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Fabrication, Microstructure, Hardness and Magnetic Properties of (W:Ti)C-Ni Cemented Carbides using Atomized Ni Powder

By Amal. A. Abd-Elghany, Walid M. Daoush, Omayma A. El-Kady,
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Abstract- (W:Ti)C cemented carbides with different Ni content fabricated by powder metallurgy technique were investigated. The Ni powder which used as a metal binder of the (W:Ti)C-Ni abrasive particles was fabricated by water atomization technique by means of induction furnace. A Ni powder of a cubical particle shape with average particle size of 2-20 μm was obtained. Six (W:Ti)C-Ni compositions with Ni contents of 5, 10, 15, 20, 25 and 30 wt.% were prepared by mechanical milling of the obtained atomized Ni powder with the abrasive (W:Ti)C particles followed by cold compaction at 600 MPa and vacuum sintering at 1450oC. Dense (W:Ti)C-Ni cemented carbides were obtained with a relative density of up to 94% with 30 wt% Ni.

Keywords: *water atomization; sintering, (W:Ti)C-Ni cemented carbides; hardness; magnetic properties.*

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Fabrication, Microstructure, Hardness and Magnetic Properties of (W:Ti)C-Ni Cemented Carbides using Atomized Ni Powder

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& Ahmed E. El-Nikhaily[¥]

Abstract- (W:Ti)C cemented carbides with different Ni content fabricated by powder metallurgy technique were investigated. The Ni powder which used as a metal binder of the (W:Ti)C-Ni abrasive particles was fabricated by water atomization technique by means of induction furnace. A Ni powder of a cubical particle shape with average particle size of 2-20 μm was obtained. Six (W:Ti)C-Ni compositions with Ni contents of 5, 10, 15, 20, 25 and 30 wt.% were prepared by mechanical milling of the obtained atomized Ni powder with the abrasive (W:Ti)C particles followed by cold compaction at 600 MPa and vacuum sintering at 1450°C. Dense (W:Ti)C-Ni cemented carbides were obtained with a relative density of up to 94% with 30 wt% Ni. The hardness of the dense (W:Ti)C-30 wt.%Ni was greater than the hardness of other different compositions; The magnetic properties, which were measured at an applied field of 2tesla, indicate that the (W:Ti)C-Ni cemented carbides have ferromagnetic properties with a higher mass saturation magnetization with higher nickel content.

Keywords: water atomization; sintering, (W:Ti)C-Ni cemented carbides; hardness; magnetic properties.

1. INTRODUCTION

Cemented carbides are used as oxygen-free ceramics in high temperature engineering applications due to its properties like, high melting temperature, hardness, elastic moduli, wear resistance, electric conductivity and high-temperature strength. Cemented carbides are also widely applied as a base of hard metals. Applications of cemented carbides include structural, heating and reflecting functions as well as tool materials in composition with other refractory compounds [1]. The compacted products of these compounds are made by powder metallurgy technology where sintering methods are of decisive importance.

In General; cemented carbides are composite materials, which consist of hard refractory carbides

containing metals of the transition groups IV, V and VI (such as WC, TiC, TaC, NbC) embedded in a tough metal binder phase like nickel or cobalt which are by far the dominating binder metals employed due to its excellent wetting to WC and its good thermo-mechanical properties [2-4].

(W,Ti)C has a high melting point and high hardness than the commercial WC. In this regard, the transition metal carbide is primarily used in cutting tools and as an abrasive material as a single phase or in composite structures. In the case of cemented (W,Ti)C, Co or Ni is added as a binder for the formation of composite structures[5-9].

There are two basic ways of obtaining cemented carbide: through melt-solidification processing at about 2000-2500 °C or by powder metallurgy processing at a temperature range of 1350-1500 °C. Fabrications of WC as well as TiC in metal-base alloys have been studied from both theoretical and practical points of view. However, the production of (W:Ti)C in metal matrices has received little attention. The comparatively light TiC particles may float during the preparation by conventional melting and casting route. A large difference in density between TiC and the metal matrix melt-results segregation in metal ingot. The (W:Ti)C as reinforcements in nickel, cobalt and iron alloy melts may be more appropriate because its density (6.66 g/cm³ for (Ti_{0.75}:W_{0.25})C [10] and 9.1 g/cm³ for (Ti_{0.5}:W_{0.5})C [11]) is higher than that of TiC (4.25 g/cm³) and close to that of iron melt(7.8 g/cm³). The hardness of (Ti_{1-x}:W_x)C (19-21 GPa) [12] is more or less the same as that of TiC (18-23 GPa) [13]. However, the fracture toughness of (Ti_{1-x}:W_x)C (6.4-7.7 MPa m^{1/2}) [14] is higher than that of TiC (3.5-4.3 MPa m^{1/2}) [15, 16] and this may result better mechanical properties of the (Ti_{1-x}:W_x)C-reinforced composite compared to those of the TiC-reinforced composite.

The sintering step in the powder metallurgy process is the main determine step among the forming processes. It can be evaluated by measuring the mechanical properties like hardness and physical properties like density and magnetic properties of the sintered product. Magnetic data shows some interesting relations between the physical properties, such as

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relations between the physical properties, such as density, and the mechanical properties such as hardness. There is interdependence between the mass saturation magnetization, M_s , and the coercive force, H_c , both of which frequently occur in an inverse relation. M_s is mostly related to the amount of magnetic material present, whereas H_c appears to be strongly influenced by the interaction between the particles and the density or between the porosity and the grain size of the carbide phase [17, 18].

In this work, cold compaction and vacuum sintering of (W:Ti)C cemented carbides samples with different binder content of a homemade water atomized Ni powder were occurred. The densification and properties of the prepared cemented carbide samples were characterized by microstructure investigations based on measurements of magnetic and mechanical properties.

II. EXPERIMENTAL

Elemental powder of Ni was prepared by atomization technique. Nickel powder was prepared by induction melting in graphite crucibles in air by superheated up to 1700°C and bottom pouring through a ceramic melt delivery nozzle of 6 mm diameter into a confined water atomizer operating at a pressure of 20 MPa. The high-pressure water jets were directed against the molten stream. The melt flow rate, estimated from the operating time and weight of the atomized melt, was about 4 kg/min. The water flow rate, calculated from the water consumption rate, was about 200 l/min. Table 1 list the atomization conditions adapted for Ni powder fabrication process. The size distribution of the Ni powder particles was measured by conventional mechanical sieving, and sieved powders with a specific size range of 20 μm and 1 μm were chosen for this investigation.

Table 1: Water atomization parameters adapted for Ni powder fabrication process.

Parameter	Condition
Pouring temperature, °C	1700
Nozzle angle	35°
Nozzle diameter, mm	6
Number of water jets	4
Molten stream flow rate, kg/min.	4
Water pressure, MPa	20
Water flow rate, l/min.	200
Water velocity, m/s	90

(W:Ti)C powder with a particle size ranged from 2-20 μm with WC: TiC ratio of 1:1 was supplied from HC. Starck Co., Germany.

The produced atomized Ni and (W:Ti)C powders were used to prepare six samples with compositions of 5 wt.%, 10 wt.%, 15 wt.%, 20 wt.%, 25 wt.%, and 30 wt.% of a Ni binder mixed with (W:Ti)C by means of Agate mortar for 30 min. After the different

compositions were prepared, they under went cold compaction at 600 MPa in a uniaxial hydraulic pressing machine, where they were compressed into a cylindrical shape.

The cold compacts were sintered in a vacuum furnace at 10⁻³torr with graphite heating elements and at a heating rate of 5 °C/min in accordance with the sintering cycle shown in Fig1. The samples were heated at 120 °C for 2 h to dry any moisture content, and the temperature was then raised to 750 °C for one hour to expel any gases embedded in the pores. The temperature was raised again to 1450 °C for one hour to start the sintering process. Finally, the furnace was turned off and the sintered compacts were cooled for 8 h by means of a water cooling system.

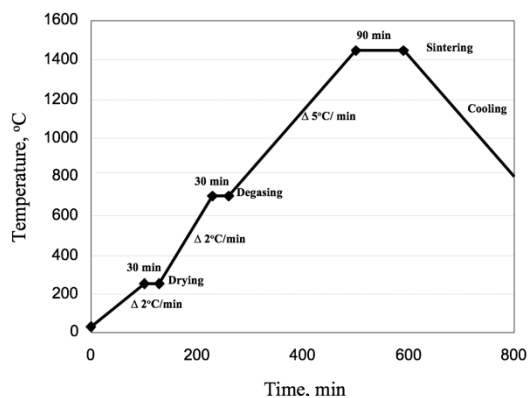


Figure 1: Heating cycle for the vacuum sintering process of (W:Ti)C–Ni cemented carbides at 1450 °C.

The dimensions of the cold compacts were measured before and after sintering to calculate the green, the sintered and the relative densities. The sintered samples were mounted and ground with 800, 1000, and 1200 grit SiC paper, respectively, and then polished with 3 μm diamond paste. To investigate the microstructure of each phase as well as the compositional analysis of the carbide and liquid phase binder, scanning electron microscope (SEM, model: JEOL, JSM-5410) is used to take SEM micrographs and EDAX-SEM were used. The phases in the specimens were analyzed by means of X-ray diffraction (XRD), for which purpose we used a Cu Ka source and a x-ray diffract meter of the model x:pert PRO PAN analytical with Cu k α radiation ($\lambda=0.15406\text{nm}$) diffract meter. The magnetic properties of samples were measured using vibrating sample magnetometer (model DEAS/FDD-2) in which the samples were vibrated at a constant frequency between a set of sense coils. As the magnetic field is varied through a specified range up to 2 Tesla, the magnetic moment of the sample is measured by the sense coils with a lock-in amplifier. The dependency between the magnetization and magnetic field (hysteresis loop) for the prepared samples was measured. Because the saturation magnetization changes with weight of the sample, the results were

divided by sample's weight. The magnetization values were expressed using the magnetic moment per gram (emu/g). The measured properties included saturation magnetization (M_s), coercivity (H_c) and remnant magnetization (M_r). The hardness was measured with a Vickers hardness tester of the model Indentec 5030 SKG. The load was selected at 30 kgf. The test was repeated five times at different points in each sample, the average being reported.

III. RESULTS AND DISCUSSION

Fig. 2(a) shows the typical SEM morphology of the as received (W:Ti)C powder. The particle shape of the as received powders was mostly irregular and had a rough surface morphology. Fig. 2(b) shows the typical optical morphology of the as atomized Ni powder. The particle shape of the as-solidified powders was mostly cubic to irregular and had a rough surface morphology. Fig. 2(c, d) shows the typical optical morphology of the admixed powder.

XRD analysis of the produced atomized Ni powder, as received (W:Ti)C as well as the admixed (W:Ti)C-Ni are shown in Fig. 3. It was observed from the results that the produced atomized Ni powder as well as the (W:Ti)C were composed only of its constituents without any foreign inclusions. On the other hand the admixed (W:Ti)C-Ni contains only the elemental constituents of the used powders. Fig. 4 shows the XRD pattern of the sintered (W:Ti)C-Ni composite at 1450°C by vacuum sintering. The results indicate the presence of (W:Ti)C and Ni in the sintered cemented carbides, meaning that the presence of a solid solution between WC and TiC at 1450°C. This is in good agreement with the equilibrium WC-TiC binary phase diagram [19]. Since there is almost no Ti solubility predicted in WC up to 2000°C, (W:Ti)C is close to pure WC and (Ti_{0.55}W_{0.45})C in composition.

