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Studying and Improving the Hardness Properties of Gray Cast Iron

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ABSTRACT

This research focuses on the hardness of gray cast iron. Hardness is a measure of the resistance to localized plastic deformation induced by either mechanical indentation or abrasion. The machinability cannot set a specific definition. However, several indicators and directories give a clear image, the most important of which is the factors that affect the machinability of gray cast iron according to the metallurgies and the metal cutting and cutting conditions. The main goal of this research is to improve the hardness of gray cast iron. Many experiments on several samples to get different results and then compare these results to get the best which is the goal of the research. The conclusions through the practical side of this research are the different values of hardness through the different hardening processes. As the hardening processes gave a sample of grey cast iron a hardness value that differs in each type of hardening. The notes through the graph that the hardness reaches its peak in the traditional hardening, where its value is (370.6), followed by the laser hardening process, which reaches (321.6) The amount of increase between the hardness of the laser and the traditional hardness takes the value of (15.24 %) The work on samples in the form of aggregates, and each group will be treated in a specific way and then subject to tests.

1. Introduction

Gray cast iron's mechanical properties are highly influenced by its structure. Typical chemical composition to obtain a graphitic microstructure is 2.5 to 4 % carbon and 1 to 3% silicon by weight. Graphite may occupy 6 to 10% of the volume of grey cast iron Various methods of improving surface qualities have been used to enhance the properties of gray cast iron for it to play an essential role, including surface treatment [1,2], nitriding [3, 4], coating [5, 6], and carburizing [7]. The hardness of ferritic-pearlitic gray cast iron is affected by the heating temperature. Increasing the heating temperature raises the content of pearlite, which raises the hardness. Gray cast iron's higher wear resistance is influenced by its increased hardness. Meanwhile, the heating rate has an impact on the hardness of the material. A quick heating rate will lower the price of hardness in gray cast iron if the heating temperature remains constant. [8]. Because of its exceptional casting ability, amazing wear resistance and shock absorption, cheap cost, and other good features, gray cast iron (GCI) play a vital role in a variety of industry domains. However, in harsh service circumstances, GCI's wear performance, hardness, and corrosion resistance are dramatically reduced. GCI's coarse grains and poor surface quality limit its use and service life. Surface modification technology is frequently used to increase GCI performance to overcome the drawbacks mentioned above [9, 10]. Laser surface strengthening is a technique that involves heating and melting a material's surface layer with a high-power density laser beam in a noncontact manner, followed by fast

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cooling of the material and the production of a microstructure with unique features not found in the material itself. Any standard processing approach will not be able to create it. [11] In recent years, laser surface strengthening technologies such as laser surface alloy [12,13], laser quenching [14], laser remelting [15–17], and laser cladding [18–20] have been widely used for GCI surface strengthening. The following are some of the benefits of laser cladding technology: I. a composition that is simple to adjust, II. a small heat influence zone, III. minor stress deformation, IV. a low dilution ratio, and V. improved metallurgical bonding with the substrate. As a result, laser cladding is an effective way to improve the wear resistance and corrosion resistance of many technical materials. The mechanical characteristics and wear resistance of Cu-based alloys are excellent [21,22].

2. Experimental work

2.1. The factors that affect according to metallurgies

- The additions that lead to the deposition of the graphite precisely, such as silicon and nickel, in proportions linked to the shape of the part and its geometrical dimensions, range between 2% and 2.5% for silicon, and 0.25% to 5% for nickel.
- Other additions in low proportions do not melt with cast iron, such as lead and titanium.
- Heat treatment annealing
- Softening the crystals of the base metal during modifiers
- Manipulation of the chemical structure to reduce manganese, chromium, and phosphorus [23].

2.2 The factors that affect machinability

- For constrained cutting conditions, removing as much of the chip as possible in less time is crucial.
- The better the machinability of metal, the lower the cutting forces required for cutting it and the lower the cut-off conditions compared to other metals.
- The better the machinability of metal, the lower the cutting temperature of the cut-off conditions.
- The metal's machinability improves as the cutting tool's age increases in dry cutting.
- The lower the metal's hardness, the easier it is to machine [24].

2.3. The cutting tool of Wear

Cutting tools are worn in the cutting process as a result of wear chip in the face of the cutting tool and the edges with the workpiece, according to this cutting tool wear is classified into:

- Flank wear

Work hardening is the cause. Because of abrasion and adhesion, flank wear develops where the tool hits the completed surface, increasing the cutting force. It has a huge impact on cutting mechanics.

