Investigation on the Chemical Analysis of Reinforcing Steel Rods Produced from Recycled Scraps

Ponle E. A[1], Olatunde O. B[2] and Fatukasi S. O[3]
(Department Of Mechanical Engineering, Faculty of Engineering Osun State Polytechnic Iree. P.M.B 301, Nigeria)
*E-mail of the corresponding author: olatundeolanrewaju07@yahoo.com

Abstract
Steel being a part of everyday life of an individual, it is incumbent to study its chemical constituent so as to enable production of reliable steel bars. In this work the chemical constituent of reinforcing steel bars manufactured from scraps and imported steel bars is investigated. The percentage chemical composition was related to the available standards. It is found that all the elements follow a consistent pattern, however, graphically, the carbon found present in the 12mm diameter steel bars conform more with the standard compared to the carbon contents of the16mm steel bars.
Keywords: Steel bar, Elements, Scraps, Chemical Composition.

1. Introduction

Steel is an essential material for society and sustainable development needed for people to satisfy their needs and aspirations. Steel is a part of people's everyday lives, in both the developed and developing world. It is used in providing transportation such as automobiles and railroads, building shelters from small housing to large multi-family dwellings, delivering energy such as electricity and natural gas, supplying water with pumps and pipelines. Steel is a material used in construction industries. It is an iron-based material containing low amounts of carbon and alloying elements that can be made into thousands of compositions with exacting properties to meet a wide range of needs. Steel is truly a versatile material. About twenty-six different elements are used in various proportions and combinations in the manufacture of both carbon and low alloy structural steels. Some are used because they impart specific properties to the steel when they alloy with it (i.e. dissolve in the iron), or when they combine with carbon, wholly or in part, to form compounds known as carbides. Others are used because they are beneficial in ridding the steel of impurities or rendering the impurities harmless. Still another group is used to counteract harmful oxides or gases in the steel. (Yeon et al.,2007) did a study on methods to classify defects namely; crack, dark spot and sharp mark, of steel Bar Coil (BIC) with cylindrical shape. They qualified each of these defect serious, that can harm quality of product relatively. Hence, it is important to detect these defects on the process of production. (Balogh and Vigh., 2013), did a study on the Cost Optimization of Concentric Braced Steel Building Structures. Aim of the study was to find structural configurations with minimum structural cost. (Harald et al.,2013) studied High Temperature Single Impact (HTSIT) to limit the range of application of different material classes up to 700°C, this was done with the purpose of evaluating deformation mechanisms at different energy and momentum levels, showing the influence of different microstructures and hardness levels and their response to single impacts. Results indicate temperature dependence of the occurrence of cracks in hard-phase rich materials, such as Metal Matrix Composites High Speed Steels and the influence of different impact momenta at constant energies on the deformation of different steels. The value of steel produced annually is easily over USD200 billion (Anthony 2010). (Oyenuga 2000), stated that the steels used for construction have been evolving ever since their initial development in the late-1800s

Hence, there is need to study critically the properties of this recycled steel in order to maintain good product production. This work is a comparative study of the chemical composition of locally made steel bars and imported steel bars in comparism to the *Standard Organization of Nigeria* (SON), (Table 1).

2. Methodology

The carbon-manganese steels, whose major alloying elements with iron are carbon and manganese is referred to as carbon steels or mild structural steels. The materials of this type are generally least expensive; they have quite adequate strength and ductility characteristics, and are therefore by far the most widely used grades.

The samples used in this study were 12mm and 16mm diameter reinforced steel bars. Two specimens each of 1m length were collected on each of the diameter. These samples were obtained from two major sources namely: locally produced steel bars and imported steel bars. This is necessary for comparative investigation and analysis. The locally produced reinforced steel bars were obtained from three steel industries namely, IFSM, PSM and PHSM (Ife Iron and Steel (IFSM). Prism Steel rolling mill (PSM"), Pheonix Steel Mill (PHSM). The imported steel sample (IM) was obtained from two different companies.

This means that four (4) specimens were collected from each rolling mill and a total of sixteen specimens (including imported steel) were available to be taken to the laboratory for proper examinations. The chemical analysis of the samples was carried out using Arc Spectrometer (AS). The experimentation was achieved by placing the grinded specimen under the Arc spectrometer. The machine was calibrated and the reading starts from zero.

