Comparative Study of Corrosion Sensitivity of Selected Ferrous Metals in Liquid Fertilizer Solutions

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Abstract-
The objective for this paper is to select an optimum metal which is suitable for agricultural equipment's so that the metal which when used on practically provides with the most effective outputs. The objective will be accomplished by performing metal testing, heat treatment and corrosion study of low, medium and high carbon steels so as to select the most optimum out of them. Some of the investigations were carried out to study critically the corrosion behavior of low, medium and high carbon steels in urea solution extracts by weight loss measurement and constant extension to fracture method respectively.
In this paper the investigations at various stages on the low, medium and high carbon steels would provide us with the different data on the basis of which different properties of different metals would be shown on the basis of these performances the suitable metal would be selected. This project is performed keeping in mind the need of agricultural equipment and their desirable Properties for them but also keeping in mind the economic aspect that the metal selected should be cost effective too. We are looking to work upon these metals and select an optimum metal that will be ideal for agricultural equipment.
The objective is to select a material on the basis of different heat treatments, corrosion and other experiments and investigations performed on them that is more efficient as off now used in Agricultural equipment's.
Keywords- EN3, EN8, EN42, Heat treatment, hardness Test, Tensile test, impact test, Corrosion.
A- Before Heat Treatment.
B- After Heat Treatment.
C- After 2 months of Corrosion.
D- After 4 months of Corrosion.
E- After 6 months of Corrosion.
F- %Elongation in length.
R- %Reduction in gauge diameter.

1 INTRODUCTION

Three grades of steels are taken for testing namely low carbon steel (EN3), medium carbon steel (EN8) and high carbon steel (EN42). Specimens of low, medium and high carbon steel are made according to the standard for tensile test, impact test and hardness test. Testing of each specimen is done and the values are noted.
Heat treatment of the remaining specimens is done and testing of the specimen is done again to note the values. The remaining specimens are immerged in a beaker containing urea solution to get corrode. The specimens are immerged in the urea solution for a period two, four and six months and after this period of intervals the specimens are carried out from the urea solution and testing of the specimens is done. Values are noted and all the values are compared to know that which metal among the low, medium and high carbon steel is better under these conditions.

2 MATERIAL SELECTIONS

Low, Medium and High Carbon Steels of the required dimensions were purchased from the market and the test specimens were prepared. The chemical composition of low, medium and high carbon steels by (wt %) is given as follows:

Low Carbon Steel (EN3)

Carbon (C)	Phosphorous (P)	Manganese (Mn)	Sulphur(S)	Silicon(Si)
0.25%	0.06%	1.00 %	0.06%	0.05%

Medium Carbon Steel (EN8)

C	P	Mn	S	Si
0.45%	0.06% max	1.00%	0.06%	0.05%

High Carbon Steel (EN42)

C	P	Mn	S	Si
0.70%	0.05%	0.75 %	0.05%	0.10%

3 PREPARATION OF TEST SPECIMEN

The test specimen for the analysis of different mechanical properties like impact, tensile strength and hardness were prepared as per ASTM standard and its description is given below.

3.1 Specimen for Charpy Test

The charpy test for low, medium and high carbon steels is determined by making standard specimen of dimensions of 55mm × 10mm × 10mm in size and has a 2mm V-notch at its center making an angle of 45°.

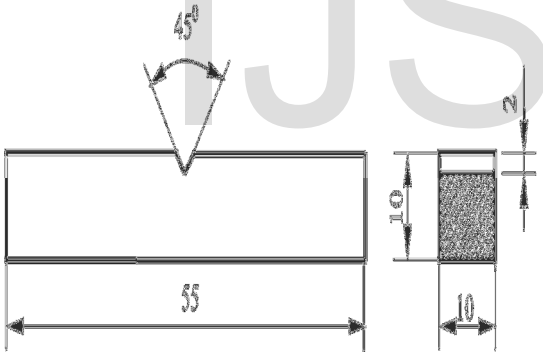

Fig.1 Dimensions of Charpy Test Specimen

3.2 Specimens for Tensile Test

The tensile test for low, medium and high carbon steels is carried out on a specimen of length 375mm, diameter 20mm, gauge length of 50mm and gauge diameter of 8mm.

