STUDY AND COMPARISON OF MECHANICAL PROPERTIES BETWEEN SCRAP RECYCLED STEEL AND SHIP RECYCLED STEEL

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CERTIFICATE OF THE RESEARCH

This thesis entitled "STUDY AND COMPARISON OF MECHANICAL PROPERTIES BETWEEN SCRAP RECYCLED STEEL AND SHIP RECYCLED STEEL" submitted by M. Sadik Al-Noor (170011021), Safayet Hossen Shuvo (160011051) and Tausif Khan (170011009) has been accepted as satisfactory in partial fulfillment of the requirement for the Degree of Bachelor of Science in Mechanical Engineering.

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DECLARATION

We hereby declare that this thesis entitled "STUDY AND COMPARISON OF MECHANICAL PROPERTIES BETWEEN SCRAP RECYCLED STEEL AND SHIP RECYCLED STEEL" is an authentic report of our study carried out as a requirement for the award of degree B.Sc. (Mechanical Engineering) at Islamic University of Technology, Gazipur, Dhaka, under the supervision of Professor Dr. Shamsuddin Ahmed, MPE, IUT in the year 2022

The matter embodied in this thesis has not been submitted in part or full to any other institute for award of any degree.

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With Deepest Regards,

Authors

Abstract

Steel is the most recycled metal in the world and it is impossible to imagine life without steel. It must be recycled maintaining its proper quality and contributing to economy. Scrap recycling and ship recycling are two processes for all of the steel recycling. Which recycling process is more sustainable in terms of quality is to be found out. Quality of steel refers to its mechanical properties. So, there has to be a logical comparison between these two types of recycled steel. It will indicate which type of steel is more suitable for different applications of steel. When the data of both recycled is available, it is easy to determine the suitable steel to meet the desired properties (i.e. yield strength, torsional strength) of steel. However, these data must be reliable based on proper sample, precious scientific experiment and obviously outright comparison between scrap recycled steel and ship recycled steel. It is very significant to execute the experiments with accuracy and precision as it has large scale practical implication. Moreover, different operations must be conducted very carefully in order to manufacture appropriate specimen from the collected sample of steel from the industries. In this paper, our sample size is not so much large. As a result, it is recommended to collect large number of samples from different industries in case of further study on this field. Only ensuring the quality is not enough, economic viability also must be checked. In this paper, economic feasibility for recommended steel is also considered. Some field of steel application one particular mechanical property (i.e., yield strength) is desired to be maximum and if we know which types of recycled steel possess that particular mechanical property better and use it on that field, desired quality will be fulfilled. The paper is based on more experimental and recommending mass practical application.

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CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

This study will suggest to the recycled steel with better mechanical properties with mass production. It will also find out the mechanical properties and micro-structure of two different recycled steels. This will play a significant role in production of commercial mild steel for better construction. One noteworthy item to note is that the shipping industry is well ahead of other industries, such as the automotive and aviation industries, in terms of recycling 85-98 percent of a ship's weight[1]. So, there is not only discussion about ship recycling but also about scrap recycling and of course there is comparison between product of these two.

1.2 PROBLEM STATEMENT

i) To put this research into context, in 2019, Bangladesh having a share of 8% of the total ship breaking in the world meeting 60% steel consumption on its own but dismantling only 55% of ships[2]. So, it is an indication that there is not enough ship recycling.

ii) In 2018, the country's per capita steel consumption was 45 kg, up to 25 kg from 2012 and forecast to reach 73 kg by 2012 resulting in steel scrap imports growing from 2.5 million metric tons in 2016 to 4-4.5 million metric ton in 2018[3]. A large demand of steel is knocking at the door.

iii) More than 4 million metric tons of steel was produced in 2016 representing a market value of 3.57 billion, which is estimated to be doubled by 2022[3]. Although, there is not enough evidence about which recycled steel has better quality, neither there is much research on comparison between scrap and ship recycled steel. This should be found out.

1.3 OBJECTIVE OF THE STUDY

There are several objectives behind this project, those are briefly discussed below

i) Comparison of the mechanical properties between scrap recycled and ship recycled steel.

ii) Finding out more suitable recycled steel through experiments, determining the qualified mild steel according to microstructure and to obtain practical evidence on behalf of the more sustainable recycled steel.

iii) To determine the qualified mild steel according to microstructure.

This project focuses on mechanical properties between scrap recycled steel and ship recycled steel. This will allow the comparative analysis of mechanical properties (torsion, tensile strength, elongation, hardness, toughness) and microstructure between scrap recycled steel and ship recycled steel.

1.4 SCOPE AND LIMITATIONS OF THE STUDY

It is proposed that additional research be undertaken. Those are given below: All samples having same sizes can be experimented. Microstructural analysis can be done also through laser induced breakdown spectroscopy (LIBS). The amount of Alloying elements like Cr, Cu, Ni, Mn, Mb, P, S, Si can be increased for increasing mechanical properties.

There are some limitations for this study: insight shipyard visiting wasn't conducted, information provided about steel and ship industries may differ slightly although ignorable.

1.5 METHODOLOGY OF THE STUDY

Discussing our methodology in short: The previous works regarding our topic are reviewed. It was decided to visit product manufacturing area to collect samples for further experimentations. The first attempt was unsuccessful when the data was revealed, it was found that the data was not perfect for further evaluation, so insight visiting and samples collection started again, and this time relevant data was captured. Comparison between data of types of recycled steel was conducted, and through experiments it becomes evident that the better one according to mechanical properties for practical applications is determined.

1.6 CONTRIBUTION OF THE STUDY

This study has a significant contribution. It's been showed that better quality micro-structure can be achieved using more accurate etching agent. As there are more chances of ship dismantling we recommended to use broken ships for recycled steel production. We can use scrap recycled steel where properties of hardness and torsion are applied.

1.7 ARRANGEMENT OF THE THESIS

Firstly, the introduction takes place representing the objectives, problems, methodology and background in very brief. Then the previous works regarding the relevant field is discussed elaborately. After that the experiments were conducted on the specimens prepared from collected sample. The experimental results were analyzed in chapter 4. Also there was comparison conducted in the same chapter. Finally, in chapter five, it was observed if the study met the objectives and what the future recommendations.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Scrap metal recycling is the process of recovering and processing recyclable metal materials from end-of-life products and structures so that they can be used as raw materials in the manufacturing of new items. There are two categories of scrap metal: ferrous and non-ferrous.

Ship recycling is a method of ship disposal that involves dismantling ships for the purpose of extracting raw materials, often scrap, or for obtaining parts that can be sold for re-use. We have ships of which 85% are recyclable[4]

This chapter discusses the current state of scrap metal recycling and ship metal recycling, as well as its applications in Bangladesh's steel sector.

2.2 SCRAP METAL RECYCLING

There are 2 types of scrap metals which are recycled in our country. One is ferrous scrap metal and another is nonferrous scrap metal.

2.2.1 Ferrous Scrap Metal

The bulk of an ocean-going vessel is composed of steel (most of which may be recycled), with hazardous elements accounting for the remaining 5%[5]. The term "ferrous" refers to both iron and steel and is derived from the Latin word for iron. Iron is the second most frequent metal found in the Earth's crust. The Earth's magnetic field is created by its intrinsic magnetism. Metal scrap yards sometimes employ enormous electromagnets installed on excavators to load and unload ferrous scrap from trucks and move it about the yard because nearly all ferrous metals are magnetic. In the United States, the most common sources of scrap ferrous metals are durable goods like appliances, tires, and furniture. According to the Environmental Protection Agency, these durable items accounted for 27.8% of all recycled ferrous metals in 2018, or 4.7 million tons[6].

2.2.2 Non-Ferrous Scrap Metals

They do not lose their chemical qualities after recycling and can be recycled indefinitely. Non-ferrous metals come in a variety of forms, but the most common basic metals are Al, Cu, Ni, Pb, Sn, and Zn. Nonferrous metals include precious metals such as gold and silver. Each one does have a diverse set of applications. Though nonferrous scrap accounts for just 10 percent of total of all resources are recyclable in the U.S, it accounts for 50% of the revenue generated by the scrap recycling sector. In 2018, the United States alone nonferrous scrap metal worth $10.4 Bn was shipped to over countries across five continents. Non-ferrous scrap is usually more valuable to recyclers because it is purchased on a per-pound basis. Nonferrous metal prices, on the other hand, are more volatile than ferrous metal prices.

2.3 SHIP METAL RECYCLING

Ship recycling is the process of completely or partially disassembling a ship at a shipbreaking yard in order to salvage components and materials for reprocessing and reuse[7]. Shipbreaking is viewed as a successful commercial activity in ship recycling, and it is a major supply of raw materials for Bangladesh's scrap iron and steel industries. Because ship recycling is the final step in a vessel's life cycle, several key commercial and engineering processes must be completed ahead of time to make deconstruction and recycling easier. Knowing and implementing ship - breaking procedures, and also considering ship recycling like a new industrial commercial enterprise, necessitates an in-depth knowledge of the thesis background operations. Bangladesh now has 149 licensed shipyards, some of which might hold 3 - 4 ships at once. The acceleration of this rise has unquestionably increased world capability. At the moment, 44 yds. have obtained ISO 30000:2009 accreditation, with another Thirteen yards in the progress. 13 yards have been certified to ISO 9000-2008, ISO-14001, & OHSAS 18000, with more on the way. Annual ship demand for recycling ins about 670[8]. In Bangladesh, the shipbreaking business employs around 22,000 people directly, with another 200,000 engaged indirectly via related activities[4]. Southeast Asia, particularly Bangladesh, Pakistan, and India, is now the international hub for shipbreaking & recycling. These 3 countries contribute approximately 70% - 80% of the international market for sea shipbreaking, of China & Turkey accounting for the largest of the remainder. Outside of these five countries, only roughly 5% of the overall volume of such vessels is demolished[9].

These findings suggest that both ship structure and equipment should be modified to reduce pollution. More significantly, a high level of engagement is required to implement effective recycling programs in compliance with international standards. This problem is particularly relevant because recycling ships have long been used in impoverished nations. As a result, the findings of the study encourage environmental experts, regulatory authorities, and ship-owners to concentrate on the most serious risks associated with ship recycling. As a result, the environmental impact of ship recycling may be decreased, and it will no longer be harmful to the marine environment or human health[10].

2.4 COMPOSITION OF SCRAP AND SHIP METALS

In the composition of scrap metals, we found on average these substances:

Carbon – 0.324%
Silicon – 0.29%
Manganese – 0.876%
Chromium – 0.131
Sulphur – 0.046%
Phosphorus – 0.0411%

It is clear That this is not a high carbon steel as it has carbon content of 0.324% which is less than 0.55%. The basis of materials science involves studying the structure of materials, and relating them to their properties (mechanical, electrical etc.). Once a materials scientist knows about this structure-property correlation, they can then go on to study the relative performance of a material in a given application. The major determinants of the structure of a material and thus of its properties are its constituent chemical elements and the way in which it has been processed into its final form.2.5 Applications of scrap and ship metal.

In this section We are going to discuss the practical and commercial application of both ship recycled steel and scrap recycled steel.

2.5.1 Scrap Metal

In the construction business, scrap iron and aluminum metals are widely employed in projects such as roads and bridges. It can be utilized in the transportation industry to make automobiles, planes, and other forms of transportation. Another more recent application is in the treatment of industrial effluent.

Home renovations are a source of scrap metal. Metals of many sorts are utilized in renovations. Copper is used in heating and cooling elements, pipelines, wires, and central air conditioning, for example. Sinks and other household fixtures can be made of brass or stainless steel. Even a weekend warrior can utilize a significant amount of metal in a modest renovation project[11].

2.5.2 Ship Metal

Shipbreaking has developed a reputation for being a successful sector in developing countries, which is now well established.

On the other hand, the sector has been widely documented to pose a variety of ecological and health hazards. Scrapped ships weigh from 5k to 40k tons unloaded (the mean is 13k+ tons), are 95 % confidence steel, and are painted in between 10 - 100 tons of Pb, cd, as, Zn, and Cr. Other harmful pollutants carried by ships include PCB-containing sealants, up to 7.5 tons of different kinds of silica, and thousands liters of petroleum (bilge oil, hydraulic and lubricants oils, bilge oil, grease and engine oil).

Tankers can also carry up to 1k cc meters of leftover oil. The Basel Convention has classified the majority of these products as hazardous waste. However, through personal experience and on-the-ground evidence, a completely different story emerges from the Chittagong ship-breaking yards in Bangladesh[12].

2.6 SUMMERY

Scrap recycling and ship recycling are the two methods of recycling of the steel in the steel industry in our country. By exploring theirs' applications and uses in the perspective of our country it is clear that ship breaking recycling is the perfect one for recycling according to us researches and knowledge and it is the better one indeed. On the contrary, there isn't enough work regarding the comparison between ship recycled steel and scrap recycled steel. So, it is an open field to do research.