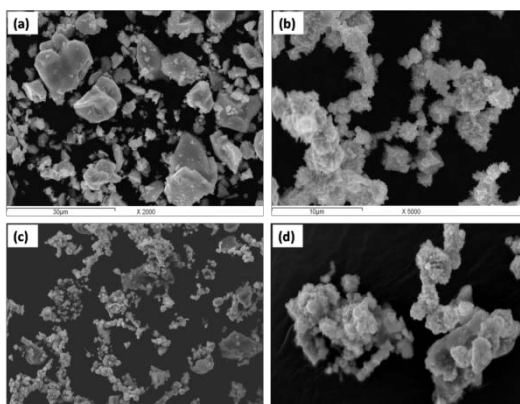


Figure 2: SEM Images for the investigated powders; where a) as received (W:Ti)C, b) the prepared atomized Ni

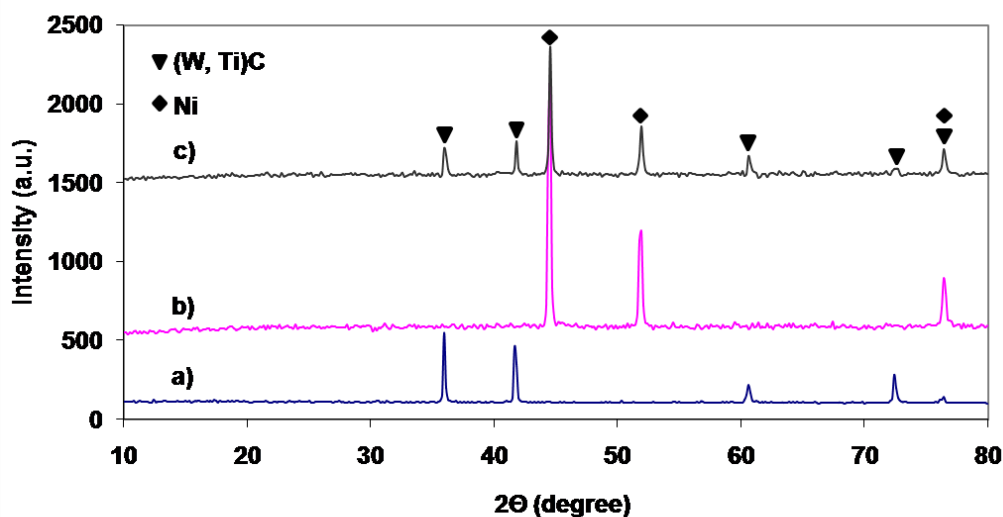


Figure 3: XRD pattern for the investigated powders, where: (a) as received (W,Ti)C, (b) atomized Ni and (c) admixed (W:Ti)C-30wt%Ni.

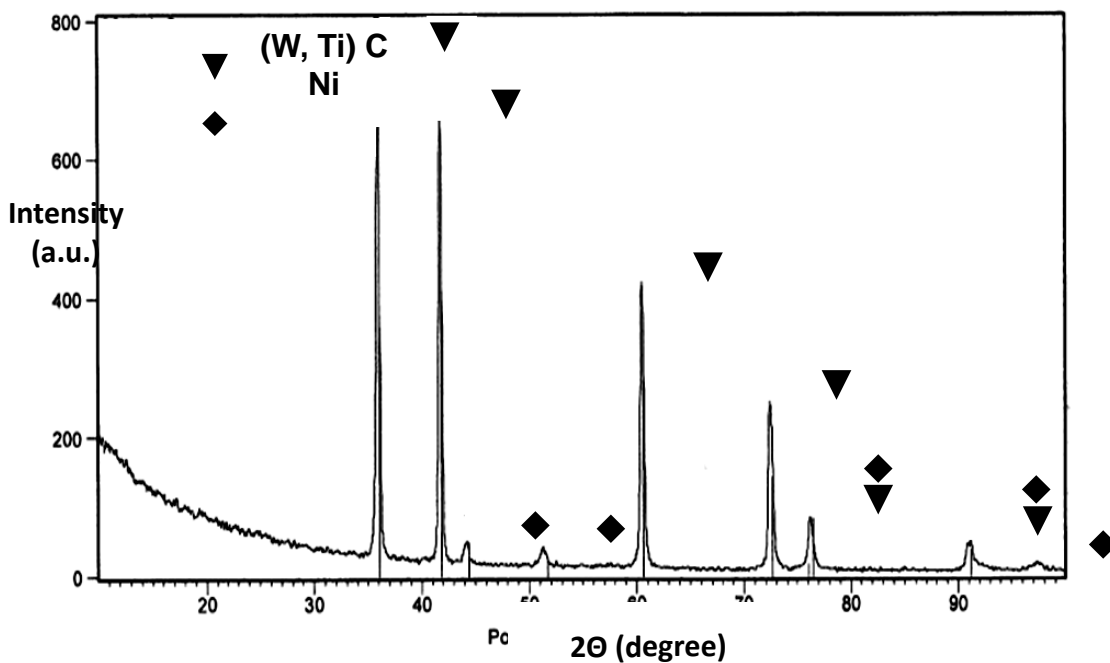


Figure 4: XRD pattern for the produced (W:Ti)C-20wt%Ni cemented carbide by vacuum sintering at 1450°C for 1h.

The maximum attainable densification of the obtained (W:Ti)C-Ni cemented carbides are due to the particles rearrangement is influenced by different parameters, such as the amount of liquid present, the particle size, the contact angle, and the solubility of the solid in the liquid. Fig.5 shows the results of the micro structural investigation with respect to the different metal binder content for (W:Ti)C-Ni. We can see, firstly, that the porosity of the materials decreases as the Ni content increases. However, when the Ni content is high, the Ni metal binder prevents the coalescence of the carbide particles, producing a more uniform and finer grain structure. In other words, all the carbide grains are

separated by a layer of the nickel metal binder and consequently produce a normal grain growth [20-23].

The results of the high resolution SEM and the composition analysis (EDAX), as shown in Fig.6, clearly reveal that the (W:Ti)C particles have a rounded morphology with a carbide core/rim structure. This morphology is formed when the carbide particles are dissolved in the Ni liquid and re-precipitated on the large carbide grains, where they cause grain coarsening, called Ostwald ripening [24,25].

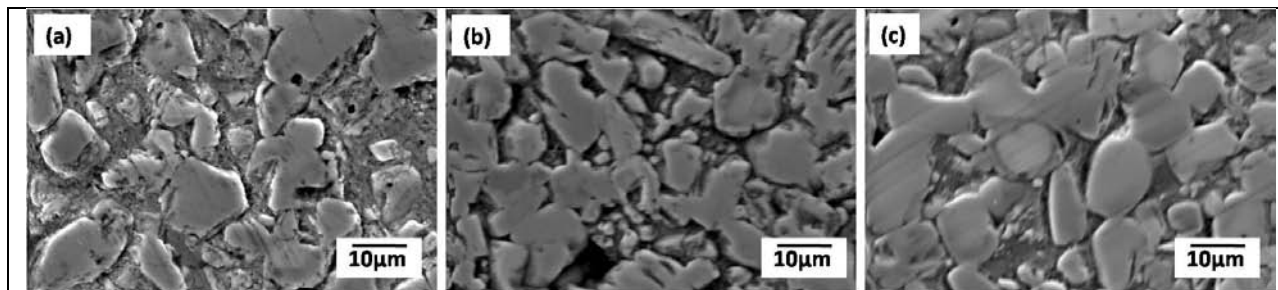


Figure 5: SEM micrographs of the cross-sectional (W:Ti)C-Ni cemented carbides samples sintered at 1450°C, where; for (a) (W:Ti)C-10 wt%Ni, (b) (W:Ti)C-20 wt%Ni, and (c) (W:Ti)C-30 wt%Ni.

According to the EDAX analysis, the estimated chemical composition of the (W:Ti)C-Ni cemented carbides, which is shown in Fig.6c which is the carbide rim, (W:Ti)C-Ni has an estimated chemical composition of $(W_{25.67}:Ti_{40.6})C_{1.73}Ni_{31.00}$ with a Ti/W ratio of 1.6. As a result of the significant difference in the way the two

phases form cemented carbides. One can show from the data of the measured density as shown in Fig.7 that by increasing the Ni binder content the density of the obtained (W:Ti)C-Ni cemented carbides were increased up to 95% in case of the (W:Ti)C-30wt%Ni.

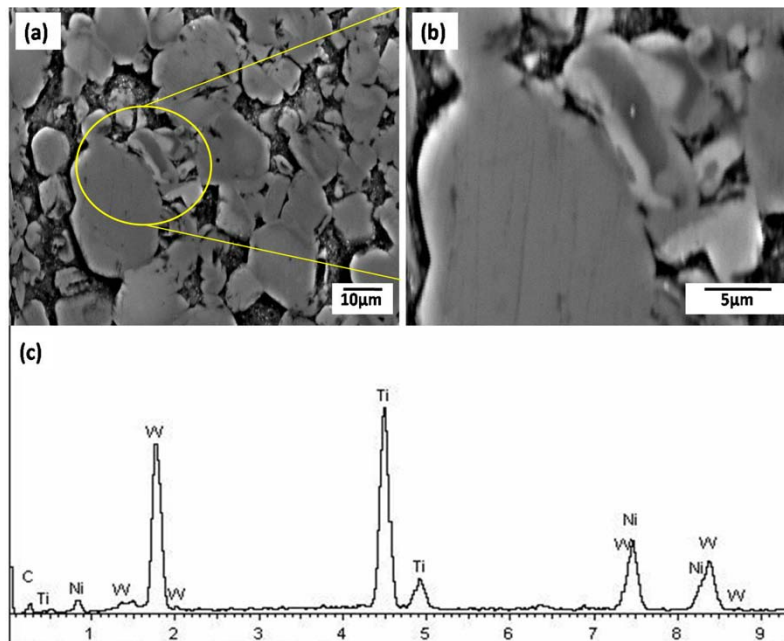


Figure 6: SEM micrographs with different magnifications and a typical compositional EDAX analysis for the cross-sectional area of the produced (W:Ti)C–30 wt. % Ni cemented carbides.

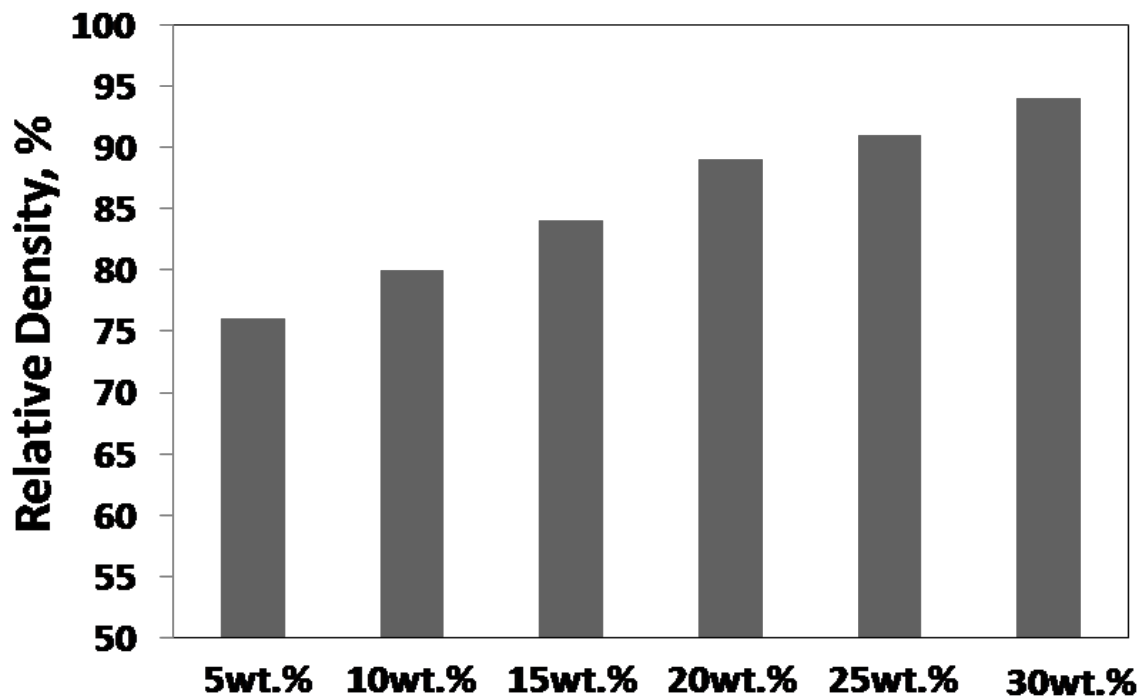


Figure 7: Effect of the Ni metal binder composition on the relative density of the produced (W:Ti)C–Ni cemented carbides by vacuum sintering at 1450°C for 1h.

