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O T T A W A May 28, 1945.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1876.

Examination of a Broken Steel Mould.

(Copy No. 6.)

Bureau of Mines
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

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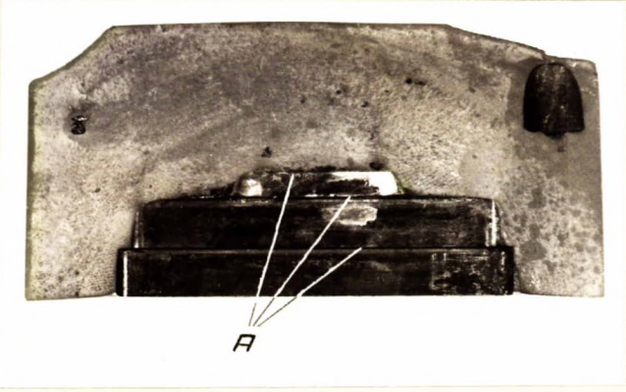
Source of Material and Object of Investigation:

On May 15, 1945, Mr. S. K. Johns, Manager, Dominion Plastics Limited, Ste. Therese de Blainville, Quebec, submitted for examination a piece of a steel mould which had failed in service. In a letter accompanying the material, it was requested that the broken section submitted be examined in order to determine, if possible, the cause of failure.

Macroscopic Examination:

Figure 1 is a photograph showing the fracture of the broken steel mould.

Figure 1.



FRACTURE OF BROKEN STEEL MOULD.

(Approximately to size).

All radii of machined sections (marked "A") of the mould appeared to be quite sharp. The fracture of the steel is fine-grained.

Chemical Analysis:

The range of chemical composition of a typical oil-hardening, non-deforming tool or die steel and the results of analysis of the steel mould are given in the following table:

(Continued on next page)

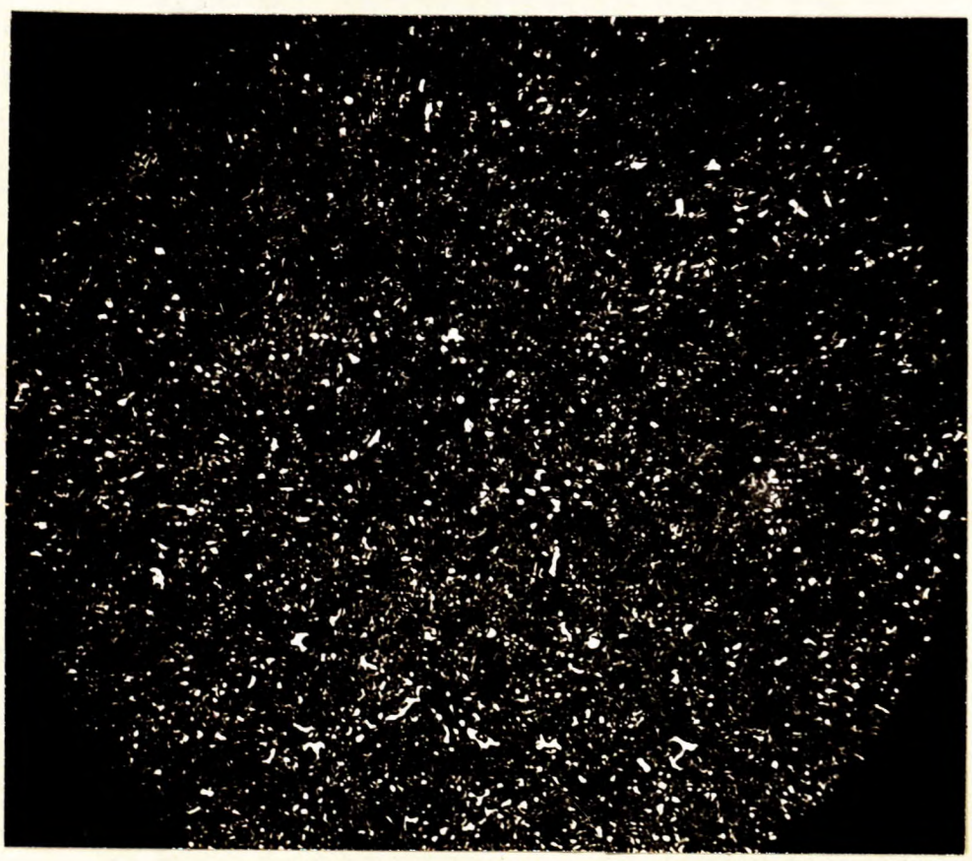
(Chemical Analysis, cont'd) -

	Non-Deforming Tool Steel	Dominion Plastics Steel Mould
	- Per Cent -	
Carbon -	0.80 to 1.30	0.88
Manganese -	0.55 to 1.80	1.28
Silicon -	0.15 to 0.50	0.28
Sulphur -		0.011
Phosphorus -		0.008
Chromium -	0.35 to 1.00	0.39
Nickel -		Nil.
Vanadium -	0.00 to 0.50	"
Tungsten -	0.00 to 2.50	"
Molybdenum -	0.00 to 0.75	"

Microscopic Examination:

A specimen cut from the broken mould was mounted in bakelite, polished, and examined under the microscope in the unetched condition. The steel was found to be fairly clean. After etching in a solution of 2 per cent nitric acid in alcohol the steel was re-examined. The structure was found to consist of tempered martensite with small carbides uniformly distributed throughout the matrix.

Figure 2.



Rockwell Hardness Number: "C" Scale, 59.

X500, etched in
2 per cent nital.
(Overetched to show up carbides, the white etching material.)

Remarks:

The broken steel die submitted had a chemical composition similar to that of an oil-hardening, non-deforming tool or die steel. Carbon in the amount found to be present should give optimum hardening properties. Manganese in the range of 1.00 to 2.00 per cent will cause the steel to harden readily, therefore such steels should be oil-quenched. Manganese adds soundness to the steel and improves its casting and forging properties. The silicon addition is made to the steel as a deoxidizer. The amount present and the low sulphur and phosphorus contents indicate that the steel was properly made. The chromium increases the depth hardening of the steel. With chromium present it is necessary to heat the steel to slightly higher temperatures to obtain maximum hardening. The microstructure and hardness of the metal indicate that the heat treatment used was satisfactory.

It was noted that there were a number of sharp radii at the point of fracture. This condition should be avoided if possible. It was also observed that the die had several holes in the section which failed in service. Sharp radius and uneven sections may cause cracks to occur in the heat treatment operation unless special precautions are observed. Even if cracking does not occur in the heat treatment, sharp radii may lead to high internal stress conditions which may lead to failure in service. The following precautions in heat treatment should be observed.

(1) Preheat slowly and uniformly to 1200° F.

(2) Heat slowly to the hardening temperature, 1450 to 1500° F.

(3) Quench in a good quantity of a reliable quenching oil, which should be at a temperature of 100 to 125° F., but do not cool the steel below the temperature of boiling water.

(4) The tempering (temperature 325 to 500° F.) should

(Remarks, cont'd) -

be carried out immediately after quenching, to avoid internal stresses in the die.

A magnaflux examination did not show any cracks in the sample submitted. It is most likely that a hairline crack may have been formed in the die during the heating-up or quenching operations. The possibility always exists that the die may have failed as the result of maltreatment in service. From the results of this examination, it is concluded:

1) That the composition and structure of the steel were satisfactory.

2) That the radii of the machined sections of the die were too sharp.

3) Failure may have been initiated by a heat treatment defect or as the result of maltreatment in service.

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