CHAPTER 3: EXPERIMENTAL DESIGN

3.1 INTRODUCTION

Insight industry visit is included with sample collection. It is not one-time process. If we find appropriate result from the collected sample, we must repeat this process. There was complete observation from scrap/ship material ingot to commercial product. There was roller process to make the desirable shape of the rods. The final roller contains groove for making ribs on the rods.

3.2 INSIGHT OBSERVATION

Scrap recycled industry: In terms of describing the process, first we find the scraps were brought to a crucible. Electromagnetic wave was used for generating high temperature to melt the steel scrap. Then it was poured into the molts. The molts were prepared from burned clay. However, this process is to confirm the desired composition. Cooling process was fast cooling in still air. Ship recycled industry: there were thick plates of broken ships spare parts. First, they were cut into narrower pieces by width. Then they were put into gas run furnace, after that they were put into rolling dies. There were 5 dies, final one has the groove for ribs. Cooling was same as scrap recycle steel.

3.3 TURNING

Turning is a metal removing process from cylindrical object using appropriate cutting.[13] We performed turning operation to prepare the torsion specimen. We used this operation in order to prepare the torsion specimen. Useful length of the specimen requires this operation to manufacture a smooth cylindrical shape and it is shown in Fig 3.1.

Fig 3.1: Torsion specimens

3.4 MILLING

Milling is a machine-operated operation in which the cutters revolve to remove material from the work piece in the direction of the angle with the tool axis[14]. This operation is required to manufacture the specimen for Charpy impact test in Izod test as these specimens have rectangular plane surfaces. It also helped to cut the notch of the specimen.

3.5 YIELD STRENGTH

Yield strength is a measure of the highest amount of stress that may be created in a material without inducing plastic deformation[15]. Yield strength is one of the most important properties of steel for our study. It is considered as one of the significant characteristics for steel in commercial and practical field.

3.6 TENSILE STRENGTH

Maximum load one object can withstand before fracture is reputed as tensile load[16]. We can find the tensile strength dividing the load by its cross sectional area. This also an important phenomenon for steel. Before getting fractured the specimen get longer and cross sectional area of the fractured point gets decreased and it is clearly seen in Fig 3.2(A1,A2,B,C1 and C2 from left to right). This situation is called necking which is called necking.

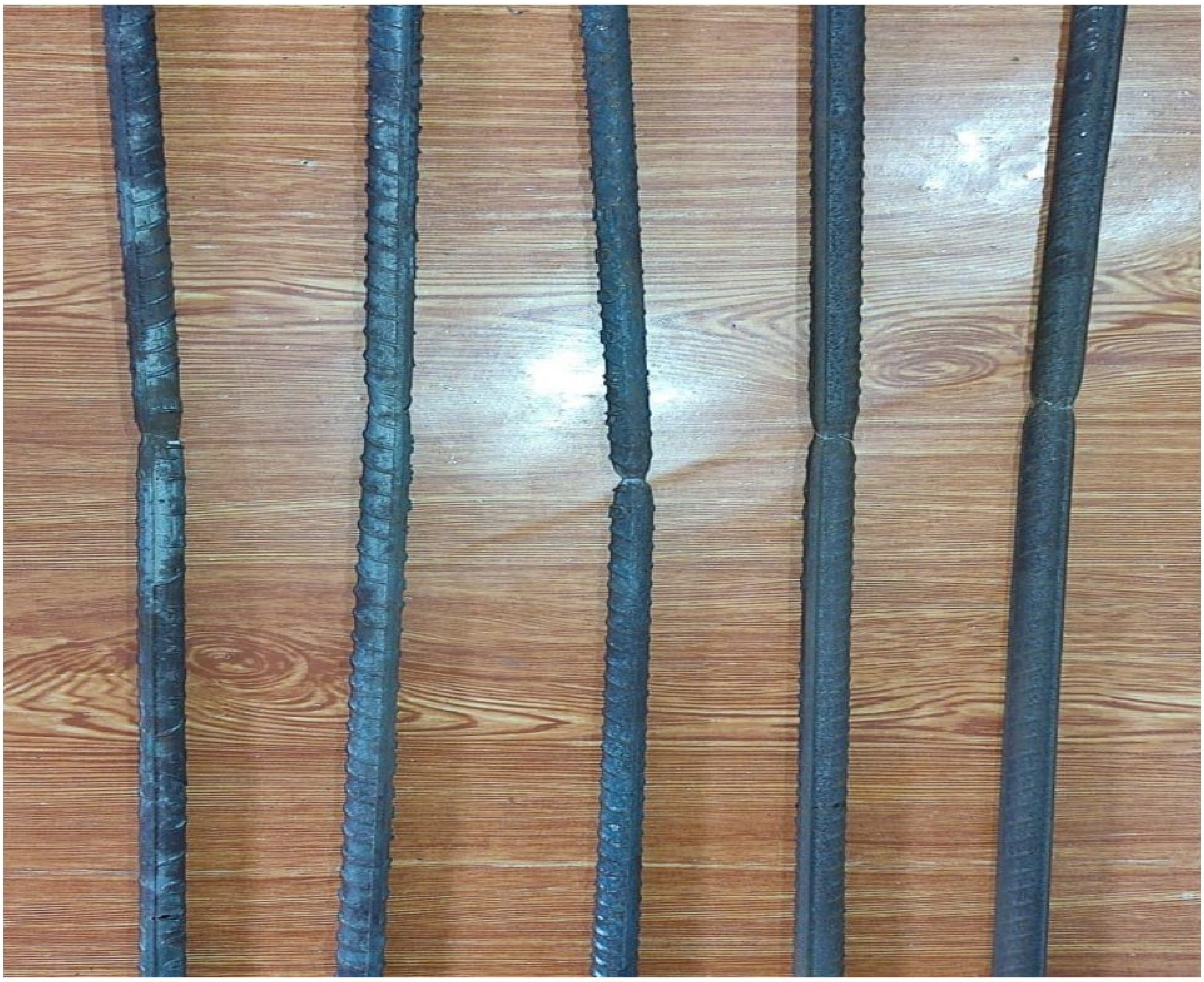

Fig 3.2: Necking before fracture

3.7 ELONGATION

It is the percentage of extra increased length to the original length[17]. It shows how ductile the steel is. Steel's ductility refers to its ability to stretch without becoming brittle or weaker in the process. Steel's ductility refers to its ability to stretch without becoming brittle or weaker in the process. Steel elongation of 0.5 percent strain is generally considered acceptable. Yield strength is defined as the elastic strain corresponding to 0.2 percent permanent strain.

3.8 HARDNESS

Hardness is resistance to indentation, abrasion, scratch, penetration on the surface of the material[18]. We tested Rockwell hardness test in this study. There are two types of indenter for hardness test. One is ball indenter and the other is diamond indenter. We used ball indenter in the experiments.

3.9 TOUGHNESS

Toughness refers to how much energy a substance can take per unit volume before rupturing.[19]. This is one of the important properties of steel. There are two types of test to determine toughness. Charpy Impact test and Izod test are those tests. We conducted both tests for the interest of our thesis.

3.10 TORSION

The capacity of a material to endure a twisting load is measured[20]. The torsion specimens on which the experiments were conducted are shown in fig. 3.1. To prepare the hexagonal cross sectional edges we used milling operations. One famous application of this property is torsion bar in automobile vehicle.

3.11 METHODOLOGY

In This section, the frame work of our complete project is discoursed. Project selection is first step. It must be kept it in the mind that there must be enough field and data available for observations and experiments. Previous works in similar field also need to be traced. Insight industry visits is enormous helpful to conduct this types of experimental thesis.

In case of toughness test experiment, proper shaped sample was not available to manufacture appropriate specimens. So, the insight workplace visiting and sample collection process was repeated. After gathering the data generated from the experiments, the main part of the study was conducted.

The process followed in this study is displayed in Fig 3.3 on the next page:

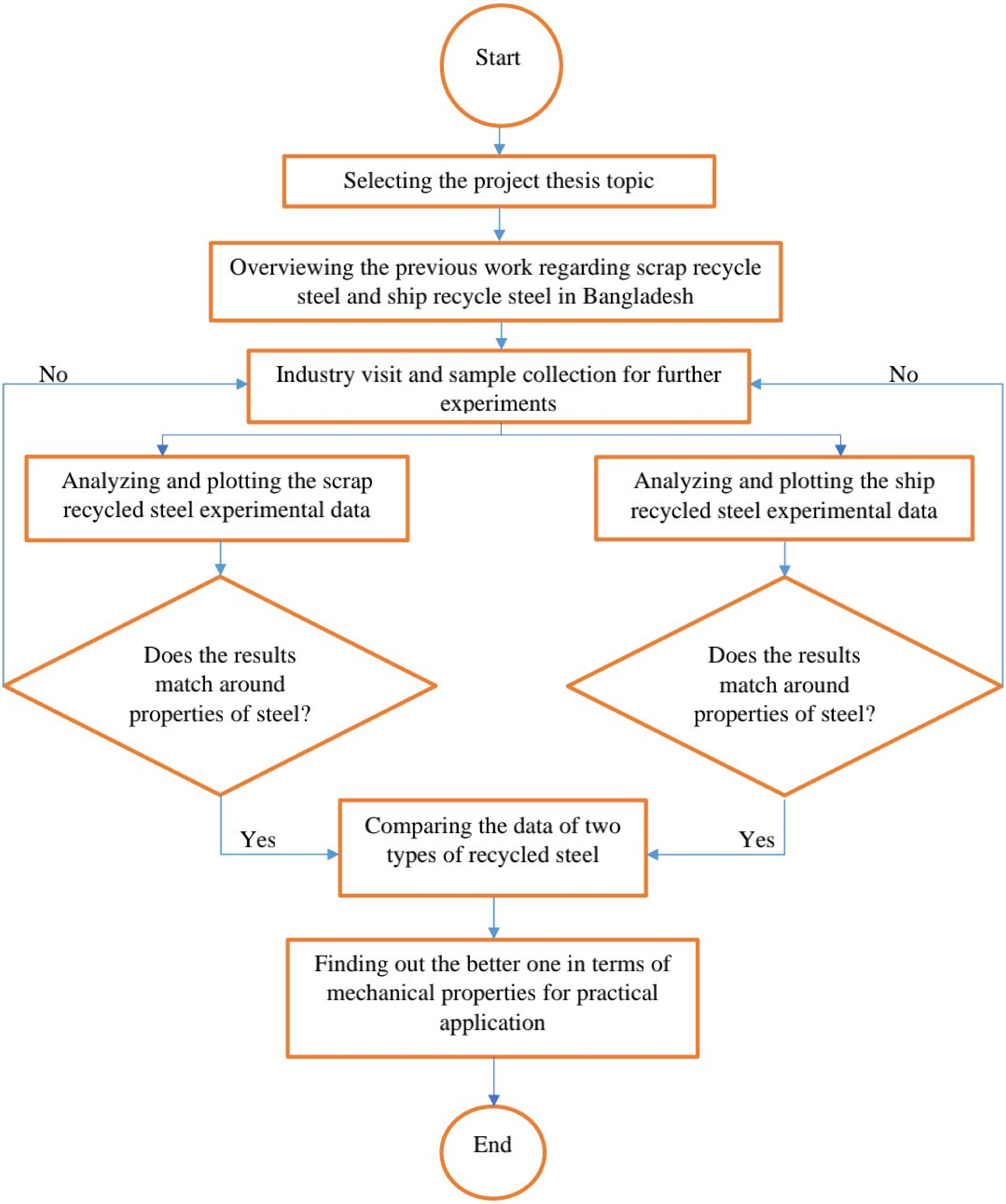

Figure 3.3: Methodology flow chart

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

The main resolution of this study is not only to investigate the mechanical properties of the scrap recycled steel and ship recycled steel but also to compare between them and find the best suitable one. The index properties tests of the two sorts of steels were performed to know the better one in respect of different mechanical properties like yield strength, tensile strength, elongation, torsional strength, hardness, toughness, microstructure analysis.

4.2 IDENTIFICATION OF STEEL SAMPLE

For the identification of the steel sample there are 2 types of steel which were brought. One is scrap recycled steel and another is ship recycled steel.

In the industry we collected 3 types steel A steel, B steel and C steel where A and B steels are scrap recycled steels and C steel is ship recycled steel. These steels were collected from various steel production industries from Gazipur and Chittagong.

4.3 YIELD STRENGTH AND TENSILE STRENGTH TEST

Three steels were taken from the industry as samples which were denoted as A steel, B steel and C steel. Here A and B steels are scrap recycled steels and C steel is ship recycled steel.