- Crater wear

As illustrated in the figures, crater wear occurs on the tool face at a short distance from the cutting edge due to chip flow over the face at extremely high temperatures (1 and 2).

The common values of flank wear and crater wear and their relationship with cutting tool life.

Figure 1. Crater wear happens on the tool face at a short distance from cutting

Figures 2. Wear area in the cutting tool

2.4. Cutting tools are made of high-speed steel (H.S.S) and ceramic tools

The wear values, according to the international organization (ISO), determine the cutting tool edge for the cutting tool, which is made of high-speed steel and the ceramic tools are one of these values. Fracture, when the value is become (VB=0.3mm) if the flank is wearing irregularly in the (B) area. When the value (VB) has become higher (0.6mm) if the flank is wearing irregularly or as a result of friction or sliding or bad drilling in the (B) area. where: -

- VB= 0.3mm
- Higher (VB) =0.6mm if the flank is wearing irregular.
- KT=0.06+0.3f   Where (f) is the feel as shown in Figure (3)

2.5. The sample operation technique

Cutting operations, grouping activities, and grinding and polishing operations were among the practical stages. Since each group will be worked on according to the steps it includes, the following will be specified for these operations:

- *Sample turning:* This procedure involves the face and exterior mapping to provide the sample with a consistent form and accurate measurements. The shape of the feathers resembles little needles, indicating that the substance is brittle [25].
- *Cutting operations:* Cutting operations function by fracturing the material being treated. The broken section is usually in little fragments called chips. Many difficulties were faced since it had been hardened under rigorous working circumstances of high pressure and temperatures, resulting in a high hardness that caused the cutting pen on the lathe machine to erode, making it impossible to cut on the lathe machine and go to alternative methods [26].

3. Result and discussion

Table 1: Arrangement of samples

No.	No. of samples	Group name	Process on group
1	2	A	Work hardening
2	1	B	Base metal hardening
3	1	C	Traditional hardening
4	2	D	Laser hardening

Work hardening (Group A):

Grinding

Following the cutting process, the test samples for working hardness are directly transported to the grinding process, where they are smoothed in many steps:

1. Remove the outer layer by grinding with (120–220) grit grinding paper. The result of the cutting operation is a rough surface.
2. Grinding using (400) grit grinding paper, which gives us a smoother surface to prepare for the following procedure.
3. procedure Using paper for grinding (800)
4. Using grinding paper to grind (1200)
5. Using the grinding and polishing equipment at (500) r.p.m., each grinding operation takes (15–20) minutes, which corresponds to [28].

The sample is polished using a soft cloth that has been chosen for this purpose. The polishing procedure is repeated for another (10–20) minutes, or until a smooth and shiny surface is achieved for measurement and testing. Base metal hardening (Group B): Annealing, Grinding, Polishing, and Measurement.

Table 2: Viker's hardness reading for group (A)

NO.	Device load (N)	Hardness type	Viker Hardness (HV)
1	9.8	Work hardening (Group A)	288.95

Table 3: Viker's hardness reading

NO.	Device load (N)	Hardness type	Viker Hardness (HV)
1	9.8	Base metal hardening (Group B)	204.47
2	9.8	Laser hardening sample D_1	173.7

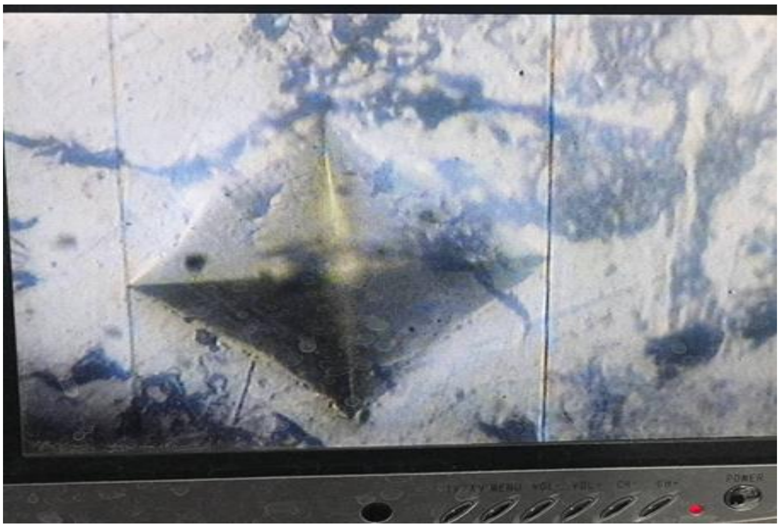

Figure 3. Viker hardness test

Traditional hardening (Group C): Annealing, Grinding, Polishing, and measurement Load 9.8 hardness traditional Viker hardness 370.6 HV Compared with [27] give good agreement. Laser hardening (Group D): In this group, many operations are done sequentially parameters for any test, four tests on two samples (two tests for any sample) the details as below:

Table 4: Details laser hardening

No.	Group name	Power (w)	Time (s)
1	D1	70 - 90	0.2
2	D2	70 - 90	0.4
3	D3	70 - 90	0.6
4	D4	70 - 90	0.8

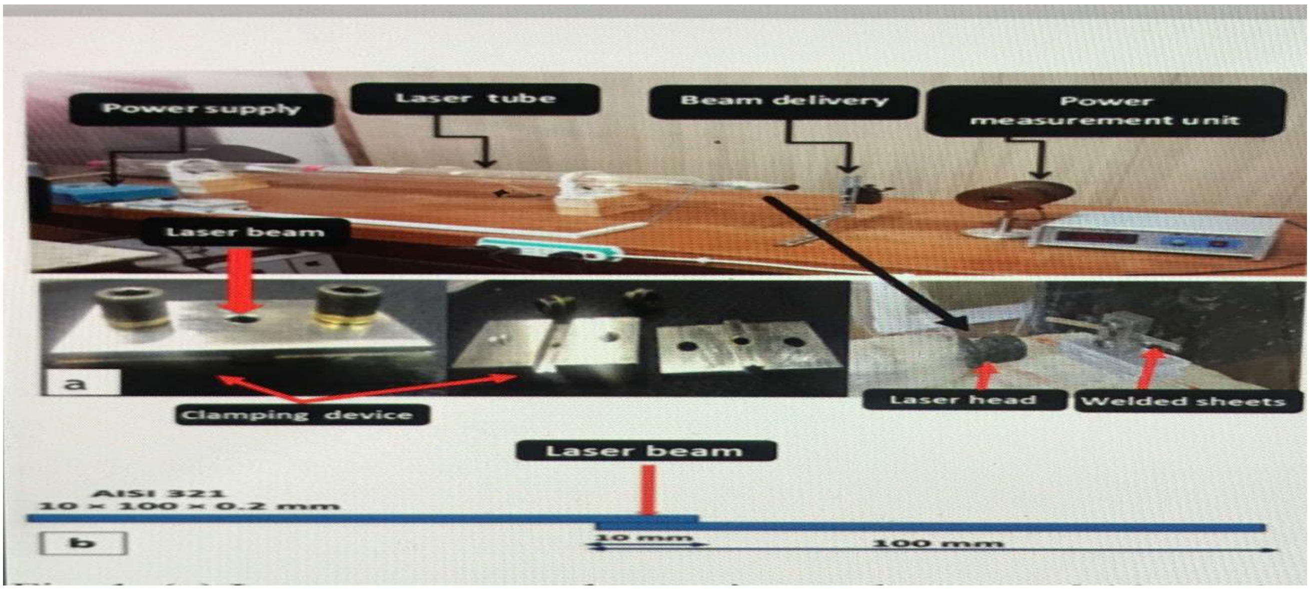

Figure 4. Laser hardening device measurements

After polishing the measuring hardness at Viker's hardness device

Table 5: Viker's hardness reading

NO.	Device load (N)	Hardness type	Viker Hardness (HV)
1	9.8	Laser hardening for D1	173.7
2	9.8	Laser hardening for D2	321.6
3	9.8	Laser hardening for D3	228.3
4	9.8	Laser hardening for D4	202.3

The relationship between the hardness of metals with machinability

As the hardness of metals is decreased, the machinability is increased; this leads to reduce the wear which is compared to the result with [28], which is occurred in the cutting tool thus the cutting tool life is increased.