3.0 Results and Discussion

The elemental composition in each of the samples is presented in Tables 2-9, from the data of laboratory tests carried out, the following observations was graphically deduced. Fig. 1 shows a plot of all the constituent elements in relation to the standard, it is clear that the locally produced and imported steel bars have higher content of carbon compared to the standard (STAND) in Fig 1, with an exception to IM12 of Carbon value, (0.377) and PSM12 of carbon value (0.416), which is slightly higher in relation to the standard value of carbon, 0.35. However, according to MIT Department, (1999) Design of Steel Structures. It is stated that next to iron, carbon is by far the most important chemical element in steel. Increasing the carbon content produces a material with higher strength and lower ductility. Structural steels, therefore, have carbon contents between 0.15 to 0.30 percent; if the carbon content goes much higher, the ductility will be too low, and for magnitudes less than 0.15 percent the strength will not be satisfactory. In other words, the locally produced steel bars can be said to be as good as the imported ones. It is evident from Figs 2 and Fig 3 that the elements follow the same trend and are consistent in form. It is noteworthy to see from Fig. 2 and Fig. 3 that the 12mm diameter steel bar conform with the standard with respect to carbon compared to the 16mm diameter steel bars.

Table 1: CONSTITUENT MATERIALS MAKING UP A REINFORCING BAR

ELEMENT	GRADE 230	GRADE 420
Carbon (C)	0.35	0.35
Silicon (Si)	0.25	0.30
Manganese (Mn)	0.80	1.20
Phosphorus (P)	0.04	0.04
Sulphur (S)	0.04	0.04
Copper (Cu)	0.25	0.25
Aluminum (Al)	0.10	0.10

Source: Standard Organization of Nigeria (SON)

Table 2: Chemical Composition (%) Result for PSM 12mm Steel Bar Sample

X	C(%) 0.416	Si(%) 0.366	Mn(%) 0.82	P(%) 0.067	S(%) 0.067	Cr(%) 0.145	Ni(%) 0.103	Mo(%) 0.0032	Al(%) 0.0034
X	Cu(%) 0.241	Cu(%) 0.0071	Ti(%) 0.0012	Nb(%) 0.0060	V(%) 0.0026	W(%) 0.0029	Pb(%) 0.0019	B(%) 0.0049	Sn(%) 0.027
X	Zn(%) 0.0074	As(%) <0.0001	Bi(%) 0.0010	Ca(%) 0.0026	Ce(%) 0.0026	Zr(%) 0.0012	La(%) <0.0012	Fe(%) 97.7	

Table 3: Chemical Composition (%) Result for PSM 16mm Steel Bar Sample

X	C(%) 0.112	Si(%) 0.149	Mn(%) 0.58	P(%) 0.071	S(%) 0.060	Cr(%) 0.186	Ni(%) 0.118	Mo(%) 0.0088	Al(%) 0.009
X	Cu(%) 0.256	Cu(%) 0.0079	Ti(%) <0.0001	Nb(%) 0.0049	V(%) 0.0055	W(%) <0.0001	Pb(%) <0.0001	B(%) 0.0021	Sn(%) 0.018
X	Zn(%) 0.0019	As(%) <0.0001	Bi(%) 0.0010	Ca(%) 0.0032	Ce(%) 0.0023	Zr(%) 0.0001	La(%) 0.0004	Fe(%) 98.4	

Table 4: Chemical Composition (%) Result for IFSM 12mm Steel Bar Sample

X	C(%) 0.321	Si(%) 0.251	Mn(%) 0.67	P(%) 0.062	S(%) 0.055	Cr(%) 0.136	Ni(%) 0.106	Mo(%) 0.0029	Al(%) 0.0058
X	Cu(%) 0.272	Cu(%) 0.0076	Ti(%) 0.0012	Nb(%) 0.0056	V(%) 0.0020	W(%) <0.0001	Pb(%) <0.0001	B(%) 0.0027	Sn(%) 0.017
X	Zn(%) 0.0067	As(%) <0.0001	Bi(%) 0.0011	Ca(%) 0.0026	Ce(%) 0.0023	Zr(%) 0.0002	La(%) 0.0004	Fe(%) 98.1	

Table 5: Chemical Composition (%) Result for IFSM 16mm Steel Bar Sample

X	C(%) 0.277	Si(%) 0.319	Mn(%) 0.72	P(%) 0.069	S(%) 0.057	Cr(%) 0.138	Ni(%) 0.115	Mo(%) 0.0052	Al(%) 0.0070
X	Cu(%) 0.285	Cu(%) 0.0099	Ti(%) 0.0010	Nb(%) 0.0055	V(%) 0.0026	W(%) 0.023	Pb(%) 0.0010	B(%) 0.0048	Sn(%) 0.022
X	Zn(%) 0.0055	As(%) 0.0004	Bi(%) 0.0008	Ca(%) 0.0025	Ce(%) 0.0027	Zr(%) 0.0005	La(%) <0.0001	Fe(%) 97.9	

