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O T T A W A   September 29th, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1506.

Examination of Aluminium Alloy Castings
for Aircraft Oil Filters.

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(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals
-
Ore Dressing
and Metallurgical
Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

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Origin of Samples and Object of Investigation:

On September 15th, 1943, Mr. H. J. Allin, Mechanical Superintendent, Stewart-Warner-Alemite Corporation of Canada, Limited, Belleville, Ontario, submitted for examination two cast aluminium alloy oil-filter cylinders used in aircraft.

The covering letters stated that the first oil filters processed by the Stewart-Warner-Alemite Corporation of Canada had been made from D.T.D. 136A magnesium alloy and that no machining difficulties were encountered. Later, because of an inability to get D.T.D. 136A alloy, the Corporation was supplied with aluminium alloy (A.C. 135W) castings as a substitute. Some of these aluminium alloy castings machined satisfactorily, but with many others

(Origin of Samples and Object of Investigation, cont'd) -

trouble was experienced with rough broken threads in ¾ B.S.P. tap holes. One of the castings submitted (designated herein Casting A) had threaded satisfactorily and the other (which will be known as Casting B) had not.

Request was made for a metallurgical examination of the aluminium alloy castings and for comments on the comparative machinability of D.T.D. 136A magnesium alloy and A.C. 135W aluminium alloy.

Chemical Analysis:

Drillings from each of the cylinders were chemically analysed. The results obtained are given below, together with the SAE specification for this type of aluminium alloy:

		Casting A	Casting B	SAE 323 Specification
			- Per cent -	
Copper	-	0.13	0.05	0.2 max.
Silicon	-	6.33	6.75	6.5-7.5
Magnesium	-	0.15	0.28	0.2-0.4
Manganese	-	0.05	0.015	-
Iron	-	0.30	0.31	0.5 max.
Titanium	-	0.09	0.11	0.2 max.
Zinc	-	None detected.	None detected.	0.05 max.

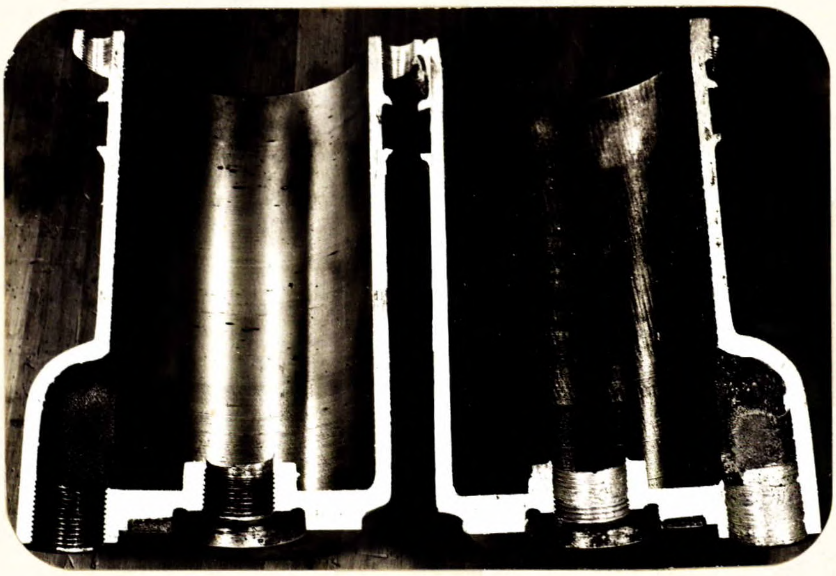
Macro-Examination:

Figure 1 is a view of a half-section of each of the castings.

(Continued on next page)

(Macro-Examination, cont'd) -

Figure 1.



HALF-SECTIONS OF CASTINGS.

(Approximately one-third actual size).

The threads in the $\frac{3}{4}$-inch hole in Casting B were rough and broken; in many places, threads were non-existent. It was noticed, however, that at the other end of this casting there were quite satisfactory threads, in holes of about $\frac{1}{2}$-inch diameter. In the other aluminium alloy casting the threads appeared to be satisfactory in all holes.

Physical Examination:

Sections were removed from the threaded portions at both ends of each cylinder and then polished. Hardness tests were next taken, using the Vickers method with a 10-kilogram load. The following results were obtained:

		VICKERS HARDNESS, 10-KILOGRAM LOAD	
		Mean	Limits
Casting A	-	54.5	48.6-60.2
Casting B	-	45.8	41.1-48.2

The hardness did not vary noticeably from end to end of the same casting; that is, the mean in all locations

(Physical Examination, cont'd) -

was approximately the same.

Two micro-tensile specimens were removed from the thickest section at the base of each casting. Test results were:

		Ultimate Tensile Strength, p.s.i.
Casting A	-	22,600 and 26,400
Casting B	-	14,800 and 20,400

These tensile test results are indicative, but they are not very accurate because of the nature of the test pieces and defects present in them.

