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Highlights

FC-0205 Copper Steel Powder

Automatic Street Light Control

Discovering Thoughts, Inventing Future

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Experimental Characterization of Milling, Compaction and Sintering of Nanocrystalline FC-0205 Copper-Steel Powder

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Keywords: nanocrystalline powder, ball milling, uniaxial die compaction, sintering, characterization.

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EXPERIMENTALCHARACTERIZATIONOFMILLINGCOMPACTIONANDSINTERINGOFNANOCRYSTALLINEFC-0205COPPER-STEELPOWDER

Strictly as per the compliance and regulations of:

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Olalekan R. Junaid [α], Tonya W. Stone [σ] & Jamel H. Alexander [ρ]

Abstract- The effect of ball milling on the compaction and sintering of nanocrystalline copper steel powder (FC-0205) was evaluated within this work. The as-received micron-sized FC-0205 copper steel powder was subjected to High Energy Ball Milling (HEBM) in an argon atmosphere at different milling times of 0, 16, 20 and 24 hours to obtain nanocrystalline structures. Unmilled, 8 and 16 hours milled powders were compacted using uniaxial die compression at pressures ranging from 274 MPa to 775 MPa to obtain a relative density range of 74% to 95%, respectively. The steel powder compacts were sintered at temperatures ranging from 400 °C to 1120 °C in high purity hydrogen and nitrogen atmospheres. X-ray Diffraction (XRD) and microscopy analysis were performed on the milled powder specimens to evaluate particle size, morphology, and extent of porosity; to establish a relationship between milling time and particle size, and to establish a correlation between grain size and milling time. Dilatometry analysis was performed on the compacts to examine the density and phase transformations of the specimens during sintering. As the mill time of the steel powder specimens increased, particle fragmentation increased, which resulted in particle size reduction and increased agglomeration of particles. The grain size of the steel powder specimens decreased as the mill time increased. An increase in density occurred as pressure increased. As temperature increased with mill time, compact density increased.

Keywords: nanocrystalline powder, ball milling, uniaxial die compaction, sintering, characterization.

I. Introduction

Nanocrystalline materials have experienced significant growth in recent years due to their wide range of applications and impressive physical and mechanical properties they exhibit. Since nanocrystalline materials possess a large number of grain boundaries and are dependent on grain size and distribution, they are superior when compared to conventional coarse-grain materials [1]. Properties include enhanced diffusivity, improved ductility, lower thermal conductivity and increased strength [2]. A nanocrystalline powder is characterized by a structural length or grain size on the order of 100 nm (0.1 μm) or less [3-4]. They can consist of single crystals of less than 100 nm or of conventionally sized particles composed of a nanocrystalline grain structure.

Materials that have grain sizes in the nanosize range tend to have higher mechanical properties, such as increased strength and hardness as compared to their coarser grained counterparts [5]. Nanosized grains prompt dislocation build up at grain boundaries, hence, making dislocation movement into adjacent grains more difficult. The higher the applied stress needed to move dislocations, the higher the yield strength of the material. The correlation between improved strength characteristics with decreased grain size is captured by the Hall-Petch (HP) relation [6] in equation (1),

$$\sigma_y = \sigma_0 + \frac{K_y}{\sqrt{d}} \tag{1}$$

Where σ_y is the yield strength, σ_0 is the lattice friction stress to move individual dislocations, K_y is a constant (HP slope), and *d* is the grain size in diameter. The HP relation implies that yield strength increases with decreasing grain size; however, there is a limit to which the material can be decreased to avoid weakening [7-8]. Experiments on nanocrystalline materials have shown that if the grains reached a critical grain size, typically around 10 nm, an inverse Hall-Petch effect is observed [9-11, 12-14]. As the grain size decreases to approximately 10 nm, grain boundaries tend to slide past one another, which results in a reduction of the material's strength.

There are three main techniques to obtain nanocrystalline structures during powder production which influence the size, shape, microstructure, chemistry, and cost of a material [15]. One method involves ball-milling micron-sized powders to obtain the nanosize powder. Another method uses gas or water atomization from which powder is formed from molten metal using a spray of the droplet, however, this method has a lower particle size limitation of ~1-5 μm [17]. The third method is inert gas condensation which results in no impurities but produces a small output capacity [15, 17, and 18]. Among these techniques, ball milling has proven to be the most cost-effective in the production of nanosized powder [15, 17] and is the production method used in most current research. High Energy Ball

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Milling (HEBM) is a type of mechanical milling (MM) technique that is utilized in powder metallurgy (PM) consisting of continuous cold welding, fracturing, and re-welding of powder particles [17].

In 1966, John Benjamin and his colleagues experimented by milling nickel and aluminum powders in an oxidizing atmosphere to form nickel super alloys hardened by oxide dispersion. The experiment showed that repeated fracturing and cold welding during milling exposed new oxide layers on the surface of the particles, which resulted in metal alloying [15-19]. This technique became the genesis of the milling and alloying technique and has since then been extremely useful in many industrial applications. Akhtar *et al.* [17] studied the mechanical milling of iron and copper powder from micrometer size to nanosize particles using HEBM. Within the experiment, mechanical energy was generated through the collision of 0.5-inch hard steel milling balls and the milling vial container in a controlled argon atmosphere. The energy produced caused deformation of the steel powder into nanosize particles. The final particle size, shape, and size distribution were dependent on material property, milling energy/ frequency, ball size, and the quantity of ball and powder [15].

Akhtar and Fecht [2, 20] observed that milling time played a significant role in obtaining the nanocrystalline aluminum powder. Brian and Poquillon [15, 22] observed that the energy produced during milling enhanced the interaction between steel powder particles, resulting in plastic deformation, fracturing, and cold welding. Suryanarayana *et al.* [21] found that excessive cold welding of particles greater than 100 nm should be avoided by ensuring a stable point between fracturing and cold welding. Similarly, Joao *et al*. [19] suggested the addition of 1-2wt% of stearic acid which acts as a Process Control Agent (PCA) to avert immoderate cold welding during milling of powder particles. Particle Size, morphology, and agglomeration all contribute to the overall density and mechanical strength of a green compact. The particle size distribution during compaction also determines the level of porosity and homogeneity of the green compact.

Poquillon *et al*. and German [22, 23] reported on the dependence of particle size on the tensile stress of green compacts made from spherical copper powders. Their research discovered that the tensile stress increased as the particle size of the copper powder decreased. Also, the smaller the particle size of the specimen, the higher the fatigue strength due to variation in the stress concentration factor with particle size [24-25]. Mechanical milling has become widely used because of its simplicity and most importantly, cost efficiency compared to other techniques [17]. However, mechanical milling still has its shortcomings that are yet to be addressed by material engineers and scientists [19-21].

Powder contamination is a issue in mechanical milling. The milling condition, milling time, surface formation, particle size and milling environment all determine the level of contamination of the new powder particles. Possible approaches to reducing contamination are to create a milled environment free of impurities, by ensuring the powder particles are free of impurities, reducing the mill time, and by using a milling vial and ball of similar material to the powdered particles.

Several research engineers and scientists have studied the quantification and modeling of high energy ball milling, but limited success has been achieved. Since the quantification and modeling has not been adequately scoped, production at the industrial-scale is difficult because predicting, controlling and optimization of the process are underdeveloped. Ball milling or mechanical milling is the least expensive method to produce large quantities of nanocrystalline powders [17].

The potential application of nanoscale materials for use as novel structural or functional engineering materials largely depends on the consolidation of nanopowders into bulk nanoscale solids. A central issue in adding nanopowder to engineered parts is the consolidation of the powder into sintered parts with full density and nanograined microstructures [3-4, 9-11, 26]. Nanocrystalline powders are much more difficult to process and handle than powders in the micron size range. Changes in properties are caused by an increase in surface atoms of nanoscale powders as the particle diameter decreases. Production and processing of nanopowders are difficult due to small particle size and high specific surface areas. Nanoscale powders tend to agglomerate, which requires additional processing to de-agglomerate or suspend the powders. The nanopowder consolidation and densification process strongly depend on the state of powder agglomeration.

Consolidation of powders into various shapes are a direct result of cold or hot-pressing techniques. Hot pressing is a technique whereby compaction and sintering of metal powder are done at the same time, however, [27] it is time-consuming. Cold pressing involves the application of pressure on metal powders in a closed shaped die to form a green compact. Vagnon *et al.* [28] reported that compacts formed via hot pressing had higher densities and improved homogeneity. Powder pressing is usually done at ambient room temperature and the compacted sample is called a green compact [15].

The compressibility of green compacts is extensively dependent on the compaction pressure [29]. The pressure reduces the volume and porosity of the compact powder and increases the density [15]. The amount of pressure needed for compaction of green compacts largely depend on powder characteristics, additives and desired density [22]. Pranav *et al.* [27] found that higher pressures were required to compress powders with coarser particles in comparison to powders that contained fine particles of the same material. Poquillon *et al.* and Sang *et al.* [22, 30] investigated the morphology of iron powder and its impact on compaction behavior. They compacted two different iron powders, one with spherical grains and the other with spongy grains at different pressures ranging from 100 to 350 MPa. Their experimental result showed that the iron spherical powder compacts produced lower density compared to the spongy powder compacts at the same compaction pressure.

Camila and Lirio [31] expanded further on the impact of morphology on the compressibility of steel powders. They observed that during compaction, particles with flattened morphologies had greater deformation capacity on compacts due to their high specific surface areas, which increased the internal friction between particles, ultimately, reducing the compressibility of the compacts. During compaction, particles tend to rearrange thereby reducing spaces and gaps, which leads to an increase in density. The density increases due to the more organized packing of the particles that create contacts points between them are referred to as the initial stage of compaction [32]. Cold welding occurs during further application of pressure because forces increase between the contact points of the particles. Plastic deformation occurs in the second stage of compaction. Material deformation takes place at this stage due to the stress between the contact points of the powder particles. The plastic flow of particles increases the stress between powder particle contact points which causes deformation of the material. Density increase is much slower in the second stage because frictional force is higher which hinders the easy movement of material. Conversely density in initial stage increases rapidly because of lower resistance of frictional force. Work hardening of the powder occurs in the third stage because of increase in compaction pressure [22].