Fig.8 shows the results of the measured hardness of the obtained (W:Ti)C–Ni cemented carbides indicated that the exact character of the microstructure has a critical influence on the resultant hardness. The in-situ hardness of nickel, namely 440, is much higher than the typical values of 240 for bulk nickel. This difference is

explained by the solid solution of W, Ti and C in the liquid phase binder and by the complex stress state resulting from the different thermal expansion coefficients of nickel and W, Ti and. The compositional analysis confirms that the hardening effect of nickel is due to the solid solution of Ti in the Ni binder. Moreover,

due to the solubility of WC in the TiC forming (W:Ti)C phase, the hardness value of the (W:Ti) C phase is 2530, which is higher than the micro-hardness value of the WC (1300) and lower than that of the TiC (3200). Fig. 9 also shows increasing in the hardness by increase the metal binder content. This result can be discussed due to the

densification effect. By increasing the metal binder content the porosity was decreased, the densification was increased and as a result the hardness increased and by increasing the Ni binder content which has lower hardness than the carbide phase [26].

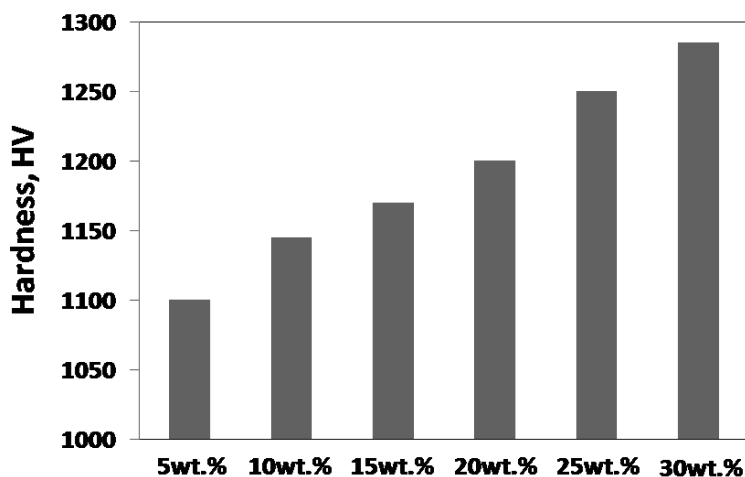


Figure 8: Effect of the Ni metal binder composition on the hardness of the produced (W:Ti)C–Ni cemented carbides by vacuum sintering at 1450°C for 1h.

The measured M–H hysteresis loops are shown in Fig. 10. The value for the mass saturation magnetization (M_s) of the obtained (W:Ti)C–Ni series at 2 Tesla as shown in Fig. 11 is lower than the absolute saturation of 54.8 emu/g for the nickel [27]. The volume fraction of liquid phase of nickel binder affects the magnetic properties. The magnetic saturation values reveal the presence of the ferromagnetic Ni phase, which intensifies as the Ni content rises, 9 emu/g for (W:Ti)C–30wt%Ni. Three factors can contribute to the lower readings in the M_s of the obtained (W:Ti)C–Ni cemented carbides: first, the ratio of the fcc phases to the hcp phases; second, the lower saturation magnetization caused by any residual tungsten, Ti or C

that are separated or combined in a solution; and, third, the presence of carbide grains, which act as magnetic voids where opposing magnetic fields can occur and in turn reduce the saturation magnetization values [28:29]. Fig. 12 illustrates the influence of the Ni binder on the coercivity (H_c). First, the coercivity decreases with increasing the metal binder content. Second, the sinter ability increases and the porosity decreases, thereby decreases the particle–particle interactions and decreasing the coercivity of the materials because of the porosity values of the (W:Ti)C–Ni, and by decreasing the porosity the particle–particle interaction was decreased and the coercivity decreased [30-33].

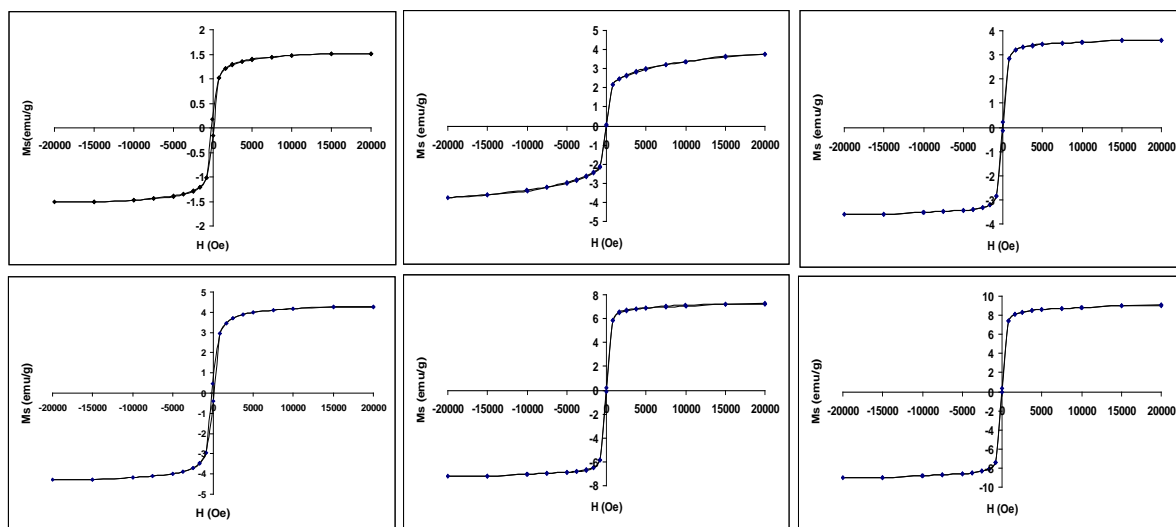


Figure 9: M–H hysteresis loops of the (W:Ti)C–Ni cemented carbides measured at 2 T for (a) (W:Ti)C–5 wt%Ni, (b) (W:Ti)C–10 wt%Ni, (c) (W:Ti)C–15 wt%Ni, (d) (W:Ti)C–20 wt%Ni, (e) (W:Ti)C–25 wt%Ni and (f) (W:Ti)C–30 wt%Ni.

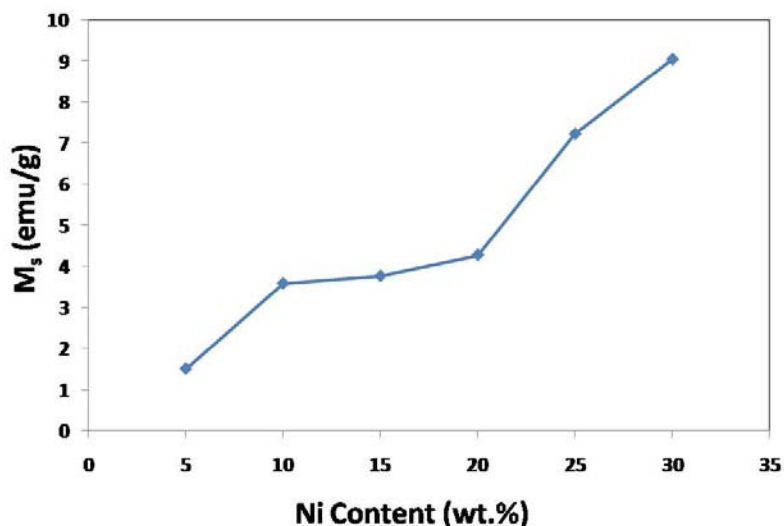


Figure 10: Effect of the Ni binder composition on the saturation induction (M_s) of (W:Ti)C-Ni cemented carbides.

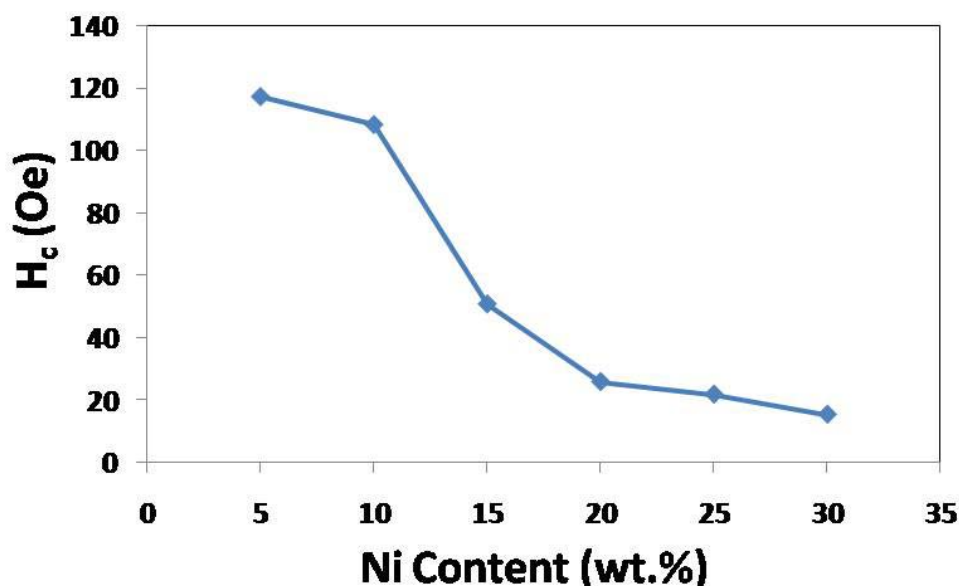


Figure 11: Effect of the Ni binder composition on the coercivity (H_c) of (W:Ti)C-Ni cemented carbides.

IV. CONCLUSION

The microstructure, hardness and magnetic properties of (W,Ti)C-Ni cemented carbides were investigated. The (W:Ti)C cemented carbides were consolidated with a water atomized Ni as the liquid phase binder by using the vacuum liquid phase sintering at 1450°C. The major results are summarized as follows:

1. A pure nickel powder can be fabricated by water atomization technique. The obtained nickel powder has a fine particle size and can be used as a metal binder for the (W:Ti)C particles.
2. As the nickel binder content in the (W:Ti)C-Ni increases, the density and the hardness values increases.
3. The measured mass saturation magnetization of the (W:Ti)C-Ni cemented carbide sat 2 Teslaincreases

as the Ni binder content increases, indicating the ferromagnetic nature of the materials at high field strength. As well as, the magnetic coercivity measurements indicate that the coercivity increases with increasing the porosity.

