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EXPERIMENTAL INVESTIGATION ON HARDNESS OF HOT AND COLD ROLLED WELDED STEEL SHEET METALS

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ABSTRACT

Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting. Hardness is a characteristic of a material, not a fundamental physical property. It is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation. More simply put, when using a fixed force (load) and a given indenter, the smaller the indentation, the harder the material.Indentation hardness value is obtained by measuring the depth or the area of the indentation using different test methods. The Rockwell hardness test method, as defined in ASTM E-18, is the most commonly used hardness test method.The Rockwell test is generally easier to perform, and more accurate than other types of hardness testing methods. The Rockwell test method is used on all metals, except in condition where the test metal structure or surface conditions would introduce too much variations; where the indentations would be too large for the application; or where the sample size or sample shape prohibits its use. The Rockwell method measures the permanent depth of indentation produced by a force/load on an indenter. First, a preliminary test force (commonly referred to as preload or minor load) is applied to a sample using a diamond or ball indenter. This preload breaks through the surface to reduce the effects of surface finish. After holding the preliminary test force for a specified dwell time, the baseline depth of indentation is measured. After the preload, an additional load, call the major load, is added to reach the total required test load. This force is held for a predetermined amount of time (dwell time) to allow for

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elastic recovery. This major load is then released, returning to the preliminary load. After holding the preliminary test force for a specified dwell time, the final depth of indentation is measured. The Rockwell hardness value is derived from the difference in the baseline and final depth measurements. This distance is converted to a hardness number. The preliminary test force is removed and the indenter is removed from the test specimen. In this method the specimens consists of hot rolled and cold rolled sheets with 2mm thickness and also these rolled sheets with TIG and Gas welding. The Rockwell hardness number is evaluated experimentally for those cases and studied. The Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload.

Keywords : Hardness, sheet metal, Rockwell hardness number

1. INTRODUCTION

Hardness is not an intrinsic material property dictated by precise definitions in terms of fundamental units of mass, length and time. A hardness property value is the result of a defined measurement procedure. Hardness of materials has probably long been assessed by resistance to scratching or cutting. An example would be material B scratches material C, but not material A. Alternatively, material A scratches material B slightly and scratches material C heavily. Relative hardness of minerals can be assessed by reference to the Moh's Scale that ranks the ability of materials to resist scratching by another material(1-3). Similar methods of relative hardness assessment are still commonly used today. An example is the file test where a file tempered to a desired hardness is rubbed on the test material surface. If the file slides without biting or marking the surface, the test material would be considered harder than the file. If the file bites or marks the surface, the test material would be considered softer than the file. The above relative hardness tests are limited in practical use and do not provide accurate numeric data or scales particularly for modern day metals and materials. The usual method to achieve a hardness value is to measure the depth or area of an indentation left by an indenter of a specific shape, with a specific force applied for a specific time. There are three principal standard test methods for expressing the relationship between hardness and the size of the impression, these being Brinell, Vickers, and Rockwell. For practical and calibration reasons, each of these methods is divided into a range of scales, defined by a combination of applied load and indenter geometry(4-6).The Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload.

Tinius Olsen has many types of hardness testers available that can rapidly and accurately determine the hardness value of a wide variety of materials including metals, plastics, large parts, small precision parts. Whether you need are bench mounted testers, large scale floor mounted testers or dedicated testers that are integrated into a production lines, it can help that within application. When choosing materials for a job, it is important to know the difference between the different types of steel available, how it is used and the advantages including by it in industrial or construction project. Following are the two different steels used under this project for the study purpose(7-8).Hot rolling is a mill process which involves rolling the steel at a high temperature (typically at a temperature over 1700° F), which is above the steel's re-crystallization temperature. When steel is above the re-crystallization temperature, it can be shaped and formed easily, and the steel can be made in much larger sizes. Hot rolled steel is typically cheaper than cold rolled steel due to the fact that it is often manufactured without any delays in the process, and therefore the reheating of the steel is not required (as it is with cold rolled). When the steel cools off it will shrink slightly thus giving less control on the size and shape of the finished product when compared to cold rolled.Hot rolled products will have a scaly grey finish and more rounded and less precise corners than cold rolled steel. This makes hot rolled steel more ideal for applications where extremely precise dimensions are not necessary, and neither is the appearance. Sometimes the scaly finish is preferred for the end product in machining or metalworking

Cold rolled steel is essentially hot rolled steel that has further processing. The steel is processed further in cold reduction mills, where the material is cooled (at room temperature) followed by annealing. This process will produce steel with closer dimensional tolerances and a wider range of surface finishes, concentricity, and straightness. The term cold rolled is mistakenly used on all products, when actually the product name refers to the rolling of flat rolled sheet and coil products(9-10). When referring to bar products, the term used is "cold finishing", which usually consists of cold drawing and/or turning, grinding and polishing.Cold finished bars are typically harder to work with than hot rolled due to the increased carbon content. However, this cannot be said about cold rolled sheet and hot rolled sheet. With these two products, the cold rolled product has low carbon content and it is typically annealed, making it softer than hot rolled sheet. Cold rolled steel end products will have shiny, oily surface finish and has a much smoother appearance along with square corners, and also more accurate in dimension and finish.

