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Application of Skewness and Kurtosis for Analysis of Barkhausen Noise Signal

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Abstract: **Barkhausen noise analysis technique is latest and preferred technique for material characterization .This technique is mainly applied for residual stress assessment. Barkhausen noise signal typically represented by a profile is known as Barkhausen noise profile, which is characterized by various parameters like peak height, peak position, rms value and full width at half maximum. Peak height of Barkhausen noise signal is mainly employed for the assessment of residual stress. Induction of tensile residual stress generally increases peak height of Barkhausen noise signal profile. Signal can be analyzed using various standard and well established parameters like Kurtosis and Skewness. In the present study Kurtosis and Skewness is used for analysis of Barkhausen noise signal obtained from ground medium carbon steel sample. Ground samples were obtained by varying process parameters, namely work velocity and downfeed. It has been observed that Barkhausen noise signal changes with process parameters, which in turn also influences the kurtosis and skewness. Analysis of results shows that skewness doesn't vary owing to no change in microstructure while Kurtosis presented a almost linear increasing trend with respect to grinding process parameter which may be attributed to increase in residual stress.**

1. INTRODUCTION

Barkhausen noise (BHN) is a form of magnetic noise signal which is caused by non-uniform motion of magnetized domain walls during magnetizing a material [1]. Barkhausen noise technique (MBN) reveals that this noise is sensitive to various parameters, which affect the domain configurations and domain-wall pinning sites. These properties are in turn strongly influenced by the grain size [3, 4], chemical composition [5, 6], ferromagnetic phases [6, 7], residual stress [8], hardness [9], and the fatigue damage [10, 11]. In order to assess the true status of the BN method and, if possible, to overcome its draw backs, more basic knowledge about demagnetization processes is needed since Barkliausen noise in effect measures irreversible demagnetization transitions [12]. The domain structure is influenced by the presence of flaws such as cavities, precipitates, inclusion of nonmagnetic matter, etc. The phenomena existing similitude between the laws governing the structural state of materials and magnetization phenomena lead to the use of BN as a nondestructive testing method for ferromagnetic materials [13]. Most ferromagnetic materials are, however, conducting and inertial effects are usually neglected because of eddy current dissipation. This approximation is usually assumed in the description of the Barkhausen effect, the noise emitted along the hysteresis loop, which indirectly reflects the dynamics of domain walls. The Barkhausen effect is the prototype of the general phenomenon of crackling noise, commonly observed in slowly driven systems with avalanche dynamics. The experimental studies of various ferromagnetic materials have provided evidence for the existence of correlated domain wall jumps, which tend to cluster into large avalanches. This occurs mainly along the steepest part of the magnetization curve. Theoretical studies of this phenomenon fall far behind the proliferation of practical uses for the evaluation of ferromagnetic materials, due, in part, to the fact that the process are irreversible, and conceivably highly nonlinear [14].

2. EXPERIMENTAL DETAILS

In the present study Barkhausen noise signal were obtained from the ground medium carbon steel sample and opened in MATLAB for analysis using kurtosis and skewness. Table 1 shows the details of grinding process employed to obtain BN signal.

Table 1. Grinding process details

Sample No.	Work speed- Vw (m/min)	Downfeed (µm)
1	4	10
2	4	20
3	4	30
4	4	40
5	8	10
6	8	20
7	8	30
8	8	40
9	12	10

10	12	20
11	12	30
12	12	40
13	16	10
14	16	20
15	16	30
16	16	40

MATLAB scripts have been developed to open the Barkhausen noise signal obtained from ground medium carbon steel samples. Figure 1 to Fig. 4 show the Barkhausen noise signal obtained from ground samples prepared at different grinding process parameters.