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Prioritizing of Reverse Logistic Implementation Factor: A Case Study on Electronics Industries

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Abstract- The reverse logistics (RL) try to discover to assist the return of consumer supplies or its ingredient materials in the production phase. Nowadays reversed logistics has been achieved more attention in supply chain management. Political, economic, green image and social responsibility etc. influence firms to develop strategies to their current systems because, substitute uses of resources must be promoted that may be cost-effective and ecology friendly by extending products' routine life cycles in the turbulent business environment. Reverse logistics activities i.e. storing, transporting and handling of used products poses a great challenge to reverse logistics managers as there is always chances of uncertainty in terms of quantity, quality and timing of return of end of life (EOL) products. This approach intends to investigate the going over dynamics of reversed logistics implementation based on survey opinion polls for Walton electronics industry by a real life case study. Fuzzy Analytic Hierarchy Process (FAHP) was selected for identify the vital gauges from different companies' professionals of confirmation and electronics firms to do the related ecofriendly management work. The priortization of each factor has been obtained. The overall weights and performance ranking of the evaluation criteria have been shown by the result of this study with respect to the reverse logistics implementation.

GJRE-G Classification: FOR Code: 290502p



PRIORITIZING OF REVERSE LOGISTIC IMPLEMENTATION FACTOR CASE STUDY ON ELECTRONICS INDUSTRIES

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Prioritizing of Reverse Logistic Implementation Factor: A Case Study on Electronics Industries

Nusrat Hossain Zerin^α & Dewan Maisha Zaman^ο

Abstract- The reverse logistics (RL) try to discover to assist the return of consumer supplies or its ingredient materials in the production phase. Nowadays reversed logistics has been achieved more attention in supply chain management. Political, economic, green image and social responsibility etc. influence firms to develop strategies to their current systems because, substitute uses of resources must be promoted that may be cost-effective and ecology friendly by extending products' routine life cycles in the turbulent business environment. Reverse logistics activities i.e. storing, transporting and handling of used products poses a great challenge to reverse logistics managers as there is always chances of uncertainty in terms of quantity, quality and timing of return of end of life (EOL) products. This approach intends to investigate the going-over dynamics of reversed logistics implementation based on survey opinion polls for Walton electronics industry by a real life case study. Fuzzy Analytic Hierarchy Process (FAHP) was selected for identify the vital gauges from different companies' professionals of confirmation and electronics firms to do the related eco-friendly management work. The priortization of each factor has been obtained. The overall weights and performance ranking of the evaluation criteria have been shown by the result of this study with respect to the reverse logistics implementation.

I. INTRODUCTION

Electronics industry is introduced in Bangladesh during the post liberalization era. Due to extension of information technology, many Bangladeshi companies start to produce electronics goods and Walton is the first local electronics industry in Bangladesh. Electronics waste or e-waste is the result of this. E-waste can be made profitable and useful by establishing RL system. Reverse logistics means the reuse of products and materials. In reverse logistics system, the source goes at least one step back in the supply chain. Normally in supply chain products move manufacturers to distributors or customers. Any process or management which maintain or continue after the sale of the product called reverse logistics. Defective product can be returned by customer. The manufacturing firm would then have to organize shipping of the defective product, testing the product, dismantling, repairing, recycling or disposing the product. The product would move in reverse through the supply chain network in order to retain any use from the defective product. The logistics for such matters is

Reverse logistics [4] found that effective RL focuses on the back-ward flow of materials to maximize value from returned items and guarantee their proper disposal [1, 5, 6]. However, many companies are not yet ready to implement RL including Walton. Walton Hi-Tech Industries Ltd. has been selected for the study because it has a high consumption volume, and major source of waste generation. Also, this is one of the few sectors which come under e-waste regulations [1, 5, and 6]. A thorough study of CSFs and their ordered implementation is essential for successful RL implementation. The major intention of this study is to understand various CSFs for RL implementation in Walton Hi-Tech Industries Ltd. The identification and prioritization of these factors will help the researchers and the managers in strategic decision making for RL implementation. After review of literature on RL and the opinion of experts, 11 CSFs factors of RL implementation were identified. The experts were asked to rate each of these 11 factors in terms of their importance. A decision matrix was developed from these responses which are used in the application of fuzzy-TOPSIS methodology for prioritizing CSFs [1, 5and 6].

II. METHODOLOGY

Fuzzy TOPSIS algorithm is used for Prioritizing Reverse Logistics Implementation Factors. This algorithm consists of 8 steps. These steps are presented in detail as follows:

Step 1: Collecting the required data containing linguistics terms. A proper scale must be chosen to represent the data. Respondents must be asked to choose the best alternative among the linguistics terms for a given question. Fuzzy numbers for the selected linguistics terms are presented in Table 1.

Table 1: Linguistic terms and corresponding Fuzzy number

Linguistic term	Fuzzy number
Low	(0.0,0.1,0.3)
Fairly low	(0.1,0.3,0.5)
Medium	(0.3,0.5,0.7)
Fairly high	(0.5,0.7,0.9)
High	(0.7,0.9,1.0)

Step 2: The TOPSIS method evaluates the following fuzzy decision matrix.

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$$D = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1j} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2j} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ x_{i1} & x_{i2} & \dots & x_{ij} & \dots & x_{in} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mj} & \dots & x_{mn} \end{bmatrix} \quad (1)$$

Where is a fuzzy number corresponding to the linguistic term assigned by the I the Decision Maker (DM) to the j th factor. $i=1, 2, \dots, m$ are the number of DMs and $j = 1, 2, \dots, n$ are the number of factors (CSFs).

$$V = [v_{ij}]_{m \times n} \quad i = 1, 2, 3 \dots m \text{ and } j = 1, 2 \dots n \quad (3)$$

The weighted normalized value v_{ij} is calculated as

$$\text{Where } [v_{ij}] = r_{ij} * w_j \quad (4)$$

Where w_j is the weight given to each decision maker? $w_i = (1, 1, 1, 1, 1) \forall j \in n$, because all the DMs are considered to have same weight for this study.

Step 5: Determine the ideal and negative-ideal solution for the CSFs

$$A^* = (v_1^*, v_2^*, \dots, v_n^*) \quad (5)$$

$$A^- = (v_1^-, v_2^-, \dots, v_n^-) \quad (6)$$

Since the positive and negative ideas introduced by Chen (1997) are used for the research. The following terms are used for ideal and negative ideal solution.

$$d(A1 - A2) = \sqrt{\frac{1}{3} [(a_2 - a_1)^2 + (b_2 - b_1)^2 + (c_2 - c_1)^2]} \quad (10)$$

Similarly, the separation from the negative ideal solution is given as

$$D_j^- = \frac{\sum_{i=1}^m d(v_{ij} - v_i^-)}{m}, \quad j = 1, 2, n \quad (11)$$

Step 7: Calculate the relative closeness to the ideal solution. The relative closeness with respect to A^* is defined as

$$CC_j = \frac{D_j^-}{D_j^* + D_j^-}, \quad i = 1, 2, \dots, m \quad (12)$$

Step 8: Prioritize the preference order based on the order of the values of C_j .

III. NUMERICAL ANALYSIS

a) Analysis of Critical Factors

Many CSFs are common to all of these studies and these factors can be utilized as base for discussion with expert from Walton Hi-tech Industries Ltd. Eleven CSFs were identified after pertinent literature review including studies discussed in "Introduction" and discussion with the number of experts from the Walton

Step 3: This step includes neutralizing the weight of decision matrix and generating fuzzy un-weighted matrix (R).

To generate R, following relationship can be applied

$$R = [r_{ij}]_{m \times n}, \quad r_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*} \right) \quad (2)$$

Where $c_j = \max_i c_{ij}^*$

Step 4: Calculate the weighted normalized decision matrix

$$v_j^* = (1, 1, 1) \quad (7)$$

$$v_j^- = (0, 0, \text{and } 0) \quad (8)$$

Step 6: Calculate the sum of distances from positive and negative ideal solution for each factor.

$$D_j^* = \frac{\sum_{i=1}^m d(v_{ij} - v_i^*)}{m}, \quad j = 1, 2, \dots, n \quad (9)$$

$D(v_{ij} - v_i^*)$ is the distance between two fuzzy numbers which can be calculated using the vector algebra. For example distance between two numbers $A1(a_1, b_1, c_1)$ and $A2(a_2, b_2, c_2)$ can be calculated as

Hi-tech Industries Ltd. These factors are Total manufacturing cost (C1), Recycling (C2), Environment concern (C3), Recycled volume (C4),

Economic Need (C5), Pressure with stakeholders (C6), Reverse logistics management information syst (C7), Top management awareness (C8), capabilities & skilled workers (C9), Increase of sales volume for new product (C10), Consumer awareness & Social acceptability (C11).

b) Decision Maker Choosing

The fuzzy TOPSIS methodology, presented in this research paper has been evaluated in context of Walton electronics industry. Four experts from electronic companies participated in this study. Profile of the decision makers and their respective organization is given as follows and their respective organization is given as follows:

First decision maker (DM1) is a supply chain manager in Walton electronic industry. Second decision maker (DM2) is a logistics manager in Walton electronic industry. Third decision maker (DM3) is a logistics manager in Walton electronic industry. Fourth decision maker (DM4) is vice president of operations management of same industry.

c) Data Analysis

Table 2: Decision matrix using linguistic variable

Factor	Decision Maker			
	D1	D2	D3	D4
Total manufacturing cost (C1)	FH	M	FL	M
Recycling cost (C2)	FH	M	M	FH
Environment concern(C3)	M	FH	H	M
Recycled volume (C4)	FH	FH	FH	M
Economic Need(C5)	FH	FH	M	H
Pressure with stakeholders (C6)	L	M	L	FL
Reverse logistics management information system(C7)	M	L	M	FH
Top management awareness(C8)	H	H	FH	FH
Process capabilities & skilled workers(C9)	FL	FL	L	FL
Increase of sales volume for new product (C10)	M	M	FL	L
Consumer awareness & Social acceptability (C11)	M	H	M	M

Table 3: Aggregate fuzzy weights for criteria

	Decision Makers			
	D1	D2	D3	D4
C1	(.5,.7,.9)	(.5,.7,.9)	(.1,.3,.5)	(.3,.5,.7)
C2	(.5,.7,.9)	(.3,.5,.7)	(.3,.5,.7)	(.5,.7,.9)
C3	(.5,.7,.9)	(.5,.7,.9)	(.7,.9,1)	(.3,.5,.7)
C4	(.5,.7,.9)	(.5,.7,.9)	(.5,.7,.9)	(.3,.5,.7)
C5	(.5,.7,.9)	(.5,.7,.9)	(.3,.5,.7)	(.7,.9,1)
C6	(0,.1,.3)	(.3,.5,.7)	(0,.1,.3)	(.1,.3,.5)
C7	(.3,.5,.7)	(0,.1,.3)	(.3,.5,.7)	(.5,.7,.9)
C8	(.7,.9,1)	(.7,.9,1)	(.5,.7,.9)	(.5,.7,.9)
C9	(.1,.3,.5)	(.1,.3,.5)	(0,.1,.3)	(.1,.3,.5)
C10	(.3,.5,.7)	(.3,.5,.7)	(.1,.3,.5)	(0,.1,.3)
C11	(.3,.5,.7)	(.7,.9,1)	(.3,.5,.7)	(.3,.5,.7)

Here all decision maker weight is 1 and A^* is (1, 1, 1) and A^- is (0,0,0). So the table for Normalized fuzzy decision matrix for criteria and weighted normalized alternatives, FPIS and FNIS are same as table 2.