Table 6: Chemical Composition (%) Result for PHSM 12mm Steel Bar Sample

X	C(%) 0.334	Si(%) 0.221	Mn(%) 0.60	P(%) 0.077	S(%) 0.058	Cr(%) 0.096	Ni(%) 0.105	Mo(%) 0.0027	Al(%) 0.0038
X	Cu(%) 0.274	Cu(%) 0.0077	Ti(%) 0.0010	Nb(%) 0.0046	V(%) 0.0007	W(%) 0.0048	Pb(%) 0.0018	B(%) 0.0021	Sn(%) 0.024
X	Zn(%) 0.011	As(%) <0.0001	Bi(%) 0.009	Ca(%) 0.0006	Ce(%) 0.0023	Zr(%) 0.0005	La(%) 0.0001	Fe(%) 98.2	

Table 7: Chemical Composition (%) Result for PHSM 16mm Steel Bar Sample

X	C(%) 0.194	Si(%) 0.245	Mn(%) 0.61	P(%) 0.043	S(%) 0.049	Cr(%) 0.264	Ni(%) 0.104	Mo(%) 0.013	Al(%) 0.0019
X	Cu(%) 0.245	Cu(%) 0.0055	Ti(%) <0.0001	Nb(%) 0.0058	V(%) 0.0069	W(%) <0.0001	Pb(%) <0.0001	B(%) 0.0020	Sn(%) 0.011
X	Zn(%) 0.0018	As(%) <0.0001	Bi(%) 0.0010	Ca(%) 0.0002	Ce(%) 0.0023	Zr(%) 0.0002	La(%) 0.0001	Fe(%) 98.2	

Table 8: Chemical Composition (%) Result for IM 12mm Steel Bar Sample

X	C(%) 0.377	Si(%) 0.227	Mn(%) 0.62	P(%) 0.076	S(%) 0.077	Cr(%) 0.147	Ni(%) 0.114	Mo(%) 0.0023	Al(%) 0.0060
X	Cu(%) 0.319	Cu(%) 0.0086	Ti(%) 0.0010	Nb(%) 0.0054	V(%) 0.0020	W(%) 0.0096	Pb(%) 0.0024	B(%) 0.0034	Sn(%) 0.029
X	Zn(%) 0.0079	As(%) <0.0001	Bi(%) 0.0009	Ca(%) 0.0049	Ce(%) 0.0028	Zr(%) 0.0007	La(%) <0.0001	Fe(%) 98.0	

Table 9: Chemical Composition (%) Result for IM 16mm Steel Bar Sample

X	C(%) 0.244	Si(%) 0.294	Mn(%) 0.70	P(%) 0.045	S(%) 0.058	Cr(%) 0.111	Ni(%) 0.106	Mo(%) 0.0011	Al(%) <0.0001
X	Cu(%) 0.246	Cu(%) 0.0061	Ti(%) <0.0001	Nb(%) 0.0045	V(%) 0.0028	W(%) <0.0001	Pb(%) <0.0001	B(%) 0.0016	Sn(%) 0.014
X	Zn(%) 0.0043	As(%) <0.0001	Bi(%) 0.0010	Ca(%) 0.0006	Ce(%) 0.0020	Zr(%) <0.0001	La(%) <0.0001	Fe(%) 98.1	

