Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

OPERATIONAL SERVICES BRANCH

ENGINEERING LABORATORY REPORT

LP152/2013

Examination of Box Car Wheel Set

Montreal, Maine & Atlantic Railway, Train MMA-002

Date of Occurrence: 06-Jul-2013

ATTENTION:

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1.0 INTRODUCTION

1.1 On 06 July 2013, a Montreal, Maine & Atlantic Railway (MMA) freight train consisting of 5 locomotives, a Van Buren car (caboose converted to hold remote-control operation equipment), a loaded box car filed with gravel (buffer car) and 72 tank cars loaded with petroleum crude oil travelled un-manned from Nantes to Lac-Mégantic, Quebec, where 63 of the tank cars and the 1 box car derailed. Numerous tank cars ruptured, and a fire ensued.

1.2 During the field investigation, a feature was observed on a wheel flange of the number 3 wheel set from the box car (CIBX 172032). The wheel set was sent to the Transportation Safety Board (TSB) Engineering Laboratory to determine the possible cause of the feature.

2.0 EXAMINATION

2.1 Tables 1, 2 and 3 show the markings that were observed on the wheel hubs, axle locking plates, and the outer race of bearings.

Table 1: Markings on Wheel Hubs

Wheel with feature	Mating wheel	Marking significance
83414	80228	Wheel serial number
05 98	05 98	Date of manufacture
CH36	CH36	1 wear, 100 ton maximum capacity per wheel, 36 inch diameter wheel, cast, wide flange wheel
C	C	Class C wheel (heat treated rim)
GC	GC	Manufactured by Griffin Wheel, Columbus, Ohio
	7 TILX98G	Wheel mounted by Trinity Industries, Greenville, PA, July 1998

Table 2: Markings on Axle Locking Plates

Wheel with feature	Mating wheel	Marking significance
TILX-G	TILX-G	Bearing mounted by Trinity Industries, Greenville, PA
ND98	NE98	Bearing mounted new in 1998, D – April, E - May

Table 3: Markings on Bearing Outer Races

Wheel with feature	Mating wheel	Marking significance
Brenco HM133416XD USA	Brenco HM133416XD USA	Name of manufacturer, bearing model number, country
D 98	E 98	Date of manufacture, D – April, E – May
67160	69378	Bearing serial number

2.2 Figure 1 shows the wheel set as received. Both wheels were cleaned so an examination could be performed. The feature observed on the flange of wheel 83414 is shown in Figures 2 through 5. Close-up examination of the feature on the wheel flange revealed that there was a rub mark on either side of it and that its edges were rounded, with a worn appearance.

2.3 Examination of the mating wheel also revealed a similar feature on the wheel flange (Figures 6 and 7). This feature was located approximately 180 degrees from the feature on the subject wheel. Similar to the other wheel, the feature on this wheel had worn edges and an overall worn appearance.

2.4 Three metallurgical sections were taken: the first through the middle of the subject wheel flange feature, the second at 90 degrees from the wheel flange feature, and the third from a random location on the wheel flange on the mating wheel. All sections were chemically etched in 2% nital solution. The metallurgical sections showed a zone of fine tempered martensite at the tip of the wheel flange and a core microstructure of ferrite–pearlite (Figures 8 to 13). No sign of welding was observed on the metallurgical section taken through the subject feature. The zone of fine tempered martensite at the tip of the wheel flange is most likely a result of the manufacturing process and would have no effect on the wheel operation or performance.

2.5 To confirm if this zone of fine tempered martensite at the tip of the wheel flange was an anomaly in this particular wheel set only, a comparison section was taken from another Griffin wheel located at the Engineering Laboratory. The wheel was type CH36, manufactured in March 2011, serial number 06568. Like the subject wheel, the tip of the wheel flange was composed of fine tempered martensite and the core microstructure was ferrite–pearlite. The 4 metallurgical sections are shown in Figure 13. The tip area of the wheel flange which has fine tempered martensite is clearly visible.