Radiographic Examination:

Both castings, when radiographed at the National Research Council, Ottawa, were found to be quite porous. The porosity, however, seemed to be of the same order in each and did not vary noticeably from end to end of the individual casting.

Micro-Examination:

Samples removed from the threaded sections at both ends of each cylinder were mounted in bakelite and polished. These were then etched with Keller's reagent (1 per cent HF + 1.5 per cent HCl + 2.5 per cent HNO_3 + 95 per cent H_2).

Considerable porosity, with connecting stringers which have the appearance of oxides but which may be part of the shrinkage defects, was found in both castings (see Figures 2, 3 and 4).

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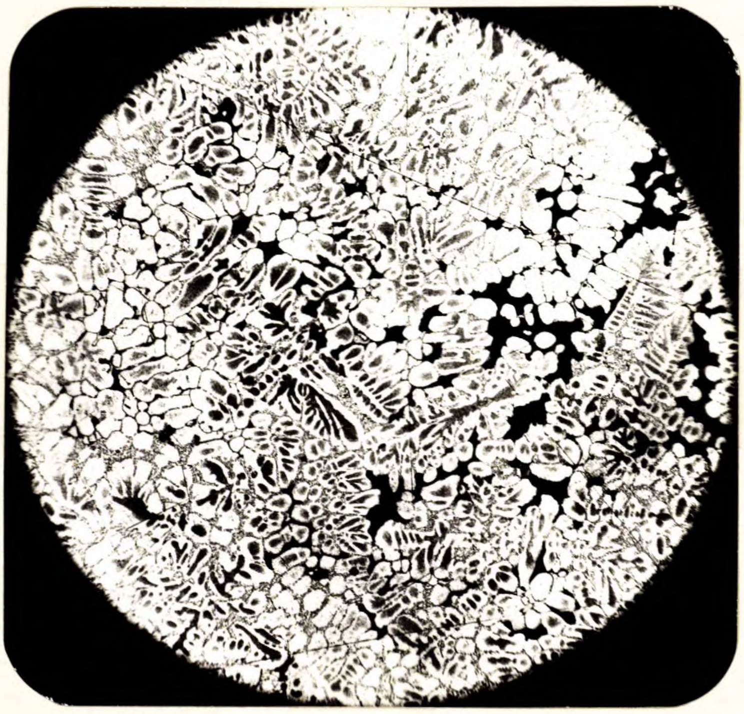
(Micro-Examination, cont'd) -

Figure 2.



X40, Keller's etch.

CASTING B.

Note shrinkage cavities (black voids) with connecting black stringers or streaks.

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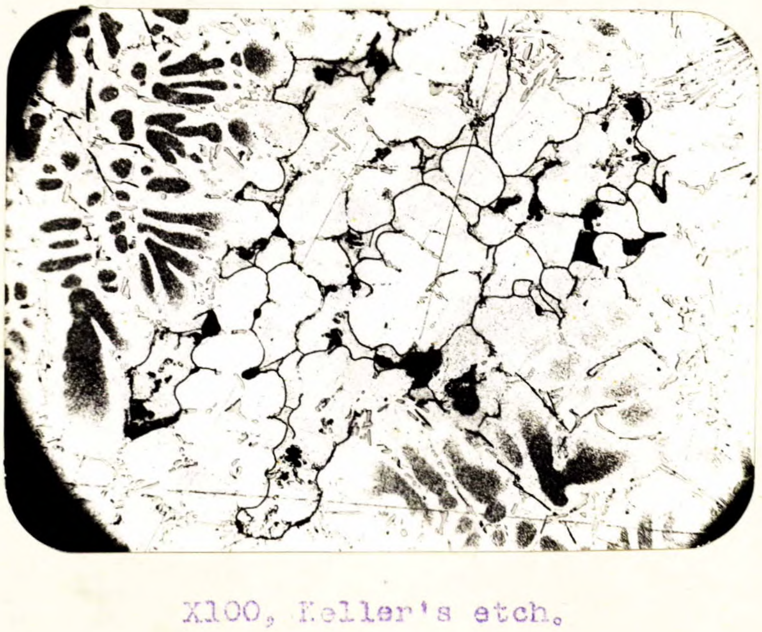
Figure 3.



X100, Keller's etch.

CASTING B.

Note shrinkage defects.