Table 4: Distance D_j^* for criteria

Factors	Decision Maker				Average
	D1	D2	D3	D4	
C1	.342	.525	.719	.525	.528
C2	.342	.525	.525	.342	.434
C3	.525	.342	.183	.525	.394
C4	.342	.342	.342	.525	.388
C5	.342	.342	.525	.183	.348
C6	.876	.525	.876	.719	.749
C7	.525	.876	.525	.342	.567
C8	.183	.183	.342	.342	.262
C9	.719	.719	.876	.719	.758
C10	.525	.525	.719	.876	.661
C11	.525	.183	.525	.525	.440

Table 5: Distance D_j^- for criteria

Factors	Decision Maker				
	D1	D2	D3	D4	Average
C1	.719	.526	.342	.526	.528
C2	.719	.526	.526	.719	.622
C3	.526	.719	.879	.526	.662
C4	.719	.719	.719	.526	.670
C5	.719	.719	.526	.879	.710
C6	.183	.526	.183	.342	.309
C7	.526	.183	.526	.719	.89
C8	.879	.879	.719	.719	.796
C9	.342	.342	.183	.342	.302
C10	.526	.526	.342	.183	.397
C11	.526	.879	.526	.526	.614

Table 6: Closeness coefficients (CCi) of the three alternatives

S No.	Factor	D^*	D^-	C	Priority
1	Total manufacturing cost (C1)	.528	.528	.500	7
2	Recycling cost (C2)	.434	.622	.590	5
3	Environment concern(C3)	.394	.662	.627	4
4	Recycled volume (C4)	.388	.6708	.634	3
5	Economic Need(C5)	.348	.710	.716	2
6	Pressure with stakeholders (C6)	.749	.309	.292	10
7	Reverse logistics management information system(C7)	.567	.489	.463	8
8	Top management awareness(C8)	.2623	.796	.752	1
9	Process capabilities & skilled workers(C9)	.758	.302	.284	11
10	Increase of sales volume for new product (C10)	.661	.394	.373	9
11	Consumer awareness & Social acceptability (C11)	.440	.614	.582	6

IV. RESULT AND DISCUSSION

To prioritize the CSFs for RL implementation in Walton Electronic industry, 11 factor legislation, Total manufacturing cost (C1), Recycling cost (C2), Environment concern(C3), Recycled volume (C4), Economic Need(C5), Pressure with stakeholders (C6), Reverse logistics management information system(C7), Top management awareness(C8), Process capabilities & skilled workers(C9), Increase of sales volume for new product (C10), Consumer awareness & Social acceptability (C11), identified in section "Identification of CSFs for RL implementation" are considered for the prioritization. Four decision makers DM1, DM2, DM3, and DM4 were asked to rate the importance of the above mentioned each CSF on a 5-point scale having the linguistic terms low (L), fairly low (FL), medium (M), fairly high (FH), and high (H). The decision makers used the linguistic variables shown in table 2 to assess the importance of the CSFs. A decision matrix was prepared based on the responses received from the DMs shown in table 3. As mentioned in the fuzzy-TOPSIS methodology step 1, triangular fuzzy numbers were used to convert linguistics variable into the fuzzy numbers. By converting the fuzzy linguistic variables into triangular fuzzy numbers using table 1, the fuzzy decision matrix D was obtained. In the next step un-weighted fuzzy decision matrix R was enumerated. Further steps were followed to obtain the weighted fuzzy

normalized decision matrix, to find the ideal and negative-ideal solutions for the CSFs. The distance D^- and D^* of each CSF is derived, respectively, by using Eqs. (7), (8), (9), and (10). The D^- and D^* closeness coefficient C for each CSF is obtained by using Eq. (11). Values of and closeness coefficient C for each CSF are shown in table 6. The prioritization of CSFs was obtained and is shown in table 6. The most important CSF among the 11 CSFs is top management awareness and the least important CSF is process capabilities and skilled workers.

The overall prioritization of CSFs is

CSF8 > CSF5 > CSF4 > CSF3 > CSF2 > CSF11 > CSF1 > CSF7 > CSF10 > CSF6 > CSF9

V. CONCLUSION

RL is in focus worldwide because of its inherent advantages of reducing the impact of hazard materials on human life and environment. Reuse/recycle of materials is important because of rising costs of materials, limited resources and growing environmental concerns. RL is relatively new for Bangladesh industry and limited studies are available for RL practices. This research paper provides the valuable information on RL implementation for Bangladesh electronics industry. The research identified 12 CSFs for RL implementation in Bangladesh electronics industry. The identified factors are somewhat similar to those identified by various researchers all over the world. Analysis of the findings

shows that top four prioritized factors top management awareness, economic need, recycled volume, and environment concern are the most important among all 12 factors. Briefly, the contributions of this study are summarized as follows:

- a) The study provides the insight into previous research on RL implementation
- b) Identifies the CSFs based on past literature review and experts opinion for successful reverse logistics implementation
- c) The research work proposes a framework for evaluating and prioritizing the CSFs by using Fuzzy-TOPSIS methodology for RL implementation
- d) The study will help the managers and practitioners implementation of RL. It will enable the managers in identifying the factors which they need to work out for successful implementation.

The findings of the research will help the managers and academicians in the development of RL strategies and practices in Bangladesh electronics industry. These CSFs can also be used for RL implementation in other sectors of Bangladesh industry. Like other studies, this study also has some limitations. This study is conducted using for experts from the Walton electronic industry. Future studies may consider larger sample size to assess the methodology and the effectiveness of the proposed solution to enable generalization. Furthermore, the wider rating of the 7 or 11-point linguistic scale could be used instead of using a 5-point linguistics scale. Researchers may utilize other methodologies including other MCDM methodologies and may compare the results. Future studies may be carried out to identify company-specific or product-specific identification of CSFs for RL implementation.

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NOMENCLATURE

Symbol	Meaning
D	fuzzy decision matrix
R	fuzzy un-weighted matrix
V	weighted normalized decision matrix
A^*	Fuzzy positive ideal solution
A^-	Fuzzy negative ideal solution
D_j^*	Distances from positive ideal solution
D_j^-	Distances from negative ideal solution
CC_i	Closeness Coefficient
i	Number of Decision Maker
j	Number of CSF



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An Egyptian Sandstone Deposit as a Source of Good Quality Kaolin and Ultra-Pure Silica Sand: Sample Characterization and Separation (Part I)

By Suzan S. Ibrahim, Wael M. Fathy, Magdy A. Elsayed, Abd El-hady M. Saleh,
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Abstract- A kaolinitic sandstone sample from Wadi Qena deposit, the Eastern Desert of Egypt, was subjected to mineralogical and chemical characterization for possible separation of kaolin and silica sand concentrates. Attrition scrubbing process was applied in two different scenarios either on the whole crude sample or on the separate size fractions to collect both the white kaolin coating the sand grains and the sand itself. Factors affecting the process and the products after attrition were optimized and evaluated.

The -0.025 mm kaolin product after the attrition scrubbing process assays 36.05% Al₂O₃, 47.72% SiO₂, 0.62% Fe₂O₃ and 1.67% TiO₂. The X-ray diffraction analysis of the kaolin product shows sharp, narrow kaolin peaks and reflects the high degree of ordering. Its brightness and whiteness optical measures satisfy the requirements of the local paper industry.

Keywords: *cellular kaolinitic sandstone, classification, attrition scrubbing, fine kaolin, silica sand.*

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On the other hand, the attritioned white sand product assays 0.036% Fe₂O₃ and 0.119% Al₂O₃. This sand product matches the specifications for tableware and colorless glass containers industries.

Keywords: kaolinitic sandstone, classification, attrition scrubbing, fine kaolin, silica sand.

I. INTRODUCTION

In Egypt, distributions of kaolinitic sandstones rocks are present in Sinai, the Eastern Desert, and the southern Western Desert, Figure 1, [1-4]. Wadi Qena is one of the largest wadies in the Eastern Desert of Egypt. It is constituted from sandstones which are represented by quartz arenite, while kaolinite is the sole clay mineral constituent. These sandstones are being inherited from felsic- granitic and reworked quartzose sediments and transported by rivers to the basin of deposition, [5-14].

Kaolinite and silica sands are belonging to the group of industrial minerals, where their characteristic features lie in their physical properties (e.g., fibrosity of asbestos, insulatory properties of mica, the high specific gravity of barite). However, kaolinite has the chemical composition Al₂O₃•2SiO₂•2H₂O. It is produced by the

chemical weathering of aluminum silicate minerals like feldspar. The main use of the mineral kaolinite (about 50%) is paper production; its use ensures the gloss on some grades of coated paper. Kaolin is also used in ceramics, in toothpaste, and in paint to extend the titanium dioxide (TiO₂) white pigment and modify gloss levels. In its altered metakaolin form, it is used as a pozzolan; when added to a concrete mix, metakaolin accelerates the hydration of Portland cement, [15-17].

On the other hand, silica sands have got the most diversified use among all the non-metallic minerals deposits. The white silica sands are defined as high purity sands in which the sand grains are composed entirely of quartz. Impurities are very minor including for example: iron oxides, feldspars, micas, heavy minerals (zircon, tourmaline), [15-17]. Silica is a basic material in the glass industry, ceramic and refractory industries, and silicon-based chemicals. Silica sand is evaluated for industrial use on the basis of its chemical composition and physical properties. However, chemical specification is of paramount importance in glassmaking, whereas grain angularity and hardness are important for sandblasting, [15-17].

The present study is devoted towards the full mineralogical and chemical characterization of Wadi Qena sandstone rock for possible separation of its main constituents: kaolin and silica sand components. Further treatment of these mineral components to satisfy the requirements of the industry is the appropriate objective.

II. EXPERIMENTAL, MATERIAL AND TECHNIQUES

A kaolinitic sandstone sample was supplied through the Egyptian Geological Survey and Mining Authority from Wadi-Qena deposit; northern Eastern Desert of Egypt. A representative sample of which was prepared and subjected to mineralogical and chemical evaluation. The petrographic examination microscope examination of the grain composition and texture are applied using an Olympus optical microscope. Powders were prepared from the same sample and were subjected to phase and chemical analysis using a Philips PW 1730 X-ray generator with Fe-filtered Co K α radiation, run at 40 kV and 30 mA and A Philips PW

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2400 X-ray spectrometer with a tube voltage and current for a W target of 40 kV and 60 mA, respectively. The dry/wet particle size analyses were conducted using a standard series of Tyler sieves and a Lazer particle size

analyzer model (COR 2001). The optical properties of different kaolin products were measured using TMI Brightness & Color Meter JY9800, Model No. 68-59-00-002.