2. METHODOLOGY

In this research paper the following four sheet metal specimens of 2mm thickness are considered.The Rockwell hardness test is performed and evaluated hardness characteristics

1. Hot Rolled Steel Sheet as show in Fig.1
2. Cold Rolled Steel Sheet as show in Fig.2
3. TIG Welded steel Sheet (Hot & Cold Rolled together) as shown in Fig.3
4. Gas Welded steel Sheet (Hot & Cold Rolled together) as shown in Fig.4

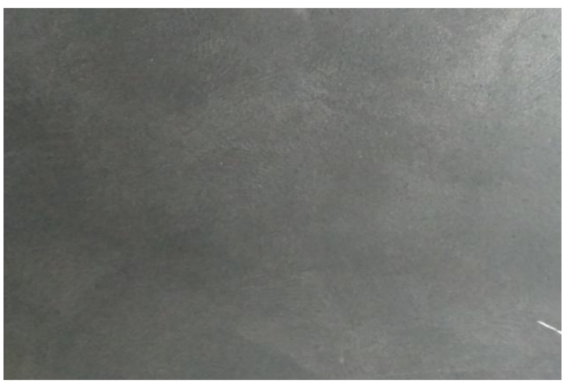

Fig.1 Hot Rolled steel sheet

Fig.2 Cold rolled steel sheet

Fig.3 TIG welded steel sheet (Hot & Cold Rolled together)

Fig.4 Gas welded steel sheet (Hot & Cold Rolled together)

The dimensions of the each metallic sheet follow

Length of the sheet metal	-	210 mm
Width of the sheet metal	-	65 mm
Thickness of the sheet metal	-	2 mm

This experiment was performed on Rockwell hardness testing machine of model: RAS, of the following specifications. The Rockwell hardness testing machine as shown in Fig.5

Specifications:

Major load : 60, 100, 150 kg, Minor load :10kg , Indenter : Diamond , ball. Scales : B&C

Fig.5 Rockwell hardness tester of model: RAS

Rockwell test is developed by the Wilson instrument co U.S.A in 1920. Hardness represents the resistance of material surface to abrasion, scratching and cutting, hardness after gives clear indication of strength. In all hardness tests, a define force is mechanically applied on the piece, varies in size and shape for different tests. Common indentors are made of hardened steel and diamond. Rockwell hardness tester presents direct reading of hardness number on a dial provided with the machine, principally this machine is similar to Brinell hardness testing. It differs only in diameter and material of the indentor and the applied force. Although there are many scales having different combinations of load and size of indentor but commonly 'C' scale is used and hardness is represented as HRC. Here the indentor has a diamond cone at the tip and applied force is of 150 kgf. Soft materials are often tested in 'B' scale with a 1.6mm dia. steel indentor at 60kgf.

Performed for determination of Rockwell hardness number as follows

a. Examine hardness testing machine and insert the diamond indentor in the holder of the machine.

b. Make the specimen surface clean by removing dust, dirt, oil and grease etc.

c. Place the specimen on platform of a machine. Using the elevating screw raise the platform and bring the specimen just in contact with the ball, now apply an initial load until the small pointer shows red mark.

d. Release the operating valve to apply additional load. Immediately after the additional load applied, bring back operating valve to its position.

e. Read the position of the pointer on the 'C' scale, which gives the hardness number.

f. Repeat the same procedure for the remaining three specimens and tabulate the values.

3. RESULTS AND DISCUSSION

The Rockwell hardness test experiment is performed on various steel sheet metal blanks individually and the blanks made by TIG (both hot rolled and cold rolled) and Gas welding (both hot rolled and cold rolled).

The resultant of 4 specimens of Hot Rolled steel sheet (Fig.6(a)), Cold Rolled steel sheet (Fig.6(b)), TIG welded both hot and cold rolled steel sheet (Fig.(6c)) and Gas Welded both cold and hot rolled steel sheet (Fig.6(d)) are follows.

The Fig.6 shows all specimens are tested under rockwell testimg machine.

(a) Hot Rolled steel sheet

(b) Cold Rolled steel sheet

(c) TIG welded steel sheet (Hot Rolled & Cold Rolled)

(d) Gas welded steel sheet (Hot Rolled & Cold Rolled)

Fig.6 Rockwell hardness test results of four specimens of steel sheet metals

The observations of Rockwell hardness number on sheets as shown in Table.1

Table.1 Observations of hardness number

S.No.	Type of sheet metal	Rockwell hardness number (HRC)		
		Sample 1	Sample 2	Average
1	Hot Rolled steel sheet	67	67	67
2	Cold Rolled steel sheet	68	70	69
3	TIG welded steel sheet (Hot Rolled & Cold Rolled)	08	12	10
4	Gas welded steel sheet (Hot Rolled & Cold Rolled)	75	69	72

1. Rockwell hardness number for Hot Rolled steel sheet = 67
2. Rockwell hardness number for Cold Rolled steel sheet = 69
3. Rockwell hardness number for TIG welded steel sheet (Hot Rolled & Cold Rolled = 10
4. Rockwell hardness number for Gas welded steel sheet (Hot Rolled & Cold Rolled) = 72

