

# DUCTILE IRON CASTINGS – SCOPE FOR ENGINEERING KNOWLEDGE

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## Abstract

It was revealed at a series of “Design Engineer Symposia” that many Engineers in industry are poorly informed about the properties and attributes of various ferrous engineering materials now available, especially of castings. In particular, Ductile iron castings are underutilised in South Africa compared with other countries. The versatility of Ductile iron is shown by its mechanical properties and some potential sugar industry applications are mentioned. The paper also describes a survey undertaken in the sugar industry and makes recommendations for engineering material usage policy.

## Introduction

Since its invention in 1948, the versatile new class of cast iron has been variously known as Spheroidal Graphite iron or SG iron, Nodular iron or Ductile iron. In this paper, the newly recommended universal description, Ductile iron, will be used.

During the last 7 years, 26 Design Engineers’ Symposia have been arranged by Mineral-Loy C C. These were presented to Engineers responsible for material selection in the Motor Mining, Sugar Milling and General Engineering sectors of the economy. The reason behind the presentation of

these meetings, at which the physical and mechanical properties and attributes of various engineering materials are discussed, was the observation that many components produced by the South African Ferrous Foundry Industry were cast in materials or grades of materials not best suited economically or functionally for the intended application. It was also noticed that industry in general made use of welding and forging in producing components that were more suitable for production in Ductile iron castings. Ductile iron castings, one of the fastest growing and one of the most widely used engineering materials, are not receiving the same attention in South Africa that they are in other parts of the world. Meaningful comparisons are difficult to obtain but as an indication of the statement that Ductile iron is not being used to full potential, the following chart was produced from statistics obtained from the American Foundryman’s Society as published in “Modern Castings”.<sup>1</sup>

The tonnage of Ductile iron castings produced per 1 ton of steel castings is shown in Figure 1.

Ductile iron was only discovered in the late 1940’s, almost simultaneously by the British Cast Iron Research Association and the International Nickel Company. Since then the material has shown phenomenal growth as an engineering