2.6 Direct Rockwell C (HRC) hardness testing was performed on the 2 sections from the subject wheel. Readings of 38 to 40 HRC were obtained in the fine tempered martensite region and 35 to 36 HRC in the core. Hardness testing on the section from the mating wheel gave average results of 36 HRC in the fine tempered martensite and 34 HRC in the core. Class C wheels have a Brinell hardness requirement of 321 to 363 HBW,[1] which is equivalent to 34 to 39 HRC. The

[1] AAR Manual of Standards and Recommended Practices, Wheels and Axles, Page G (M-107/M-208) 6, Section 10.1

hardness results of the core were within the AAR hardness specification for this class of wheel.

2.7 Energy dispersive spectroscopy (EDS) was performed on the metallurgical section taken from the subject wheel and the standard less results show the subject wheel gave manganese and silicon contents consistent with the AAR specification. The amount of carbon, phosphorus, and sulphur could not be measured. A representative spectrum is shown in Figure 14.

2.8 Wheel wear measurements were performed on both wheels and the results are shown in Table 4. Both wheels were within the serviceable limits specified by the AAR.

Table 4: Wheel Wear Measurements

Measurement	AAR standard (condemning limit)	Subject wheel	Mating wheel
Flange width (inch)	15/16 or less[2]	>15/16	>15/16
Rim thickness (inch)	>7/8[3]	1 3/8	1 9/16
Vertical flange height (inch)	<1[4]	>1	>1
Hollow tread wear (mm)	>4[5]	3.25	0.75

3.0 DISCUSSION

3.1 The features observed on the subject and mating wheels were most likely caused by mechanical damage as a result of contact with some foreign object. The rounded edges of the rub marks and their worn surfaces suggest that they were present on the wheel flange for some time and most likely pre-dated this derailment.

3.2 The 2 features observed on the wheel flanges may have been caused by the brake components; they are located very close to the wheel flange and might have contacted the wheel at some point. The other cause might have been contact with some equipment along the track and/or switch.

3.3 The microstructure of the wheel material in the feature areas did not show any changes associated with exposure to heat from processes such as welding or torch cutting.

[2] 2013 Field Manual of the AAR, Rule 41, A1a
[3] Ibid, Rule 41, A1h2
[4] Ibid, Rule 41, A1b
[5] Ibid, Rule 41, A2d

4.0 CONCLUSION

4.1 The feature on the subject wheel flange was caused by some type of mechanical damage. The feature had the appearance of being present on the wheel flange for some time and most likely pre-dated the occurrence.

4.2 The mating wheel had a similar type of feature on the wheel flange approximately 180 degrees from the feature on the subject wheel. This feature also appeared to have pre-dated the occurrence.

4.3 The wheel tread wear, flange wear and hollow tread wear were within the AAR specifications.

4.4 Both wheels met the AAR Class C wheel specifications for hardness. No discrepancies were noted with the subject wheel material which met the AAR requirements.

