On the influence of varying the crystallographic texture of alumina CVD coatings on cutting performance in steel turning. *International Journal of Machine Tools and Manufacture* 2022, 176, 103885.
28. Jia, Y.; Ouyang, W.; Liu, G.; Hayden, R. Method for making bandsaw blade and bandsaw blade. China, 201610738676.X, 2019. (in Chinese)
29. Erasteel ASP2042. <https://www.erasteel.com/products/asp2042-2/>
30. Erasteel ASP2051. <https://www.erasteel.com/products/asp2051/>

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.