CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 64-56

POLISHING NICKEL-RICH ALLOYS OF THE 80 Ni-20 Cr TYPE

by

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COPY NO. 14

JUNE 15, 1964

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SUMMARY OF RESULTS

Four samples of nickel-rich alloys, which were said to contain grain boundary cavities, were supplied for experimental polishing trials.

It was shown that these cavities were artifacts produced by the polish-etch-polish technique, and that no such cavities existed when proper sample preparation was used.

Vibratory polishing, which produces an excellent finish on other material, was shown to be too slow to be of practical value in this instance.

The polishing techniques used are described.

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INTRODUCTION

Samples of nickel-rich alloys of the 80 Ni-20 Cr type mounted in bakelite were received from Mr. E. Mitchell of the Sinfin Metallurgical Laboratory of Rolls-Royce Limited, Derby, England, with the request that a reliable method of producing a high quality polish be developed. Mr. Mitchell stated in his covering letter that these sections contained grain boundary cavities which were readily lost if the samples were "over-polished", and that these cavities were best revealed by a polish-etch-polish technique. It was requested that the samples be repolished, particularly, using vibratory polishing techniques, to see if the cavities could be more sharply defined. The degree of cavitation in the samples was listed as follows:

BJ1-43	Heavy
BL1-35	Moderate
"A"-384	Light
"C"-384	Light

PROCEDURE

Examination of all the samples in the as-received condition at X250 magnification showed a network of fine dots in grain boundaries and around inclusions. Figure 1 is a typical field. When the magnification was increased to X1000, the appearance was similar to that of etch pits around particles of constituent located in the matrix and in an almost continuous network at grain boundaries. Figure 2 is an enlarged view of the sample shown in Figure 1.

Sample C-384 was retained in the as-received condition for reference purposes. Sample BL1-35 was cut into two pieces and remounted, BJ1-43 was remounted, and A-384 was retained in its original mount. The four samples were reground using water lubricated silicon carbide discs on a rotary lap to 600 grit prior to each polishing test. Tests were carried out on rotary laps using napless, short napped, and long napped cloths, with the samples held either manually or in automatic fixtures and on vibratory polishers using napless or short napped cloths with up to 350 g additional weight on the sample. Polishing media used were aqueous suspension of alumina with and without soap additions, and kerosene or amyl alcohol lubricated diamond abrasives. Polish attack procedures using alumina or diamond were also attempted.

The polish attack procedures were the only techniques attempted which yielded structures similar to those seen on the as-received samples and even these could be removed by polishing all traces of the previous etch from the samples.

Aqueous polishing with alumina appeared to buff the sample, and although inclusions in the matrix were revealed by these techniques, their colour was dull and grain boundary networks were usually not apparent. Soap additions appeared to effect an improvement but this was not consistent. Long napped cloths also appeared to result in improvement but relief effects were excessive.

Diamond abrasives on short napped cloths (Metron B) with amyl alcohol lubricant gave the best results. This procedure results in a reproducible polish of the true structure in a short time without requiring complicated apparatus or sophisticated techniques. The structures, although scratched, are fully developed after a quick polish on 9 micron diamond. Most of these scratches are removed by hand finishing on a slow rotary lap using 3 micron diamond and further improvement is attained by proceeding to 1/4 micron diamond. The total times required were about 2 min on 9 micron, 5 min on 3 micron and five or more additional minutes on 1/4 micron diamond. Figures 3 and 4 are fields at X250 and X1000, respectively, of sample A-384 after finishing for 7 min by hand on 1/4 micron diamond and etching for 4 sec in Carapella's reagent.* In the photomicrograph at lower magnification there appear to be some "grain boundary cavities" but at X1000 it is suggested that these are due to optical effects caused by the fine grain boundary precipitates. No cavities were observed on the as-polished material.