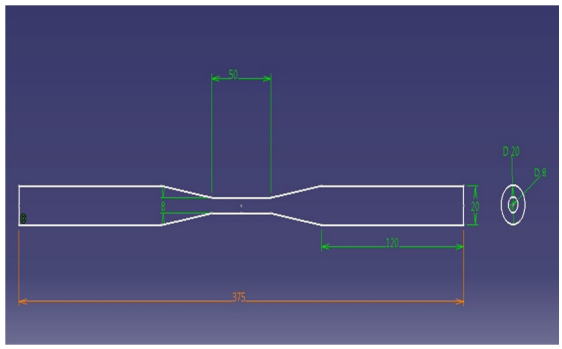

Fig.2 Dimensions of Tensile Test Specimen

3.3 Specimens for Rockwell's Hardness Test

The hardness test for low, medium and high carbon steel is carried out on a specimen of diameter 40mm and 10mm thick.

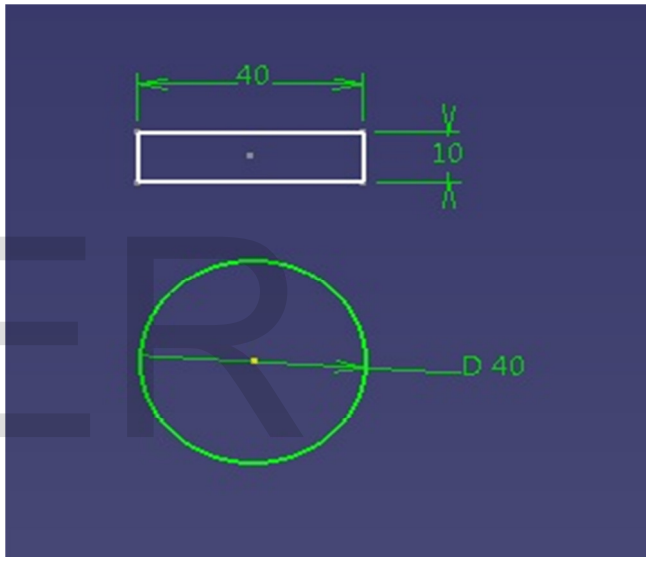

Fig.3 Dimensions for the Specimen for Rockwell's Hardness

4 TESTING OF SPECIMEN AFTER CORROSION

4.1 After a period of two months of corrosion

After a period of two months some of the specimens of low, medium and high carbon steel were taken out and charpy, Rockwell's and tensile tests were again done and the values were noted.

Fig.4 Specimen after tests after two months of Corrosion

4.2 After a period of four months of corrosion

After a period of four months some of the specimens of low, medium and high carbon steel were taken out from the urea solution and charpy, Rockwell's and tensile tests were again done and the values were noted.

Fig.5 Specimen after tests after four months of Corrosion

4.3 After a period of six months of corrosion

Again after a period of six months rest of the specimens of low, medium and high carbon steel were taken out from the urea solution and charpy, Rockwell's and tensile tests were done and the values were noted. After this all the values from beginning to the end (before heat treatment to the sixth month of corrosion) all the values were compared.

Fig.6 Specimen after tests after six months of Corrosion

5 RESULTS

5.1 Results for low carbon steel (EN3)

5.1.1 From Charpy Test:

This shows that breaking strength of the metal is greatly enhanced by the heat treatment and decreases due to the effect of corrosion. The effect of corrosion on the material is found to have a very low effect on the breaking strength for first four months but the effect is quiet considerable after being corroded for six months.

Speci-mens	A	B	C	D	E (Joules)
1	65	81	78	81	71
2	64	84	79	82	73
3	68	87	81	79	73
4	62	85	81	77	72
5	61	83	86	82	70