Here A1,A2,B,C1 and C2 shown in Fig 4.1 are scrap recycled steel and ship recycled steel where A1,A2,B are scrap recycled steels and C1 and C2 are ship recycled steels.

Fig 4.1: Tensile specimen sample

A1,A2,B,C1 and C2 from left to right

From these figures (Fig 3.2 and Fig 4.2) it is easily seen that B steel has larger necking. A and C steels have almost same necking which indicates that B steel has lower yield strength and tensile strength. It is also evident from Table 4.1 where sample length, gauge length, diameter of the sample, gauge length after test are available. So, ship recycled steel has better yield strength and also tensile strength. C steels have better ultimate strength which indicates ship recycled steel has better ultimate strength.

Table 4.1: Parameters and properties of sample steel

Sample Steel	**Sampe Length (*mm*)**	**Gauge Length (*mm*)**	**Sample Diameter (*mm*)**	**Weight (*kg*)**	**Yield Strengh (*MPa*)**	**Ultimate Strength (*Mpa*)**	**Load (*kN*)**	**GL after Test (*mm*)**	**% of Elongation**
A steel 1	618	364	10.07	0.3865	450	640.82	50.99	425	16.76
A steel 2	612	358	10.05	0.3812	447	636.31	50.46	410	14.53
B steel	717	463	9.65	0.4123	316	448.08	32.8	558	20.52
C steel 1	614	360	10.52	0.4189	530.06	714.35	62.1	420	16.67
C steel 1	623	369	10.44	0.4191	538.51	713.02	61.09	422	15.18

From Fig 4.2 it is showing the experimental result of A steel 1 on Universal Testing Machine.

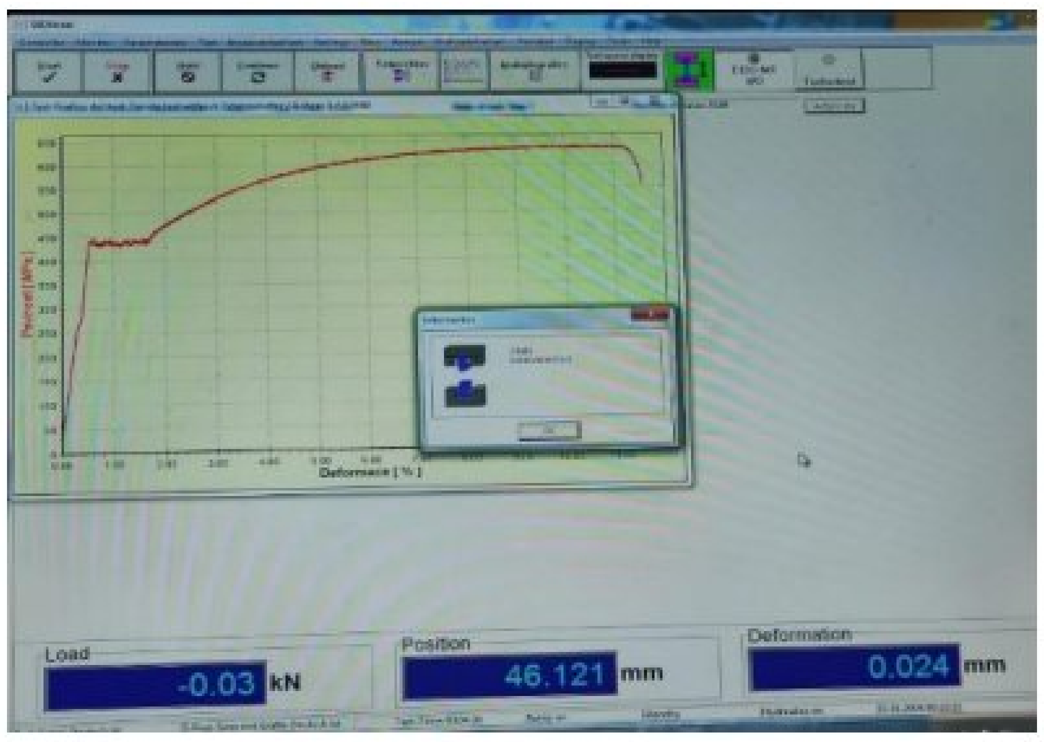

Fig 4.2: Tensile Test of A steel 1

Fig 4.3 is the zoomed part of the stress vs strain curve graph of Fig 4.2. Its deformation is almost 10.6%.

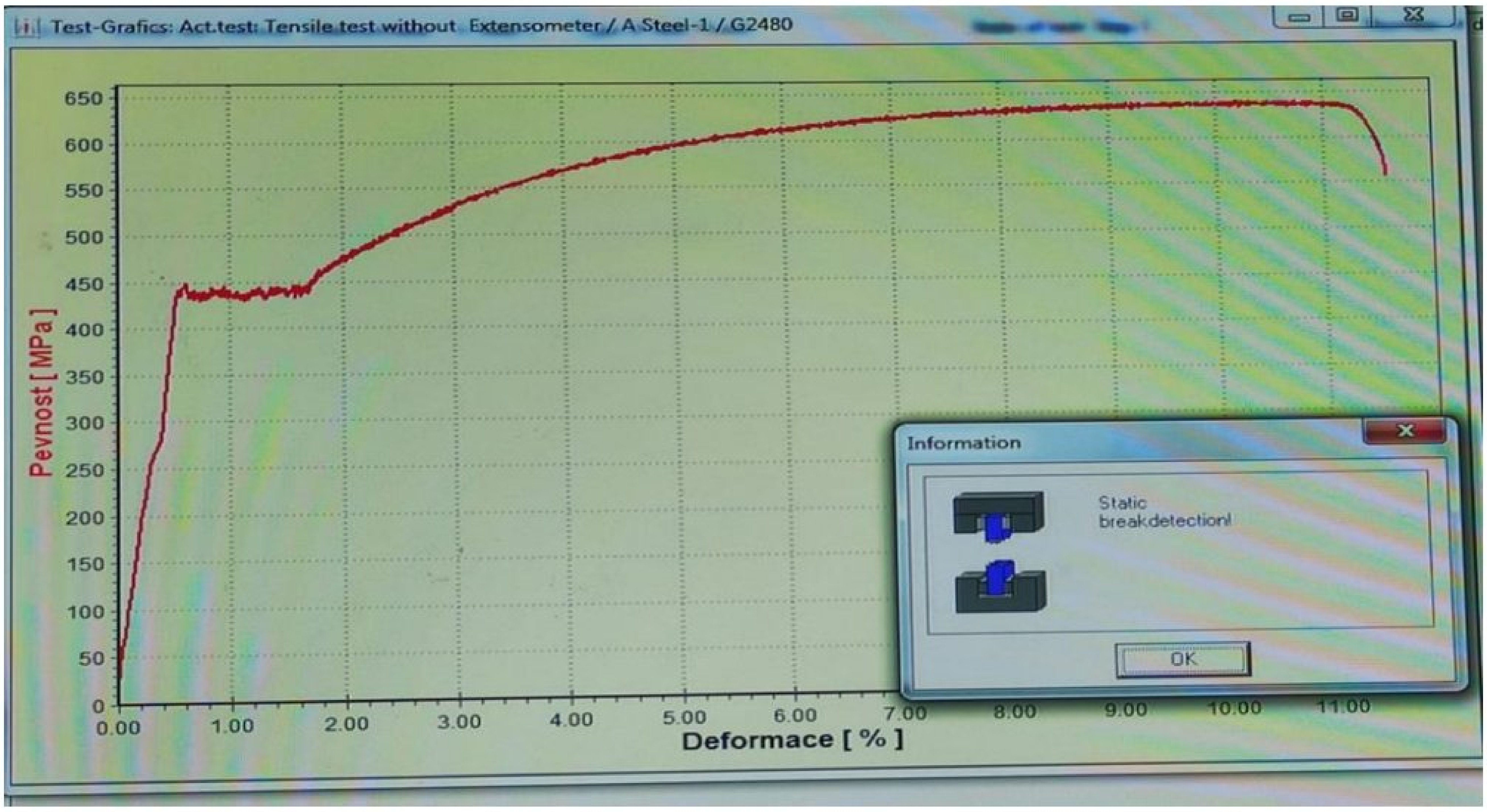

Fig 4.3: Stress vs strain graph of A steel 1

From Fig 4.4 the experimental result of A steel 2 on Universal Testing Machine is displayed.

Fig 4.4: Tensile Test of A steel 2

Just like the previous one, this one has also a zoomed portion in Fig 4.5. Its results are almost similar to A steel 1 which is expected because both are collected frome same workplace.

Fig 4.5: Stress vs strain graph of A steel 2

B steel is collected from another industry. So, the result may differ in large scale and it is visible in Fig 4.6. Its deformation is just below 16%.

Fig 4.6: Tensile Test of B steel

Fig 4.7 helps to read the data easier rather than Fig 4.6.

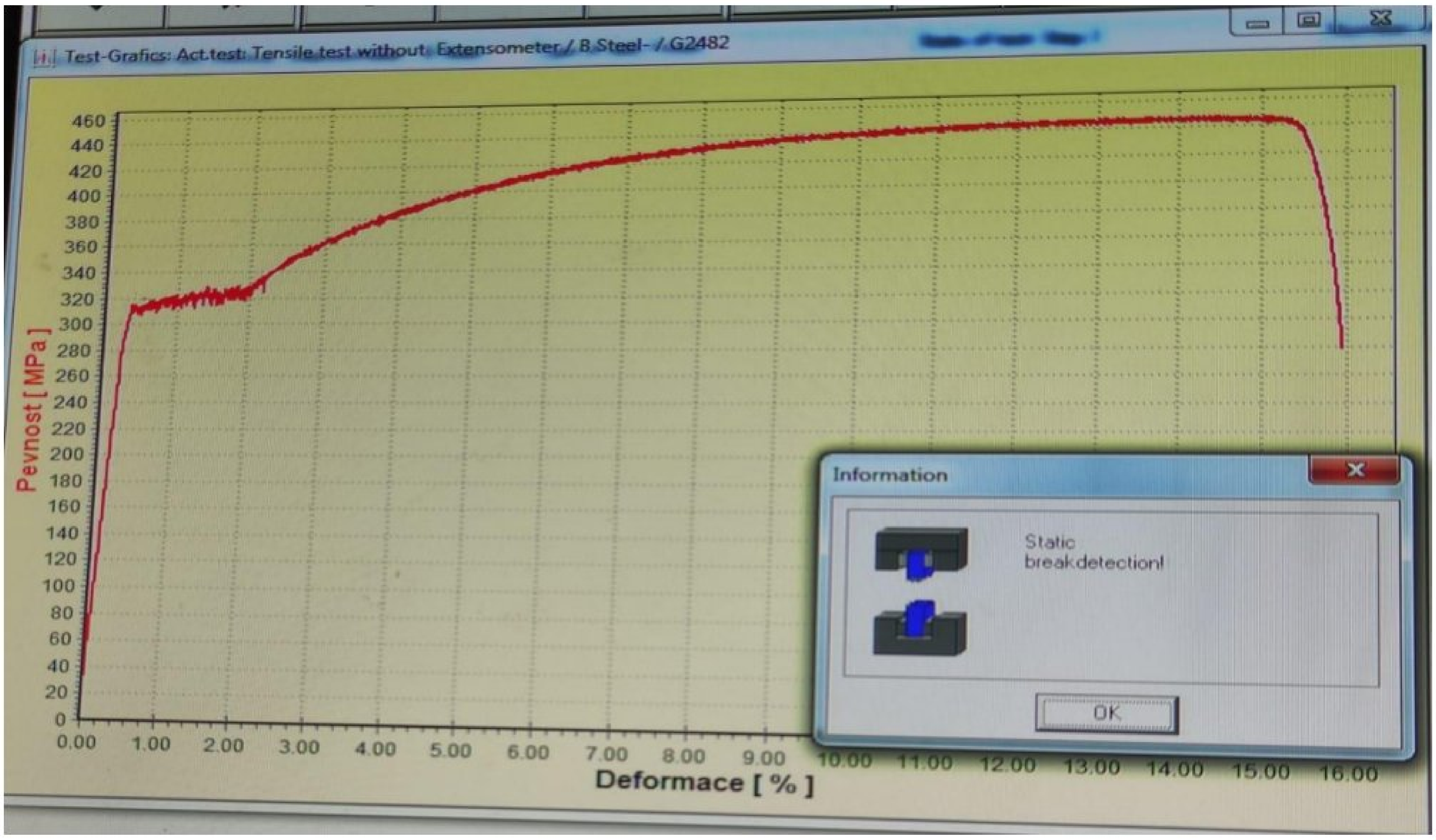

Fig 4.7: Stress vs strain graph of B steel

Fig 4.8 represents tensile test graph of ship recycled steel C steel 1. In the zoom graph of stress vs strain curve in Fig 4.9 we can see the deformation is almost 11.2%.