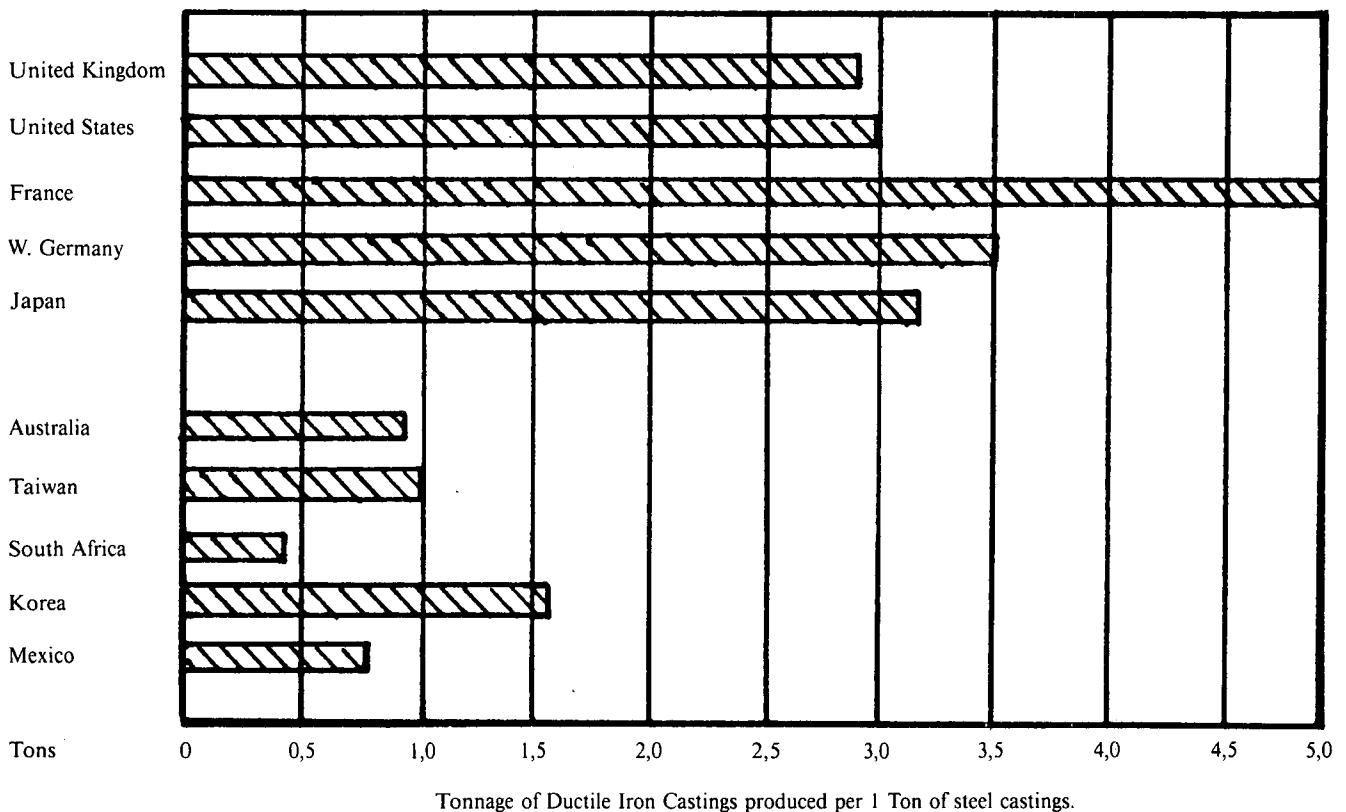


FIGURE 1 The ratio of Ductile Iron Casting Production vs Steel Casting Production in Various Countries.

material. It is estimated that the current world production is in excess of eight million tons per annum. Approximately half of this production is accounted for by the Ductile Iron Centrifugally Cast Pipe producers. Of the balance, approximately 35% finds its way into the automotive industry and the rest into a multitude of engineering industries which include mining, agriculture, paper making, cement manufacture, earth moving and sugar milling.

The reason for this rapid growth and wide acceptance of Ductile iron castings can only be ascribed to functional suit-

ability and of course, economics. It has competed successfully against fabrications, forgings, steel and malleable iron castings in some of the most competitive industries in the world.

The use of Ductile iron castings compared with other cast materials in Europe is shown in Figure 2.<sup>2</sup>

### The versatility of Ductile iron castings

The ability to be easily cast into complex shapes and varying section sizes within any one component can be said to be one of the biggest assets of Ductile iron castings. The function of several components can be combined into one component due to the castability of the material. Ductile iron affords the Designer maximum freedom of design and the ability to distribute evenly the stresses encountered during service. Table 1 compares some properties of Ductile iron castings with those of other ferrous engineering materials:-

The properties of Standard Ductile and Grey iron castings, unlike all the other materials in Table 1, can be obtained in the as-cast condition. In other words no heat treatment is necessary. The five most popularly specified grades of Ductile iron can be produced either unalloyed or through alloying with small amounts of copper.

For all practical purposes, Ductile iron can be described as steel with graphite spheroids dispersed throughout. It is largely this graphite that accounts for the superior castability and machinability that Ductile iron enjoys when compared with steel castings. Ductile iron can seldom compete with steel castings when welding is required.

Ductile iron castings can vary in size from a few grams to the present world record of 200 tons.

Why is Ductile iron apparently not being used to its full potential in South Africa? In order to try to answer this question, it was decided to personally conduct a number of surveys in various industries. The sugar milling industry was selected first and the survey conducted at chief engineer level or above on the use of various engineering materials.