4.5 The metallurgical analysis of the wheel flanges indicated that there was no welding associated with these features.

Figure 1: Photograph showing the wheel set as received

Figure 2: Photograph showing the feature observed on the flange of wheel 83414

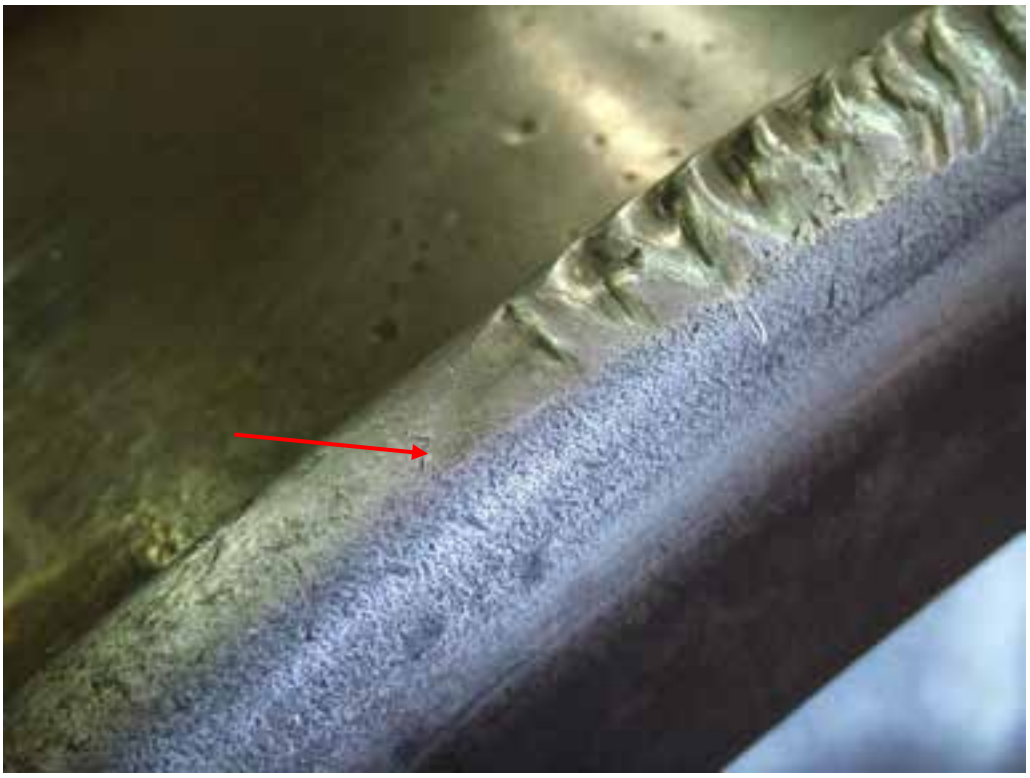


Figure 3: Photograph showing a portion of the feature on the flange of wheel 83414. The red arrow points to the end of the rub mark.

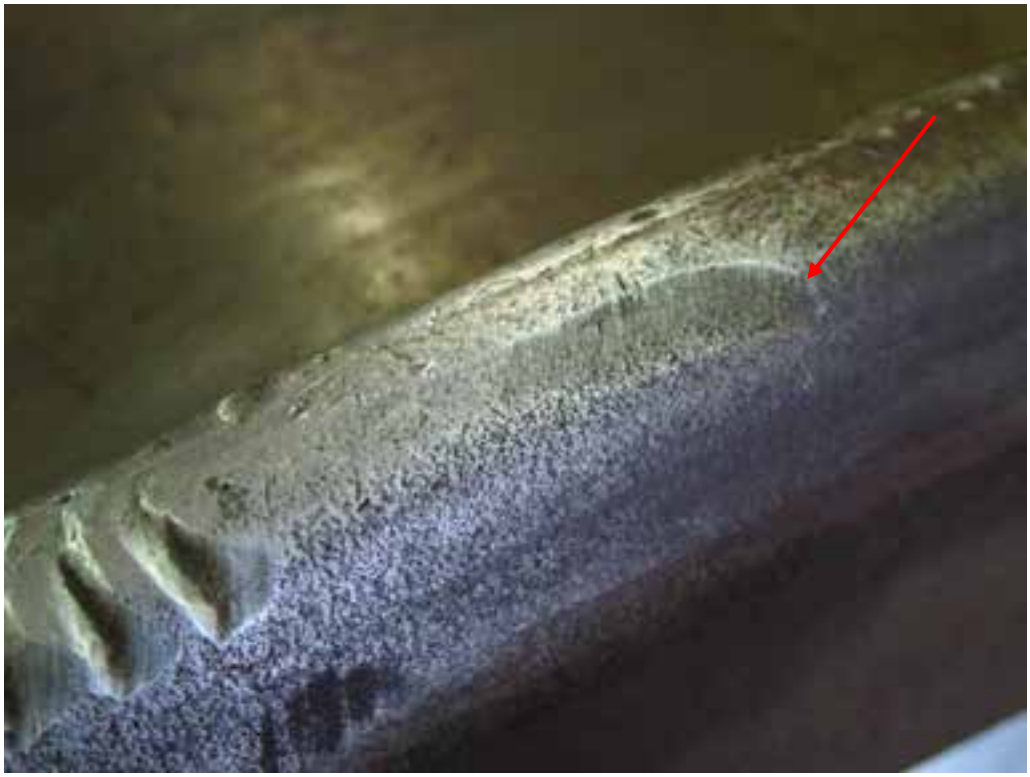


Figure 4: Photograph showing the rub mark at the end of the feature on the flange of wheel 83414 (red arrow)

Figure 5: Photograph showing the feature on the wheel flange. Note how the edges have a rounded appearance.

Figure 6: Photograph showing the feature observed on the mating wheel 80228

Figure 7: Photograph showing a closer view of the feature on the mating wheel 80228. Note how the edges have a rounded appearance similar to the feature on wheel 83414.