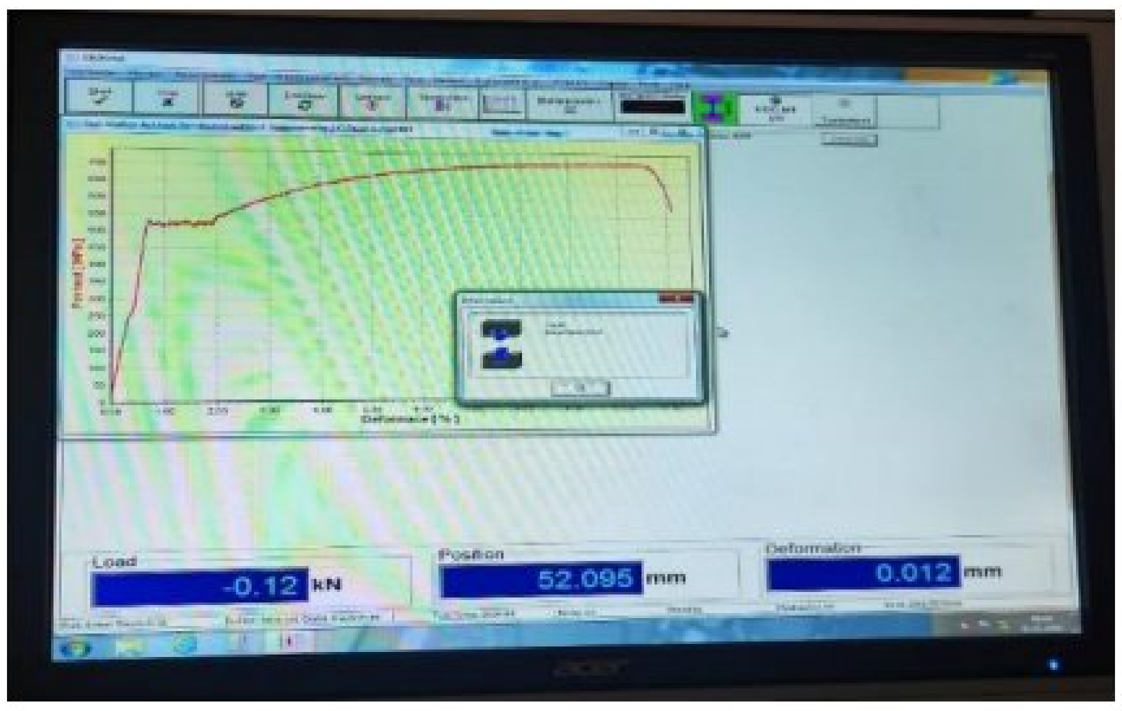

Fig 4.8: Tensile Test of C steel 1

A massive increase is observed in yield strength and ultimate strength compare to the scrap recycled steel.

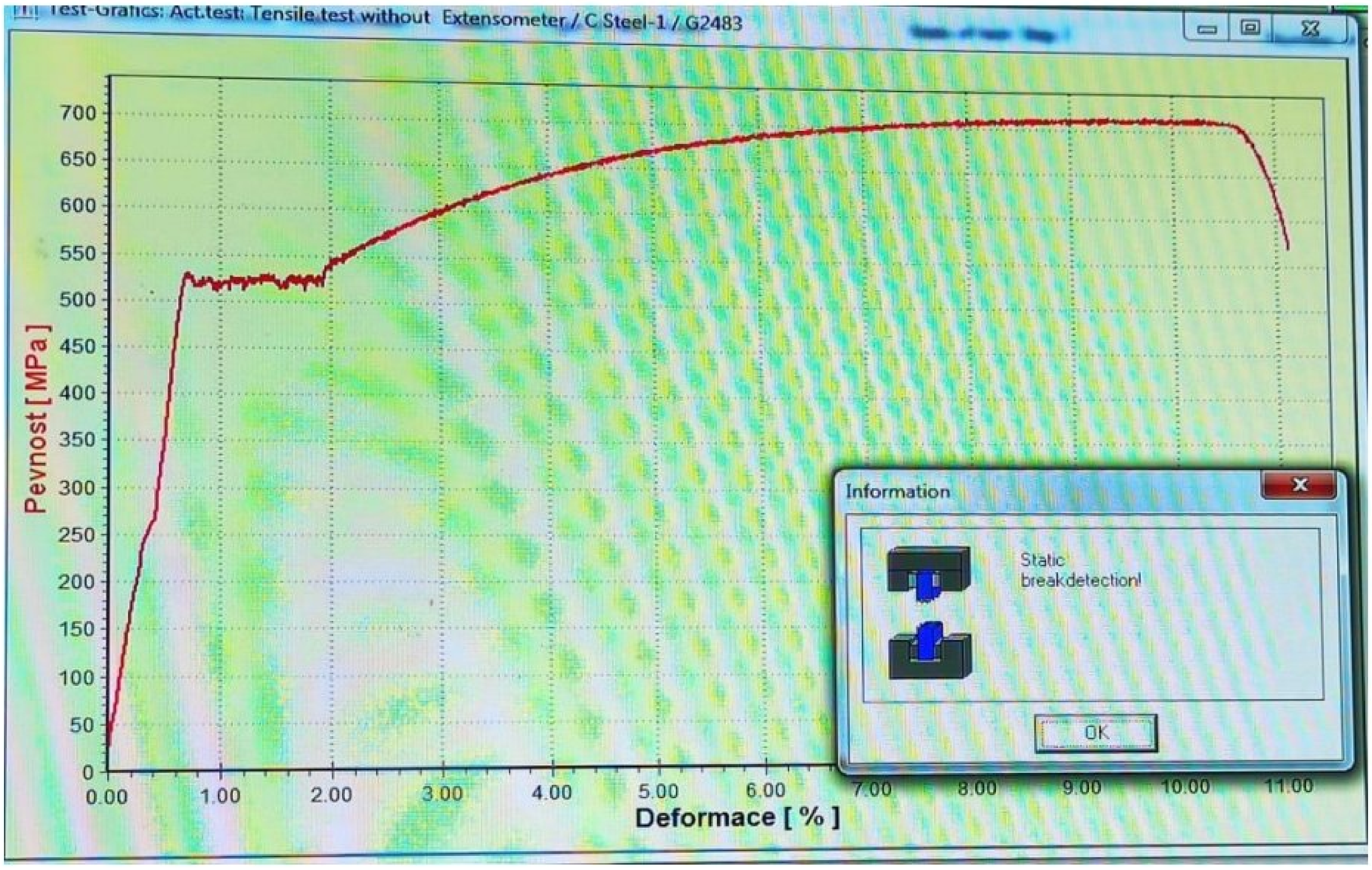

Fig 4.9: Stress vs strain graph of C steel 1

Fig 4.10 is same as Fig 4.8 but it is of C steel 2. This is second sample from same ship recycled industry.

Fig 4.10: Tensile Test of C steel 2

Fig 11 confirms similar result to C steel 1 and it was well expected.

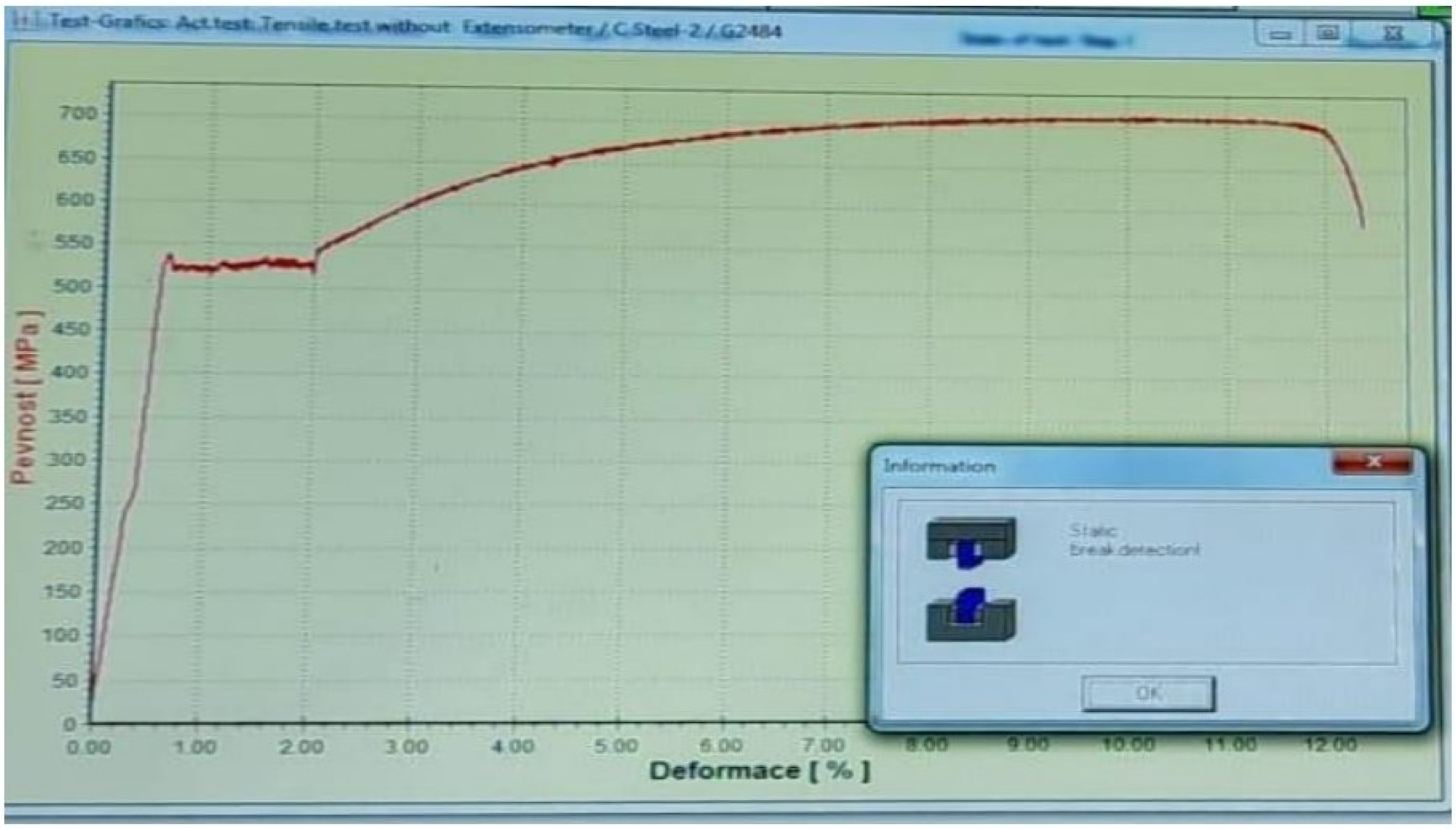

Fig 4.11: Stress vs strain graph of C steel 2

After observing A, B & C steels it is found out that C1 and C2 steel has higher both of yield strength and tensile or ultimate strength and B steel has much lower yield and tensile strength. So ship recycled steels have much more yield strength and tensile strength.

4.4 ELONGATION TEST

Although elongation does not guarantee fixed quality of steel, it is better to know this for various safety purposes. Elongations of each sample is presented in Table 4.2. It indicates how ductile a metal is. A metal can be less ductile but more ultimate and yield strength which is always considered as better quality.

Table 4.2: Elongation of the sample steels

Sample Steel	**% of Elongation**
A steel 1	16.76
A steel 2	14.53
B steel	20.52
C steel 1	16.67
C steel 2	15.18

In this test A steel, B steel and C steel are run through experiment. It was found out that B steel has better elongation than A and C steels where B steel represents scrap recycled steels and C steels are ship recycled steels and also A steels are scrap recycled steels. So it is found out that scrap recycled steels have better elongation through providing external forces.

4.5 TORSION TEST

The diameter and length of 3 of our specimen are not same. So, we are portraying a graph applied torque divided by torsion constant vs twist per length.

Torsion constant, $J = (\pi d^4)/32$

Table 4.3: Properties of A steel Torsion specimen

D (mm)	**3.89**
L (mm)	**86**
R (m)	**0.001945**
J	**4.49602E-11**

Table 4.3 informs about useful length, diameter and torsion contant of the specimen of A steel. Without these data we can not plot torsiongraph. Fig 4.12 is Showing us the torsion graph of A steel.

Fig 4.12: Torsion graph of A steel

Table 4.4: Properties of B steel Torsion specimen

D(mm)	**4.163**
L(mm)	**82**
R(m)	**0.00208**
J	**5.88035E-11**

Table 4.4 informs about useful length, diameter and torsion contant of the specimen of B steel.

Fig 4.13 is the graphical representation torsion test of B steel.