Lubricants are necessary during compaction to reduce frictional forces that hinder the free movement of powder particles. Lubricants help to form a uniform distribution of particles during compaction [33]. However, immoderate lubrication can store in interparticle pores thereby preventing a uniform distribution and proper compaction of powder. The green compact is then heated at lower temperatures to remove the lubricants so that it has no effect on the density and strength of the sample [15].

The final stage in the press-sinter approach is to sinter the green compact at a temperature below its melting point. Sintering of green compacts is essential in that the loosely bounded particles are taken from their green state to higher densified compact parts with enhanced thermal and mechanical properties through metallurgical bonding. There are three processes for sintering; solid-state sintering, liquid-phase sintering and activated sintering [34]. Liquid-sintering of alloy metal powders can be accomplished in one of the two ways; by sintering at temperatures above the melting point of one of the constituent powders or by sintering at temperatures below the melting point of the base powder according to a Fe-Cu phase diagram [34, 35].

Compact shrinkage occurs during sintering due to diffusion thereby reducing space and porosity within the sample. Vagnon *et al.* [28] studied the effect of sintering on swelling and shrinkage of steel powder. They observed shrinkage within the steel powders at lower temperatures during the removal of the lubrication. However, at higher sintering temperatures, the copper diffused into the iron thereby causing the compact to swell and reduce in shrinkage. Also, during sintering, recrystallization of atoms, grain growth, and phase change were all noticed [36].

Sintering parameters [29, 37] affect the strength, density and grain size of the of the sintered compact. These parameters include sintering temperature, material composition, powder morphology, time and atmosphere. [17, 28]. Nanocrystalline powders densify at sintering temperatures significantly lower than conventional powders. Densification typically occurs at 0.2 to 0.4 times the melting temperature (T_m) as compared to 0.5 to 0.8 T_m for conventional powders [38].

Several researchers have studied the effects of sintering time and temperatures on the mechanical properties of metallic powders. Akhtar *et al.* [2] studied the effects of sintering on steel powders and reported a 50% increase in grain size from the initial powder post-compaction, sintering, and annealing at elevated temperatures. Pranav *et al*. [27] investigated the sintering mechanisms of molybdenum powder and reported that less sintering work was required to achieve the same densification at higher compaction pressures than at lower compaction pressures. Narasimhan [34] stated that metallic powder type and desired geometry determine both sintering time and temperature. He performed an experiment on several alloying elements and concluded that Fe-B-C has the potential to undergo higher sintering temperature than Fe-Cu-C due to the low solubility of boron in iron as compared to copper. Therefore, Fe-B-C can be used in the production of hard steels.

Sintering atmosphere is also a key factor in the sintering process of metal powders [29, 37]. The sintering atmosphere should be controlled to prevent oxidation and unwanted chemical reactions, eliminate

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existing oxides and control carburization and decarburization. [37]. Several types of sintered atmospheres are used in powder metallurgy; however, the method in which the atmosphere is controlled during sintering is consequential in relation to the strength of the green compact. The sintering atmosphere is usually controlled with hydrogen, argon, helium, nitrogen, or under vacuum [27, 34]. Previous studies have shown that sintering in a hydrogen environment results in better mechanical properties than under vacuum [37]. Depending on the sintering time and temperature, powder particles start to bond together by forming necks throughout the diffusion process. These necks grow at the points of particle contact and as sintering time increases the neck size ratio increases which help to increase the mechanical strength [37]. At elevated temperatures and increased time, grain growth was noticeable, and pores became spherical and isolated [36]. Vagnon *et al.* [28] postulated two methods to reduce sintering temperature to minimize the growth of grains. They suggested a small amount of elements such as Ni, Pt, Pd, and Co be added to the base powder to activate the sintering process thereby reducing the sintering temperature and time. Nevertheless, the addition of some of these elements with the base powder can reduce the ductility of the sintered sample thereby affecting the mechanical properties. The researchers [37] also stated that nanosize particles require higher compaction pressures at lower sintering times and temperature for grain growth reduction.

This experimental study establishes a correlation between milling time, particle size, temperature and grain growth through HEBM on copper steel powder. The aim of this work was to characterize the structure-property relations of ball-milled nanocrystalline FC-0205 copper steel powder with Ancorsteel 1000B as the base Fe powder; analyze the morphology of powder particles from different milling times and how that particle size affects the density and mechanical properties of the green compact; and lastly, analyze the effects of ball milling on powder consolidation into dense compacts using uniaxial die compression and sintering. The FC-0205 powder system was chosen due to its widespread use in the powder metallurgy industry for automotive applications. The study utilizes a press-sintering technique using uniaxial die compaction followed by sintering.

II. Experimental Procedures

a) Milling

As-received copper steel powder FC-0205 mixed with 0.6% zinc stearate lubricant, also known as Acrawax from Hoeganaes was used for this study. Table 1 summarizes the nominal chemical composition of the as-received iron powder. The prefix (F) designates an iron-based material and the second prefix (C) is copper, which is known as the primary alloying element. The first two digits (02) represent the percentage of the primary alloying element which is 2% copper. Carbon content is represented by the third and fourth digits whereby 05 designates the amount of carbon in a range between 0.3%-0.6%. The base iron powder for FC-0205 is an Ancorsteel 1000B alloy mix commonly used in the powder metallurgy industry. The chemical composition of Ancorsteel 1000B is provided in Table 2.

Table 1: The nominal chemical composition of the as-received FC-0205 iron powder

MPIF designation/ Component	Fe	C	Cu	Acrawax
FC-0205	97.1	0.5	2	0.6

Table 2: Ancorsteel 1000B chemical composition by wt%

	Fe	C	O	N	S	P	Si	Mn	Cr	Cu	Ni
Ancorsteel 1000B	Bal.	<0.01	0.09	0.001	0.009	0.005	<0.01	0.1	0.03	0.05	0.05

The as-received FC-0205 powder was milled by Union Process at intervals of 0,8,16, 20 and 24 hours. The milling process was carried out in a Model SD-1 Laboratory Attritor with 6.35 mm (0.25 inch) stainless steel grinding media. A ball-to-powder ratio of 16/1 was used, and the milling speed was set to 350 RPM in a sealed argon environment to lessen the contamination of oxygen and humidity. The stearic acid lubricant was added to the milling process to reduce friction, minimize die wear, aid in the part ejection, and avoid cold welding of the materials. The material properties of the final components are unaffected by the lubricant since the lubricant is burned off before sintering.

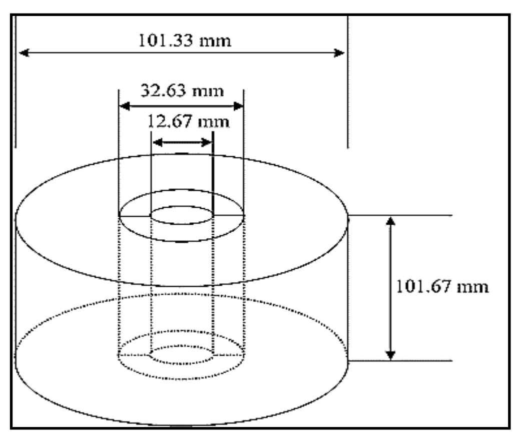

Figure 1: Die Compact

b) Compaction

Uniaxial cold pressing was performed on the milled and unmilled FC-0205 copper steel powder each.

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The shaped die used for compaction and sintering was made of Vasco Max C-350 and had an inner diameter of 32.63 mm (1.3 inches), and an outer diameter of 101.33mm (4 inches) as shown in Figure 1. A cylindrical split hollow die with a diameter of 12.67 mm (0.5 inches) was made of the same material for easy removal of the sample after compaction. An Instron 5882 mechanical test frame with 100 kN load cell was used to exert a compressive force on the shaped die at a constant compression rate of 10 mm/min in a controlled environment. The steel powder was filled into the shaped die, and the upper punch compressed the powder at various heights to achieve different densities. Density measurements were taken before sintering.

c) Dilatometer Tests

A vertical push rod dilatometer (Anter Corporation Unitherm Model 1161) was used for the dilatometry analysis to examine the density and phase transformations of the unmilled samples during sintering. FC-0205 compacts were heated to 1150 °C (2102 °F) in a nitrogen atmosphere at different heating rates (2C/min, 5C/min, and 10C/min). The samples were held for 30 minutes followed by an uncontrolled cool down from the sintering cycle. Dilatometry measurements were captured when the push rod attached to a transducer displaced with the shrinkage or expansion of the compact. The signals obtained from the motion transducer and thermocouple were correlated by a computer which provided the dimensional change of the sample as a function of time and temperature.

d) Sintering

A Carbolite 1600°C (2912 °F) tube furnace was used to sinter the compacts in a controlled environment of 75% hydrogen and 25% nitrogen to avoid oxidation and contaminants. The bulk specimens were de-lubed at 400 °C (752 °F) to get rid of the stearic acid in order not to hinder the overall density and strength. Bulk samples from each milling hour were sintered at 900 °C (1652 °F) and 1120 °C (2048 °F) which is close to the critical sintering temperature of FC-0205 powder [31]. The temperature was set to ramp at 15 °/min and dwell for 30 minutes before it was slowly cooled to room temperature. The compaction and sintering schedule minimize grain growth and maximize densification during the process.

e) Microstructure Analysis and Sample Preparation

Struers LaboPress hot mounting technique was carried out on each sample for easy handling of the sample during grinding and polishing. Each surface of the mounted samples was subjected to grinding and polishing for proper analysis of the microstructure using SEM, optical microscopy (OM) and image analysis. The sintered samples were etched with 2% nitric acid and 78% ethanol to remove a uniform thin layer of the surface off for analysis of the grain size and grain growth. Zeiss Evo Supra 40 Field Emission Gun Scanning Electron Microscope FEG-SEM was used to analyze the morphology, particle distribution, grain size and agglomeration of milled and compacted FC-0205. Rikagu Ultima III x–ray diffraction system was used to analyze the average grain size of milled FC-0205. A thin layer of FC-0205 iron powder was evenly spread on a glass sample holder. This procedure was carried out on each powder sample of different milling time. The 2θ° (FWHM) range was set from 10° to 90° at 1°/min to cover the essential part of the powder pattern. ImageJ analysis was performed on images obtained from optical microscopy to analyze the extent of grain growth in the FC-0205 samples.

f) Hardness Test

Rockwell hardness (HRA) measurements using Leco Rockwell Hardness Tester were carried out on bulk specimens obtained through the compaction and sintering of FC-0205 steel powders. The indenter had a diamond cone shape for indenting. The indenter was forced into the material under a total load of 60 kgf. At least four different readings were taken from each surface of the sample, and the arithmetic average was obtained.