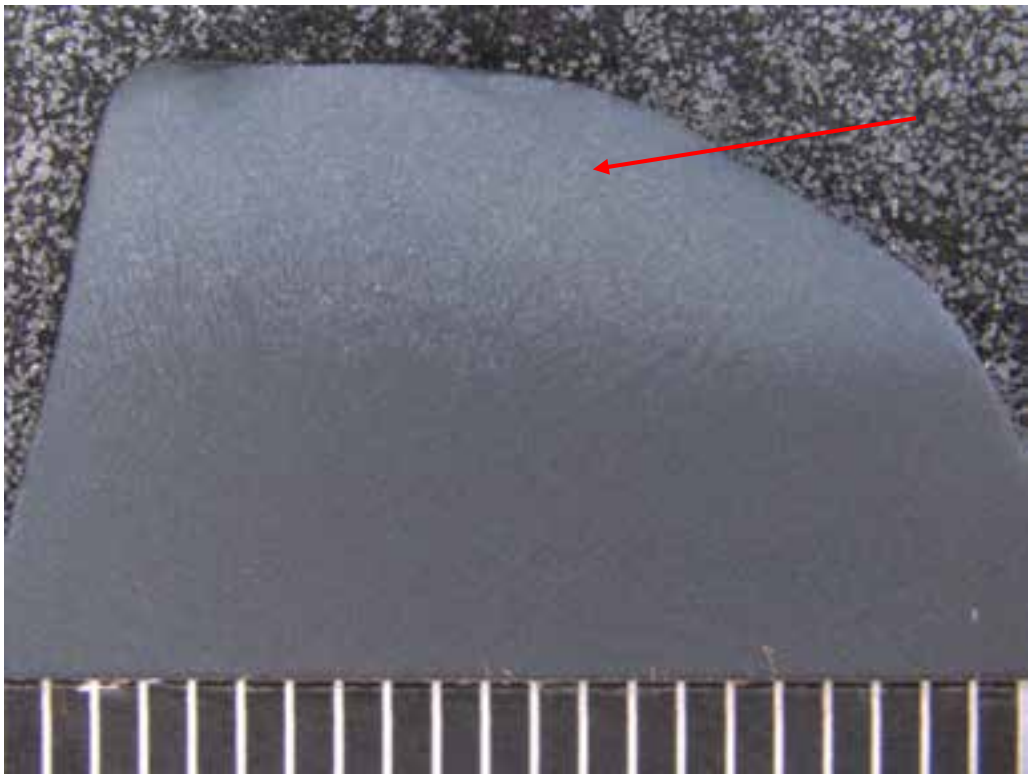


Figure 8: Photograph showing the metallurgical section taken through the feature on the wheel flange. The red arrow points to the zone of fine tempered martensite. (Nital etchant)