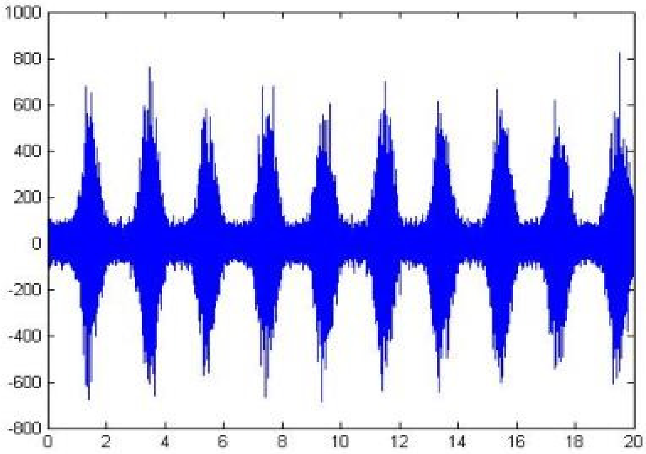

Figure 1. The Barkhausen noise signal obtained from ground samples prepared at Vw-4 (a=10)

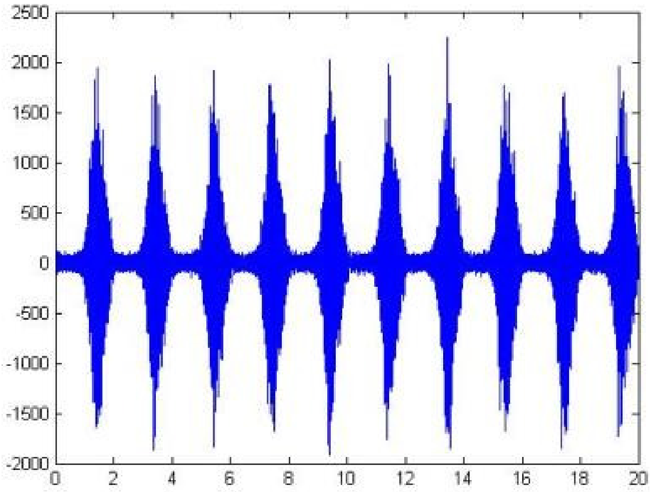

Figure 2. The Barkhausen noise signal obtained from ground samples prepared at Vw-4 (a=40)

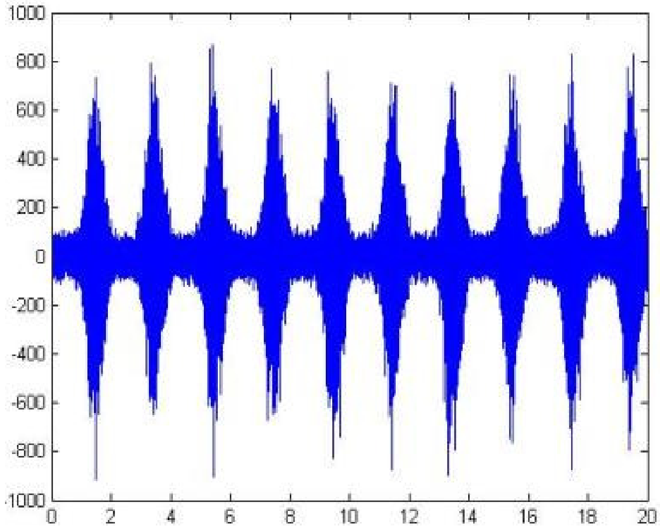

Figure 3. The Barkhausen noise signal obtained from ground samples prepared at Vw-16 (a=10)

