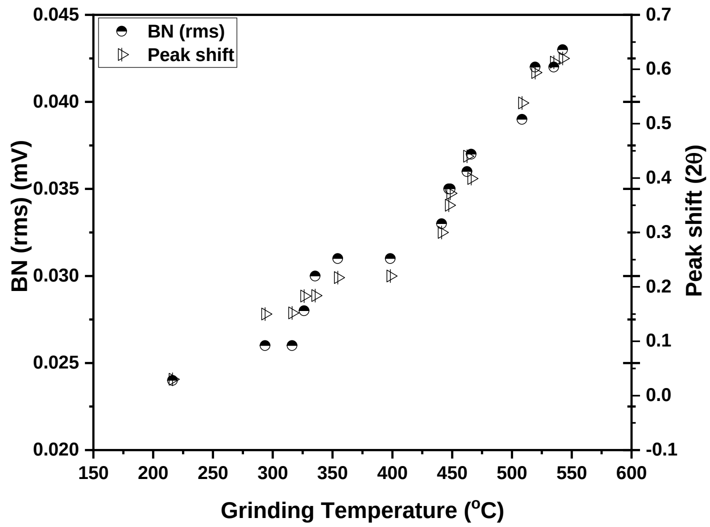
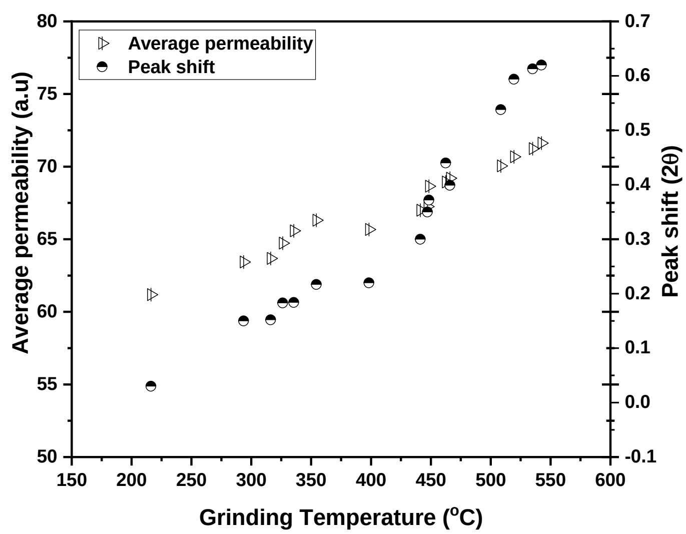
Chapter 5 | Summary and Conclusions

The present research aimed at to study the assessment of surface integrity upon grinding using non destructive magnetic Barkhausen noise method. Two different material one having good magnetic response (low carbon steel) and the other having poor magnetic response (hardened steel) were chosen so as to cover wide spectrum application of the technique. In order to have deeper understanding on the surface integrity upon grinding, grinding performance were also checked in terms of grinding forces, specific grinding energy and grinding temperature. The grinding experiment was performed with variation in downfeed, work velocity and grinding environment (dry and wet). This wide range of process parameter induces different level of surface integrity upon grinding.

It has been observed thermal damage is one of the major cause of poor surface integrity upon grinding as it leads to changes in undesirable microhardness in the subsurface which is associated with the microstructural alteration. The higher grinding zone temperature results into expansion of the surface whereas in the subsurface the temperature is still smaller. This leads to generation of tensile residual stresses on the surface. The quantitative assessment of this residual stresses were performed using the changes in the peak position of the x-ray diffraction peak. A linear correlation were observed between peak shift and magnetic parameter (RMS and average permeability) in case of unhardened steel despite of the simultaneous change in microstructure, microhardness and surface roughness and can be observed from the Fig. 5.1.



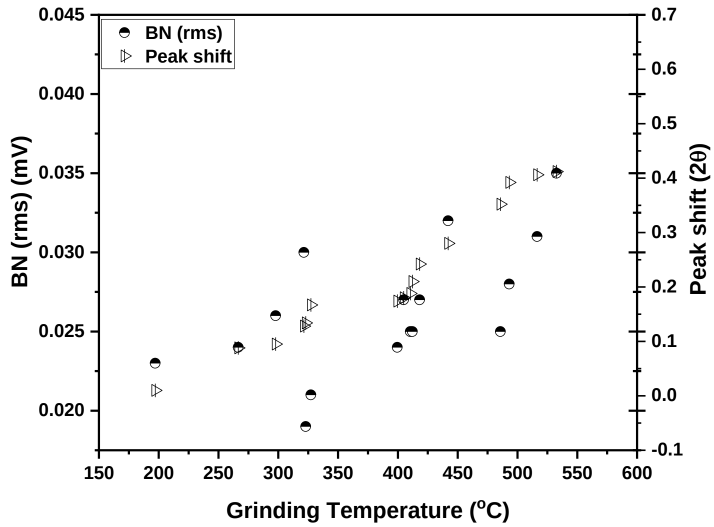
(a)