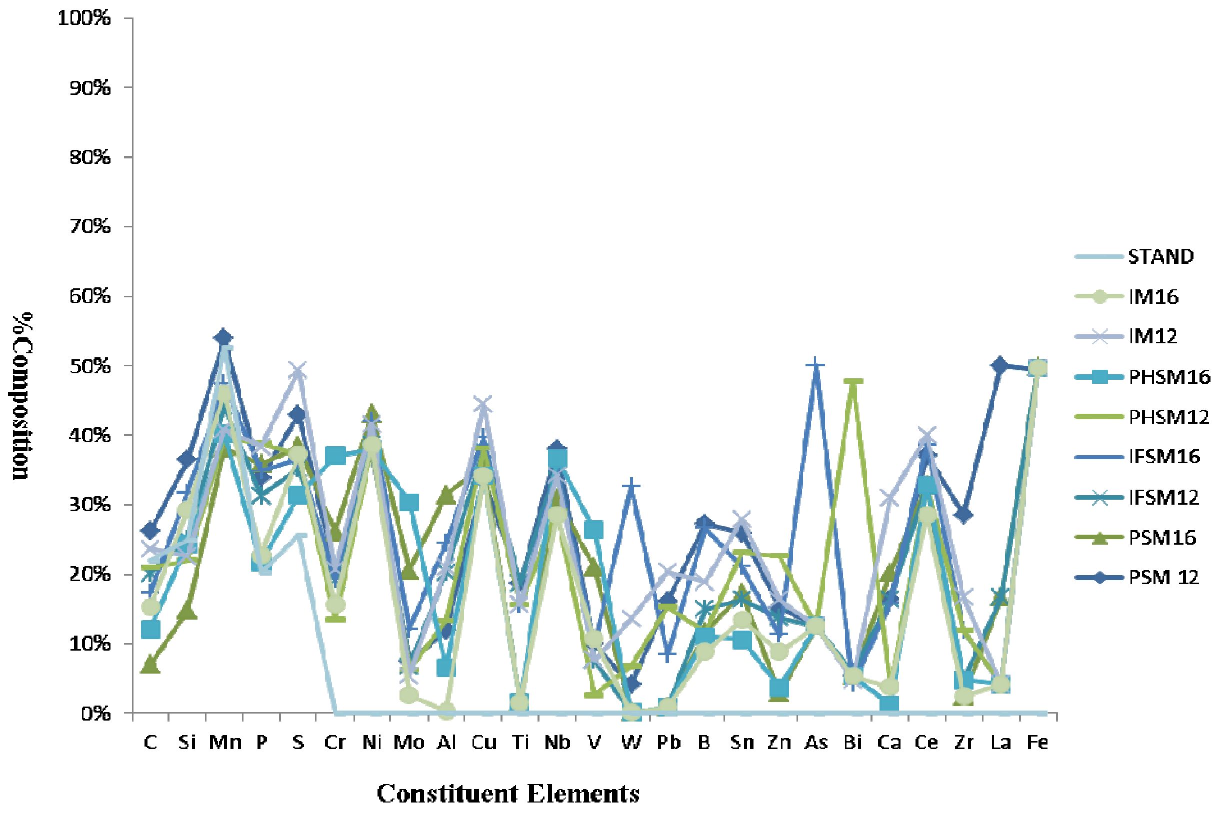

Fig 1: Chemical Constituents of Imported and Locally Produced Steel bars in Relation to Standard (STAND)

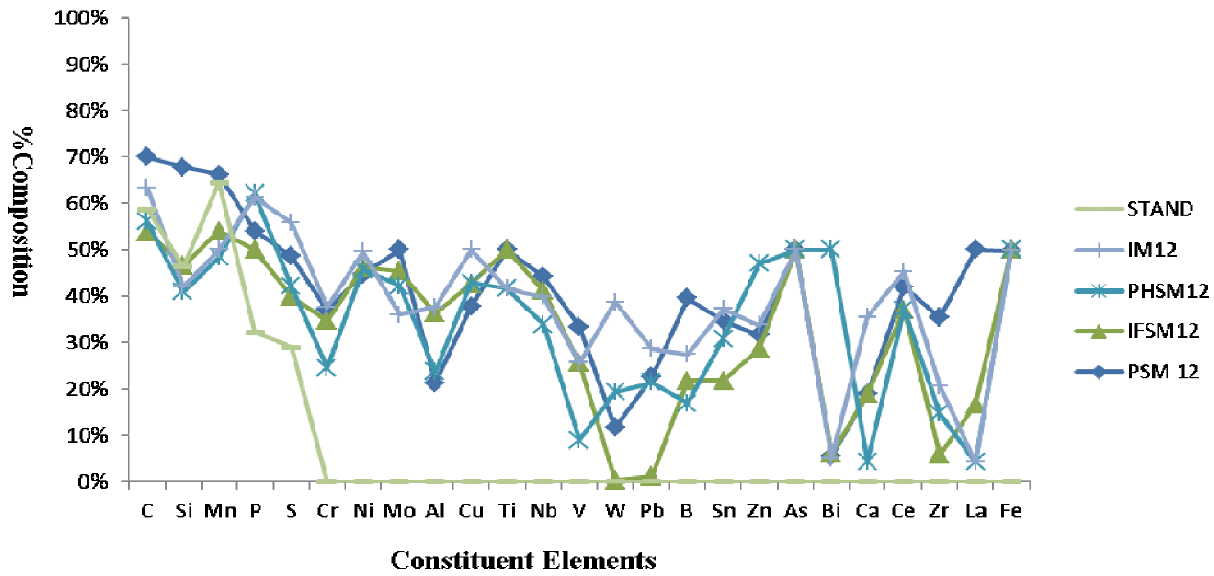

Fig. 2: Chemical Constituents of Imported and Locally Produced Steel bars of Diameter (12mm) in Relation to Standard (STAND)