III. Milling, XRD, and Microscopy Results

a) Ball Milling of Nanocrystalline Copper Steel Powders

Table 3 and Figure 2 shows analysis of FC-0205 particle size using particle size analyzer. A linear function relationship is obtained between milling time and average particle size of the copper steel powder. The linear function relationship is experimentally expressed in equation (2).

$$D = kt + 71.57 \quad (2)$$

Where D is the average particle size in (μm), t is the milling time in (hour) and k is a constant. The correlation coefficient of equation (2) is 0.998.

It was observed that as milling time of powder increased the average particle size decreased which agrees with previous studies [22,2] (see Table 3). As milling time increased from 0 to 16 hour, the rate of fragmentation of particles was high leading to a high reduction in particle size from 72.37 (μm) to 25.64 (μm). After further milling from 16 to 24 hours, it was noticed that fragmentation of particles decreased which led to a reduction in particle size from 25.64 (μm) to 3.7 (μm). The reduction in particle size is due to an increase in milling energy which causes an increase in the contact area between the grains.

Table 3: Milling time and average particle size

Milling Time (hours)	D_{50} (μm)	% Decrease D50 (μm)	D_{90} (μm)	Median Value (μm)
0	72.37	33.7709	165.6	82.23
8	47.93	46.50532	117.1	57.17
16	25.64	33.50234	76.95	26.05
20	17.05	78.29912	44.61	22.89
24	3.7	100	35.1	12.14

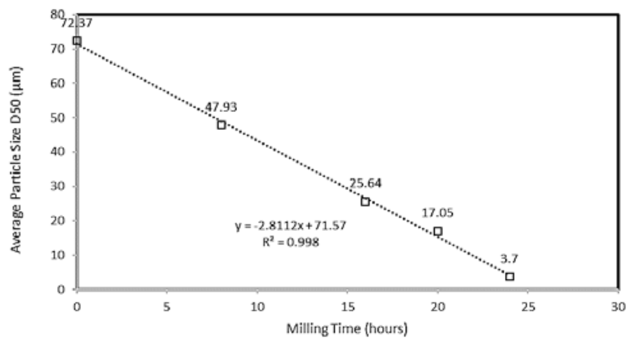
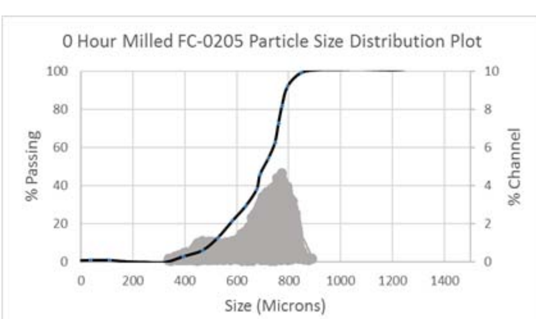


Figure 2: Milling Time vs. Average Particle Size

The particle size analysis experiments also offered information on the distribution of particle diameters in each sample. Figure 3 shows the particle size distribution plots for each powder analysis. For each successive increase in milling time, the peak of the distribution is seen to gradually skew from a right-sided distribution at 0-hour to a significantly left-sided distribution after 24 hours of milling with the peaks becoming narrower. The particle size distribution for the 8, 16, and 20-hour milled samples shows a mono-modal peak type compared to 0 (unmilled) and 24 milling hour which show a bi-modal peak type. The reason for the bi-modal peak could be as a result of higher particle size and coarser morphology of the 0 (unmilled) powder and high agglomeration obtained in the 24-hour milled powder. It was observed that at maximum peak for each milling distribution, the corresponding particle size decreased with increased milling time. For the unmilled powder, the average particle size is 72 (μm). In comparison, for the 24-hour milled powder, the average particle size is less than 5 (μm).



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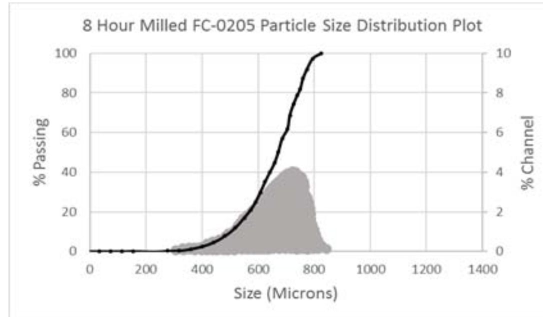

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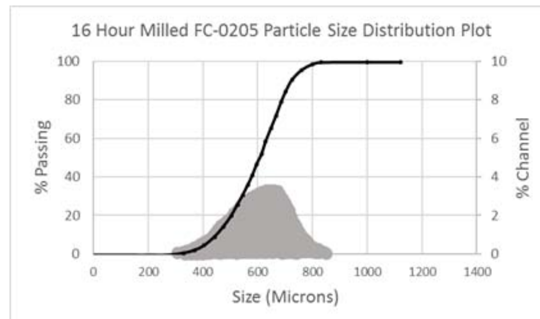

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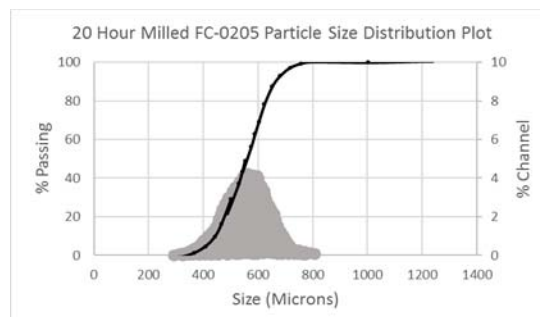

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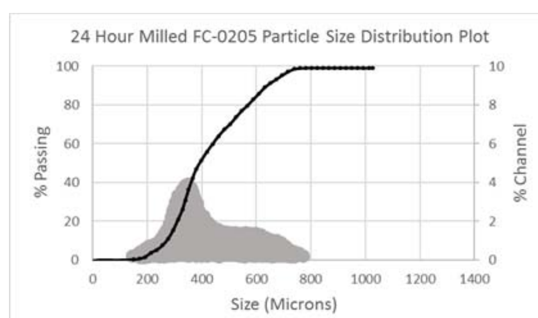
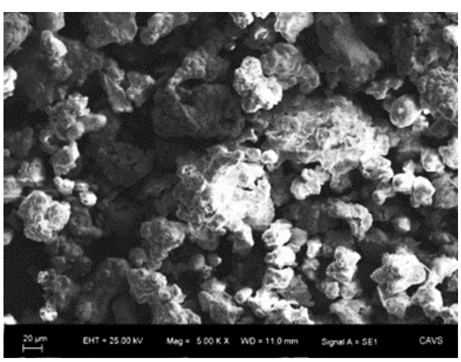


3(e)

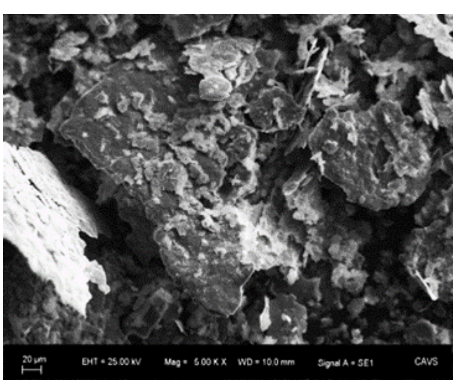
Figure 3 (a-e): Particle size distribution plots of FC-0205 powder after milling durations of (a) 0 (un-milled), (b) 8, (c) 16, (d) 20, and (e) 24 hours

b) Scanning Electron Microscopy (SEM) of Copper Steel Powders

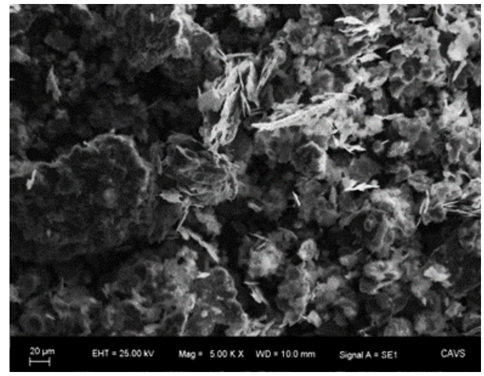
Scanning electron microscopy of the copper steel powder was performed to compare the morphology, agglomeration and particle size at different milling time and to determine the effect of particle size on consolidation. The SEM micrographs of the 0, 16, 20 and 24-hour milled copper steel powder at 5000X magnification is shown in Figure 4. It was observed that as milling time increased from 0 to 24-hour, the particle size became less coarse but was still in the micron meter range. However, higher agglomeration and morphology change of the steel powder was noticed as milling time increased. The morphology of the particle size for 0-hour (unmilled) powder is spherical as shown in Figure 4. As the milling time increased the particle size became flat and spongy with little agglomeration as shown in Figures 4 (b) and 4(c). The morphology change of the particles is due to an increase in milling energy which causes the contact area between grains to increase, as well as, an increase in the amount of coalesced particles, and a reduction in the plastic deformation of particles. The flat and spongy structure obtained due to increase milling time will be difficult to compact because of the high surface area which increases internal friction between particles. Hence, higher compaction pressure will be required to avoid high porosity and obtain high density. Increased agglomeration and a changes in morphology are also apparent in the 24-hour milled powder, as shown in Figure 4 (d). Increase in milling time causes more fracture of particles which results in further deformation and fragmentation of the steel particles.