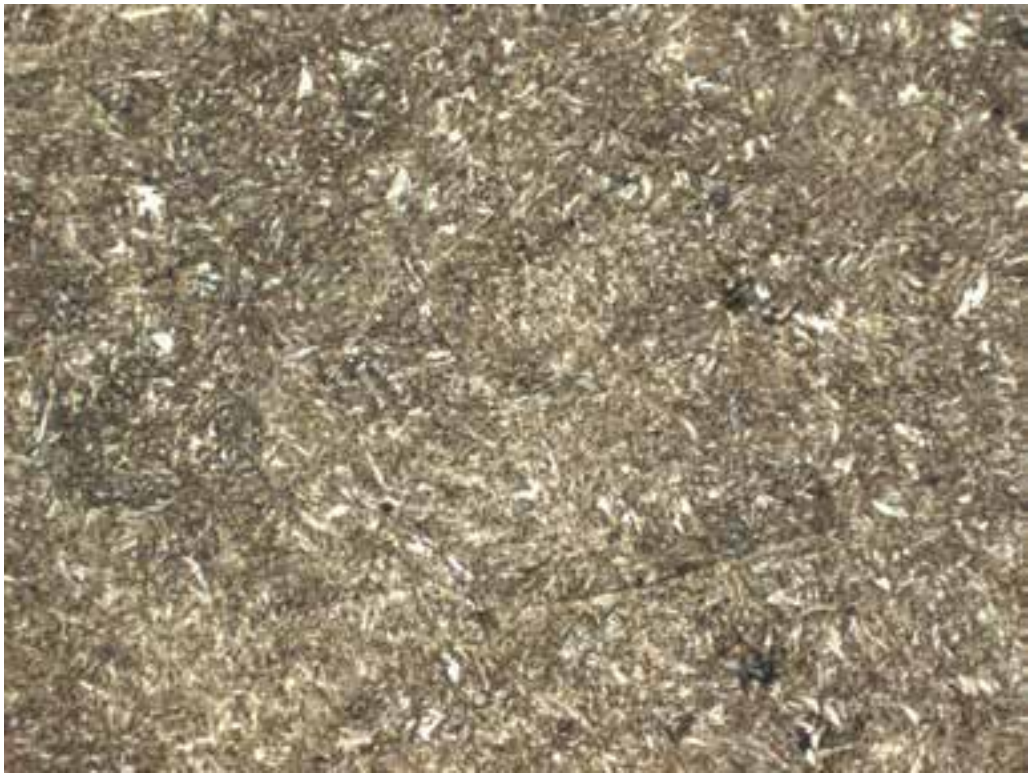


Figure 9: Micrograph showing the fine tempered martensite in the tip area of the wheel flange (Nital etchant, original magnification ×200)

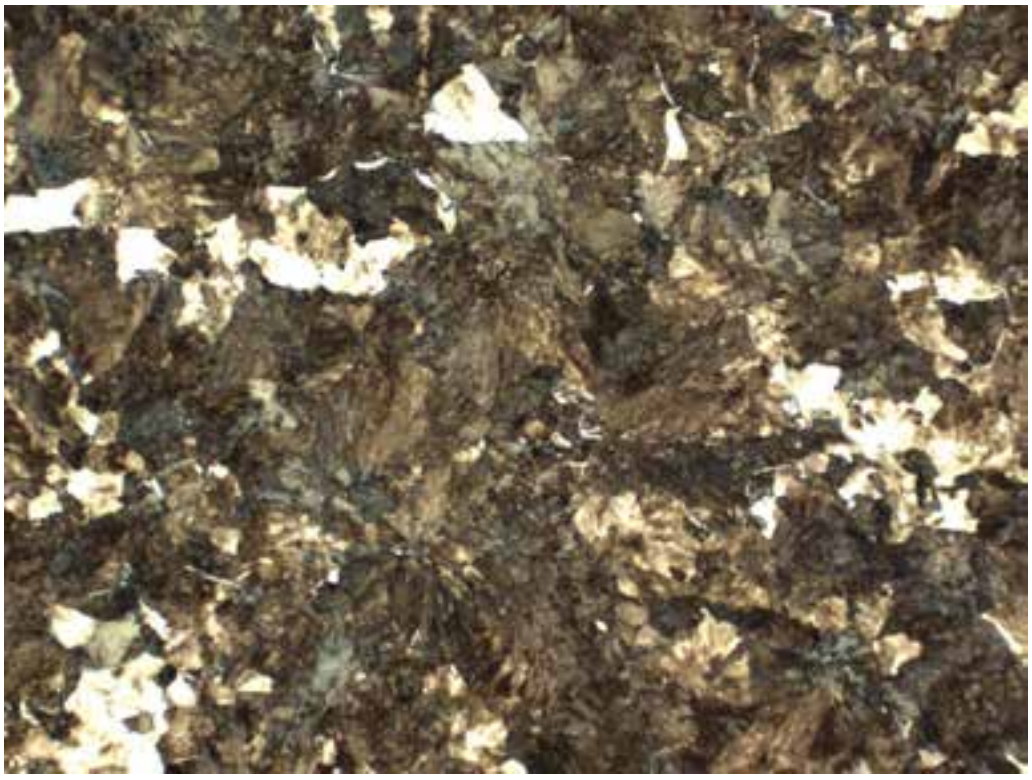


Figure 10: Micrograph showing the ferrite–pearlite microstructure in the wheel core (Nital etchant, original magnification ×200)