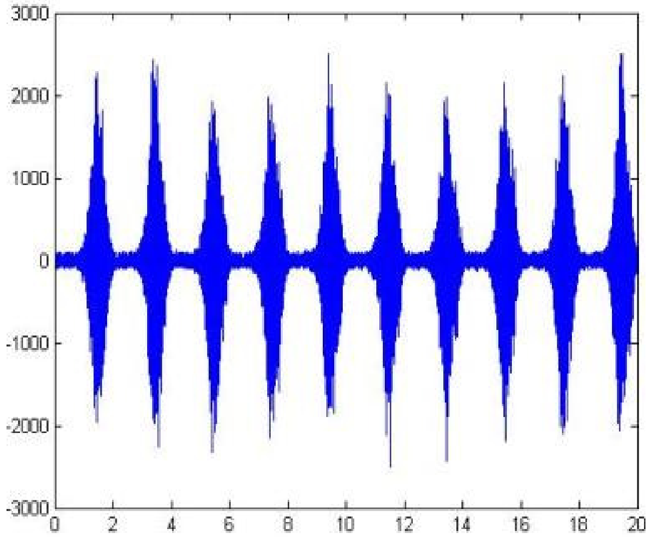

Figure 4. The Barkhausen noise signal obtained from ground samples prepared at Vw-16 (a=40)

Effect of change in grinding process parameters on BN signal can be clearly seen in Figure 1 to Fig. 4 as the amplitude of Barkhausen noise signal is increases when the downfeed increases for same workspeed.

3. RESULT AND DISCUSSION

Barkhausen noise signal technique is latest and preferred technique for material characterization .This technique is mainly applied for residual stress assessment. Barkhausen noise signal obtained from ground medium carbon steel sample has been analyses by using Skewness and Kurtosis value. Skewness shows the variation of microstructure of the sample. Kurtosis is the well-established parameter for signal analysis. Tensile residual stress increases in grinding with increase in the downfeed and work speed due to thermal effect. Barkhausen noise signal peak height is an important parameter to indicate the residual stress. This parameter increases with respect to residual stress. In our own observation we found that Kurtosis increases in similar manner peak height of Barkhausen noise signal but skewness remains same.

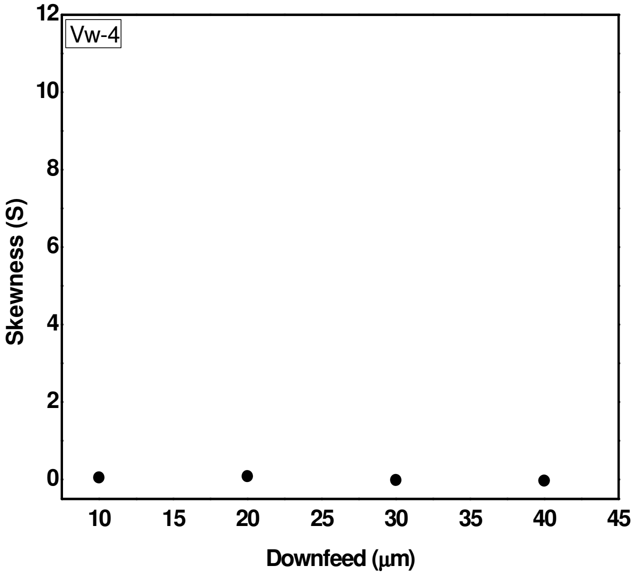

Figure 5. Variation of skewness with respect to downfeed at work speed 4m/min.

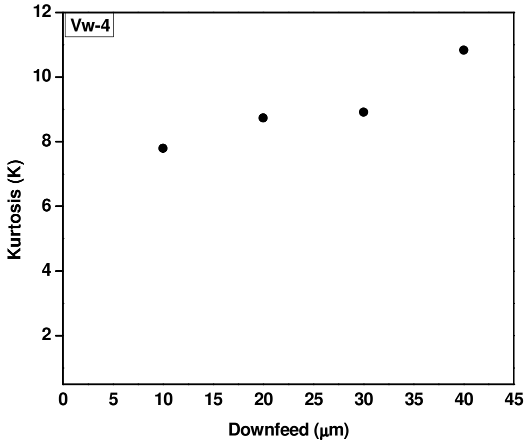

Figure 6. Variation of kurtosis with respect to downfeed at work speed 4m/min

Figure 5 and 6 shows that skewness remains almost constant as the downfeed increases which indicate that the symmetry city of Barkhausen noise signal. .Kurtosis is continuously increases as the downfeed increases which depicts the increase in tensile residual stress, as generally tensile residual stress are induced due to thermal effect., Kurtosis increases by 12.07 % in the range of 10 to 20 of downfeed and in the range of 20 to 30 of downfeed, Kurtosis increases by 2.02 % but in the range of 30 to 40, Kurtosis is increases sharply by 21.53 % indicating the severe thermal damage upon grinding.