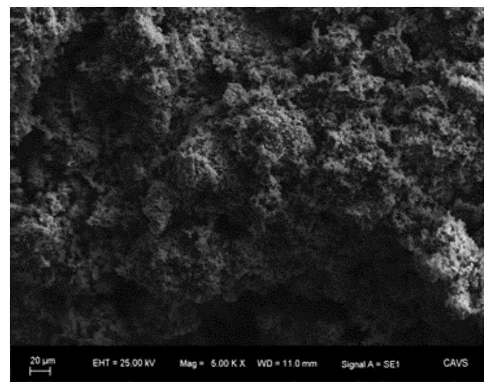
4(a)



4(b)



4(c)



4(d)

Figure 4 (a-d): Figure 4 SEM Images 5000X magnification of (a) (Unmilled) (b) 16 hour milled (c) 20 hour milled (d) 24 hour milled FC-0205 Powder respectively

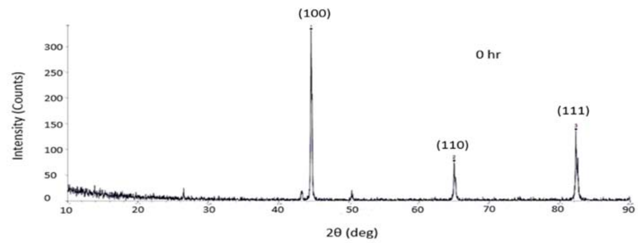
c) *X-Ray Diffraction of Copper Steel Powders*

The results of the X-ray diffraction experiment, used to characterize the correlation between the grain sizes and milling time, are shown in Table 4 and Figure 7. It is empirically shown that a linear relation exists between grain size and milling time with a correlation coefficient of 0.998 as shown in equation (3).

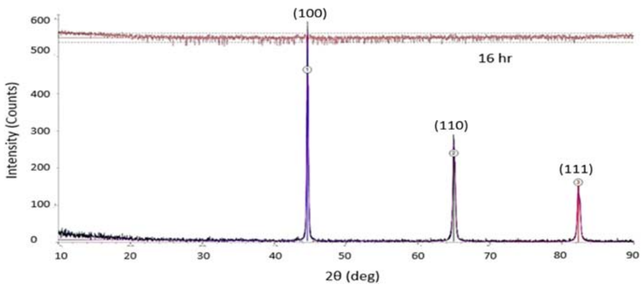
$$L = -3.15t + 88.567 \quad (3)$$

where *L* is average grain size in (nm), *t* is milling time in (hour)

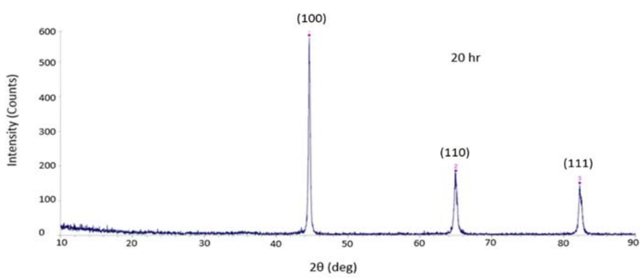
A linear reduction in grain size is obtained as milling time increases from 0 (unmilled) to 24-hour milled powder as shown in Figure 7. The X-ray diffraction peak patterns with angle 2θ° values in the range from 10° to 100° for FC-0205 copper steel powders as shown in Figure 5. Figure 5 (a) shows a sharp diffraction line known as the full widths at half maximum (FWHM), which occurs in the micrometer range as shown in Table 4. However, as milling time increased, the diffraction line widths broadened, as shown in Figures 5 (b, c, and d) and grain decreased to the nanosize range as shown in Figure 6. The change noticed as a result of milling time is due to grain size refinement and increase in atomic level strains.



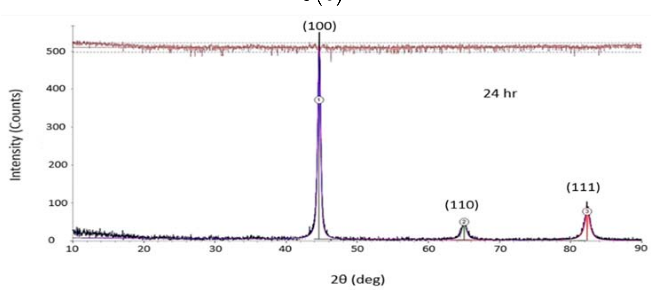
5(a)



5(b)



5(c)



5(d)

Figure 5: X-Ray diffraction peak profiles of milled powder samples at (a) 0 hour, (b) 16 hour, (c) 20 hour, (d) 24 hour.

Table 4: XRD result of average grain size for different milling times

Sample	Angle (°)	Centroid	Shape	FWHM (°)	Diameter (nm)
0Hr	64.961 (0.004)	1.4344Å	0.755v	0.145	>1000
16Hr	64.950 (0.004)	1.4347Å	0.495v	0.285	38.5
20Hr	64.934 (0.006)	1.4352Å	0.543v	0.412	24.9
24Hr	65.011 (0.012)	1.4342Å	0.880v	0.735	13.3

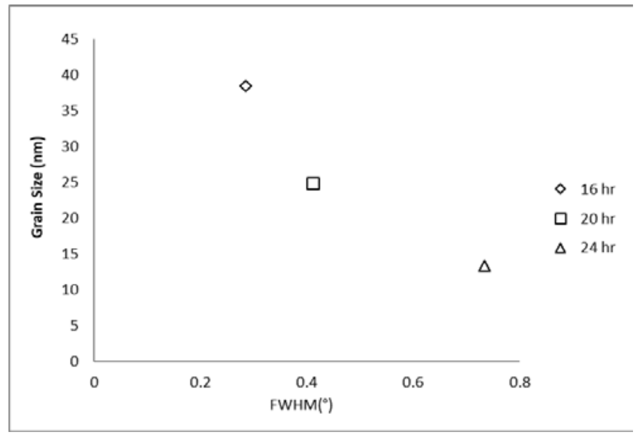


Figure 6: XRD Grain size vs. peak width

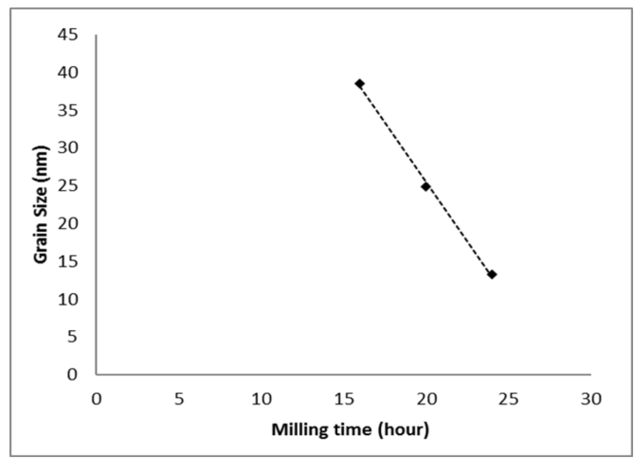


Figure 7: Grain Size vs. Milling Time

IV. Compaction And Sintering Results

Figure 8 shows the variation in relative density of 0 (unmilled), 8 and 16-hour green compacts of FC-0205 powder as a function of compaction pressure. As pressure increased from 300 MPa, the 0-hour (unmilled) green compacts had higher relative density than 8-hour green compacts. Similarly, the 8-hour green compacts show a higher relative density when compared to the 16-hour green compacts. Thus, increased milling time of the powders resulted in decreased the density of the green compacts at a given pressure. The observation agrees with previous studies on copper steel powder [39]. It was observed that between 300 MPa to 400 MPa, 0-hour (unmilled) compacts show a higher relative density than 8-hour 16-hour compacts. Also, an insignificant difference in relative density between 0-hour and 8-hour green compacts is noticed. However as milling time increased to 16 hours, a significant drop in relative density is observed. The spongy structure that resulted from increased milling, hindered compaction. Therefore, higher compaction pressures are required to increase the density of the milled powder compacts.