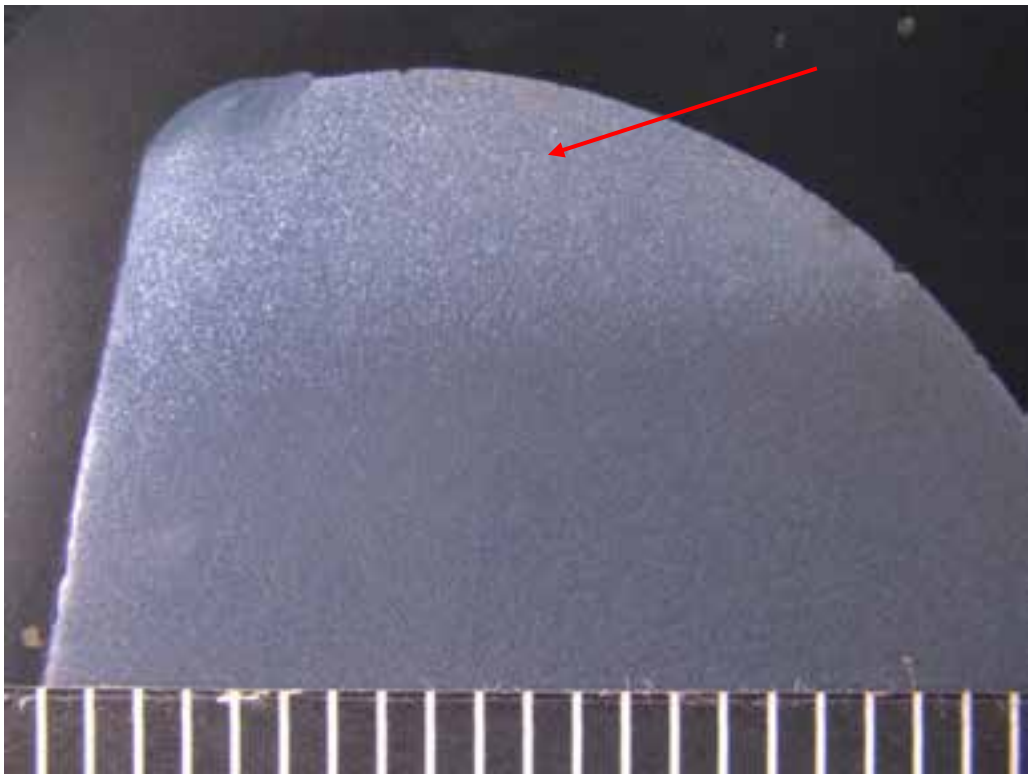


Figure 11: Photograph showing the metallurgical section taken from the subject wheel 90 degrees from the observed feature on the wheel flange. The red arrow points to the zone of fine tempered martensite. (Nital etchant)