Table 1. Charpy Test values of Low Carbon Steel (EN3) under different conditions

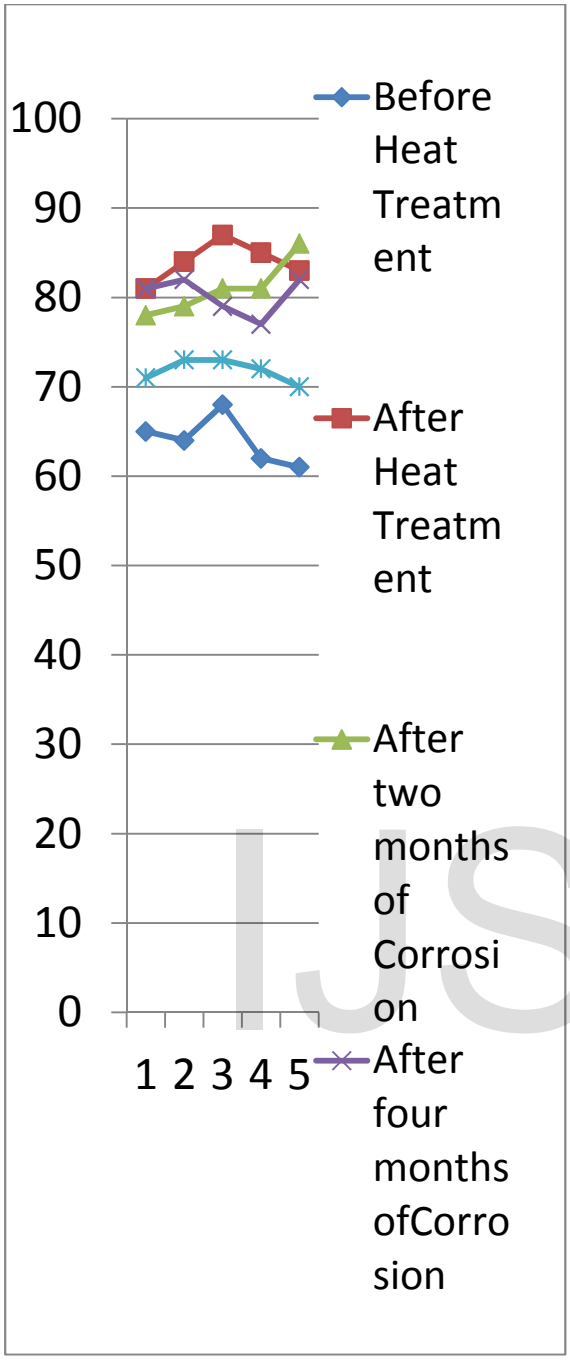

Fig.7 Shows the breaking strength of low carbon steel (EN3) under different conditions

5.1.2 From Rockwell Hardness Test:

This shows that the hardness of the material is greatly enhanced by the heat treatment and decreases due to the effect of corrosion. The effect of corrosion on the material is found to have a very low effect on the hardness for first four months but the effect is quiet considerable after being corroded for six months.

Table 2 Rockwell's Hardness test values of Low Carbon Steel (EN3) under different conditions

Speci-mens	A	B	C	D	E (HRC)
1	95	93	95	91	81
2	92	95	97	92	85
3	93	96	94	90	86
4	95	92	93	90	82
5	94	92	96	88	87

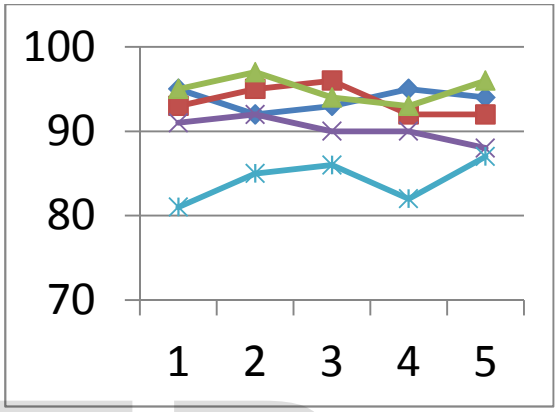

Fig. 8 Shows the Hardness of Low Carbon Steel (EN3) under different conditions

5.1.3 From Tensile Test:

This shows that the hardness of the material is greatly enhanced by the heat treatment and decreases due to the effect of corrosion. The effect of corrosion on the material is found to have a very low effect on the hardness for first four months but the effect is quiet considerabl.e after being corroded for six months.