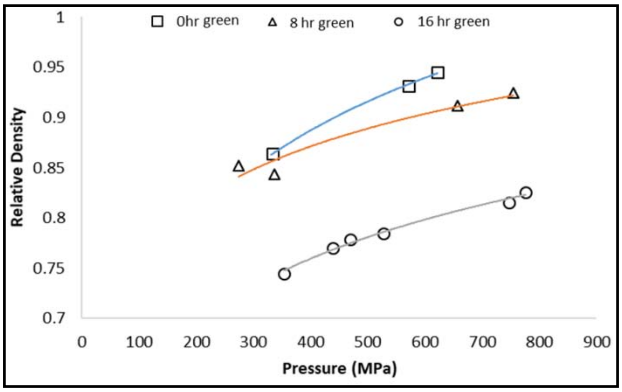


Figure 8: Compressibility Curve for 0, 8 and 16-hour milled FC-0205 powder

Figure 9 shows the rate of densification of 0 unmilled, 8 and 16-hour green compacts. The relationship between densification *ln*(1/(1-*D*)) and compaction pressure of the compacts show an elastic deformation property where particle sliding and rearrangement occur. A gradual increase in densification rate was noticed for unmilled compacts as compaction pressure increased. However, as milling time increased the densification rate decreased because of high frictional forces. Frictional force can be minimized by the addition of a moderate amount of lubricants which provide uniform flow during compaction. The densification function for 0-hour (unmilled), 8-hour 16-hour green compacts can be expressed as equations (4), (5) and (6), respectively.

$$\ln\left[\frac{1}{(1-D)}\right] = KP + 0.96 \qquad (4)$$

$$\ln\left[\frac{1}{(1-D)}\right] = KP + 1.4 \qquad (5)$$

$$\ln\left[\frac{1}{(1-D)}\right] = KP + 1.1 \qquad (6)$$

Where *D* is relative density, *P* is compaction pressure and *K* is a proportionality constant. The correlation coefficient of the equations is 0.99, 0.97 and 0.98 respectively.

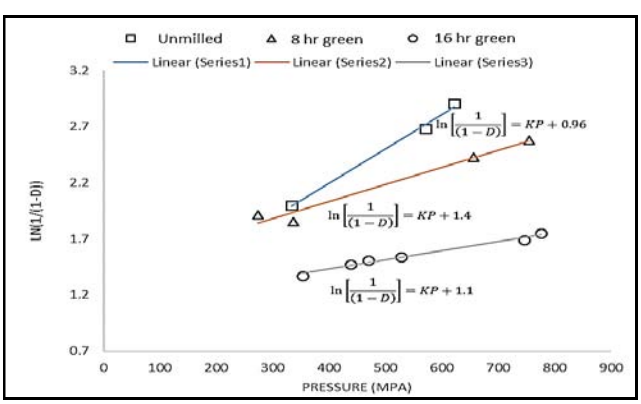


Figure 9: Figure 9 Ln(1/(1-D)) Vs Pressure

a) Dilatometer tests

The resulting dimensional change from the dilatometer experiments for the unmilled FC-0205 compacts heated at 10 C/min, along with the corresponding temperature cycle is shown in Figure 10. The FC-0205 compact presents dimensional change after sintering due to the difference in alloy composition and powder size. As shown in Figure 10, the copper steel compacts experienced a thermal expansion of 0.7% at 700 °C (1292 °F). At this point, the iron ferrite, having a bcc structure, started to transform to austenite an FCC structure with some evidence of sample contraction. As temperature increased, carbon diffused into the austenite region. The copper in the sample began to melt at 1083 °C (1981 °F) which caused expansion of the compact. Near 1120 °C (2048 °F) all the copper melted and penetrated the austenite structure. During the 30 minutes hold time the sample started to contract again. As temperature decreased during uncontrolled cooling, copper precipitated from iron and austenite iron transformed into ferrite and pearlite (a mixture of ***α*** ferrite and cementite Fe_3C). After sintering the copper regions were no longer in the form of discrete particles, and the pearlite structure dominated the ferrite structure.

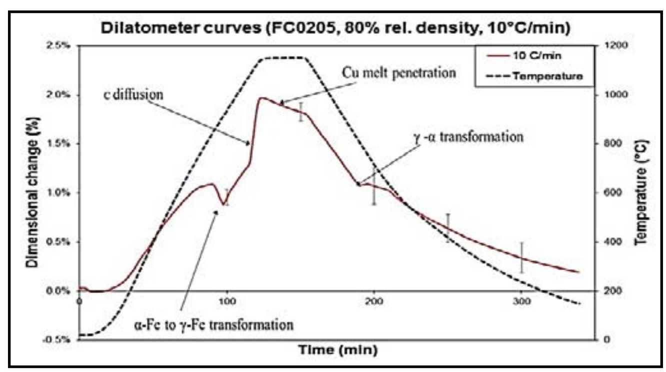


Figure 10: Dilatometer curves of dimensional change for the FC-0205 and FC-0208 at a heating rate of 10 °C/min.

The sintering behavior of the iron-copper-carbon system is very different compared to that of other PM metals. Figure 11 shows the typical shrinkage behavior during heating for nickel, 316L stainless steel, and bronze as compared to the expansion of the FC-0205 material during heating. The FC-0205 sample expanded to 1.5% at the maximum heating temperature 1150 °C (2102 °F). As the FC-0205 sample cooled, the material contracted, resulting in an overall dimensional change (shrinkage) of only 0.2% in the sample.

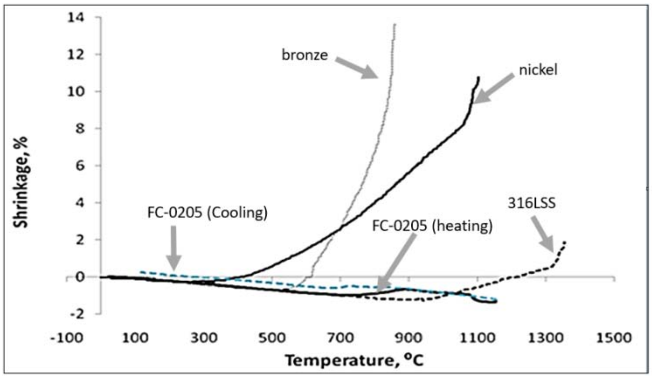


Figure 11: Comparison of sintering behavior of FC-0205, nickel, 316L stainless steel, and bronze

c) *Sintering*

FC-0205 copper steel powder samples were compressed to various heights to achieve different densities. Subsequently, the bulk samples were sintered at 900 °C (1652 °F) and 1120 °C (2048 °F) in a controlled nitrogen and hydrogen atmosphere to analyze density change with an increase in temperature. An insignificant difference in relative density Was obtained between green compacts and bulk compacts sintered at 900 °C for 0 (unmilled) powder as shown in Figure 12. However, as milling time increased to 8 hours, a slight increase in relative density was noted between green compacts and compacts sintered at 900 °C (1652 °F) and 1120 °C (2048 °F) as shown in Figure 13. Figure 14 shows a significant increase in relative density with increased temperature for the 16-hour milled compacts. The increase in relative density is due to finer particles dissolving or diffusing into the base metal thereby creating a bonded final compact. Shrinkage during sintering can also be a factor due to a reduction in space and pores in the compact.

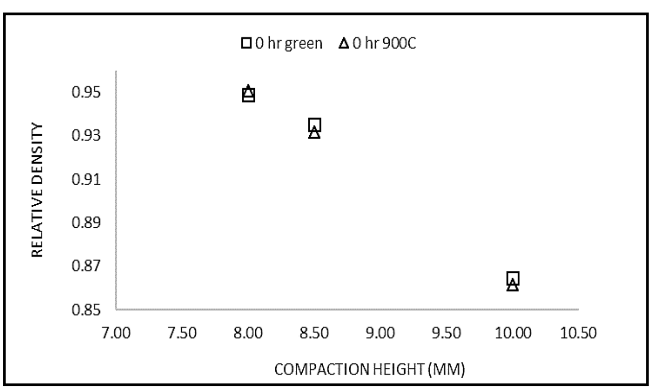


Figure 12: Relative density vs. compaction height for green and sintered (900 °C) unmilled compacts

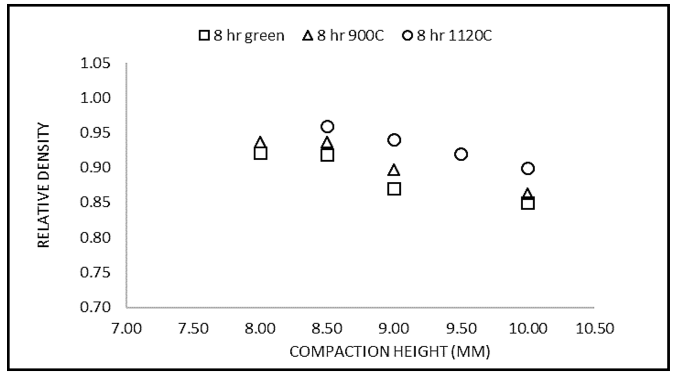


Figure 13: Relative density vs. compaction height for green and sintered (900 °C and 1120 °C) 8 hour milled powder compacts.

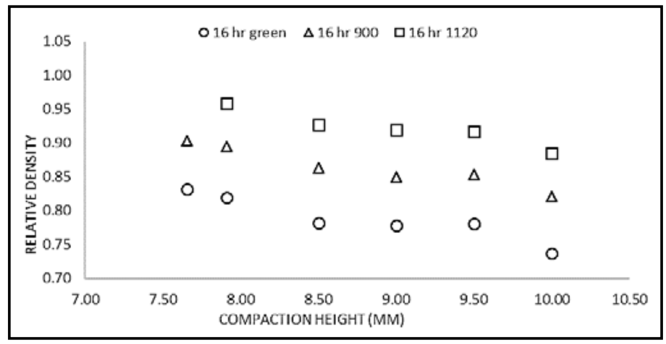


Figure 14: Relative density vs. compaction height for green and sintered (900 °C and 1120 °C) 16 hour milled powder compacts.