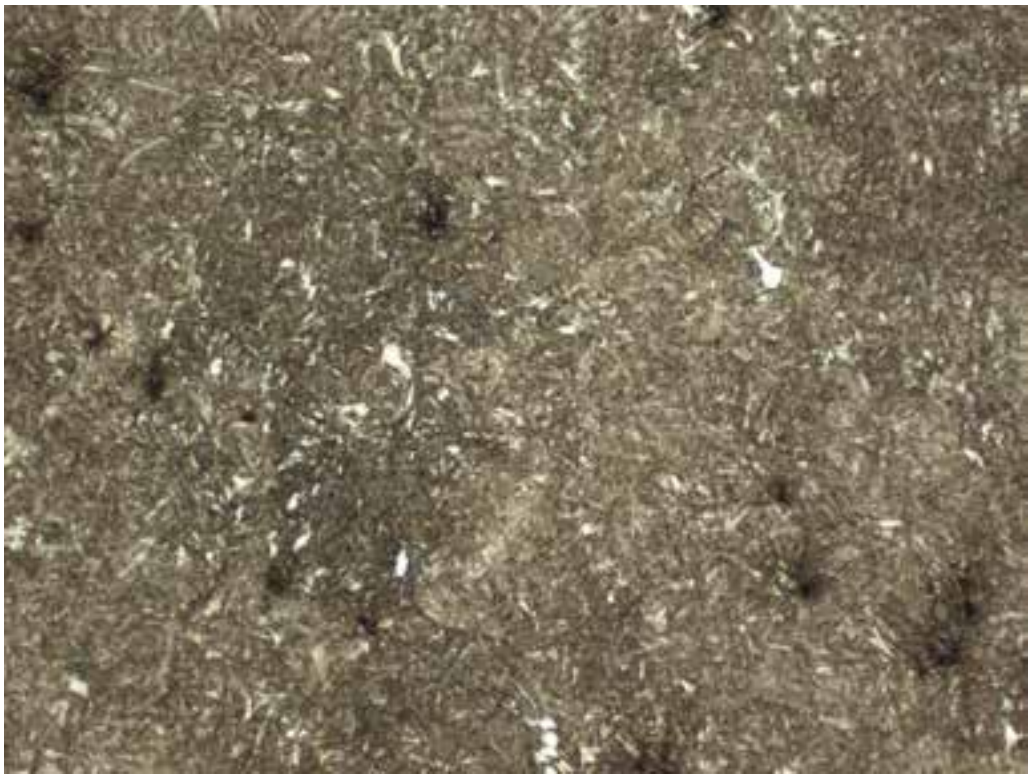


Figure 12: Micrograph showing the fine tempered martensite in the tip area of the wheel flange on the section taken at 90 degrees to the feature on the wheel flange. (Nital etchant, original magnification ×200)