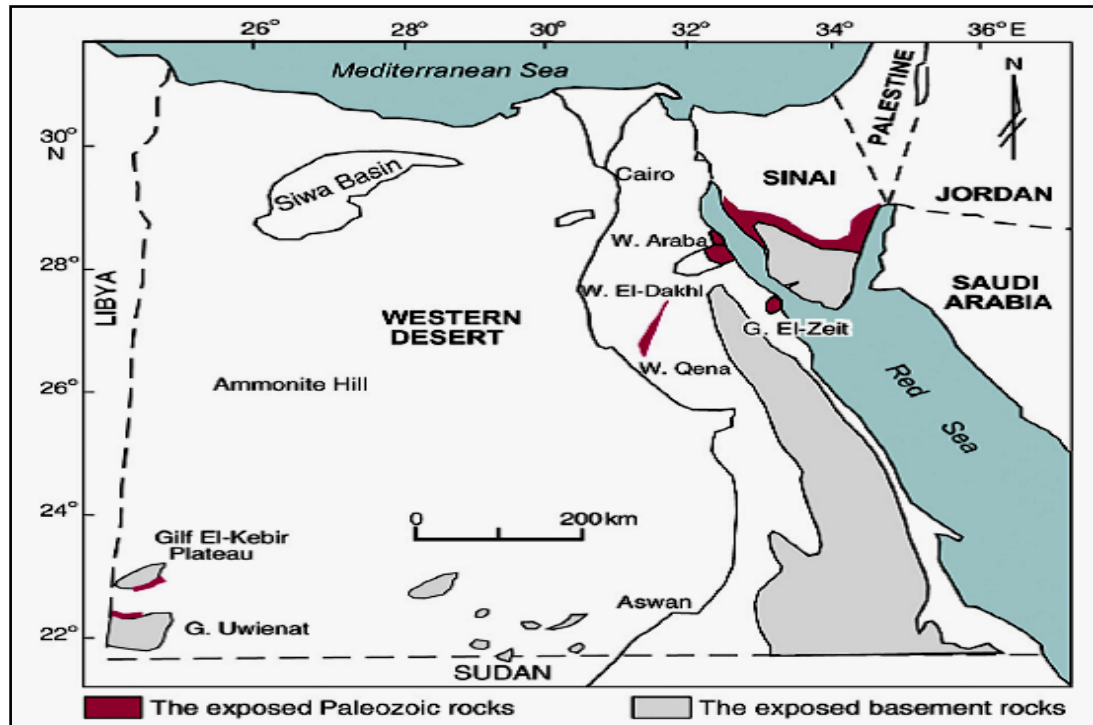


Figure 1: Location map showing the areas of the main kaolinitic sandstones distributions in Egypt, [13]

The attrition scrubbing tests were conducted using a 5 liter Pyrex glass container of a Denver 12 flotation cell. Two attrition scrubbing scenarios according to the type of feeding material were applied. The indicator of prevailing was the amount of the produced kaolin product (the 25-micron product) and its grade concerning the optical properties, mainly the whiteness and the brightness were determined. The first scenario was the attrition scrubbing of the overall sandstone sample as received. The second scenario was to gather the 25-micron products after the separate attrition scrubbing of the dry classified the +0.60 mm fraction, the -0.6+0.10 mm fraction, and the -0.10 mm fraction. The attrition time optimized in this study. Other vital parameters like pulp solid% and the attrition impeller speed were kept constant at the maximum predetermined levels (65% solid and 2700 rpm) throughout all the experiments. The silica sand and kaolin products after the optimized attrition scrubbing process were evaluated for the local industry.

III. RESULTS AND DISCUSSION

a) Characterization of the Head Sample

The x-ray diffraction analysis of the head sample shows the presence of silica and kaolin

minerals, Figure 2. It contains 89.97% silicon dioxide, 6.95% alumina, 0.138% iron oxide, and 0.356% titanium oxide, Table 1. SEM photomicrograph shows that the original sample is composed of large to medium quartz grains cemented with white kaolin which appeared mainly as grain rimming and coatings of the silica quartz grains, Figure 3. SEM photomicrograph shows also quartz grains with conchoidal fractures, straight grooves, and crescent gouges, which suggests its deposition in moderate to high energy aqueous environments, [18-21]. The surface textures of the quartz grains indicate that they are the product of mechanical weathering, [18-21].

The microscopic investigation of the sample shows heavy minerals inclusions on the sand surfaces, Figure 4. After the sink/float separation (using bromo form), it is noticed that black and colored particles are more enriched in the fine fractions below 100 micron. These minerals are mainly rounded grains of zircon, tourmaline, and rutile, Figure 4. This suggests that the deposit derivation was either from igneous or metamorphic rocks, [18-21]. The presence of needle and round crystals of biotite and of fine magnetite grains was confirmed.

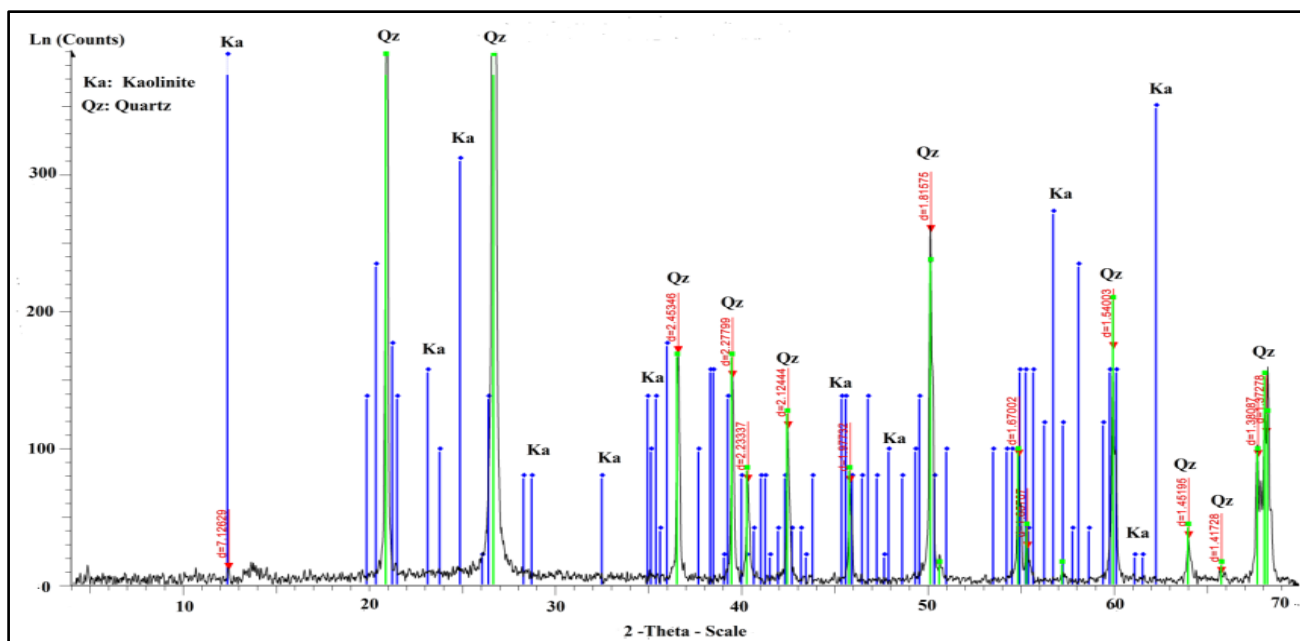


Figure 2: The X-ray diffraction analysis of the rock head sample

Table 1: Complete chemical analysis of the head sample

Constituent	Wt.%
SiO ₂	89.968
Al ₂ O ₃	6.952
Fe ₂ O ₃	0.138
TiO ₂	0.356
SrO	0.021
CaO	0.192
Na ₂ O	0.065
K ₂ O	0.022
P ₂ O ₅	0.061
Cl	0.072
SO ₃	0.213
ZrO ₂	0.040
L.O.I	1.90