The microstructure in the 0-hour and 8-hour compacts sintered at 900 °C (1652 °F) show a better compaction and sintering of iron particles as shown in Figure 15 (b & d). Large pores are noticed in the 0-hour (unmilled) green compact as shown in Figure 15 (a) due to low compaction pressure. The large pores can affect the strength of the compact and act as a point of crack initiation which can lead to pre-mature fracture. High compaction pressure and sintering temperature can help control large porosity. Figure 15 (a) also shows elements and particles that are distinctly separated from each other,i.e., heterogeneous due to the unmilled powder of the green compact. The heterogeneous separation of particles allows the fine particles to fill in the inter-space between large particles, hence, increasing the powder packing and density of the green compact as obtained in the compressibility curve. The microstructure in 0 and 8-hour milled compacts sintered at 900 °C (1652 °F) show sinter bonding of powder particles and also the formation of pearlite as seen in Figure 15 (b and d). The shape, space and amount of pearlite depend on carbon diffusion and processing conditions. As temperature increases to 900 °C (1652 °F), iron ferrite transforms to austenite. As the sintering temperatures increase from 900 °C to 1120 °C (2048 °F), the diffusion of carbon into austenite takes

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place, along with the formation of pearlite in 0 and 8-hour sintered compacts as shown in Figure 15 (c and e). Copper completely diffuses into austenite as temperature increases from 900 °C (1652 °F) to 1120 °C (2048 °F) for 0, 8 and 16 hour compacts. The diffusion of copper into iron austenite created some pores as shown in Figure 15 (c & e). Similarly, increase in sintering temperature of the compact causes phase change and grain redistribution. As temperature increases from 900 °C (1652 °F) to 1120 °C (2048 °F) for 0 and 8 hour compacts, phase changed occurred from solid state phase to liquid state phase with the formation of high dominant pearlite in the microstructure as shown in Figure 15 (c & e). In the process of slow cooling, copper precipitate with the formation of pearlite and ferrite (cementite Fe_3C) as shown in Figure 15 (c & e).

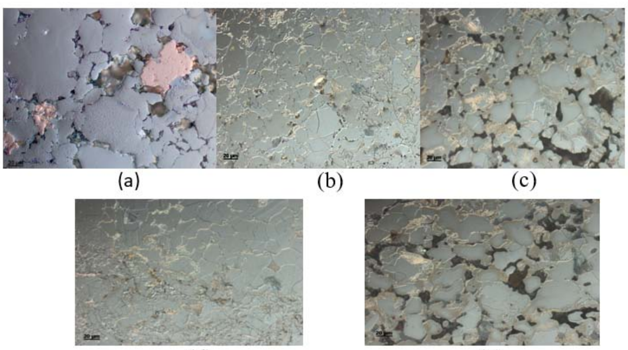

Figure 15: OM 500X magnification of (a) 0 (unmilled) green (b) 0 (unmilled) 900 °C (c) 0 (unmilled) 1120 °C (d) 8 hr 900 °C (e) 8 hr 1120 °C images showing grain size, grain distribution and voids of etched samples.

V. Microstructure Measurement

The microstructural grains of FC-0205 sintered compacts were measured using ImageJ analysis free software according to ASTM standard E 112. The objective was to ascertain the extent of growth concerning sintering temperature. The sintered microstructure obtained from OM shows the variation of grain size distribution of copper steel compact in Figure 16 and also the image analysis grain size data in Table 5. As temperature increases to 900 °C (1652 °F), the formation of big and small microstructural non-uniform grain structures was noticed as seen in Figure 15 (b and d). Further increase in sintering temperature to 1120 °C (2048 °F) resulted in smaller grains coalescing to form a more uniform grain structure with pores due to copper diffusion into austenite iron as shown in Figure 15 (c and e). The increase in temperature resulted in grain size increase from 13.45 (μm) to 13.76 (μm) for 0-hour (unmilled) sintered compacts, similarly from 13.49 (μm) to 13.77 (μm) for 8-hour sintered compacts as obtained in Table 5. As temperature increased, grain growth is obtained as seen in Figure 16. Unmilled and 8-hour sintered compacts indicated little increase in grain size and density as temperature increased from 900 °C (1652 °F) to 1120 °C (2048 °F). However, as temperature increased from 900 °C (1652 °F) to 1120 °C (2048 °F) in 16-hour sintered compacts, a significant increase in grain size and density is evident due to morphology and size of the powder.

Table 5: Average grain size

Sample	Relative Density (%)	Count	Total Area (nm^2)	Average Size (μm)	%Area	Mean (μm^2)	Mean Diameter (μm)
0hr-900C	0.92	284	54660.03	192.47	91.6	142.07	13.45
0hr-1120C	0.95	284	54789.03	192.92	90.82	148.62	13.76
8hr-900C	0.94	235	55422.57	235.84	92.18	142.87	13.49
8hr-1120C	0.95	283	54551.93	192.76	91.2	149	13.77
16hr-900C	0.91	380	54698.83	143.94	90.98	155.97	14.09
16hr-1120C	0.92	211	55683.8	263.9	92.62	173.66	14.87

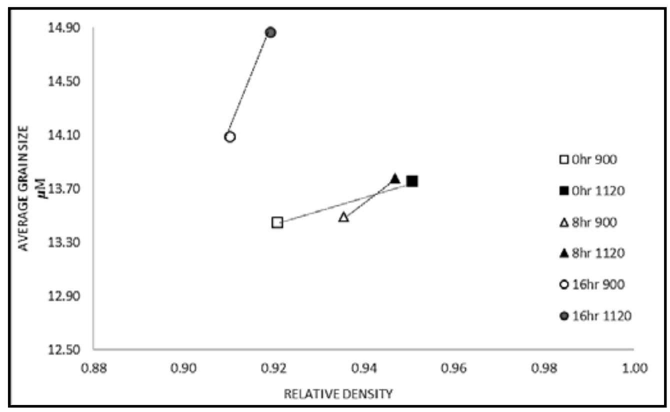

Figure 16: Average grain size vs. relative density for 0,8 and 16-hour milled powder compacts sintered at 900 °C and 1120 °C.grain size, grain distribution and voids of etched samples.

a) Hardness Test

Table 6 shows the mechanical properties obtained for FC-0205 copper steel powder using Rockwell hardness test at a maximum load of 60 kg. Four separate tests were performed on each sample, and the average was obtained for proper analysis of the strength. Each sample was polished to avoid spatial variability in hardness. It was noticed that Rockwell hardness for each milling hour increased as temperature increased, demonstrating the impact of sintering temperature on compact strength. However, Rockwell hardness for the 0-hour (unmilled) and 8-hour compacts was relatively close, but a significant difference was observed in the 16-hour compacts as temperature increased. Increase in density increased hardness of the sintered compacts as shown in Figure 17 and Table 7. Also, in Table 7, the 16-hour compacts show lower mechanical properties as regards to the density and hardness than the 0 (unmilled) and 8 hour sintered compacts. The reduced mechanical properties of the 16-hour compacts are due to the fine particle structure of the powder which makes compaction difficult and possible formation of pores in the compacts. It is observed that the finer the particle size of the powder, the more difficult to compress, hence lower strength is obtained.

Table 6: Rockwell Hardness results for sintered compacts

Sample	1	2	3	4	Average (HRA)
0hr 900	31.9	30.8	27.7	27.3	29.43
0hr 1120	32.2	29.5	32.4	31.4	34.88
8hr 900	34.4	32.6	32.1	31.8	32.73
8hr 1120	35.1	34.9	34	33.8	34.45
16hr 900	16.1	17.9	18.4	16.9	17.33
16hr 1120	22.2	22.8	20.3	21.6	21.73
Method	Rockwell Hardness HRA				
Indentor	Diamond cone				
Total Load	60kgf				

Table 7: Hardness, relative density, and grain size relationship

Sample	Relative Density	Average HRA (kGF)	Mean Daimeter (um)
0hr 900	0.921	29.43	13.45
0hr 1120	0.951	34.88	13.76
8hr 900	0.936	32.73	13.49
8hr 1120	0.947	34.45	13.77
16hr 900	0.91	17.33	14.09
16hr 1120	0.919	21.73	14.87

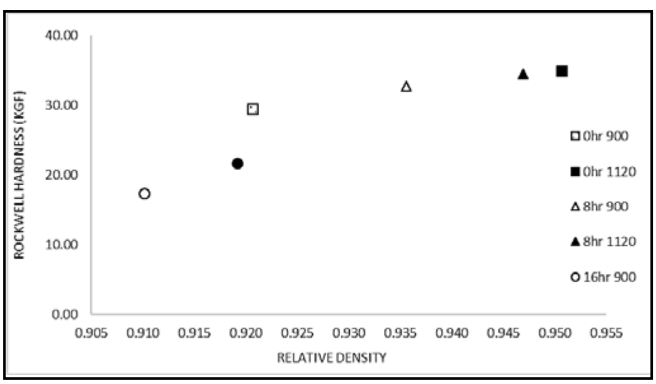

Figure 17: Hardness vs. Relative density

VI. Conclusion

This experimental study establishes a correlation between milling time, particle size, temperature and grain growth through HEBM on copper steel powder. Results from this study agrees with previous studies which show that increased milling time of powder particles decreased the average particle size as well as grain size due to high rate of particle fragmentation. Although at higher milling time, fragmentation rate was low resulting in low reduction in particle size. The particle size reduction rate was as a result of higher milling energy which increases the contact areas between grains, therefore, welding of particles is obtained. Particle size analysis showed distribution peaks that was getting narrower and also skewing from right to left due to increased milling time of the copper-steel powder. The increase in milling time caused change in morphology and higher agglomeration of the powder particles. The change in morphology noticed with increased milling can hinder compaction because of high surface area that increases internal friction between particles. Therefore, higher compaction pressure will be required to achieve a good dense compact. A linear reduction in grain size was obtained as milling time increased. As pressure was increased in green compacts, density also increased. It was noticed that at the same pressure range, lower milling hour compacts obtained higher density. Therefore higher compaction pressure is required for higher milling hour to avoid a high porous compact. Contraction of copper steel compact was noticed at 700 °C (1292 °F) as the microstructure transformed from iron ferrite to iron austenite. Further increase in temperature to 1083 °C (1981 °F) resulted in copper melting into iron austenite which led to expansion of the compacts. It was observed that increase in milling time between 0 (unmilled) and 8 hour compacts showed a slight increase in relative density as temperature increased to 1120 °C (2048 °F). A significant increase in relative density was obtained for 16 hour compacts at the same temperature. Hence, higher milling time and higher temperatures resulted in increased density of the compacts. increases the density of the compacts at the same temperature increase. However, grain growth was significant in the 16-hour milled compacts as temperature was increased during sintering as compared to the 0 (unmilled) and 8 hour compacts sintered at the same temperature. As compared to the 0-hour and 8-hour milled and sintered samples, the 16-hour milled, sintered compacts The finer sized powders require higher compaction pressure to increase pre-sintering density and reduced sintering temperature to prevent grain growth.