Table 3. Percentage Elongation of Tensile Test of Low Carbon Steel (EN3) under different conditions

Specim ens	A	B	C	D	E
1	20	14.3	21.2	24.4	19.6
2	21	15.5	22.2	25.8	17.9
3	22	16.6	23.5	21.5	18.5
4	20	12.9	24.7	20.5	16.6
5	19	13.7	21.8	24.4	17.8

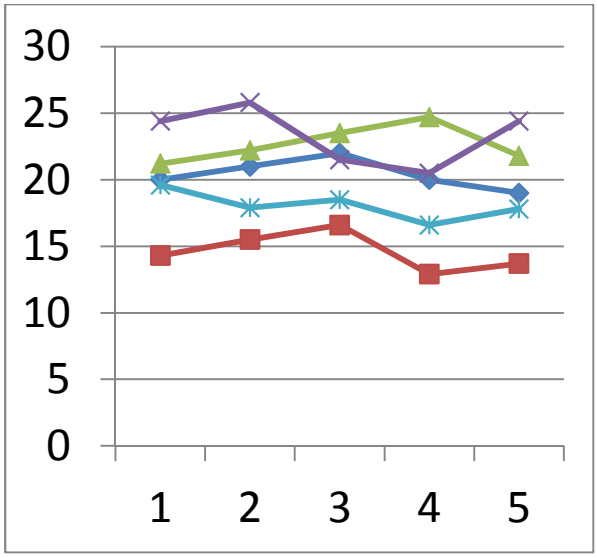

Fig.9 Shows the percentage elongation of low carbon steel (EN3) under different conditions

5.2 Results for medium carbon steel (EN8)

5.2.1 From Charpy Test:

This shows that breaking strength of the metal is greatly enhanced by the heat treatment and decreases due to the effect of corrosion. The effect of corrosion on the material is found to have a very low effect on the breaking strength for first four months but the effect is quiet considerable after being corroded for six months.

Table.4 Charpy Test values of Medium Carbon Steel (EN8) under different conditions

Specimens	A	B	C	D	E
1	65	86	81	78	74
2	66	88	80	77	76
3	69	82	80	75	73
4	68	88	79	81	73
5	67	87	85	80	77

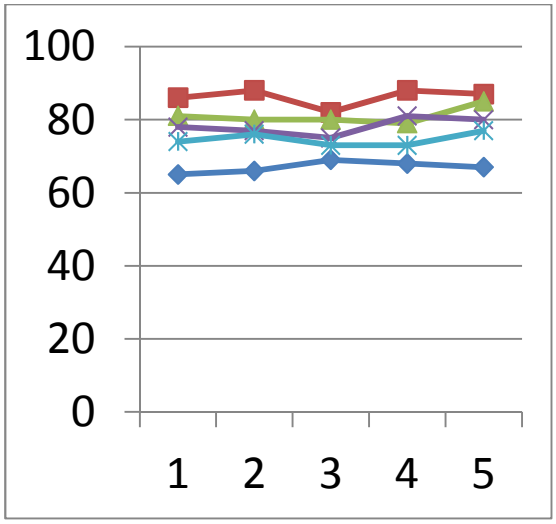

Fig. 10 Shows the breaking strength of medium carbon steel (EN8) under different conditions

5.2.2 From Rockwell Test:

This shows that the hardness of the material is greatly enhanced by the heat treatment and decreases due to the effect of corrosion. The effect of corrosion on the material is found to have a very low effect on the hardness for first four months but the effect is quiet considerable after being corroded for six months.

Table 5. Rockwell's Hardness test values of Medium Carbon Steel (EN8) under different conditions

Specimens	A	B	C	D	E
1	96	97	96	98	86
2	98	95	98	95	85
3	97	94	95	96	87
4	94	98	94	95	86
5	95	97	97	94	89

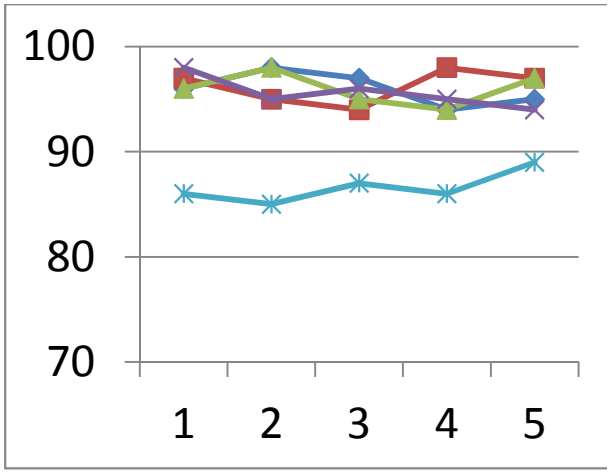

Fig.11 Shows the hardness of medium carbon steel (EN8) under different conditions