The results of Rockwell Hardness Test on various steel sheet metals, individually and also made it together by TIG and Gas welding as shown in Fig.7.From the Figure for the same thickness of 2mm Hot Rolled and Cold Rolled steel sheets the Rockwell hardness number (HRC) was found out to be higher for the Cold Rolled steel sheet than that of a Hot Rolled steel sheet. From the results it is confirmed that Rockwell hardness number (HRC) is slightly varies for a Hot Rolled steel sheet to Cold Rolled steel sheet but for a Gas welded sheet (Hot Rolled & Cold Rolled) the Rockwell hardness number (HRC) is much greater than that of TIG welded steel sheet (Hot Rolled & Cold Rolled).

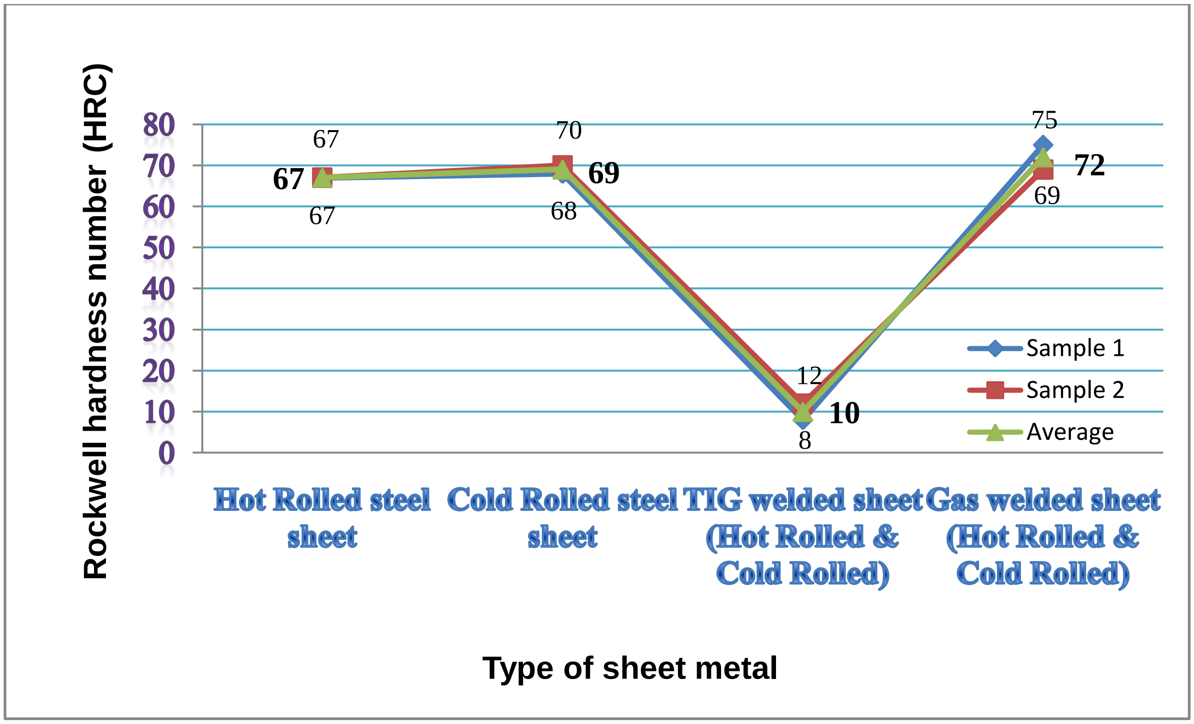

Fig.7. HRC varies with various sheet metals

On the other hand for the same 2mm thick of TIG welded steel sheet (Hot Rolled & Cold Rolled) and Gas welded steel sheet (Hot Rolled & Cold Rolled) the Rockwell hardness number (HRC) was found to be higher for the Gas welded steel sheet (Hot Rolled & Cold Rolled) than that of a TIG welded steel sheet (Hot Rolled & Cold Rolled).

4. CONCLUSIONS

When choosing a material for a job, it is important to know the difference between the different types of raw material available with required factors, how it is used and the advantages including by it in the industrial or construction project. Following are the few factors of steel that are been evaluated and concluded that

- Higher Rockwell hardness number is obtained in Cold Rolled steel sheet when compared to Hot Rolled steel sheet.
- Higher Rockwell hardness number is obtained in Gas welded sheet when compared to TIG welded steel sheet.

- Higher Rockwell hardness number in Gas welded steel sheet when compared to other three samples and therefore higher hardness can be achieved and in case of TIG welded steel sheet it is very much lesser hardness number was noted.

Hardness can also be used as an indirect measurement of sheet metal formability. Typically, the harder the material, the stronger it is and less it will stretch before failure. It has good consistency, easy to perform and ability to simulate desired forming mode is good. The based on the actual component geometry of sheet metals one can decide which formability index and forming characteristics of sheet metals should be used as a criterion for selecting and grading the sheet metal for that component.

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