Vibratory polishing with aqueous media appears to require quite critical conditions of sample weight, machine amplitude and time of polishing. Using diamond abrasives a fair to good polish could be attained but times were excessive so that this technique could only be recommended for final polishing where a very high quality finish is required. As an experiment these samples were polished for seventeen days using 9 micron diamond and 350 g added sample weight. Even this did not completely remove the scratches from the 600 grit paper but, at the same time, no pits or over-polishing effects were noted. Figure 5 and 6 are photomicrographs of sample BJ1-43 as-polished for this time and Figures 7 and 8 are of BL1-35 after the same polish, and etching for 4 sec in alcoholic ferric chloride**.

CONCLUSIONS

From the appearance of the as-received samples, and from the fact this structure could be reproduced only by an incomplete repolish of an etched surface, it is concluded that the cavities observed by Rolls-Royce are polishing artifacts, and do not represent oxide penetration of grain boundaries.

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*Ferric chloride 5 g, HCl 2 ml, Ethanol 99 ml.
**Ferric chloride 1 g, HCl 1 ml, Ethanol 15 ml.

It is shown that the true structure of the material supplied can best be revealed by water-free polishing with diamond abrasives on napless or short napped cloths attached to slow speed rotary laps.

Polishing by vibratory machines is excessively slow and would not be warranted in this instance unless an extremely high class finish is required.

Polishing with aqueous media should be avoided if possible, since this tends to obscure grain boundary constituents in the as-polished condition.

TABLE 1

List of Materials, Reagents and Equipment

Material		Source
Silicon Carbide Paper		A. Buehler
Alumina	Coarse 600 mesh	A. Buehler
	Intermediate Linde A	Linde Co.
	Fine Linde B	Linde Co.
	Fine Gamma Alumina	Fisher Scientific
Diamond	15 micron	A. Buehler
	9 micron	A. Buehler
	3 micron	A. Buehler
	1/4 micron	A. Buehler
Polishing Cloths	Napless - Metcloth	A. Buehler
	Napless - Pellon discs	Micro Metallurgical
	Short Nap - Metron B	Micro Metallurgical
	Long Nap - Gamal Cloth	Fisher Scientific
	Long Nap - Rayvel	A. Buehler
Lubricant and Etches	Reagent grade or equivalent throughout	
Grinding and Polishing Machines	Grinding, 8 in. dia. 375 rpm	
	Polishing, 8 in. dia. 1150 rpm	
	750 rpm	
	Diamond Lap. 8 in. dia. 150 rpm	
	Vibratory Polisher 2 rpm (sample travel-5 in. bowl)	