5.2.3 For Tensile Test:

This shows that the tensile strength of the metal is enhanced by heat treatment and after being corroded for two months the elongation is increased and material possess more ductile property as the elongation is found to lie between 20 to 25 and after being corroded for four months the material starts to enhance brittleness and the elongation various from 18 to 24 and after being corroded four six months the material is almost brittle and the elongation varies from 15 to 19.

Table 6. Percentage Elongation of Tensile Test of Medium Carbon Steel (EN8) under different conditions

Specimens	A	B	C	D	E
1	21	15.8	22.0	19.2	15.5
2	22	16.9	21.9	18.2	16.6
3	23	14.8	20.7	21.9	17.5
4	21	17.7	24.8	23.5	16.4
5	23	16.7	20.9	21.4	18.6

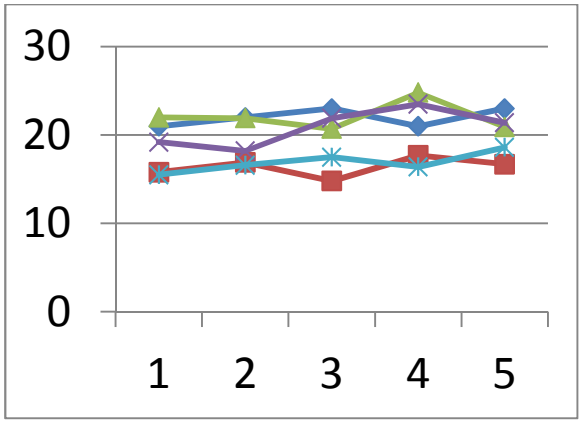

Fig.12 Shows the percentage elongation of medium carbon steel (EN8) under different conditions

5.3 Results for High Carbon Steel (EN42)

5.3.1 For Charpy Test:

This shows that breaking strength of the metal is greatly enhanced by the heat treatment and decreases due to the effect of corrosion. The effect of corrosion on the material is found to have a very low effect on the breaking strength for first four months but the effect is quiet considerable after being corroded for six months.

Table 7. Charpy Test values of High Carbon Steel (EN42) under different conditions

Specimens	A	B	C	D	E
1	77	95	84	79	75
2	75	92	86	78	78
3	78	97	88	81	80
4	74	91	85	80	80
5	76	88	87	78	77

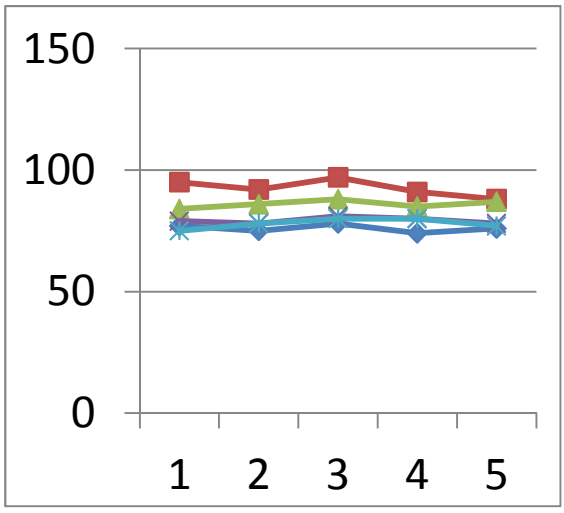

Fig.13 shows the breaking strength of High Carbon Steel (EN42) under different Conditions

5.3.2 For Rockwell Hardness Test:

This shows that the hardness of the material is greatly enhanced by the heat treatment and decreases due to the effect of corrosion. The effect of corrosion on the material is found to have a very low effect on the hardness for first four months but the effect is quiet considerable after being corroded for six months.