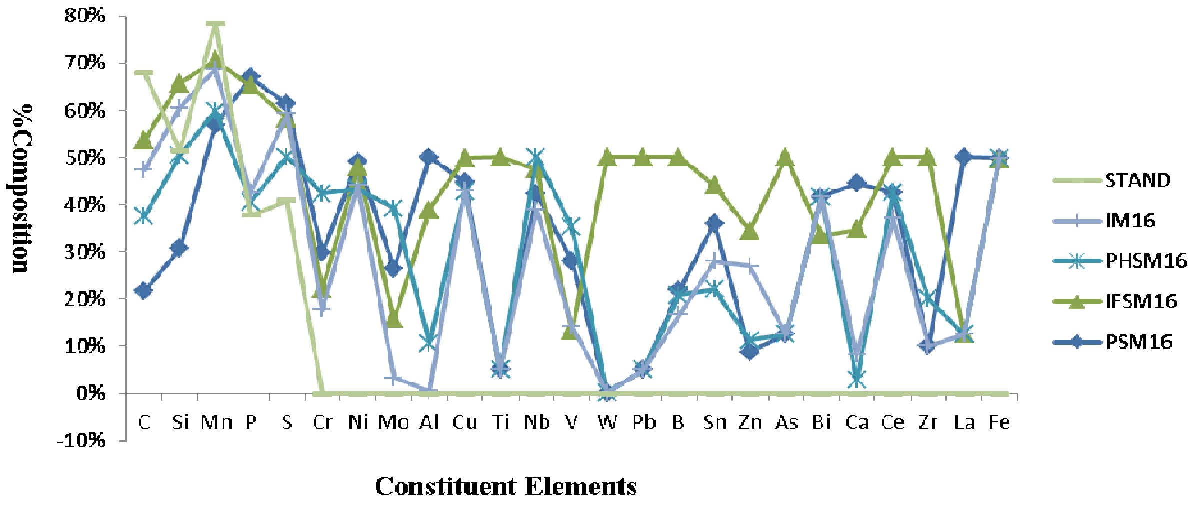

Fig 3: Chemical Constituents of Imported and Locally Produced Steel bars of Diameter (16mm) in Relation to Standard (STAND)

4.0 Conclusions

All the three indigenous steel companies investigated use scraps as their major raw material. This is because it is economically advantageous since currently there is no functional steel making industry in the country. The results of the chemical analysis revealed that all the steel samples including the imported steel contain more or lesser carbon than those recommended by the standard organization of Nigeria. Other alloying elements were found to be in relevant traces. However, copper and manganese were found to be in proportions that are relevant to producing adequate yield and tensile strengths.

References

Anthony Nkem Ede. (2010), Building Collapse in Nigeria, International Journal for Civil and Environmental Vol. 10 No. 0632.

Balogh . T and L. G. Vigh. (2013), Cost Optimization of Concentric Braced Steel Building Structures. World Academy of Science, Engineering and Technology. Vol. 78, Pp. 06-21.

Gilchrist, J.D. and Thomas M.T. (1879), Extraction Metallurgy. 3rd Edition, Pregamon Press, Oxford UK.

Harald Rojacz, Markus Varga, and Horst Winkelmann. (2013), Deformation Mechanisms at Elevated Temperatures: Influence of Momenta and Energy in the Single Impact Test. World Academy of Science, Engineering and Technology. Vol. 77, Pp. 05-23

MIT Department of Civil and Environmental Engineering, (1999). Design of Steel Structures. Pp 1-2

NIS 117 – 1992, (1992), Specification for steel bars for reinforcement of concrete. Nigerian Industrial Standards Organization of Nigeria (SON) Abuja, Nigeria.

Oyenuga V.O. (2000), Design of Reinforcement Concrete; Longman Publisher; Nigeria Report Coordinated by the United Nations Environmental Programme (2002) At Johannesburg, South Africa.

Yeon Tak Kim, Jong Pil Yun, Boyeul Seo, Youngsu Park, and Sang Woo Kim. (2007), A Classification Algorithm for Steel Bar in Coil using Wavelet Transform. World Academy of Science, Engineering and Technology. Vol. 9, Pp. 09-23.