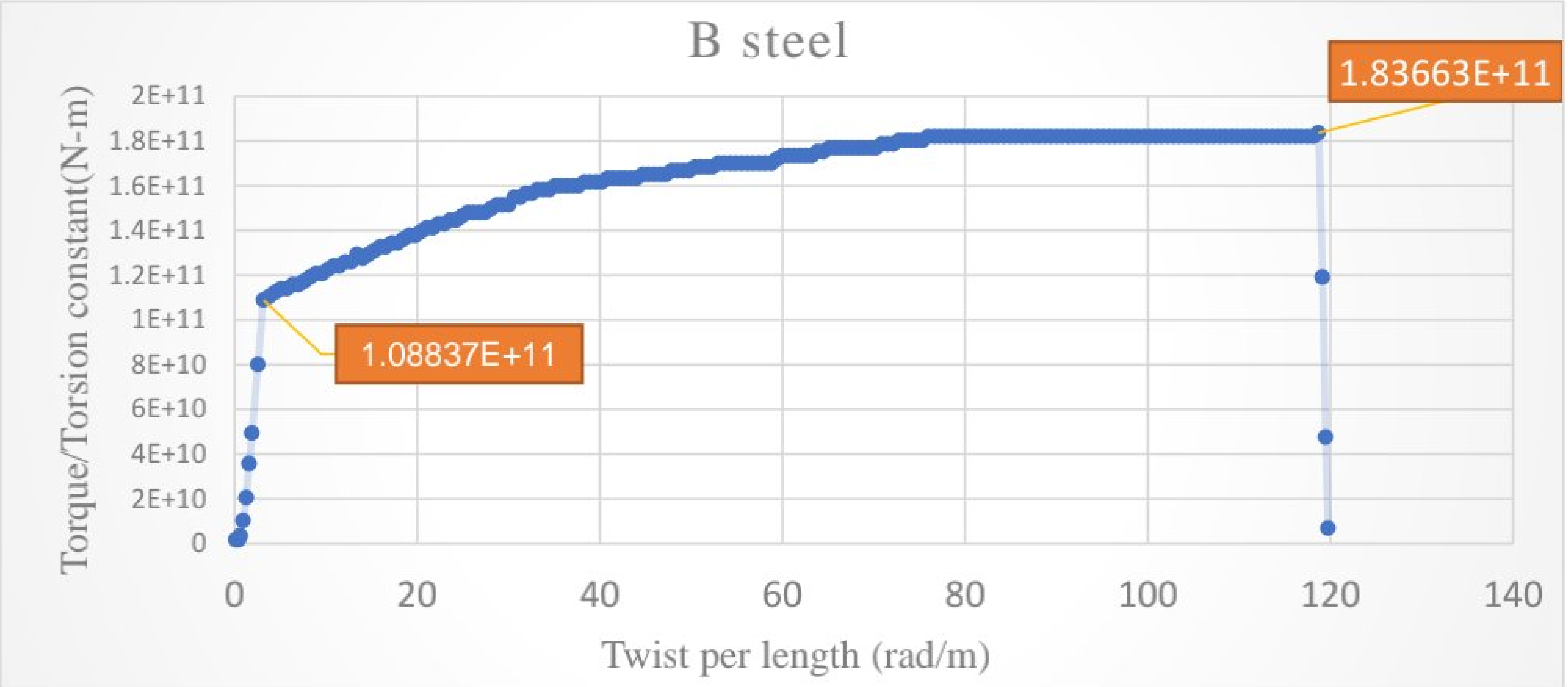

Fig 4.13: Torsion graph of B steel

Table 4.5 informs about useful length, diameter and torsion contant of the specimen of C steel.

Table 4.5: Properties of C steel Torsion specimen

D(mm)	**4.163**
L(mm)	**82**
R(m)	**0.00208**
J	**5.88035E-11**

Finally, Fig 4.14 provides the graph of torsion test for ship recycled steel and it will helps comparing with the scrap recycled steel in case of torsion test.

Fig 4.14: Torsion graph of C steel

In case of torsion, B steel has better performance for both yield strength and ultimate strength over A and C steel.

A steel has the lowest yield and ultimate strength. So ship recycled steels have the better ultimate strength and yield strength in terms of mechanical properties.

4.6 ROCKWELL HARDNESS TEST

100kN ball indenter with diameter of 1/16 inch. In B Scale Rockwell hardness average we get from Table 4.6

A Steel B 85

B Steel B 88.5

C Steel B 78.6

Table 4.6: Rockwell Hardness (in B scale)

A Steel	B Steel	C Steel
B 86.5	B 86	B 81
B 90	B 87.5	B 75
B 87.5	B 92	B 80

Hardness is very important to resist wear. Gears are one of the most useful application where hardness is required to counter friction between metal bodies.

In case of Rockwell hardness, it is visible from the Table 4.6 that A steel & B steel have almost same quality but for C steel it has less hardness. So ship recycled steels have less hardness compared to other steels.

4.7 TOUGHNESS TEST

There has already been a discussion about toughness in section 3.9. However, Fig 4.15 indicates clearly that A steel has the highest fracture B steel has less and C steel got the least fracture in Izod test. We can also see b steel is the most ductile among these three from Charpy Impact test. A steel specimen is completely broken in Charpy test. B steel specimen is fractured mediocre. C steel has the least fracture in Charpy Impact test too.

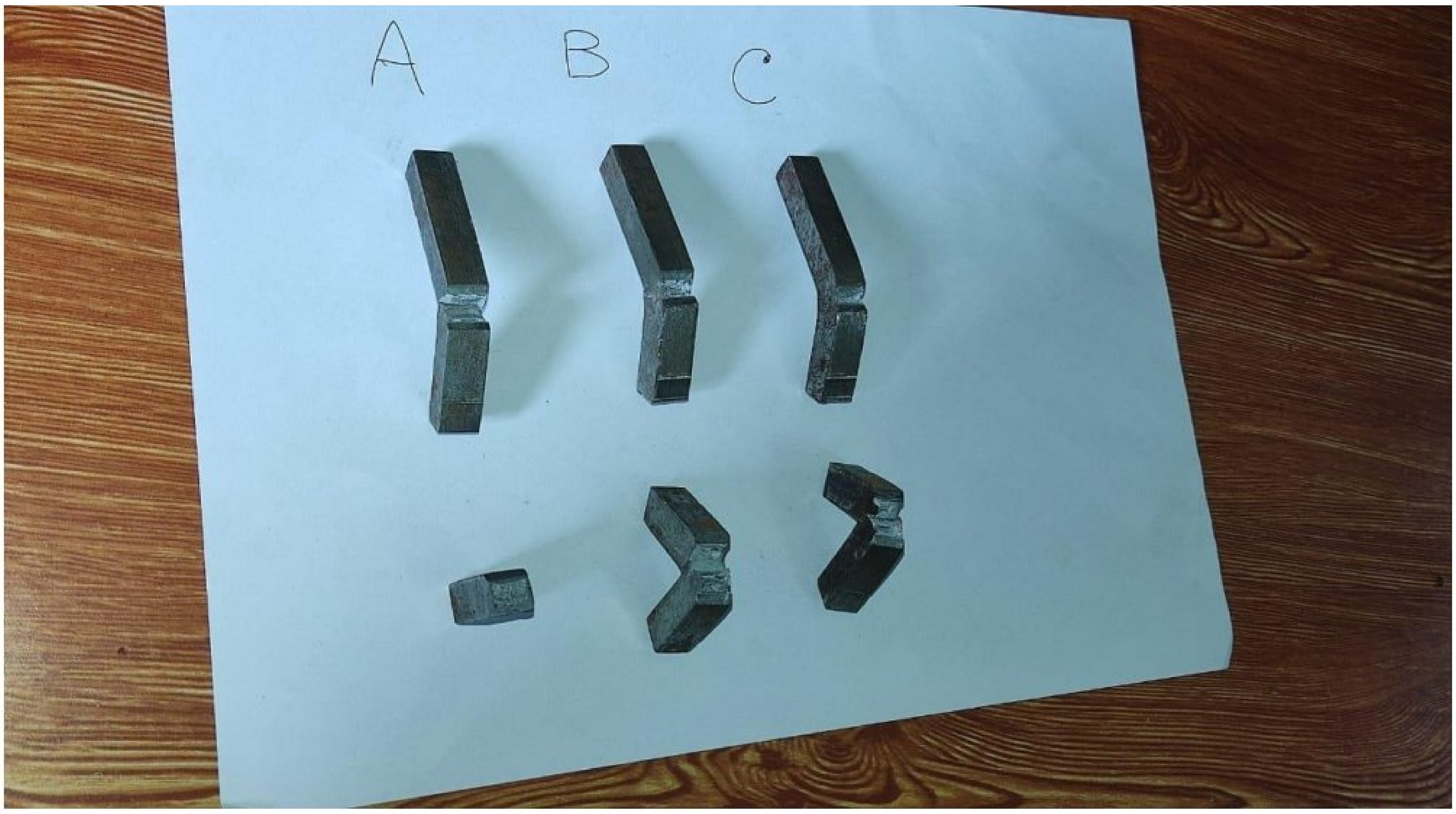

Fig 4.15: Shock absorbed specimens

4.7.1 Charpy Test

Mass of hammer 21*kg*.

Drop angle 140º

Striking velocity 5.35 *m/s*

Friction loss 0.5*%*

Maximum capacity of energy 320 *J*

Notch angle (45 ±1) *degree*

This is our constant value for all of the specimen in Charpy Impact test. Table 4.7 shows us the length of the specimens. The difference is not so much large. The standard length is 55 *mm.*

Table 4.7: Specimen length for Charpy impact test

Steel Name	A Steel	B Steel	C Steel
Length(*mm*)	56	54	53

Table 4.8: Energy Absorption in Charpy impact test

Steel Name	**Energy (*Joule*)**
A Steel	50
B Steel	180
C Steel	214

From Table 4.8 we get the energy absorption in Charpy impact test. It will be discussed later along with the result of Izod test.

4.7.2 Izod Test

Mass of hammer 21 *kg*.

Drop angle 85°

Striking velocity 3.85 *m/s*

Friction loss 0.5%

Maximum capacity of energy 160 *J*

Notch angle (45 ±1) *degree*

Izod test is mostly similar to Charpy impact test, only difference is drop angle is narrower. This results less velocity than that of Charpy test. Moreover, there is another difference on specimen length which is displayed on Table 4.9.

Table 4.9: Specimen length for Charpy impact test

Steel Name	**A Steel**	**B Steel**	**C Steel**
Length(*mm*)	75	75	75

Table 4.10 represents the results of Izod test of our specimens prepared from three sample steels.

Table 4.10: Energy Absorption in Izod test

Steel Name	Energy (*Joule*)
A Steel	64
B Steel	144
C Steel	154

Cross sectional area for all cases are 10mm×10mm.

So in case of toughness it is evident that A steel has less toughness & C steel has the highest steel for both Charpy test & Izod test. So we can observe that ship recycled is tougher than the ship recycled steel. So ship recycled steel has better toughness.

4.8 MICROSTRUCTURE

Microstructure of unetched A steel (scrap recycled) is shown in Fig 16. straight lines are the carbon content.