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Can Broken Multicore Hardware be Mended?

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Abstract- A suggestion is made for mending multicore hardware, which has been diagnosed as broken.

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CANBROKENMULTICOREHARDWAREBEMENDED

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Can Broken Multicore Hardware be Mended?

János Végh [α] & József Vásárhelyi [σ]

Abstract- A suggestion is made for mending multicore hardware, which has been diagnosed as broken.

I. The Multicore Era is a Consequence of the Stalling of the Single-Thread Performance

The multi- and many-core (MC) era we have reached was triggered after the beginning of the century by the stalling of single-processor performance. Technology allowed more transistors to be placed on a die, but they could not reasonably be utilized to increase single-processor performance. Predictions about the number of cores has only partly been fullfield: today's processors have dozens rather than the predicted hundreds of cores (although the Chinese supercomputer [3] announced in the middle of 2016 comprises 260 cores on a die, but the new PEZY chip has 2048 cores [5]). Despite this, the big players are optimistic. They expect that Moore-law persists, though based on presently unknown technologies. The effect of the stalled clock frequency is mitigated, and it is even predicted [7] that "*Now that there are multicore processors, there is no reason why computers shouldn't begin to work faster, whether due to higher frequency or because of parallel task execution. And with parallel task execution it provides even greater functionality and exibility!.*"

Parallelism is usually considered in many forums [4] to be the future, usually as the only hope, rather than as a panacea. People dealing with parallelism are less optimistic. In general, the technical development tends to reduce the human effort, but "*parallel programs ... are notoriously difficult to write, test, analyze, debug, and verify, much more so than the sequential versions" [12]. The problems have led researchers to the ViewPoint [11], that multicore hardware for general-purpose parallel processing is broken.*

II. Manycore Architectures Could Be Fresh Meat On The Market Of Processors, But They Are Not

The essence of the present Viewpoint is that multicore hardware can perhaps be mended. Although one can profoundly agree with the arguments [11] that using many-core chips cannot contribute much to using parallelism in general, and especially not in executing irregular programs, one has to realize also that this is not the optimal battlefield for the manycore chips, at least not in their present architecture. Present manycore systems comprise many segregated processors, which make no distinction between two processing units that are neighbours within the same chip or are located in the next rack. The close physical proximity of the processing units offers additional possibilities, and provides a chance to implement Amdahl's dream [1] of cooperating processors.

Paradigms used presently, however, assume a private processor and a private address space for a running process, and no external world. In many-core systems, it is relatively simple to introduce signals, storages, communication, etc., and deploy them in reasonable times. They cannot, however, be utilized in a reasonable way, if one cannot provide compatibiliy facades providing the illusion of the private world. Cooperation must be implemented in a way which provides complete (upward) compatibility with the presently exclusively used Single-Processor Approach (SPA) [1]. It means that on the one hand that new functionality must be formulated using the terms of conventional computing, while on the other, it provides considerably enhanced computing throughput and other advantages.

It is well known, that general purpose processors have a huge handicap in performance when compared to special purpose chips, and that the presently used computing stack is the source of further serious inefficiencies. Proper utilization of available manycore processors can eliminate a lot of these performance losses, and in this way (keeping the same electronic and programming technology) can considerably enhance (apparently) the performance of the processor. Of course, there is no free lunch. Making these changes requires a *simultanous* change in nearly all elements of the present computing stack. Before making these changes, one should scrutinize the

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promised gain, and whether the required efforts will pay off.

Below, some easy-to follow case studies are presented, all of which lead to the same conclusion: we need a cooperative and exible rather than rigid architecture comprising segregated MCs, and the 70-years-old von Neumann computing paradigms should be extended. At the end, the feasibility of implementing such an architecture is discussed. The recently introduced Explicitly Many-Processor Approach [10] seems to be quite promising: it not only provides higher computing throughput, but also offers advantageous changes in the behavior of computing systems.

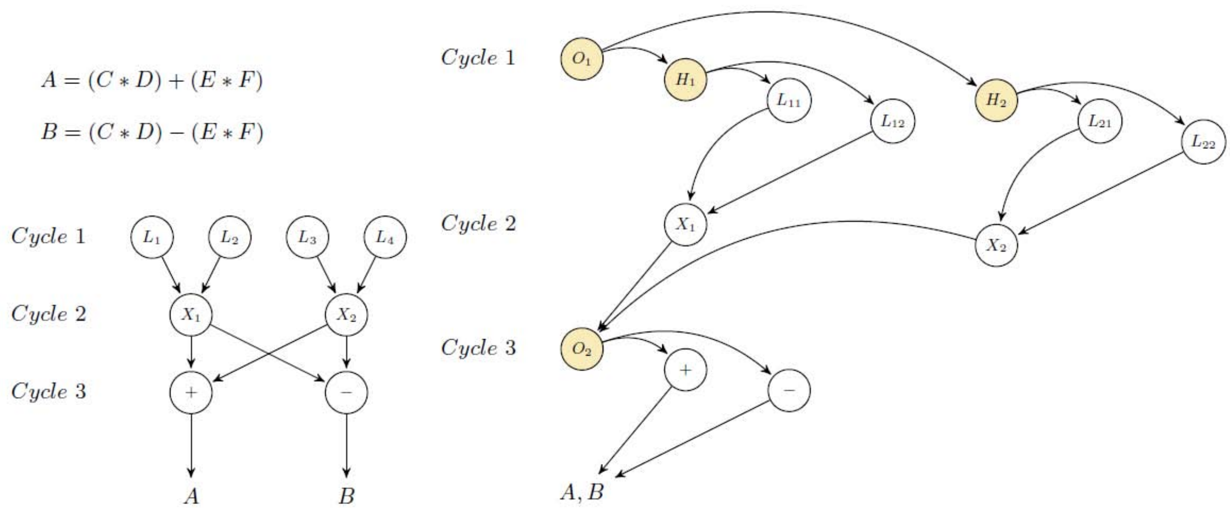

Fig. 1: Theoretical parallelism (left) vs dynamic parallelism implemented on a processor system with runtime configurable architecture (right).

III. Is Implementing Mathematical Parallelism Just a Dream?

Today's computing utilizes many forms of parallelism [6], both hardware (HW) and software (SW) facilities. The software is systematically discussed in [11] and hardware methods are scrutinized in [6]. A remarkable difference between the two approaches is, that while the SW methods tend to handle the parallel execution explicitly, the HW methods tend to create the illusion that only one processing unit can cope with the task, although some (from outside invisible) helper units are utilized in addition to the visible processing unit. Interestingly enough, both approaches arise from the von Neumann paradigms: the abstractions process and the processor require so.

The inefficiency of using several processing units is nicely illustrated with a simple example in [6] (see also Fig 1, left side). A simple calculation comprising 4 operand loadings and 4 aritmetic operations, i.e. altogether 8 machine instructions, could be theoretically carried out in 3 clock cycles, provided that only dependencies restrict the execution of the instructions and an unlimited number of processing units (or at least 4 such units in the example) are available. It is shown that a single-issue processor needs 8 clock cycles to carry out the calculation example.

Provided that memory access and instruction latency time cannot be further reduced, the only possibility to shorten execution time is to use more than one processing unit during the calculation. Obviously, a fixed architecture can only provide a fixed number of processing units. In the example [6] two such ideas are scrutinized: a dual- issue single processor, and a two-core single issue processor. The HW investment in both cases increases by a factor of two (not considering the shared memory here), while the performance increases only moderately: 7 clock cycles for the dual-issue processor and 6 clock cycles for the dual-core processor, versus the 8 clock cycles of the single-issue single core processor. The obvious reasons here are the rigid architecture and the lack of communication possibilities, respectively.

Consider now a processor with exible architecture, where the processor can outsource part of its job: it can rent processing units from a chip-level pool just in the time it takes to execute a few instructions. The cores are smart: they can communicate with each other, and even they know the task to be solved and are able to organize their own work while outsourcing part of the work to the rented cores. The sample calculation, borrowed from [6] as shown in Fig. 1, left side, can then be solved as shown on the right side of the figure.

The core O_1 originally receives the complete task to make the calculation, as it would be calculated by a conventional single-issue, single core system, in 8 clock cycles. However, O_1 is more intelligent. Using the hints hidden in the object code, it notices that the task can be outsourced to another cores. For this purpose it rents, one by one, cores H_1 and H_2 to execute two multiplications. The rented H_x cores are also intelligent, so they also outsource loading the operands to cores L_{x1} and L_{x2}. They execute the outsourced job: load the operands and return them to the requesting cores H_x, which then can execute the multiplications (denoted by X_x) and return the result to the requesting core, which can then rent another two cores $\oplus$ and $\ominus$ for the final operations. Two results are thus produced.

This unusual kind of architecture must respond to some unusual requirements. First of all, the architecture must be able to organize itself as the received task requires it, and build the corresponding "processing graph", see Fig. 3, for legend see [8]. Furthermore, it must provide a mechanism for mapping the virtually infinite number of processing nodes to the finite number of cores. Cores L_{xy} must receive the address of the operand, i.e. at least some information must be passed to the rented core. Similarly, the loaded operand must be returned to the renting core in a synchronized way. In the first case synchronization is not a problem: the rented core begins its independent life when it receives its operands. In the second case the rented core finishes its assigned operation and sends the result asyncronously, independently of the needs of the renting core. This means that the architecture must provide a mechanism for transferring some (limited amount of) data between cores, a signalization mechanism for renting and returning cores, as well as a latched intermediate data storage for passing data in a synchronized way.

