Effect of Thermal High-Frequency Surface Hardening on the Hardness and Microstructure of Bandsaw Teeth

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Summary. Examination of the bandsaw teeth (1) untreated, (2) swaged and (3) treated by thermal high-frequency surface hardening method has shown that their average microhardness is 473 DPN (< 46 R<sub>c</sub>), 502 DPN (< 49 R<sub>c</sub>) and 836 DPN (> 62 R<sub>c</sub>) respectively. Scanning electron microscopy revealed that no significant change occurred within the crystalline microstructure of untreated and swaged specimens. The high-frequency treated specimen, however, has shown a definite structural modification of a very finely grained martensitic type, extending from the apex for a distance of 0.24 mm. The relationship between DPN microhardness distribution throughout the bandsaw steel and the range of H.F. impulse times from 24/50 to 36/50 of a second was also investigated, and depth of the hardened zone determined. The optimal H.F. impulse time length corresponding to the optimal tooth hardness appears to lie between 32 and 33/50 of a second. Operating with 32/50 impulse time on a conventional 2.41 mm thick SANDVIK bandsaw with 0.73 mm side swage, it was found that the average hardness of a H.F. treated tooth apex is about 905 DPN (> 64 R<sub>c</sub>) to a depth of 415 μm and in practical terms approaches the estimated optimum for high-speed cutting.

Introduction
Besides some basic concepts covering the practical application of the thermal high-frequency treatment of bandsaw teeth, and a certain amount of progressive manufacturing effort [Anonymous 1970], there appears to have been no serious attempts to carry out intensive research studies in this particular direction. Indeed, past works are limited essentially to tempering of framesaw teeth [Biryukov, Chernyshev 1954; Ljanguzov 1955; Demjanovskij, Byoz 1964; Borovikov, Pozdeev 1970; Karpunin 1970] representing a mere facet of log breakdown machinery. In the absence of any published data of some practical value on this subject, an investigation has been carried out with a view to establishing the basic pattern of the internal hardness distribution throughout the crystalline microstructure of a bandsaw blade, and in particular to determine the microhardness value of the sawtooth apex treated by thermal high-frequency surface hardening method. This paper seeks also to investigate the relationship between DPN microhardness readings and different H.F. impulse times applied to the sawblade teeth, as well as the corresponding range of thicknesses of the hardened layer in a tentative approach to establish the optimum value for tool hardening.
Material and method

A thermal H.F. installation for hardening of bandsaw teeth usually consists of a high-frequency tube-generator, control panel, a load circuit and an operating inductor for the actual heating of the treated piece. A conventional induction unit operating on such principles was used for this purpose [Krilov 1975]. The investigation has been carried out in two stages:

**Test A**

A comparative assessment of microhardness and its internal distribution was made, using a conventional SANDVIK bandsaw of standard steel composition, length, width and thickness, which was chosen at random from production stock of blades processing softwood in a regional sawmill. From a section of this bandsaw three separate samples were prepared by different treatment:

1. standard (only re-ground),
2. ground, swaged and shaped,
3. ground, swaged, shaped and H.F. hardened.

For detailed assessment of these samples a polished metallographic section half way through each tooth was prepared and microhardness measurements were made with a Leitz Microhardness Tester using a diamond pyramid indentor under load of 100g. The microhardness indents were numbered from the apex of each tooth at regular intervals. Further observations of the crystalline microstructure modifications were made by means of a Philips Scanning Electron Microscope PSEM 500, operating at 12 Kv.

**Test B**

In order to determine the optimum hardness and to evaluate the extent of modification within the crystalline microstructure of bandsaw teeth treated by the H.F. hardening method, another section of the same blade was taken for separate assessment. Out of this section seven separate samples of sawteeth with 0.73 mm swage were prepared. Each was induction-hardened using different H.F. impulse times, ranging from 24/50 to 36/50 of a second. In this experiment particular attention has been paid to determine the comparative hardness value for each specimen, its qualitative aspect and the depth of the hardened region from the tooth apex down. The same techniques and equipment, as described above, were used for the microhardness measurements. In this experiment hardness indentations were carried out at measured intervals from the apex in a line parallel to and approximately 50μm away from the swaged edge of the tooth. The depth of the hardened zone was also measured by visual observation of the structure of each polished and etched sample. Complementary observations of the crystalline microstructure were made by a Philips Scanning Electron Microscope PSEM 500, operating at 12 Kv as in Test A.