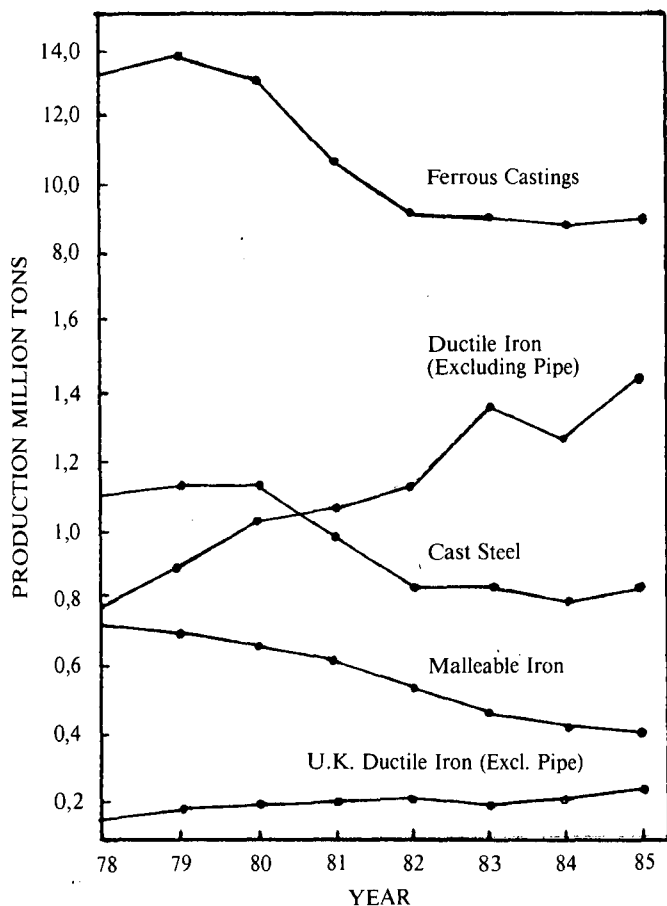


FIGURE 2 Production of ferrous castings in Europe 1978-1985.

### Findings from the survey

The general preferences of respondents are shown in Figure 3.

Table 1  
Properties of some Ferrous Engineering Materials

	Iron			Steel		
	Ductile		Grey	Malleable	Cast	Forged
	A.D.I. -	Standard A536	A48	A002	A27	A290,A-D
ASTM Specification						
Ultimate Tensile Strength (MPa)	860-1380	400-700	138-414	345-725	415-480	550-1170
Yield Strength (MPa)	590-965	275-480	-	220-585	210-275	310-1000
% Elongation	10-2	18-2	-	10-1	24-22	22-10
Hardness (HBN)	260-460	160-260	180-220	140-250	160-200	220-300

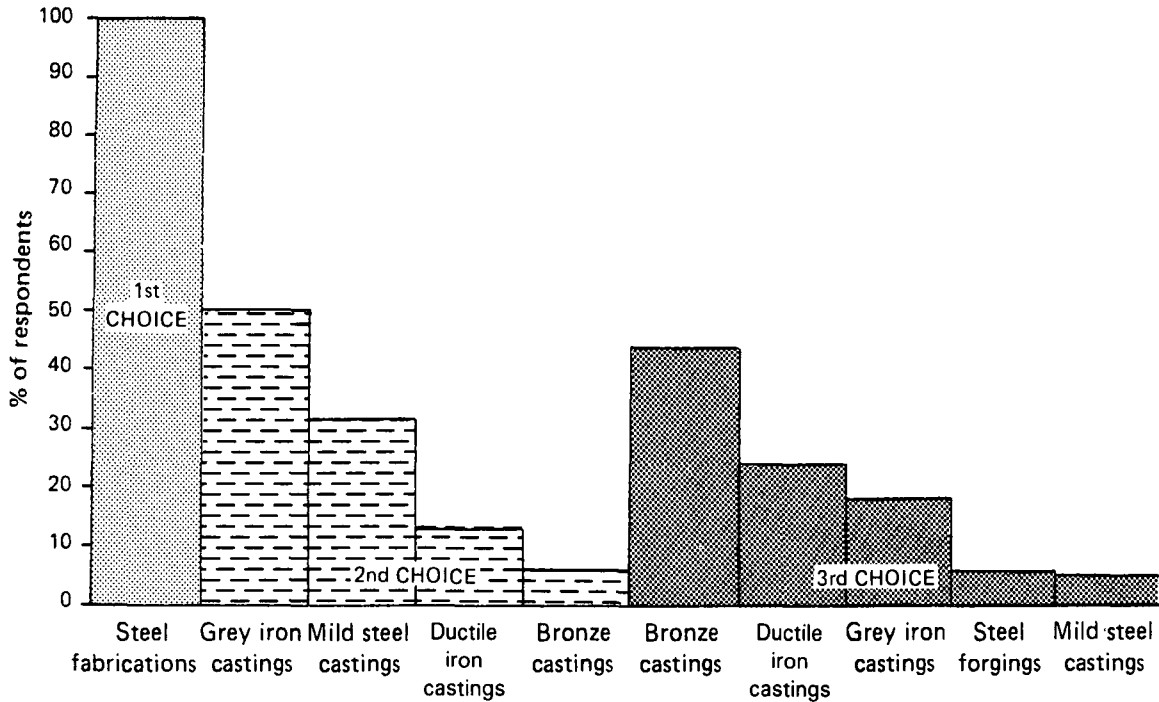


FIGURE 3 Preferred material for production of parts and components.

The degree to which respondents were conversant with the properties of the different materials is depicted in Figure 4.