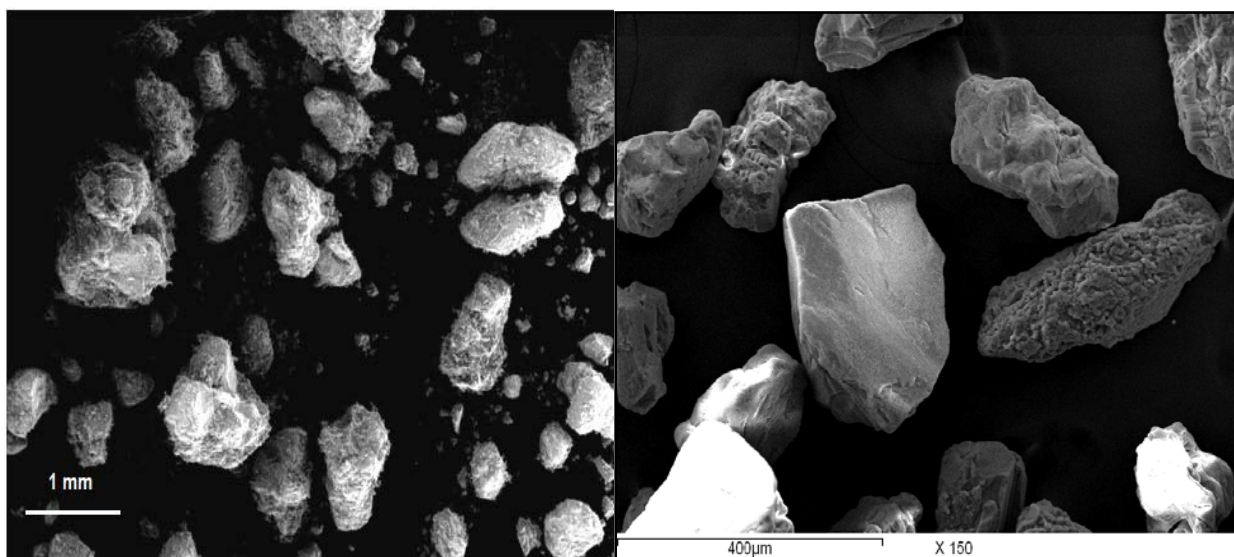


Figure 3: SEM photomicrograph of the head sample

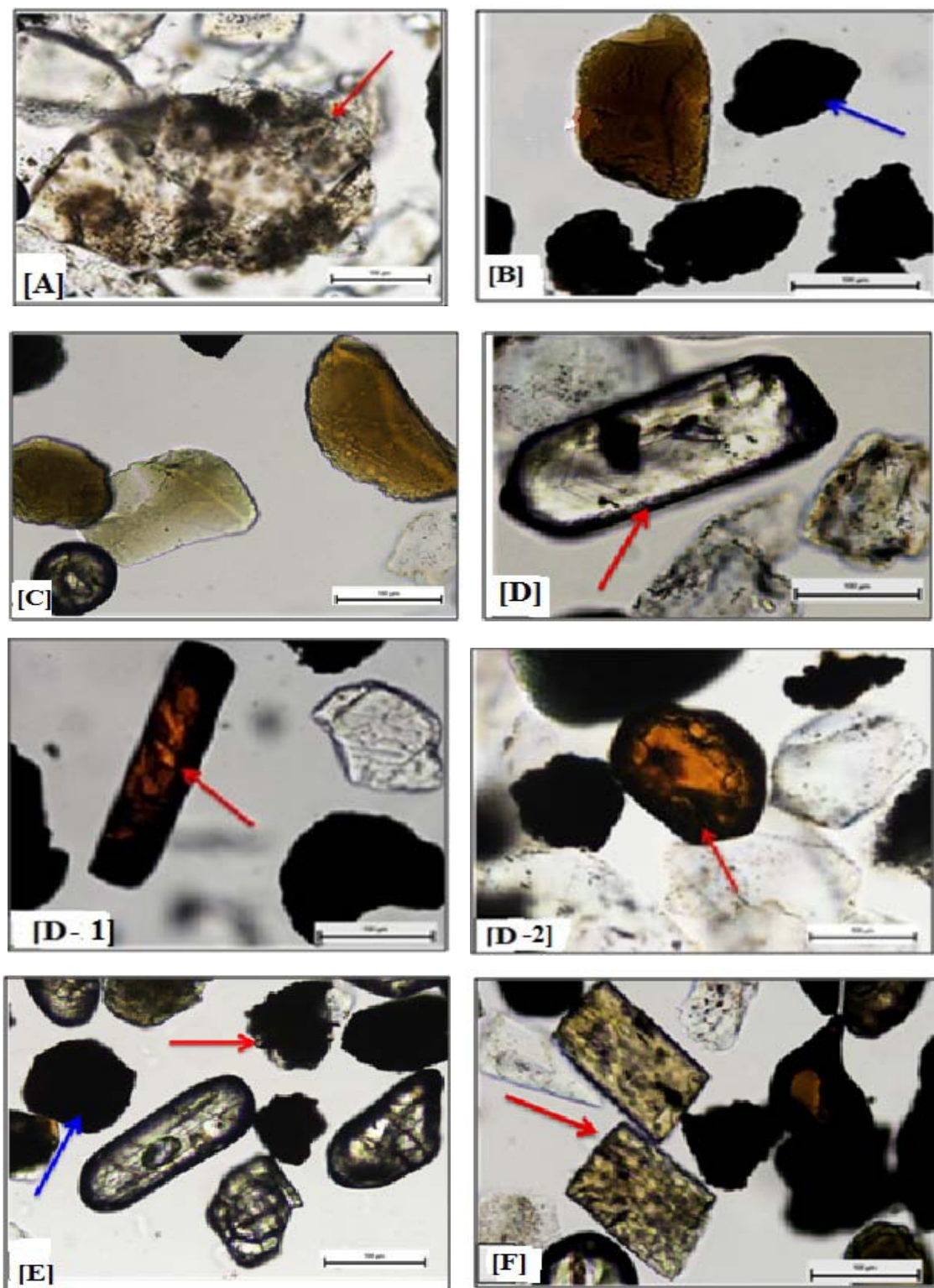


Figure 4: Photomicrograph of different gangue minerals found in the head sample

[A]: Inclusions in silica grains, [B]: iron oxides, [C]: Biotite, [D, D-1, and D-2]: different forms of Rutile, [E]: Zircon, and [F]: Tourmaline

b) *The Dry/ Wet Classification of the Head Sample*

The chemical analysis of the dry and wet classified products shows great upgrading in the sand quality compared to the original head sample, Tables 2 and 3. The silica content increases from 89.97% in the feed sample to 96.97% in the dry classified -0.60+0.106 mm sand product. Additionally, the dry classification of the head sample helped to reduce the iron oxide content from 0.138% in the feed sample to 0.065% in the dry classified product, Table 3, with removal yield reaching 53%. The sand upgrading is due to the rejection of most iron oxides minerals, mainly magnetite below 100 micron.

In addition, the alumina content decreased from 6.95% in the head sample to 2.57% in the dry classified sand product with a removal yield reaching 63%. This is due to the separation of most of the free kaolin particles to below 100 micron, and in addition to the rejection of aluminum bearing minerals that are below 100 micron like biotite. On the other hand, titanium oxide is reduced from 0.36% in the head sample to 0.128% in the dry classified sand sample due to the separation of rutile particles by screening to below 100 micron, with 64% removal yield, Table 3.

It is noticed that wet screening of the head sample has no effect on the sand grade despite the notable change in the particle size distribution of the 0.60+0.106 mm products before and after the wet screening, Table 3. This change in the particle size distribution is due to the disintegration of the sandstone accumulations in the +0.60 mm fraction which represents 11.74% by overall weight of the head sample by just simple water showering. This data illustrates how much the clusters fragility of the present sandstone sample is, while it does not need any crushing process to disintegrate into individual grains. However, this water showering is not enough to take off the kaolin coatings that cover the surfaces of the silica grains, and this may be the reason why the grade of the washed sample is not affected by the water washing process, Table 3.

Table 2: The dry and wet sieve analysis of the classified products

Size fraction, um	Dry Classification		Wet Classification	
	Wt., %	Cum. wt., retained %	Wt., %	Cum. wt., retained %
+600	11.74	11.74	1.32	1.32
- 600 + 106	79.76	91.50	87.28	88.60
-106+45	2.37	93.87	2.53	91.13
-45+ 25	0.98	94.85	1.42	92.55
-0.025	5.15	100.00	7.45	100.00
Total	100.00		100.00	

Table 3: The Chemical analysis of the dry and wet classified -0.60+0.106 mm sand products

Constituent	Wt.% (dry classified)	Wt.% (wet classified)
SiO ₂	96.97	97.050
Al ₂ O ₃	2.568	2.530
Fe ₂ O ₃	0.065	0.051
TiO ₂	0.128	0.128
SrO	0.008	0.008
CaO	0.070	0.075
Na ₂ O	0.021	0.021
K ₂ O	0.007	0.008
P ₂ O ₅	0.017	0.015
Cl	0.023	0.021
SO ₃	0.056	0.054
ZrO ₂	0.036	0.036

c) *Attrition Scrubbing of the Sample*

After much attrition scrubbing exploratory tests on the present kaolinitic sandstone sample, it shows that the optimum attrition time for all tested samples is 3 minutes in two steps (two min followed by 1 min). Screening on 100 microns sieve with enough water showering of the over screen product after attrition scrubbing for 2 min shows to be enough to detach the kaolin coatings away from the sand surface. Attrition Scrubbing of the 100+ micron washed sand for another 1 min is sufficient to attain complete cleaning of the sand surface and to recover the most amount of the white kaolin that coat the surface of the sand grains, Tables 4-5. The 100- micron kaolin product is further screened on 25 microns sieve to reject most of the fine silica, also of the most heaviest and colored oxides that found in the range from 100 microns to 25 microns, Tables 4-5.

On the other hand, the cumulative weight percent of the produced -0.025 mm kaolin product after the attrition scrubbing of the fractionated sand sample is 1.65+4.79+4.39= 10.83% after the attrition scrubbing of the size fractions, +0.60 mm, -0.10 mm and 0.60+0.10 mm fractions, respectively, Table 5.

Table 4: Particle size distribution of the attrition product of the original head sample

Size fraction, um	Operational wt., %
+600	1.35
-600+106	84.25
-106+40	3.00
-40+25	1.45
-25	9.95
Total	100.00

Table 5: Operational and overall particle size distribution of the attrition products after different sand fractions
A= +0.60 mm fraction, B= -0.10 mm fraction, C= -0.60+0.10 mm fraction

Size fraction, mm	Wt., %					
	[A]		[B]		[C]	
	Opt.	overall	Opt.	overall	Opt.	overall
+0.60	4.11	0.48	---	---	---	---
-0.60+0.106	72.11	8.47	---	---	92.83	74.02
-0.106+0.045	5.53	0.65	32.22	2.37	1.22	0.97
-0.045+0.025	4.22	0.50	11.64	0.98	0.46	0.36
-0.025	14.03	1.65	56.14	4.79	5.49	4.39
Total	100.0	11.74	100.0	8.50	100.0	79.74

i. *Evaluation of the kaolin product*

The optical properties of these kaolin fractions after the attrition scrubbing of the fractionated sand sample show lower values compared to that of the kaolin product after the attrition scrubbing of the overall sample without fractionation, Table 6. However, the kaolin product obtained after the attrition scrubbing of the 0.60+ mm fraction shows excellent optical properties measures, but it is of a relatively low weight percent compared to the head sample, Tables 5 and 6.

However, the weight percent of the produced 25- micron kaolin product after the attrition scrubbing of the head sample reaches 9.95% by overall weight, with optical properties measures reaching 79.30% brightness 85.97% iso-brightness, 92.72% whiteness, and 4.98 yellowness, Table 7.

Particle size distribution of kaolin shows that its D50 is 12.36 micron and the D80 is 23.51 micron, Figure 4. The XRD analysis of this kaolin product shows sharp narrow kaolin peaks reflect a high degree of ordering, Figure 5. Additionally, its chemical analysis shows that it contains 36.05% alumina, 47.72% silica, 0.62% iron oxide and 1.67% titanium oxide, Table 8. These chemical and optical properties specifications are

Table 6: Optical properties and particle size distribution measures of the 25- micron kaolin products after different samples

Sample	Brightness%	Iso-brightness%	Whiteness%	Redness%	Yellowness%	D ₅₂ , um	D ₈₀ , um	D _{96.7} , um
A	79.45	86.40	92.95	0.25	5.08	11.11	21.12	36.73
B	75.09	83.07	91.14	0.34	5.96	12.36	26.16	45.22
C	77.00	85.00	92.20	0.36	5.86	11.11	23.51	40.81

Table 7: The optical properties and particle size distribution of the 25- micron kaolin product

Property	Measure, %	Property	Measure, %
Brightness	79.30	Yellowness%	4.98
Iso-brightness	85.97	D ₅₂ , um	12.36
Whiteness%	92.72	D ₈₀ , um	23.51
Redness%	0.25	D _{96.7} , um	40.89

matching the needs of glass and ceramics industries. However, this kaolin product needs lowering its iron and titanium oxides contents to match advanced applications like paper, cosmetic and medical industries. This issue will be covered in a separate study.

Scanning electron microscope investigation of the 25- micron kaolin product records this kaolin as vermicular, euhedral and pseudo-hexagonal plates (booklets), Figure 6. The hexagonal kaolinite plates are found either as discrete individual platelet or associated with the stacks in varying sizes (up to 30 micron). The majority of kaolinite particles show parallel orientation and have face-to-edges fluctuation.

The SEM pictures of the attrition sand product show the presence of mineral remains inside the cracks cavities of the sand grains surfaces, Figure 7. In such cases, the use of ultrasonic cleaners in high- frequency range may provide cleaning for the sand surfaces where no other means of agitation is effective. The energy imparted by ultrasonic is aggressive and specific for such cases, [22].

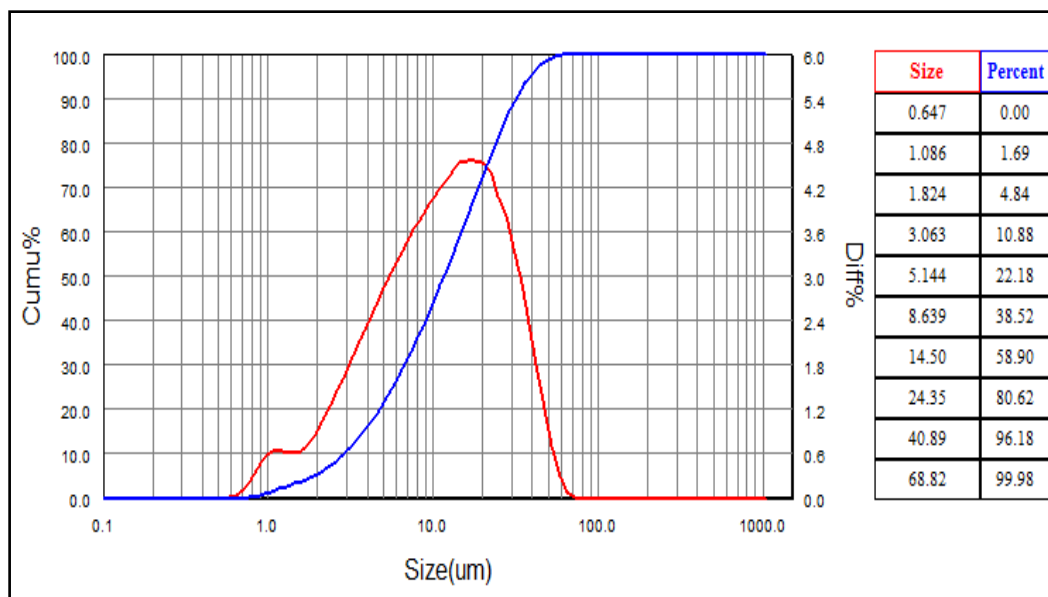


Figure 4: Particle size distribution of the kaolin product

Table 8: Chemical Analysis of the 25- micron kaolin

Constituent	Wt.%	Constituent	Wt.%
SiO ₂	47.72	K ₂ O	0.04
Al ₂ O ₃	36.05	P ₂ O ₅	0.21
Fe ₂ O ₃	0.62	Cl	0.04
TiO ₂	1.67	SO ₃	0.09
CaO	0.32	ZnO	0.01
MgO	0.16	ZrO ₂	0.05
Na ₂ O	0.08	Cr	145 ppm
SrO	0.133	L.O.I	12.8