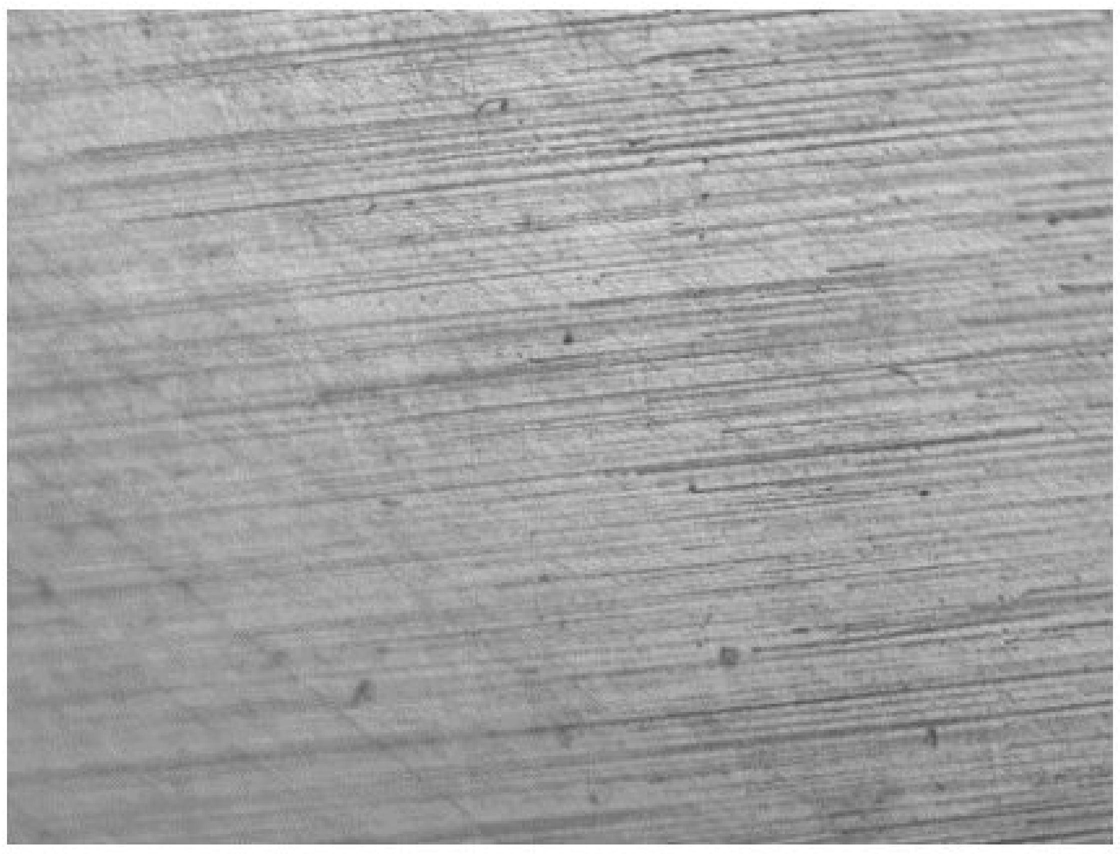

Fig 4.16: A steel (scrap recycled) unetched

From microstructure of etched a steel (scrap recycled) shown in Fig 4.17 the carbon content is much clearer. There is also some precipitated carbon detected.

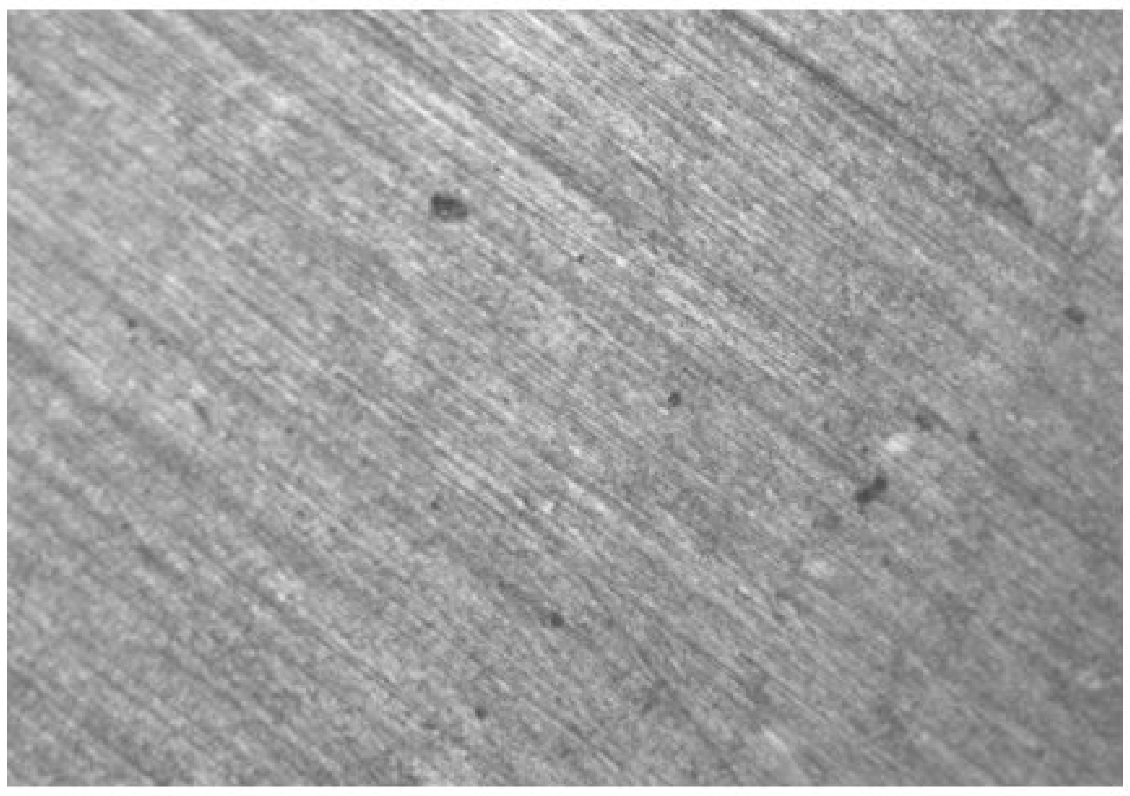

Fig 4.17: A steel (scrap recycled) etched

From unetched B steel (scrap recycled) in Fig 4.18 the lines are thinner than that of A steel but there is some more dotted area than A steel which are precipitated carbon content.

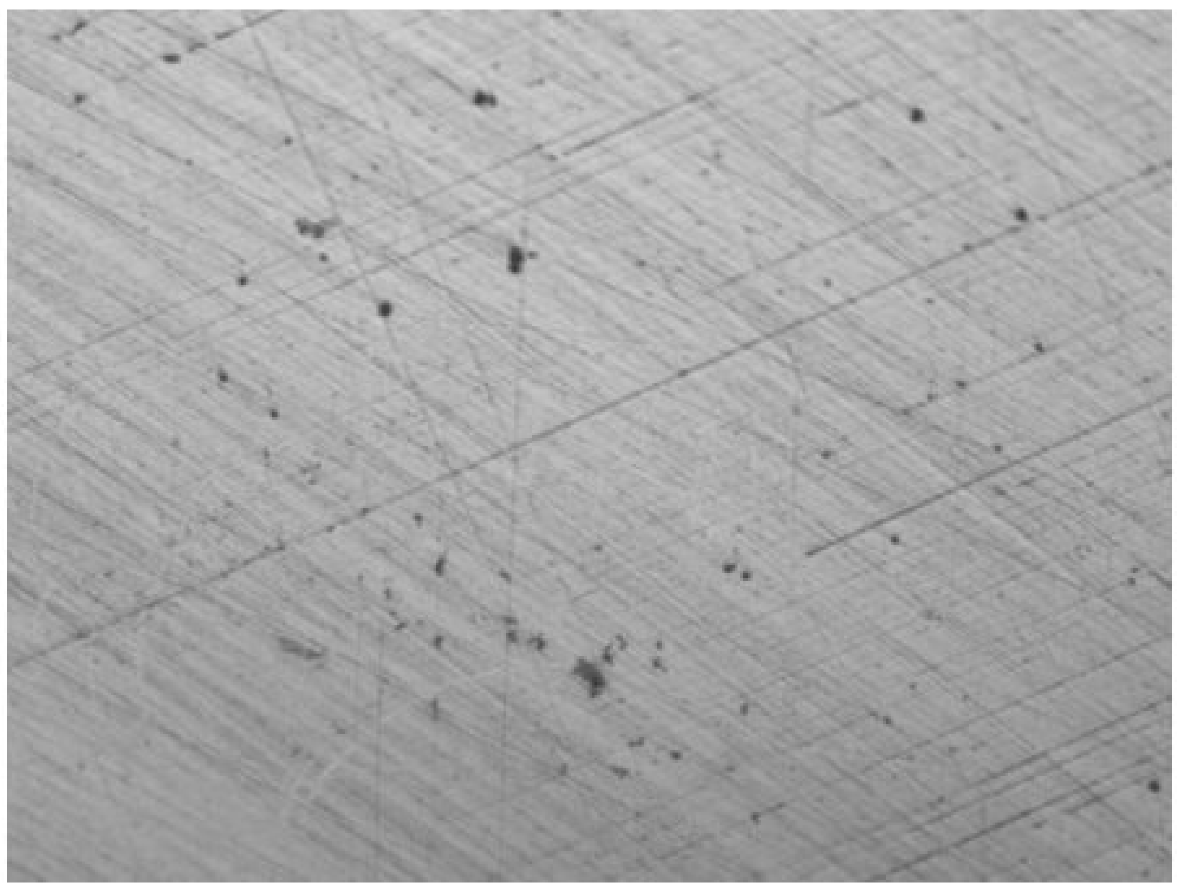

Fig 4.18: B steel (scrap recycled) unetched

In fig 4.19 etched B steel (scrap recycled) is same as Fig 4.18 with enhanced picture quality.

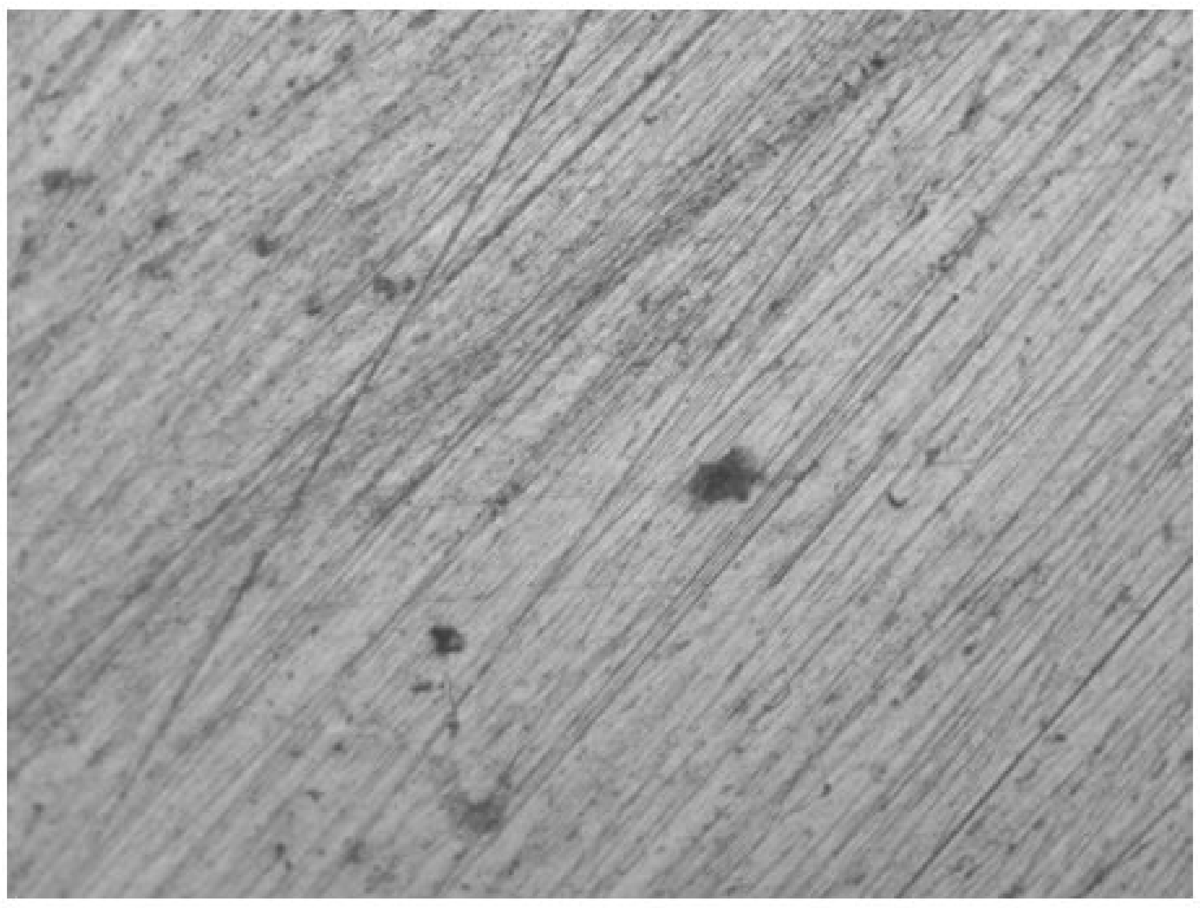

Fig 4.19: B steel (scrap recycled) etched

Fig 4.20 beholding unetched C steel (ship recycled) which has less dotted area. So, precipitated carbon content is less than that of A steel and b steel.