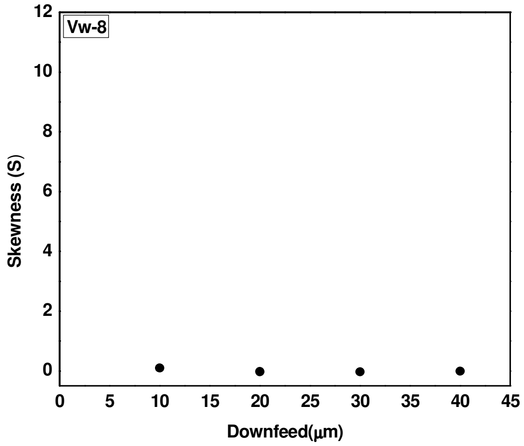

Figure 7. Variation of skewness with respect to downfeed at work speed 8m/min

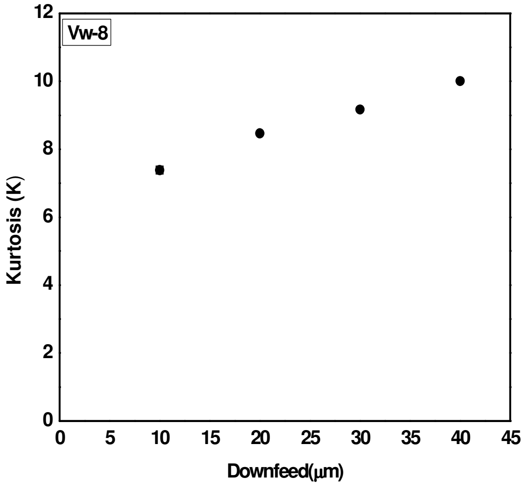

Figure 8. Variation of kurtosis with respect to downfeed at work speed 8m/min

In the figure 7 and figure 8 skewness remains constant with respect to downfeed which shows the symmetry city of Barkhausen noise signal curve. Kurtosis is continuously increases as the downfeed increases which show the peak amplitude of Barkhausen noise signal curve. In the range of 10 to 20 downfeed, Kurtosis is increases the 14.61 %, in the range of 20 to 30, Kurtosis is increases 8.28 % and in the range of 30 to 40, Kurtosis is increases 9.19 %. Hence it shows that Kurtosis is increases linearly with the induction of residual stress.