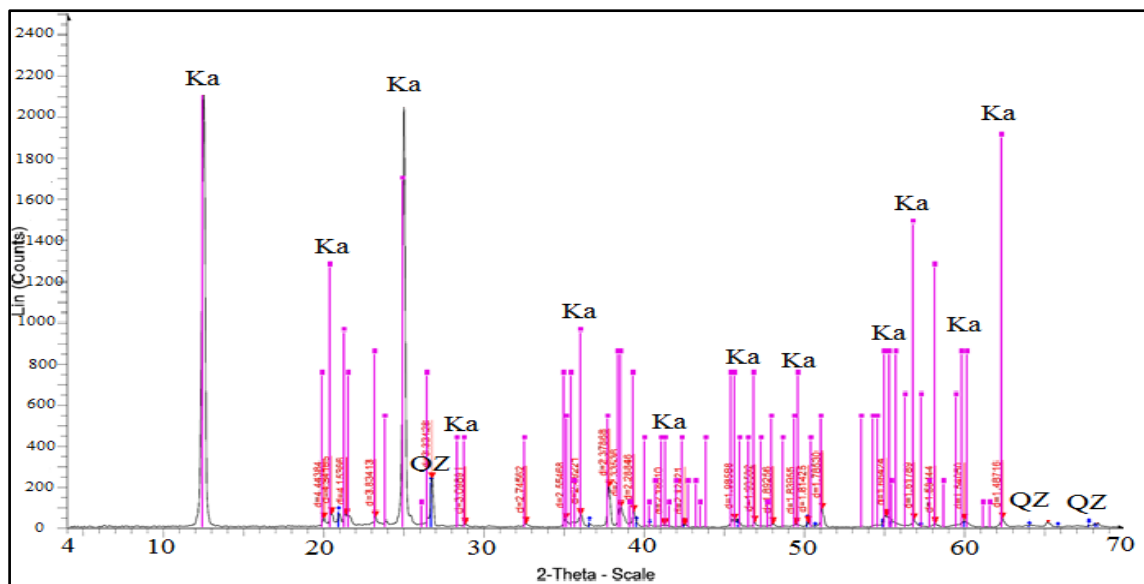


Figure 5: X-ray diffraction analysis of the kaolin product

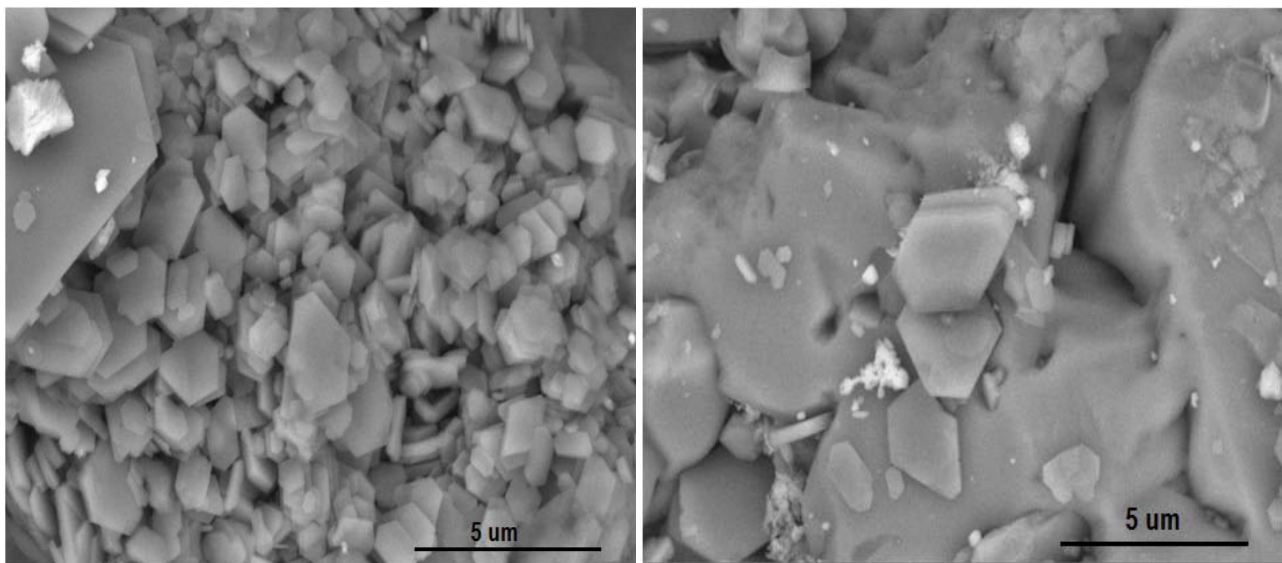


Figure 6: SEM pictures of the 25- micron kaolin product

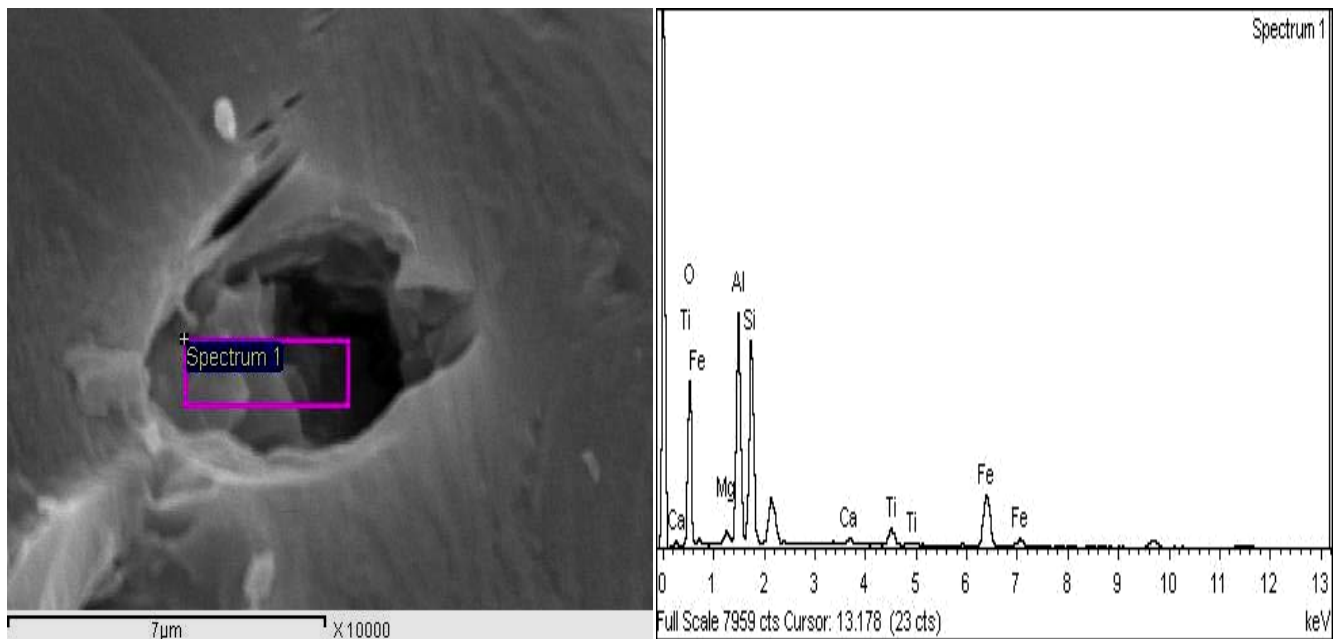


Figure 7: EDEX analysis of cavity components of an attrition sand particle

ii. Evaluation of the attrition sands

The microscopic examination of the attrition sand product shows varieties of colored and refractory minerals still present after the attrition process. These minerals include biotite, magnetite, rutile, zircon and tourmaline minerals. The iron oxide and alumina contents decrease from 0.138% and 6.952% in the feed to 0.036% and 0.119% in the attrition product, with removal yields reaching 74% and 83%, respectively, Table 9. The particle size distribution of the attrition product is depicted in Table 10. This product matches the sheet and Paper industries.

Table 9: Chemical analysis of the attrition sand product

Constituent	Wt. %
SiO ₂	99.754
Al ₂ O ₃	0.119
Fe ₂ O ₃	0.036
TiO ₂	0.038
CaO	0.023
P ₂ O ₅	0.006
Cl	0.017
SO ₃	0.008
ZrO ₂	0.018

Table 10: Size distribution of the attrition sand product

Size fraction, mm	Wt. %	Cum, wt. % retained
-0.6	5.56	5.56
-0.420	43.18	48.74
-0.250	16.08	64.82
-0.210	22.22	87.04
-0.160	12.96	100.00
Total	100.00	

IV. CONCLUSION

Results show that the kaolinitic sandstone of Wadi Qena, Eastern Desert, Egypt contains notable amount of white kaolin coating the silica grains. The preferable scenario to detach this kaolin is to apply an intensive attrition scrubbing process for the whole head sample at 65% pulp solid density, 2400 rpm impeller speed for 3 min in two attrition steps separated by proper water washing step on 100 microns screen. The attrition process yields 25- micron kaolin of about 9.50% by weight of the sample. This kaolin product shows good optical properties which makes it acceptable for many domestic applications. However, it needs to minimize its iron and titanium oxides contents to match advanced applications, e.g. pharmaceutical, porcelain, and paper industries which will discuss in another issue.

On the other hand, the dry classification of the sandstone sample acts remarkable improvement in the sample grade. Further quality improving occurs after the attrition scrubbing of the whole sample. The iron and aluminum oxides decrease from 0.138% and 6.952% in the feed sample to 0.036% and 0.119% in the attrition sand product, with removal yields reaching 74% and 83%, respectively. The chemical and particle size distribution specifications of this product match the 4th grade level acceptable for plate and sheet glass industries. The attrition product needs further surface cleaning to remove the minerals remains found inside the sand surface cracks using power ultrasound treatment. Moreover, the attrition sand is in need to further processing to remove iron and heavy oxides via high intensity magnetic separation or anionic froth flotation to reach the chemical specifications of advanced types of glass applications.

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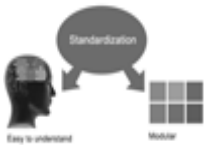
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13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.



21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium through which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.



Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.



Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.



Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

THE ADMINISTRATION RULES

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CRITERION FOR GRADING A RESEARCH PAPER (COMPILATION)
BY GLOBAL JOURNALS

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	C-D	E-F
<i>Abstract</i>	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
<i>Introduction</i>	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
<i>Methods and Procedures</i>	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
<i>Result</i>	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
<i>Discussion</i>	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
<i>References</i>	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



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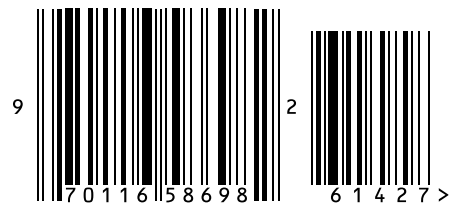


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