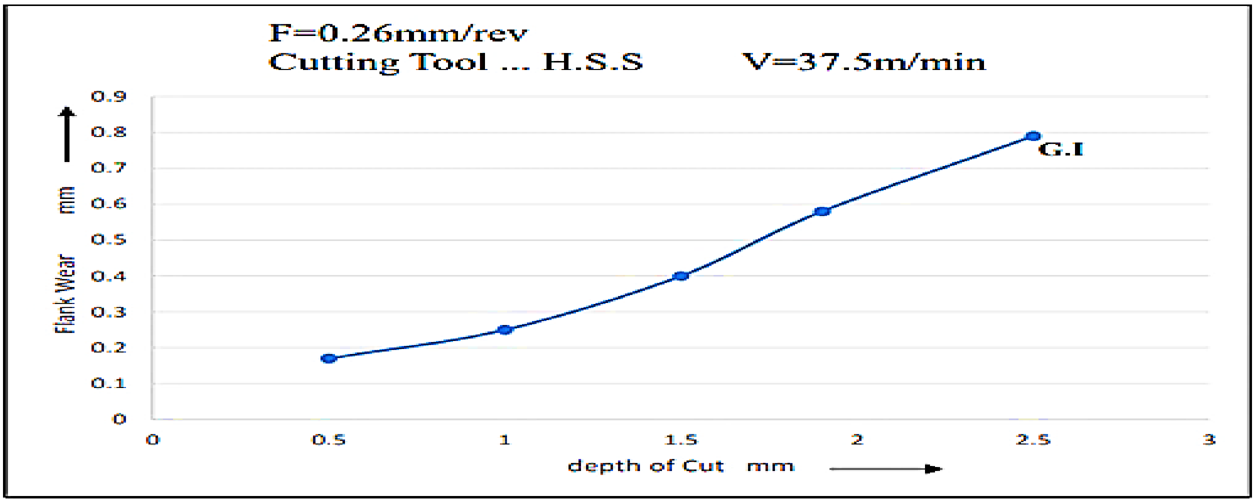

Figure 5. Effect of depth of cut on the flank wear

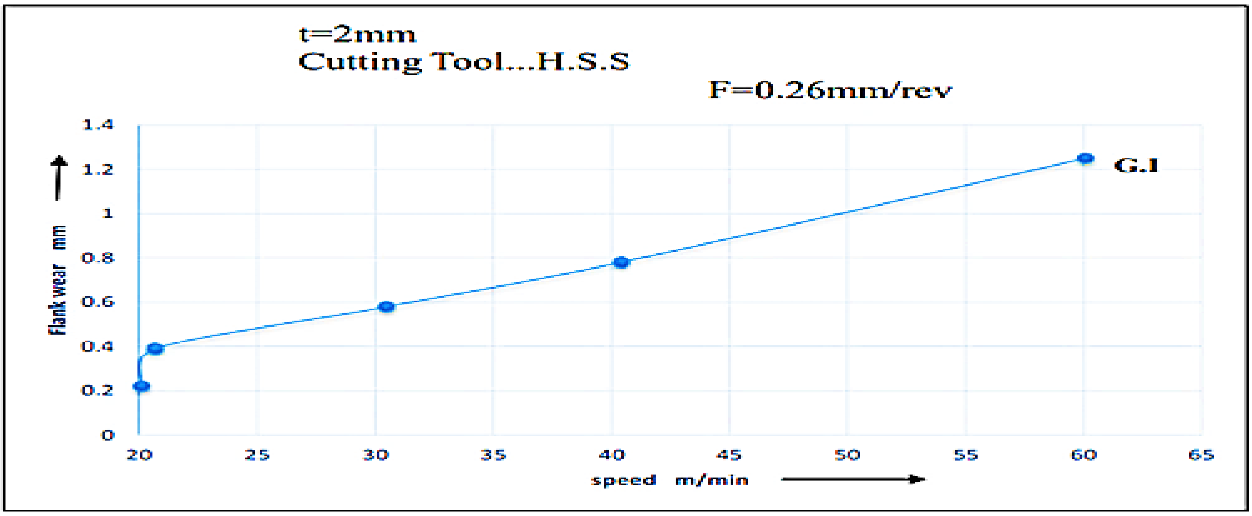

Figure 6. Effect of feed of cut on the flank wear

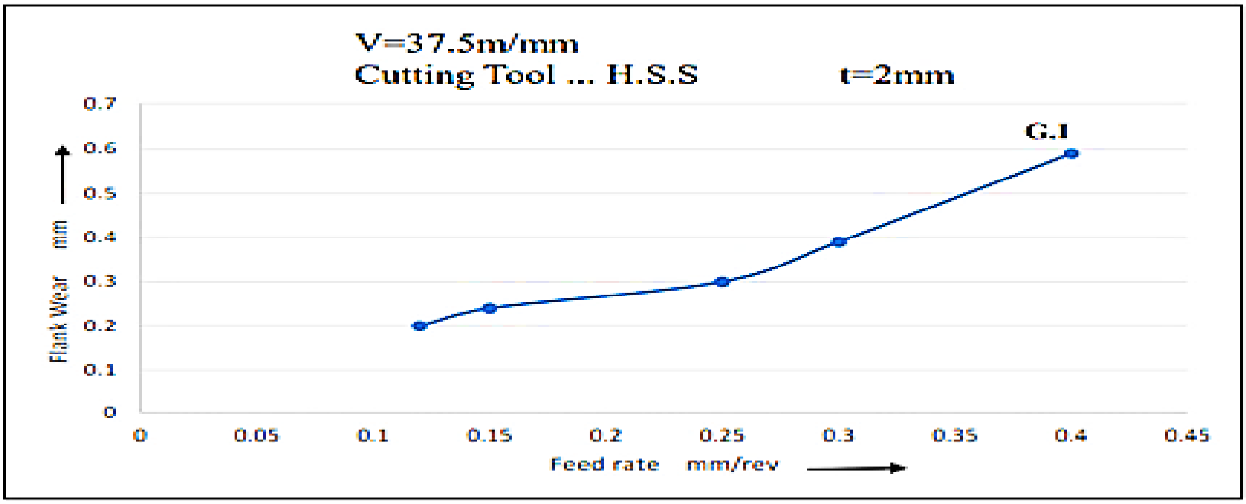

Figure 7. Effect of speed on the flank wear

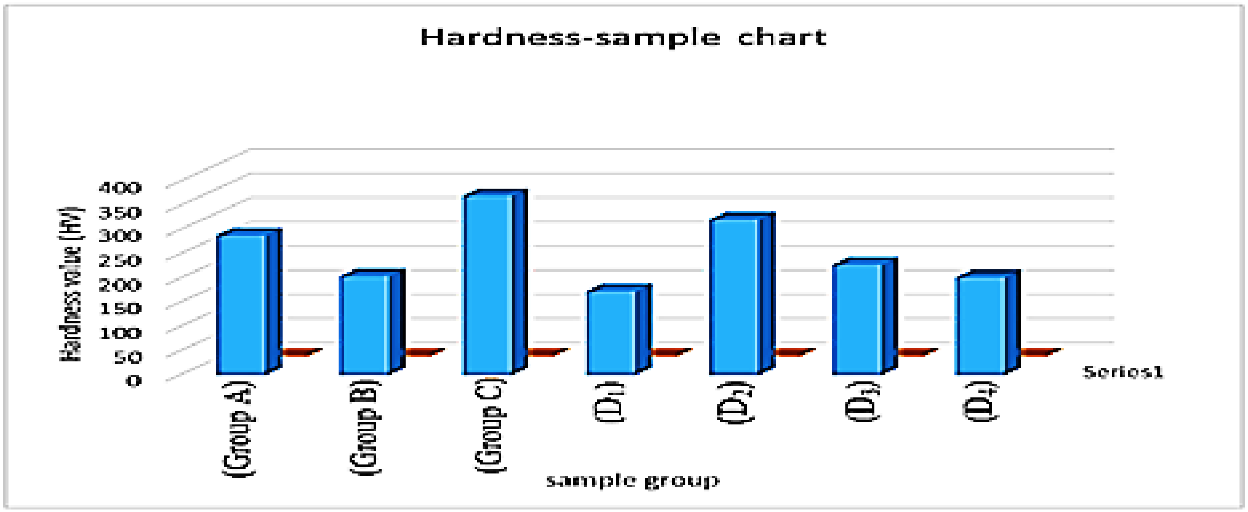

Figure 8. Hardness – samples

The varying levels of hardness obtained through various hardening methods are what they infer from the practical side of this research... Each form of hardening provided a sample of grey cast iron with a different hardness value.

4. Conclusion

1. The conventional hardening process achieves its peak with a value of 370.6, followed by the laser hardening process, with a value of 321.6 in the sample (D2), and then the remainder of the hardening types, as indicated in the graph of hardening values with their types below, which was compared to [29].
2. The difference in hardness between the laser and the standard hardness compass
3. The reason for the lack of considerable hardening in laser hardening is that the proportion of carbon in this type of mineral is minimal, resulting in low hardness.
4. The wear on the cutting tool's cutting edge can be used to measure machinability. The wear value is lower the better the machinability and reverse. As the material's hardness rises, so does cutting-edge wear, limiting machinability. As the size of the graphite chips within the crystal structure increases, the machinability improves.
5. The machinability of metals improves when their hardness decreases, which leads to less wear on the cutting tool and longer tool life.

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