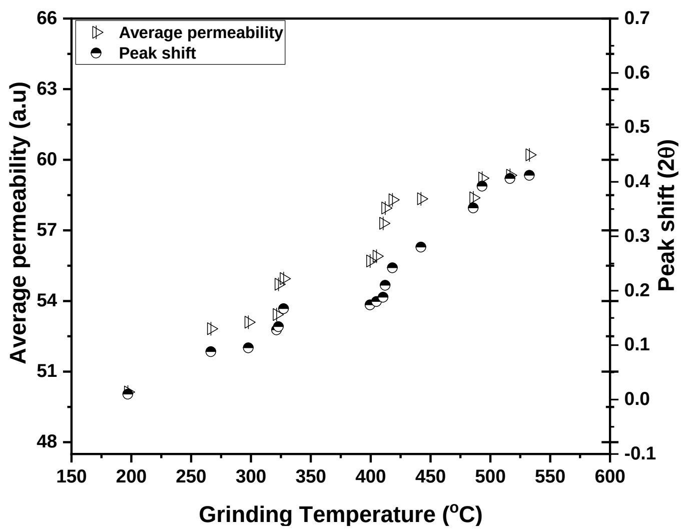
(b)

Fig. 5.1 The correlation between (a) BN (rms), peak shift and grinding temperature (b) Average permeability, peak shift and grinding temperature in unhardened steel

However, in case of hardened steel, BN (rms) is not found sensitive towards peak shift whereas average permeability derived from hysteresis loop shows a good correlation with the peak shift and the same is depicted in the Fig. 5.2.



(a)



(b)

Fig. 5.2 The correlation between (a) BN (rms), peak shift and grinding temperature (b) Average permeability, peak shift and grinding temperature in hardened steel

Chapter 5 | Summary and Conclusions

On the basis of the experimental findings, the below listed conclusions can be drawn:

5.1 Conclusions

1. No significant microstructure alteration (white layer) is observed in unhardened as well as in hardened steel upon grinding in the chosen range of process parameter.
2. Increase in peak shift associated with the increase in tensile residual stress is observed with increase in downfeed and work velocity. Also, larger peak shift is witnessed during dry grinding as compared to wet grinding.
3. Under similar condition of process parameter, higher peak shift is observed in unhardened steel in relative to hardened steel.
4. Surface roughness of the ground surface increases with the increase in downfeed and work velocity irrespective of grinding environment, but lower surface roughness is observed in wet grinding in comparison to dry grinding. Moreover, lower surface roughness is observed during grinding of hardened steel in relative to unhardened steel.
5. Due to very small value, the effect of surface roughness on the generated Barkhausen noise and hysteresis loop can be neglected which in turn improves the sensitivity of magnetic Barkhausen noise (rms value) and average permeability towards residual stress.
6. Barkhausen noise (rms value) and average permeability derived from hysteresis loop shows a linear correlation with the peak shift upon grinding of unhardened steel.

7. In case of hardened steel nonlinear variation is observed between Barkhausen noise (rms value) and peak shift. However, average permeability still shows a linear correlation with the peak shift.
8. Under similar grinding condition, the magnetic response (rms value and average permeability) observed in hardened steel is lower as compared to that of unhardened steel.

5.2 Major Contributions:

1. Grinding of unhardened and hardened steel induces tensile residual stress along with the change in microhardness, microstructure and plastic deformation. Despite of simultaneous presence of these grinding damages linear correlations between magnetic parameters (rms value and average permeability) and state of residual stress have been established.

2. Though, low carbon steel under hardened conditions provides poor magnetic response, the newly introduced average permeability follows a linear correlation with the state of residual stress. The average permeability can be used to monitor the residual stress state when material under examination exhibit poor magnetic response.

5.3 Future scope:

1. It has been seen that mechanical property has significant influence on the magnetic response of the material. The magnetic response is often measured in terms BN (rms), peak position, peak width etc. to quantify the material properties. However, with material possessing poor magnetization new

parameter needs to be introduced as the above mentioned parameter fails to provide enough sensitivity towards change in mechanical properties.

2. Study on frequency content of the Barkhausen noise signal with respect to change in properties can also be utilized to establish a correlation between the two.
3. Barkhausen technique is mostly employed in the assessment of mechanical property upon machining operation like grinding, milling, turning etc. Thereby its application in other areas of manufacturing is also open for researcher round the world.