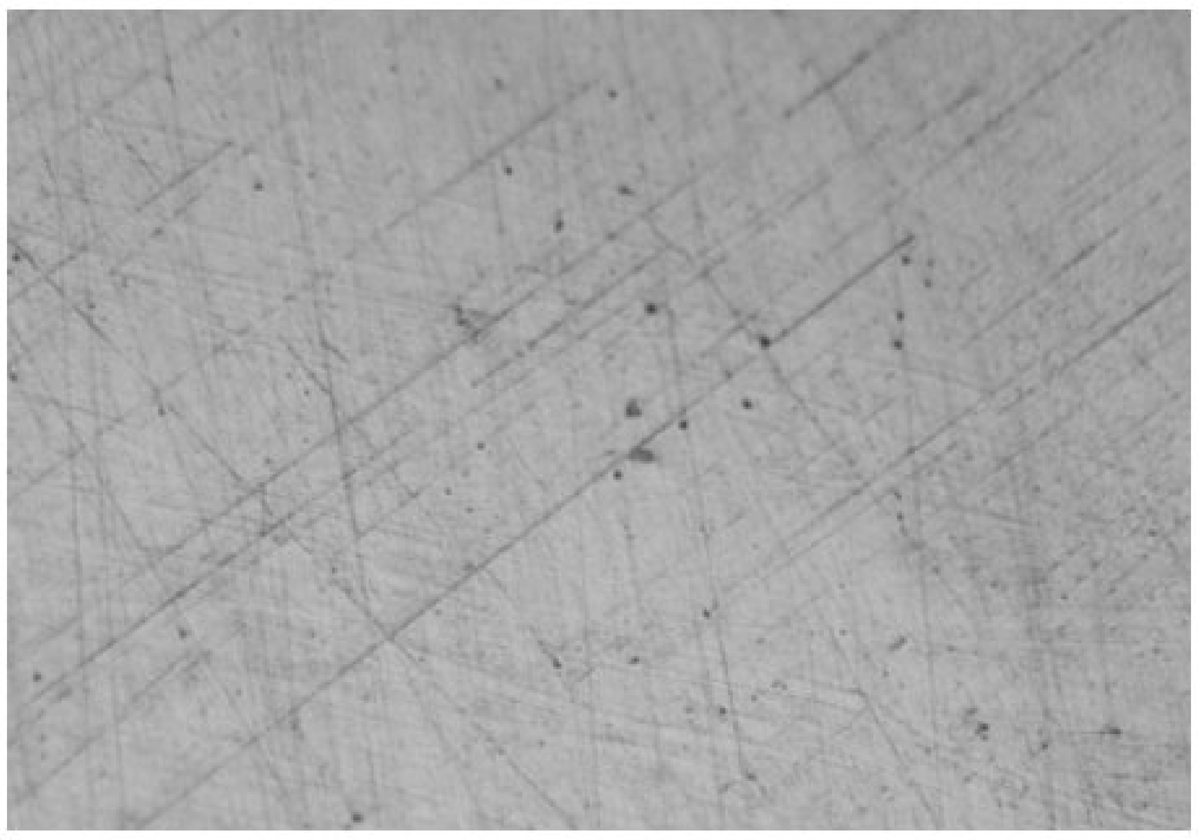

Fig 4.20: C steel (ship recycled) unetched

Etched C steel (ship recycled) diagram in Fig 4.21 shows clearer picture of C steel.

Fig 4.21: C steel (ship recycled) unetched

Ingot of A steel (scrap recycled) unetched is shown in Fig 4.22 and etched ingot of A steel shows that is similar to the end product.

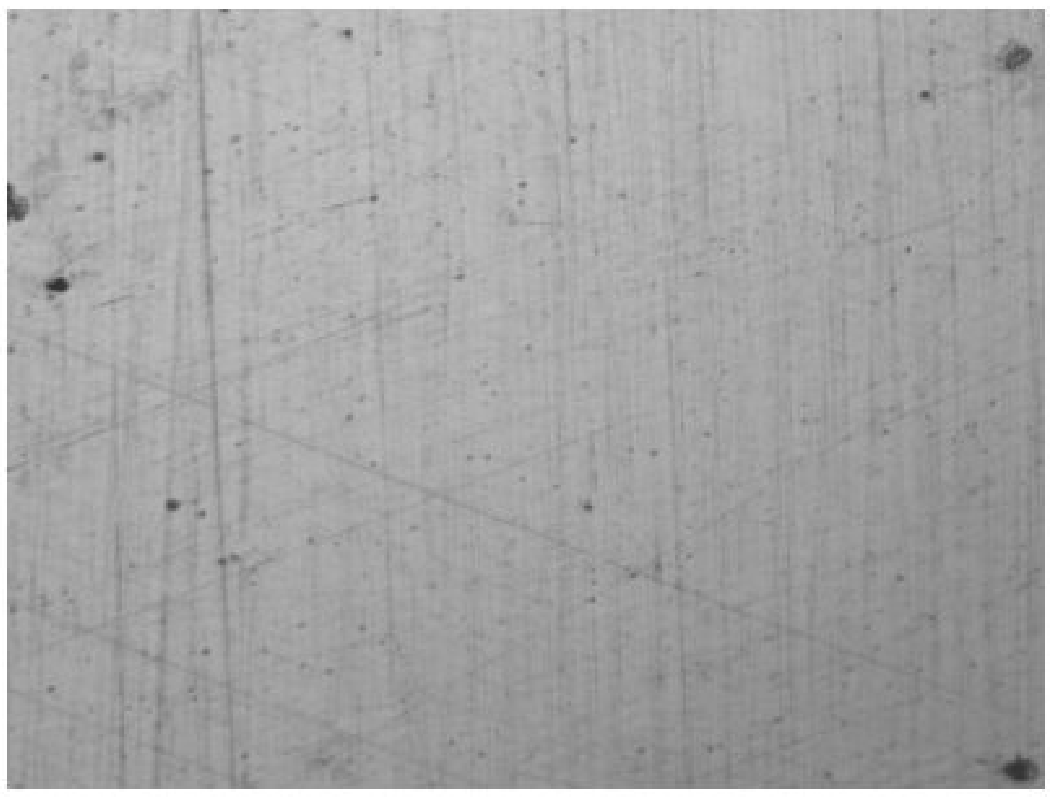

Fig 4.22: Ingot of A steel (scrap recycled) unetched

Fig 4.23: Ingot of A steel (scrap recycled) etched

Both ingot of C steel (scrap recycled) unetched (Fig 4.24) and etched (Fig 4.25) indicating the similarity to the Fig 4.20 and Fig 4.21.

Fig 4.24: ingot of C steel (scrap recycled) unetched

Fig 4.25: Ingot of C steel (scrap recycled) etched

The specimen was washed by ethanol and then nitric acid. This process was a mistake and ended up damaging the specimen surface.

Figure 4.26, 4.27, 4.28, 4.29, 4.30, 4.31 displaying A, B, C, A (ingot), C(ingot) respectively.