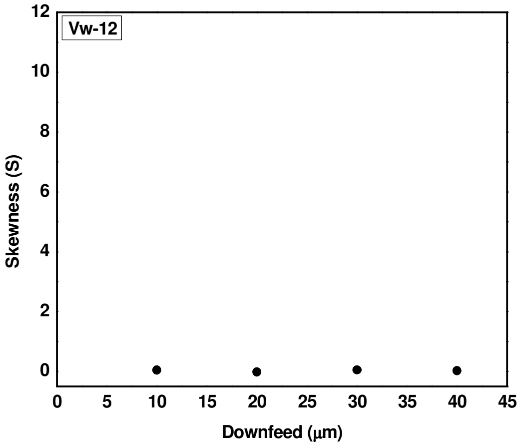

Figure 9. Variation of skewness with respect to downfeed at work speed 12m/min

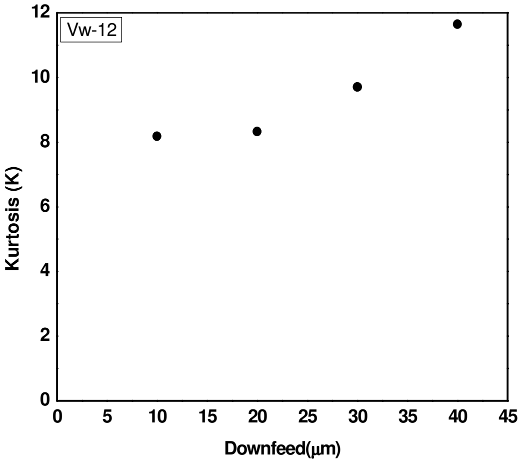

Figure 10. Variation of kurtosis with respect to downfeed at work speed 12m/min

Figure 9 and figure 10 shows that Skewness remains constant with the downfeed which shows the symmetry city of Barkhausen noise signal curve. Kurtosis is continuously increases as the downfeed increases which indicates rise in peak amplitude of Barkhausen noise signal curve. In the range of 10 to 20 downfeed, Kurtosis is increases by 1.73 %, but in the range of 20 to 30 downfeed, Kurtosis is increases sharply 16.51 % and in the range of 30 to 40 downfeed, Kurtosis is increases 19.97 %. Hence it is show that amplitude of Barkhausen noise signal curve increases sharply after the 20(µm) downfeed owing to rise in thermal stresses induced into the ground samples.

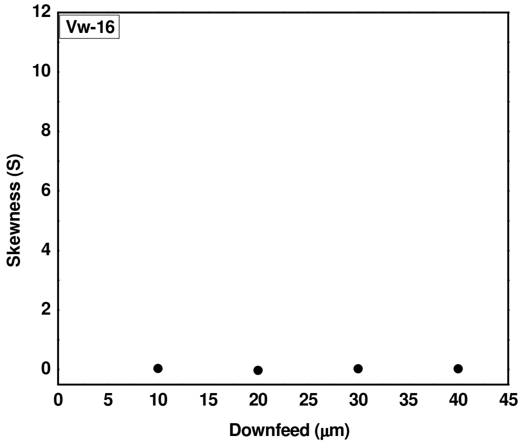

Figure 11. Variation of skewness with respect to downfeed at work speed 16m/min

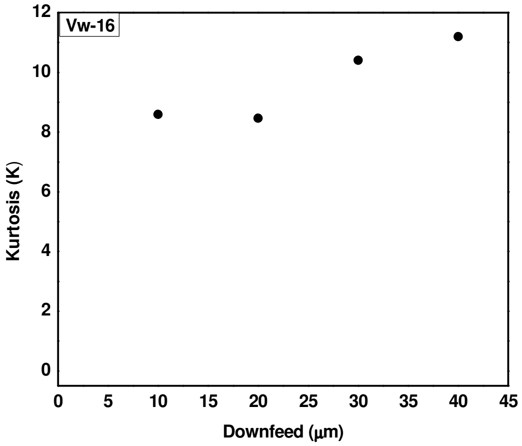

Figure 12. Variation of kurtosis with respect to downfeed at work speed 16m/min

Similar effect of downfeed on kurtosis is observed in figure 11 and 12. Kurtosis is continuously increases as the downfeed increases which indicates increase in the peak amplitude of Barkhausen noise signal curve .In the range of 10 to 20 downfeed, Kurtosis is decreases the 1.5 %, but in the range of 20 to 30 downfeed, Kurtosis is increases sharply 22.98 % and in the range of 30 to 40 downfeed, Kurtosis is increases 7.58 %. This observation shows that downfeed is having more dominant effect on Kurtosis in comparison to workspeed.

4. CONCLUSION

Following conclusions can be drawn from present work:

1. Kurtosis and Skewness can be applied for Barkhausen noise signal analysing obtained from ground medium carbon steel samples.

2. Kurtosis increases continuously with increases in downfeed. This may be used as a parameter for assessment of residual stress as residual stress increases with increasing in downfeed and workspeed.

3. Skewness was observed to remains constant when downfeed varies in wide range from 10μm to 40μm .This indicate that Barakhausen noise signal remains symmetrical with respect to grinding process parameter like work speed and downfeed.

4. Downfeed is having more dominant effect on Kurtosis in comparison to workspeed.

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