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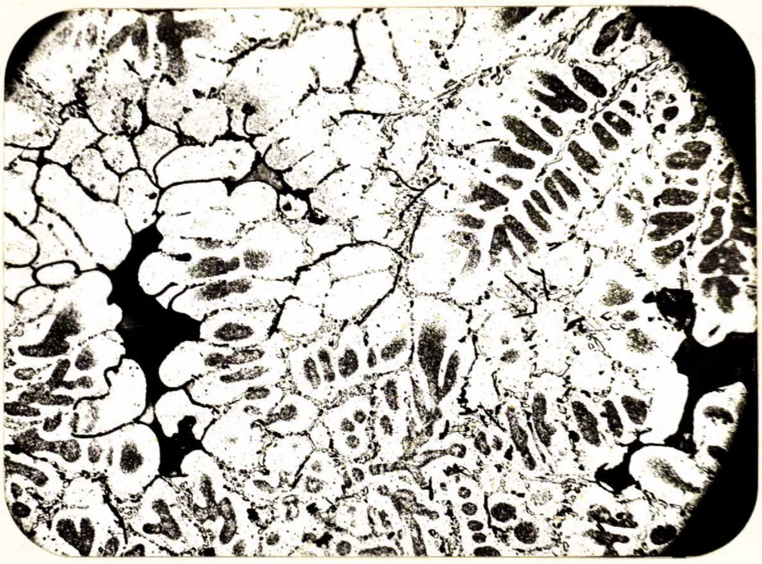
(Micro-Examination, cont'd) -

Figure 4.



X100, Keller's etch.

CASTING A.

Note shrinkage defects.

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Machining Properties of Magnesium Alloys:

Magnesium alloys have what is probably the best machinability of any commercial metal. As compared with other metals, (1) they allow higher cutting speeds, greater feeds, and deeper cuts; (2) they do not tend to drag or tear, readily taking a high finish; and (3) they may often be machined with no lubricant.

Discussion of Results:

Chemical analysis results show that the composition of both castings conforms to A.C. 135W (Al-Si-Mg alloy) nominal composition, but that the magnesium content of Casting A is lower than specified in the SAE specification.

Chemical, physical, radiographic and microscopic

(Discussion of Results, cont'd) -

examinations show that the only significant difference between the two castings is that the casting which machined satisfactorily (Casting A) has a slightly higher hardness, with resulting higher ultimate tensile strength. It is evident from this that the thermal history of the castings is slightly different, the harder one apparently having been cooled faster from the casting temperature or been given a solution or partial-solution heat treatment. This higher hardness would be expected to result in some improvement in machinability but would hardly be the complete explanation of such a radical difference as that noticed in the tapping of the two castings. It seems that there must have been some difference in the tools or operation. Because satisfactory threads were found at the other end of the casting in which trouble was experienced, it must be possible to thread the softer castings under some conditions. A partial explanation might be that the angles on the tools used for the ¼-inch holes were nearly correct for the harder casting but were unsuitable for the softer one, whereas the tools and operations used in threading the ½-inch holes were more of a compromise. It is also conceivable that in the casting found to thread unsatisfactorily the tool, in cutting the thread, broke out some metal undermined by shrinkage defects and thus tended to tear up threads. It is generally conceded, in any case, that porosity does tend to decrease ease of machining.

If service conditions are such that no harmful effects will result from increased hardness, the machinability should be increased by a hardening heat treatment. A high-temperature solution heat treatment, giving a Brinell hardness (500 kilogram, 10 m.m. ball) of 50-70, is the one to use where the best combination of strength, ductility, and shock-resisting

(Discussion of Results, cont'd) -

ability is desired. If this is followed by a precipitation treatment, a Brinell hardness of 60-80, with resultant higher tensile and yield strengths and improved machinability, is obtained. These Brinell values are approximately directly convertible to Vickers readings.

Discussing the relation of hardness and porosity to the machining of cast aluminium alloys in "Notes on the Machining of Aluminium and its Alloys," (Journal of the Institute of Metals, No. 2, 1939, Vol. LXV, p. 40) authors J. H. Dickin and G. A. Anderson state:

> "It was generally noticed that the harder the alloys, as judged by Brinell values, the better the machining qualities. It was also very noticeable that the chill-cast were better than the sand-cast specimens. Where pin-holing was experienced inferior machining results were obtained, and the application of a fluxing treatment gave improved results; from a machining point of view it is desirable that the alloys should be free from pinholes. The mechanical properties of some of these alloys can be improved by heat treatment, and the increased Brinell hardness obtained in this manner considerably improves machining properties."

A further quotation from this same paper may also be of interest:

> "In the case of the less satisfactory (machining) alloys, some modification of the tools, angle, etc., would give considerable improvement."

As regards comparative machinability, the machineability of this aluminium alloy will, it is thought, be inferior to that of the magnesium alloy formerly used no matter what presently known metallurgical treatments are given to improve it.

CONCLUSIONS:

1. This examination disclosed a comparatively small difference in hardness and ultimate tensile strength as the only significant difference between the satisfactorily and unsatisfactorily machining castings.

2. It is evident, from threads on one end of the unsatisfactorily machining casting, that under proper tool and operation conditions this casting can be threaded.

3. Machinability of these castings would be improved by increasing the hardness and decreasing the porosity.

4. Machinability of this type of aluminium alloy castings is, in general, inferior to that of the magnesium castings formerly employed.

According to report the supply situation is now definitely easier for magnesium than for aluminium. Therefore, since machining of the magnesium castings previously used apparently gave no trouble, the logical course would appear to be to return to the original manufacturing procedure.

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