Respondents were asked:- Based on your experience with and/or perceptions of steel fabrications, rank it in terms of the following considerations: Mechanical properties; Physical properties; Chemical properties; Machinability; Weldability; Familiarity; Weight of part; Confidence in meeting specifications; Cost. Their replies are depicted in Figure 5.

In answer to the same question, but asking for the rankings in respect of Ductile iron castings, 73% failed to complete the question due to lack of knowledge of the material.

The materials used at present for nine common sugar mill items are shown in Table 2.

Other potential large scale applications are chain links, casings, gears, conveyor slats and wear pads. Various grades of Ductile iron could perhaps provide the most cost effective material for some of these applications, if engineers were more conversant with its properties.

This unfamiliarity is not unique to the sugar milling industry. With the exception of a survey in the automotive industry, it is strongly suspected that all our surveys will show a similar picture. Again this is not unique to South

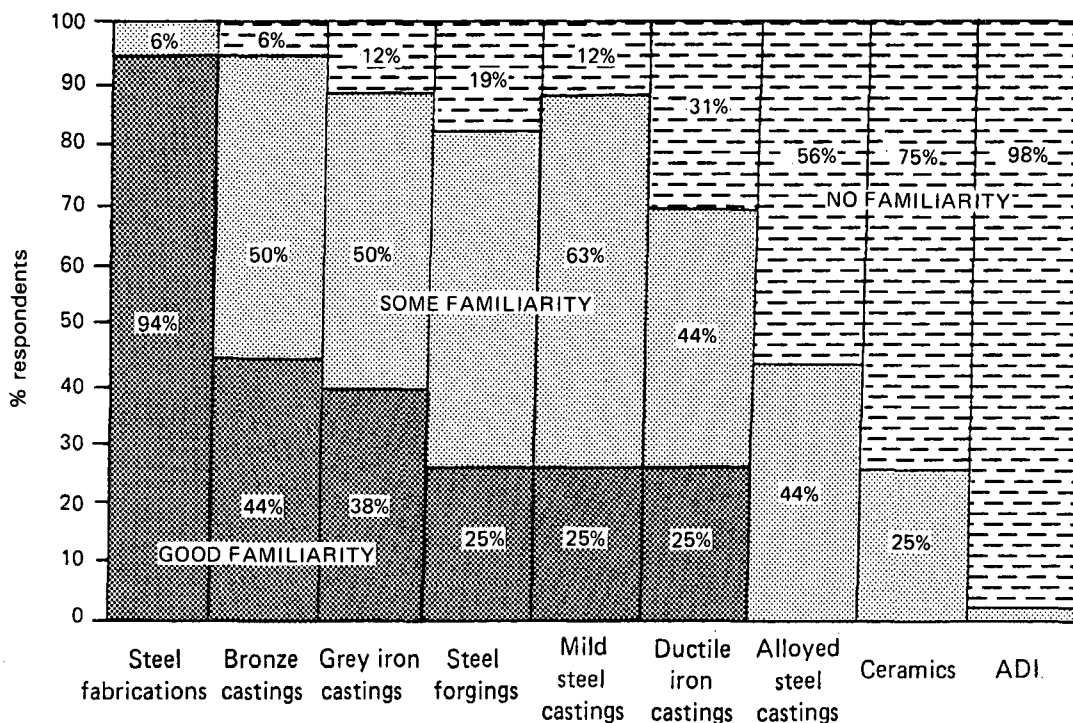


FIGURE 4

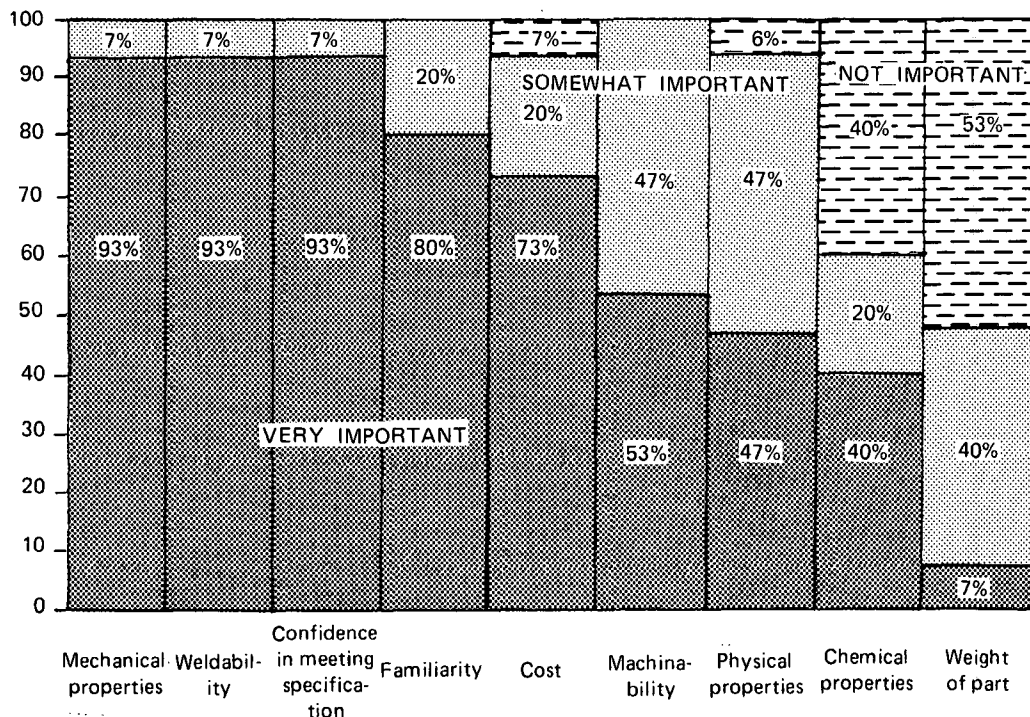


FIGURE 5

Africa: a survey conducted in the United States in all industries excluding automotive and pipe manufacture, showed a very similar response from design engineers.

Table 2

Some materials currently used in the Sugar Milling Industry

	% Steel	% Grey	% Ductile	% Spec. Unknown
Shredder Hammers	100	-	-	-
Mill Pinions	100	-	-	-
Coupling Box	80	10	10	20
Millroll Shell	-	100	-	20
Trash Plates	40	30	30	30
Scrapers	40	30	30	60
Cane Knife Palm	100	-	-	70
Grate Bars	12,5	50	37,5	62,5
Grate Shoes	-	50	50	50

**What is to be done?**

Design Engineers' Symposia will continue to be run and staff of the foundries will be encouraged to make more contact with engineers than they have done in the past. A booklet is being produced for the sugar mill engineer. The booklet will cover principles of iron casting design, specifications, physical and mechanical properties of various grades of irons which can be compared with other cast or forged ferrous materials.