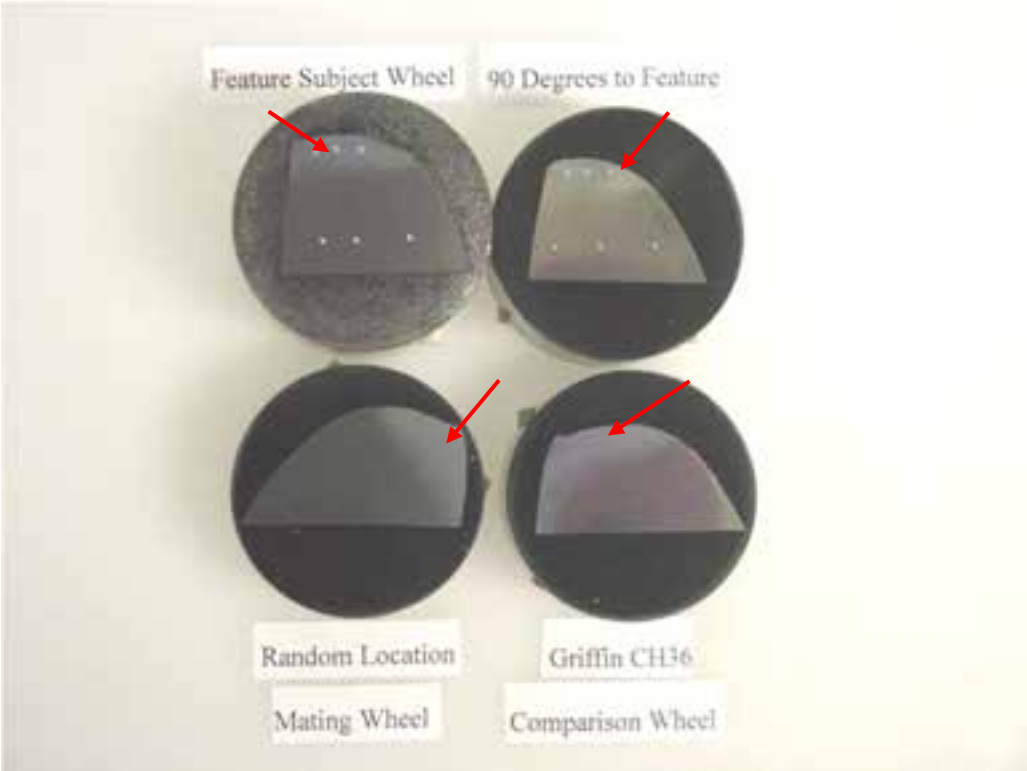
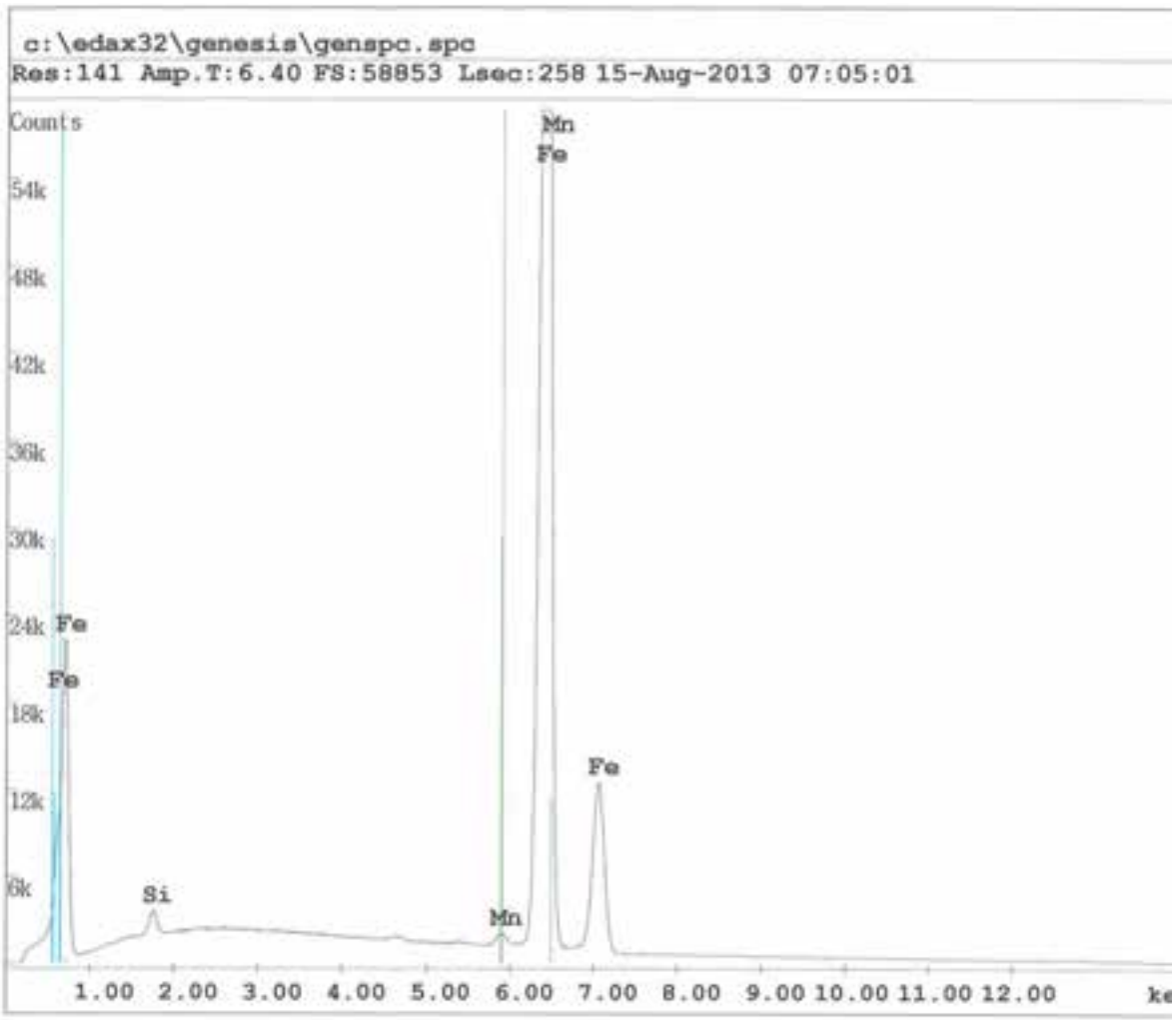


Figure 13: Photograph showing the 4 metallurgical sections taken of the wheel flanges. The arrows point to the zone of fine tempered martensite at the tip area of the wheel flange.



EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Element	Wt %	At %	K-Ratio	Z	A	F
SiK	1.14	2.24	0.0057	1.1142	0.4507	1.0015
MnK	0.95	0.96	0.0093	0.9793	0.9956	1.0000
FeK	97.91	96.80	0.9775	0.9986	0.9998	1.0000
Total	100.00	100.00				

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
SiK	85.80	51.32	1.00	1.67
MnK	46.18	63.46	1.77	0.73
FeK	4168.72	54.03	0.10	77.16

Figure 14: EDS spectrum and standard less analysis results for the subject wheel material showing the iron (Fe), manganese (Mn) and silicon (Si) peaks