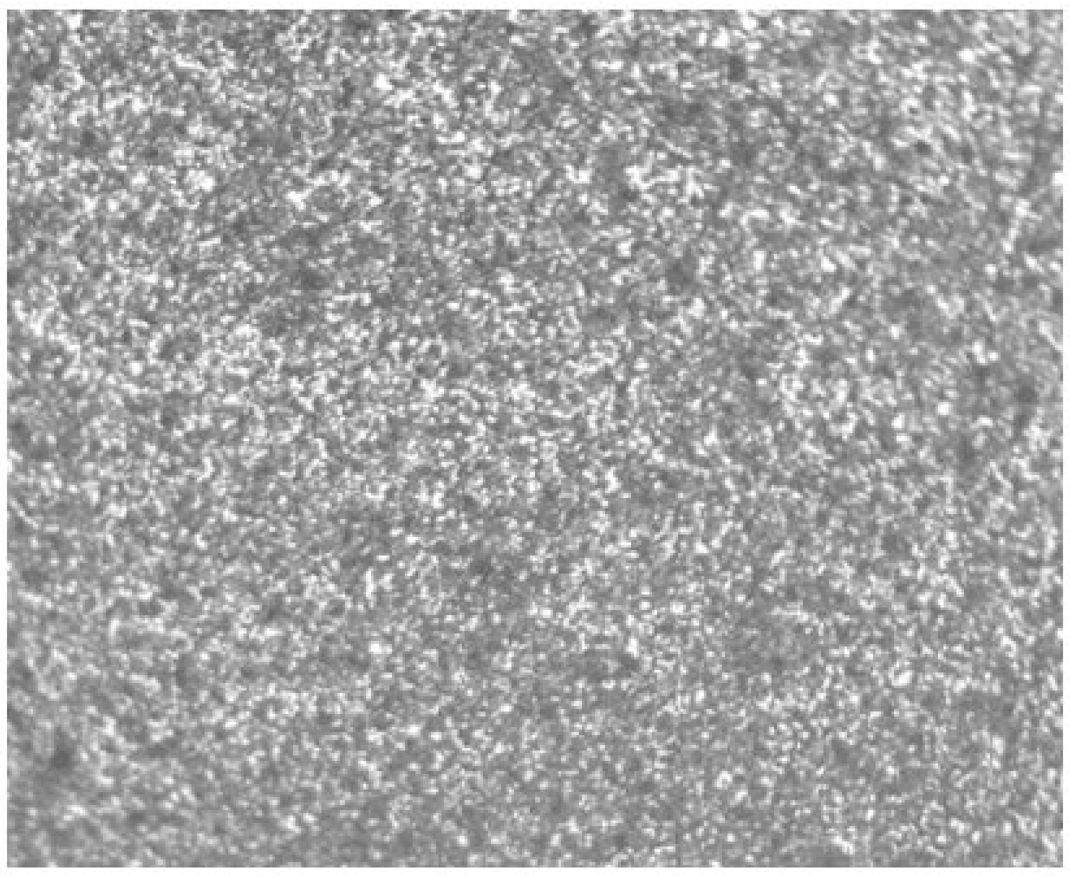

Fig 4.26: Damaged surface A

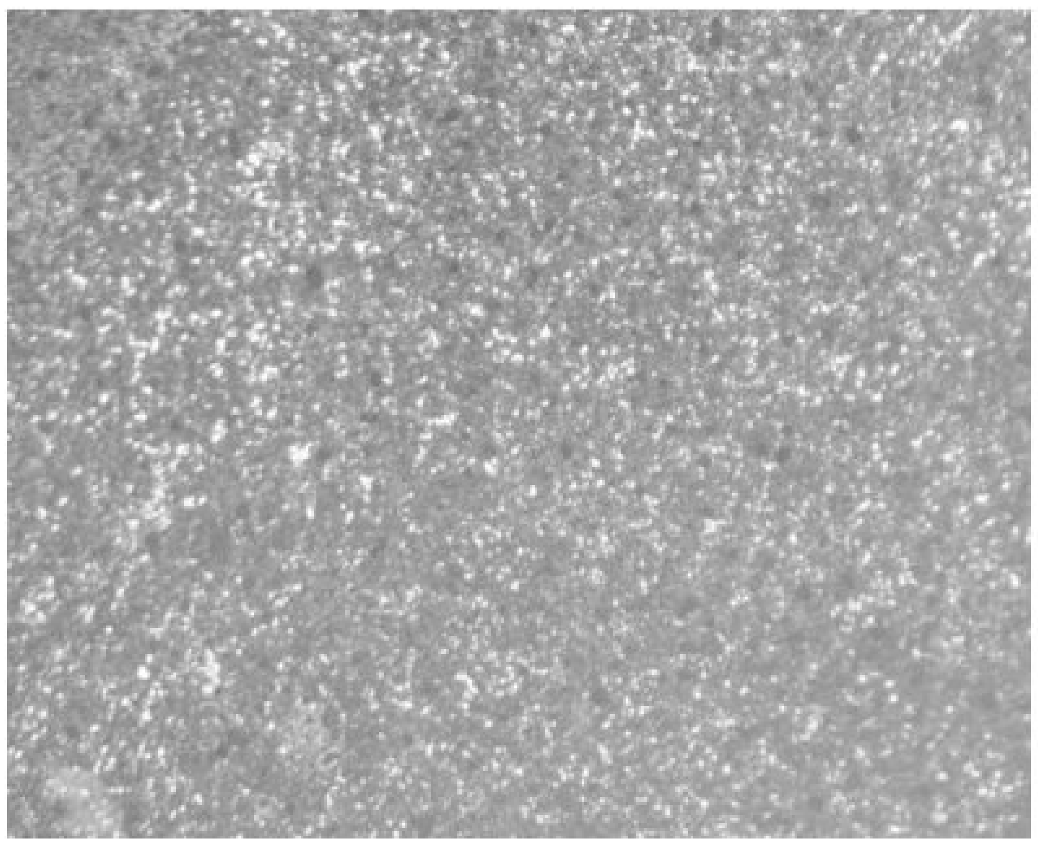

Fig 4.27: Damaged surface B

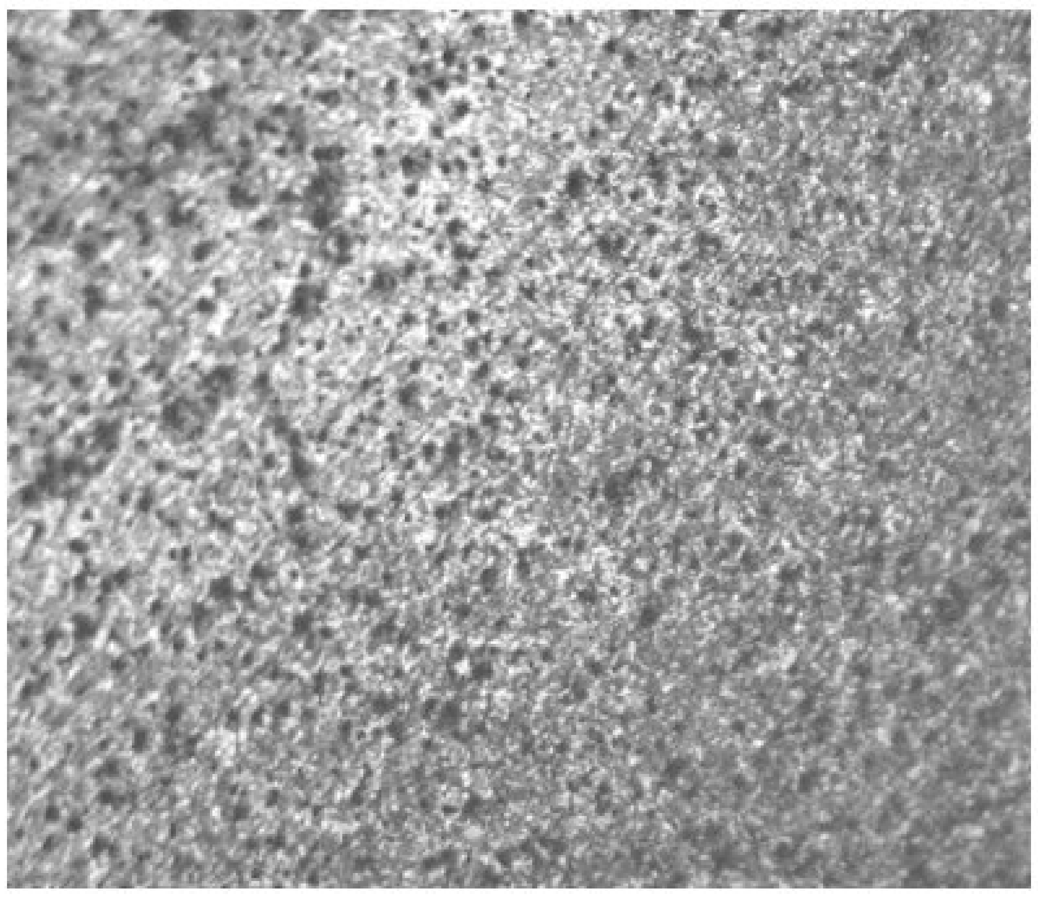

Fig 4.28: Damaged surface C

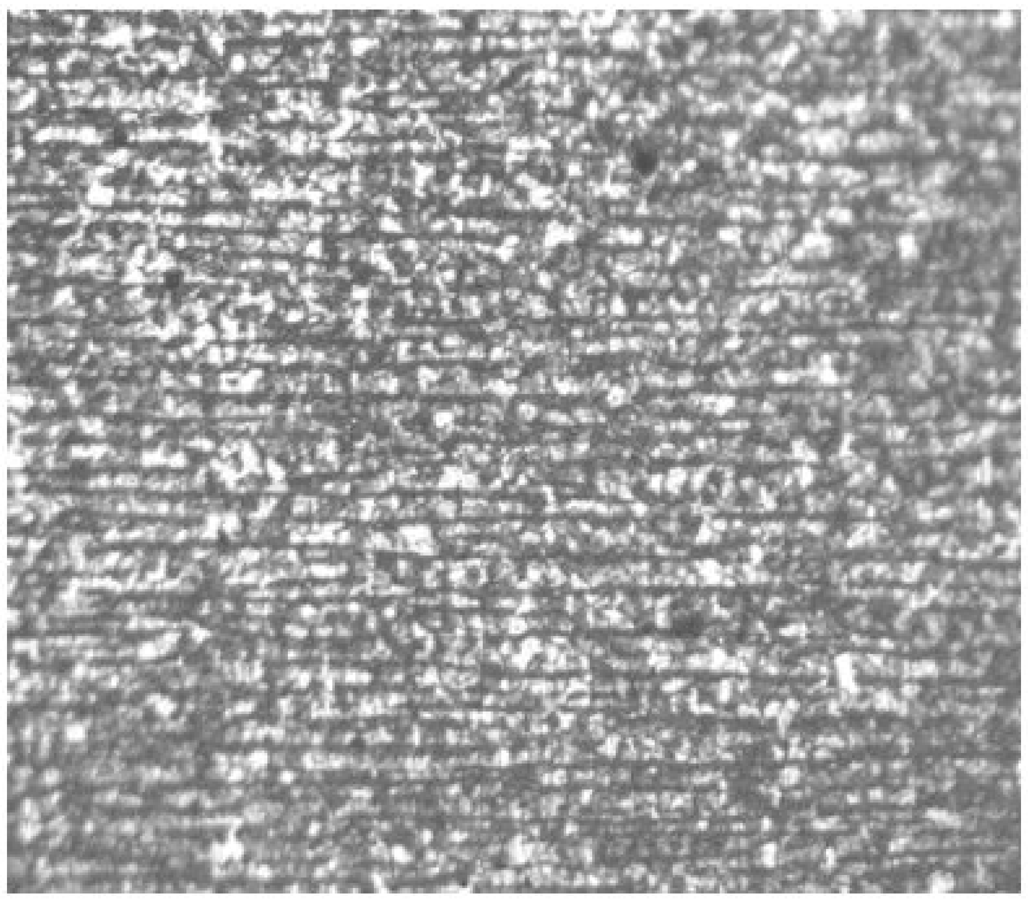

Fig 4.29: Damaged surface A(Ingot)

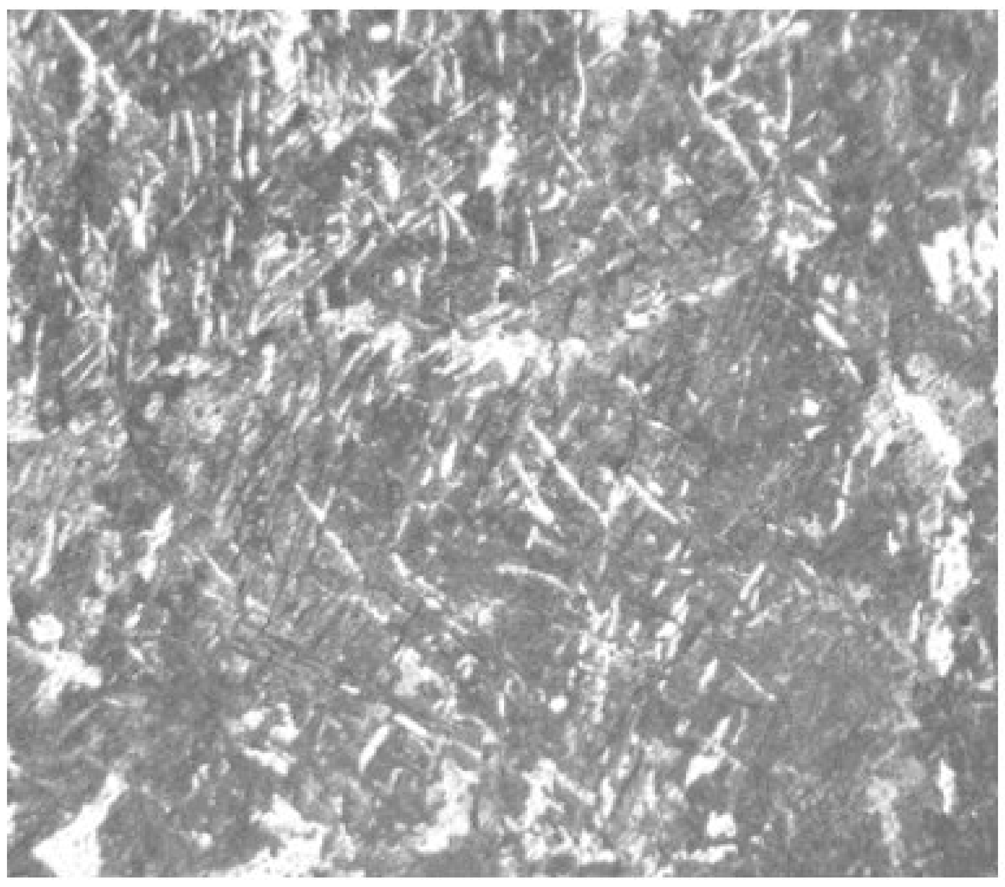

Fig 4.30: Damaged surface C(Ingot)

In all samples we can see that black lines are more in number in etched. So after etching carbon contents are clearer to be observed.

4.9 SUMMARY

In the respect of tensile strength, yield strength we got C (ship recycled) steel as a better steel than A & B (Scrap recycled)steel.

In the case of toughness for both Charpy impact test & Izod test again we got C steel out qualifying A steel & B steel.

Only in the case of Rockwell hardness test both A & B steel have better hardness than C steel.
In the toughness test C steel is brittle & A steel & B steel are ductile.

So, clearly we understand the reason behind higher elongation of A and B steel.
In torsion test we can see that C steel is better than A steel but not better than B steel. So in the case of application of torsion we can use scrap recycled steel (B steel).
In the most of the cases we got ship recycled steel as a better steel in the respect of mechanical properties. So it is economically viable to lean towards more ship recycled steel production. Its net worth is about US$770 million and through taxes and customes duties it has paid US$68 million[21]

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 GENERAL

The main goal of this study is a comparative discussion among ship and scrap recycled steel which is stated in objective (i) and also determines the better qualified steel. Different experiments were run to see the better steel. 90-95% International transportation commercial goods takes place through sea[22]. Our objectives of this study is about comparing ship and scrap recycled steel is fulfilled. Determining the better qualified steel we run several experiments regarding torsion, tensile strength, yield strength, elongation, hardness, toughness & microstructure observationsn. It is determined that for majority portion ship recycled steel is better qualified. Using more ship recycled steel will results in meeting the growing demand of steel and lowering importing cost of steel scrap.

In tensile strength test it was found that ship recycled steel the better one having much better tensile strength compared to the scrap recycled steel. So where tensile strength is used in a process it is recommended that ship recycled steel should be used in that case.

Ship recycled steel was shown to have significantly higher yield strength than scrap recycled steel in tensile strength tests. When yield strength is required in a process, ship recycled steel is recommended.

In the toughness test we ran Charpy test and Izod test. Both tests showed ship recycled steel has better toughness. So when toughness is required in a process, ship recycled steel is recommended to use.

Scrap recycled steel was shown to have significantly higher hardness than ship recycled steel in the experiments we ran. So when hardness is required in a process, scrap recycled steel is recommended to use. In this case, scrap recycled steel was shown to have significantly higher torsional strength than ship recycled steel in the experiments we ran. So when torsional strength is required in a process, scrap recycled steel is recommended to use.

So, objective (ii) for finding more suiatable for different properties still is also fulfilled. Moreover, in section 4.8 objective (iii) meets the micro-structure observation.

5.2 RECOMMENDATIONS

In the most of the cases we got ship recycled steel as a better steel in the respect of mechanical properties. So it is economically viable to lean towards more ship recycled steel production.

As there are more chances for ship dismantling it is recommended to use broken ships more for recycled steel production.

We can use scrap recycled steel where properties of hardness and torsion are applied.

It can be achieved better quality microstructure using more accurate etching reagent. We can use scrap recycled steel where properties of hardness and torsion are applied.

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CERTIFICATE OF THE RESEARCH

This thesis entitled "STUDY AND COMPARISON OF MECHANICAL PROPERTIES BETWEEN SCRAP RECYCLED STEEL AND SHIP RECYCLED STEEL" submitted by M. Sadik Al-Noor (170011021), Safayet Hossen Shuvo (160011051) and Tausif Khan (170011009) has been accepted as satisfactory in partial fulfillment of the requirement for the Degree of Bachelor of Science in Mechanical Engineering.

Supervisor

Prof. Dr. Shamsuddin Ahmed

Head of the Department

Dr. Md. Anayet Ullah Patwari

Professor

Department of Mechanical and Production Engineering (MPE)

Islamic University of Technology (IUT)

DECLARATION

We hereby declare that this thesis entitled "STUDY AND COMPARISON OF MECHANICAL PROPERTIES BETWEEN SCRAP RECYCLED STEEL AND SHIP RECYCLED STEEL" is an authentic report of our study carried out as a requirement for the award of degree B.Sc. (Mechanical Engineering) at Islamic University of Technology, Gazipur, Dhaka, under the supervision of Professor Dr. Shamsuddin Ahmed, MPE, IUT in the year 2022

The matter embodied in this thesis has not been submitted in part or full to any other institute for award of any degree.

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