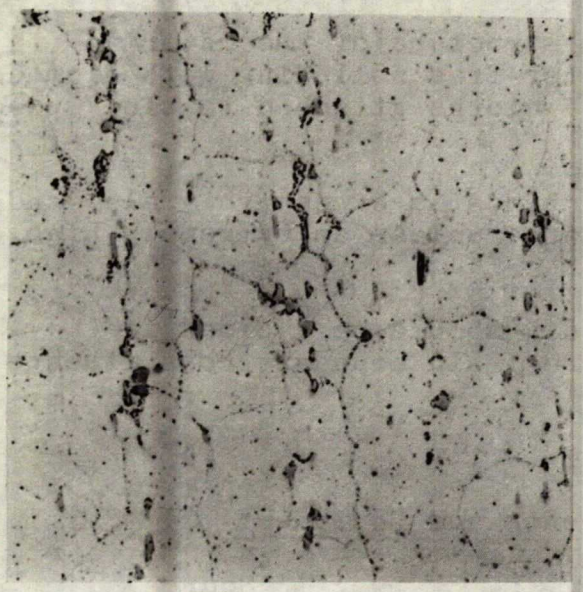

Figure 1. X250

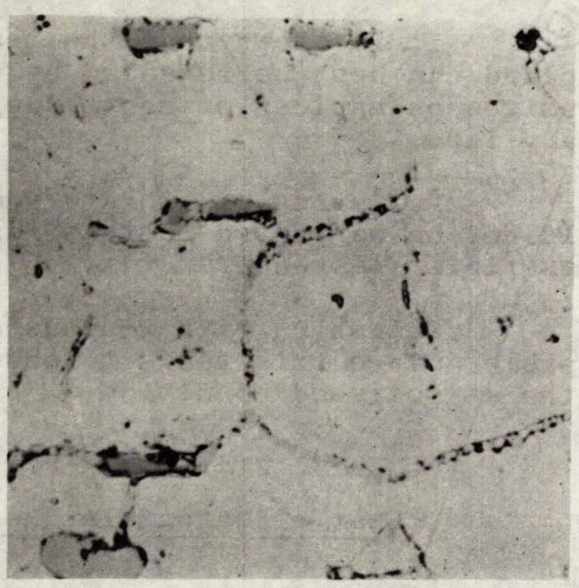

Figure 2. X1000

Sample C-384, as-received; repeated polish-etch attack preparation.

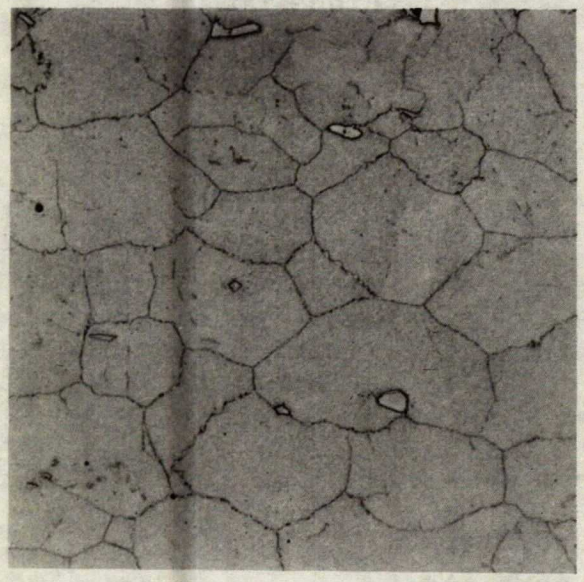

Figure 3. X250

Figure 4. X1000

Sample A-384, using 1/4 micron diamond finish. Etched 4 sec Carapella's Reagent*

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*Ferric chloride 5 g, HCl 2 ml, Ethanol 99 ml

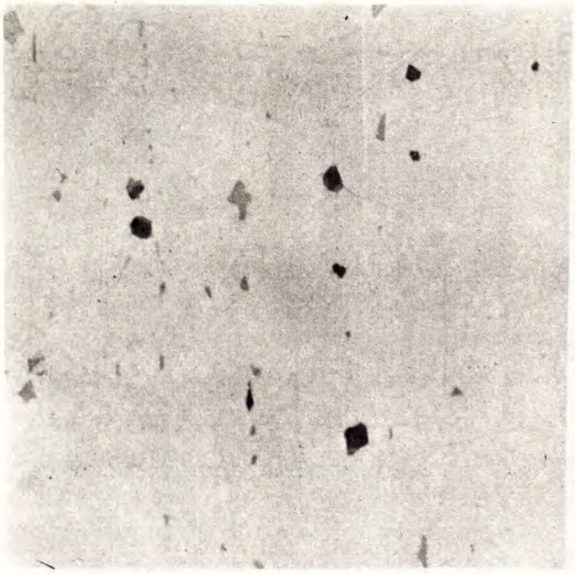

Figure 5. X250 Figure 6. X1000

Sample BJ1-43, using 9 micron diamond for 17 days on a vibratory polisher. As-polished.

Figure 7. X250 Figure 8. X1000

Sample BL1-35. Same polish as Figures 5 and 6. Etched 4 sec alcoholic ferric chloride**.

**Ferric chloride 1 g, HCl 1 ml, Ethanol 15 ml