Table 8. Rockwell's Hardness Test values of High Carbon Steel (EN42) under different conditions

Specimens	A	B	C	D	E
1	99	96	96	98	91
2	102	104	98	97	92
3	98	100	98	95	88
4	97	97	97	95	89
5	103	102	99	98	90

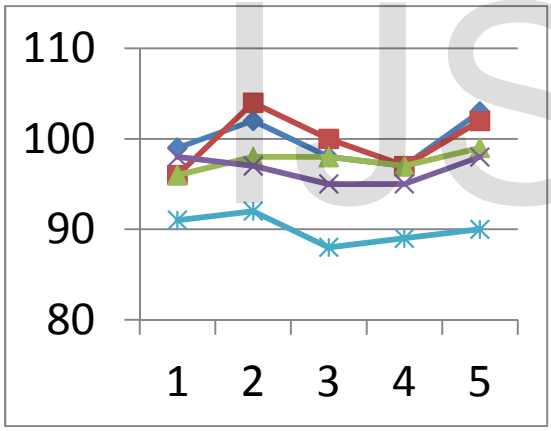

Fig. 14 Shows the hardness of High Carbon Steel (EN42) under different conditions

5.3.3 For Tensile Test:

This shows that the tensile strength of the metal is enhanced by heat treatment and after being corroded for two months the elongation is decreases and material posses brittle property as the elongation is found to lie between 18 to 22 and after being corroded for four months the material starts to enhance brittleness and the elongation various from 19 to 23 and after being corroded four six months the material is almost brittle and the elongation varies from 15 to 19.

Table 9. Percentage Elongation of Tensile Test of High Carbon Steel (EN8) under different conditions

Specimens	A	B	C	D	E
1	31	24.5	20.5	20.2	15.5
2	32	25.4	21.6	21.2	14.8
3	32	28.6	18.5	20.5	17.9
4	34	24.1	19.4	19.5	18.8
5	33	25.5	20.5	22.5	15.5

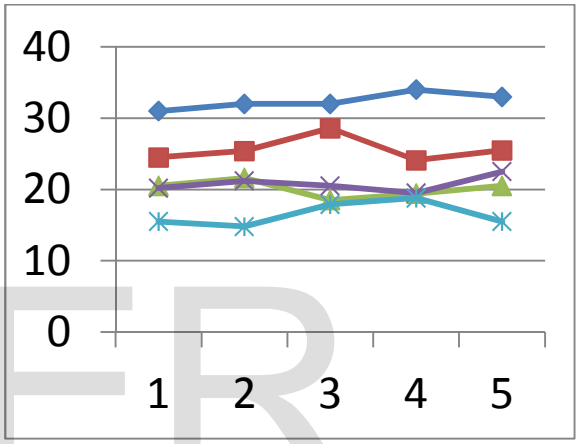

Fig.14 Shows the percentage elongation of high carbon steel (EN42) under different conditions

COMPARISION OF TEST VALUES OF LOW (EN3), MEDIUM (EM8), HIGH (EN42) CARBON STEEL.

5.3.4 Charpy Test:

Table 10. Showing comparative results for charpy test

Materials	A	B	C	D	E
EN3	64	84	81	80.2	71.8
EN8	66	86.2	81	78.2	74.6
EN42	76	92.6	86	79.2	78

5.3.5 Rockwell Hardness test:

Table 11. Showing comparative results for Rockwell's hardness test

Materials	A	B	C	D	E
EN3	93.8	93.8	95	90.2	84.2
EN8	96	96.2	96	95.6	86.6
EN42	99	99.8	96.6	96.6	90

5.3.6 Tensile Test:

Table 12. Showing comparative results for tensile test

Materials		A	B	C	D	E
EN3	**F**	20.4	14.6	22.6	23.3	18.1
	R	52.4	19.5	41.5	42.8	44.1
EN8	**F**	22	16.3	22	20.8	16.9
	R	44	21.2	43.7	51	43.1
EN42	**F**	32.4	25.6	20	20.7	16.5
	R	43.4	26.6	52.3	43.7	43.1

6 CONCLUSION

The comparative study of low, medium and high carbon steel was studied under different conditions and was successively completed with a number of tests which are key in determining the mechanical properties of the carbon steels, these results have been shown in the previous chapter.

From the above work we can conclude that medium carbon steel would be most preferable for agriculture tools and equipment's.

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