**Recommendations**

- All existing specifications should be examined by a materials engineer and recommendations should be made as to their suitability for the function to be performed. Specifications should be drawn up for those components that do not have a specification.
- The industry, the groups or the individual mills should consider either in-house or externally appointed quality control inspectors who visit the foundries and ensure adherence to the specifications. Non destructive examination (NDE) techniques should be considered for application on certain castings.
- The groups or individual mills should establish "An approved suppliers list" with the assistance of a suitably qualified Engineer.
- Life cycle costing should be introduced. This is an economic assessment of competing alternatives taking into account all significant costs over the economic life of each alternative as illustrated in Figure 6.

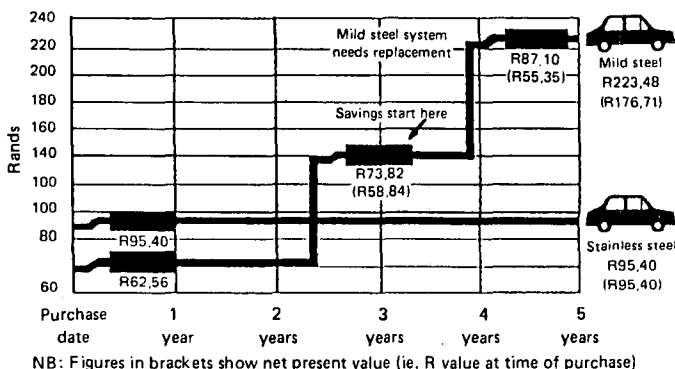


FIGURE 6

- When designing a new component or switching from one material to another for an existing component, the designer should involve the technical department of a foundry on the approved list of suppliers.

These recommendations, if followed, will result in the use of the most appropriate and cost effective material for each application. This in turn will result in savings in time and money.

#### **Acknowledgements**

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#### **REFERENCES**

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2. British Cast Iron Research Association Conference entitled, Ductile Iron – The Next 40 Years: KJ Smith and J Morrison, Tayforth Foundries Limited, *Cost effective substitution of steel components by Ductile iron.*