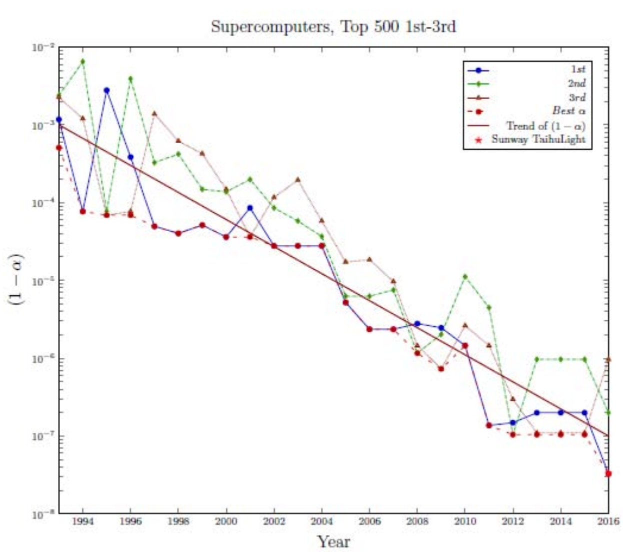

Fig. 2: Timeline of supercomputer parallelism. The diagrams show (1 – α) values for the actual first three out of the Top500 supercomputers over the past 24 years, and to guide the eye, their tendency.

The empty circles are the theoretically needed operations, and the shaded ones are additional operations of the "smart" cores. The number of the cores being used changes continuously as they are rented and returned. Although physically they may be the same core, logically they are brand new. Note that the "smart" operations are much shorter - they comprise simple bit manipulations and multiplexing -, than the conventional ones that comprise complex machine instructions, and since the rented cores work in parallel (or at least mostly overlap), the calculation is carried out in 3 clock periods. The cycle period is somewhat longer, but the attainable parallelism approaches the theoretically possible one, and is more than twice as high as the one attainable using either two-issue or dual-core processors.

Although the average need of cores is about 3, these cores can be the simplest processors, i.e. the decreasing complexity of the cores (over)compensates for the increasing complexity of the processor. In addition, as the control part of the processors increases, the need for the hidden parallelization (like out-of-order and speculation) can be replaced by the functionality of the exible architecture, the calculational complexity can be decreased, and as a result, the clock speed can be increased. A processor with such an internal architecture appears to the external world as a "superprocessor", having several times greater performance than could be extracted from a single-threaded processor. That processor can adapt itself to the task: unlike in the two issue processor, all (rented) units are permanently used. The many-core systems with exible architecture comprising cooperating cores can approach the theoretically possible maximum parallelism. In addition, the number of the cores can be kept at a strict minimum, allowing reduction of the power consumption.

IV. How Long Can The Parallelism Of The Many-Many Processor Supercomputers Still Be Enhanced, At A Reasonable Cost?

In the many-many processor (supercomputer) systems the processing units are assembled using the SPA [1], and so their maximum performance is bounded by Amdahl's law. Although Amdahl's original model [1] is pretty outdated, its simple and clean interpretation allows us to derive meaningful results even for today's computing systems. Amdahl assumed that in some part of the total time the computing system engages in parallelized activity, in the remaining (1 – α) part it performs some (from the point of view of parallelization) non-payload activity, like sequential processing, networking delay, control or organizational operation, etc. The essential point here is that all these latter activities behave as *if they were sequential* *processing*. Under such conditions, the efficiency E is calculated as the ratio of the total speedup S and the number of processors k:

$$\mathrm{E} = \frac{S}{k} = \frac{1}{k(1-\alpha) + \alpha} \qquad (1)$$

Although in the case of supercomputers (1 – α) comprises contributions of a technically different nature (it can be considered as the "imperfectness" of implementation of the supercomputer), it also behaves as if it were a sequentially processed code.

Fig. 2 shows how this "imperfectness" was decreased during the development of supercomputers, calculated from the actual data of the first three supercomputers in the year in question over a quarter of a century. As the figure shows, this parameter behaves similarly to the Moore-observation, but it is independent of that one (because the parameter is calculated from $\frac{Rpeak}{Rmax}$, any technology dependence is removed).

At first glance, it seems to be at least surprising to look for any dependence in function of "imperfectness". The key is Equ. (1). Since the **α** approaches unity, the term *k*(1 – **α**) determines the overall efficiency of the computing system. To increase *k* by an order or magnitude alone is useless if not accompanied by an order of magnitude decrease in the value of (1 – **α**). However, while increasing *k* is simply a linear function, decreasing (1 – **α**) as any kind of increasing perfectness, is exponentially more difficult.

Fig. 2 proves that today's supercomputers are built in SPA, and makes it questionable whether further significant decrease of value (1 – α) could be reached at reasonable cost. This means that it is hopeless *to build exa-scale computers, using the principles drawn from the SPA*.

Looking carefully at k (1 – α), one can notice that the two terms describe two important behavioral features of the computing system. As already discussed, (1 – α) describes, how much the work of the many-processor system is coordinated. The factor k, on the other hand, describes, how much the processing units cooperate. In the case of using the SPA, the processing units are segregated entities, i.e. they do not cooperate at all.

If we could make a system where the processing units behave differently in the presence of another processors, we could write *f(k)* in Equ. (1). Depending on how cores behave together in the presence of another cores when solving a computing task, the *f(k)*, the cooperation of the processing units can drastically increase the efficiency of the many-processor systems. In other words, to increase the performance of many-many-processor computers, the cores must cooperate (at least with some) other cores. *Using cooperating cores is inevitable for building supercomputers at a reasonable cost.*

V. Can We Eliminate Non-Payload Calculations By Replacing Them With Architectural Changes?

A computer computes everything, because it cannot do any other type of operations. Computational density has reached its upper bound, so no further performance increase in that direction is possible. In addition to introducing different forms of HW and SW parallelism, it is possible to omit some non-payload, do-not-care calculations, through providing and utilizing special HW signals instead. The signals can be provided for the participating cores, and can be used to replace typical calculational instruction sequences by using special hardware signals. The compilation is simple: where the compiler should generate non-payload loop organization commands, it should give a hint about renting a core for executing non-payload instructions and providing external synchronization signals.

A simple example: when summing up elements of a vector, the only payload instruction is the respective add. One has, however, to address the operand (which includes handling the index, calculating the offset and adding it to the base address), to advance the loop counter, to compare it to the loop bound, and to jump back conditionally. All those non-payload operations can be replaced by handling HW signals, if the cores can cooperate, resulting in a speed gain of about 3, using an extra core only. Even, since the intermediate sum is also a do-not-care value until the summing is finished, a different sumup method can be used, which may utilize dozens of cores and result in a speed gain of dozens. When organizing a loop, the partial sum is one of the operands, so it must be read before adding a new summand, and must be written back to its temporary storage, wasting instructions and memory cycles; in addition it excludes the possibility of parallelizing the sumup operation. For details and examples see [8].

This latter example also demonstrates that *the machine instruction is a too rigid atomic unit of processing. Utilizing HW signals from cooperating cores rather than providing some conditions through (otherwise don-not-care) calculations, allows us to eliminate obsolete calculational instructions, and thus apparently accelerate the computation by a factor of about ten*.

VI. Do We Really Need To Pay With An Indeterministic Operation For Multiprocessing?

The need for multi-processing (among others) forced to use exceptional instruction execution. I.e., a running process is interrupted, its HW and SW state is saved and restored, because the hard and soft parts of the only processor must be lent to another process. The code of the interrupting process is effectively inserted in the flow of executing the interrupted code. This maneuver causes an indeterministic behavior of the processor: the time when two consecutive machine instructions in a code flow are executed, becoming indeterminate.

The above is due to the fact that during development, some of the really successful accelerators, like the internal registers and the highest level cache, became part of the architecture: the soft part of the processor. In order to change to a new thread, the current soft part must be saved in (and later restored from) the memory. Utilizing asynchronous interrupts as well as operating system services, implies a transition to new operating mode, which is a complex and very time-consuming process.

All these extensions were first developed when the computer systems had only one processor, and the only way to provide the illusion of running several processes, each having its own processor, was to detach the soft part from the hard one. Because of the lack of proper hardware support, this illusion depended on using SW services and on the architectures being constructed with a SPA in mind, conditions that require rather expensive execution time: in modern systems a context change may require several thousands of clock cycles. As the hyper-threading proved, detaching soft and hard part of the processors results in considerable performance enhancement.

By having more than one processor and the Explicitly Many-Processor Approach [9], the context change can be greatly simplified. For the new task, such as providing operating system services and servicing external interrupts a dedicated core can be reserved. The dedicated core can be prepared and held in supervisor mode. When the execution of the instruction flow follows, it is enough to clone the relevant part of the soft part: for interrupt servicing nothing is needed, for using OS services only the relevant registers and maybe cache. (The idea is somewhat similar to utilizing shadow registers for servicing an asynchronous interrupt.)

If the processors can communicate among each other using HW signals rather than OS actions, and some communication mechanism, different from using (shared) memory is employed, the apparent performance of the computing systems becomes much faster. *For cooperating cores no machine instructions (that waste real time, machine and memory cycles) are needed for a context change, allowing for a several hundredfold more rapid execution in these spots.* The application can even run parallel with the system code, allowing further (apparent) speedup.

Using the many-processor approach creates many advantageous changes in the real-time behavior of the computing systems. Since the processing units do not need to save or restore anything, the servicing can start immediately and is restricted to the actual payload instructions. The dedicated processing units cannot be addressed by non-legal processing units, so issues like exluding priority inversion are handled at HW level. And so on.

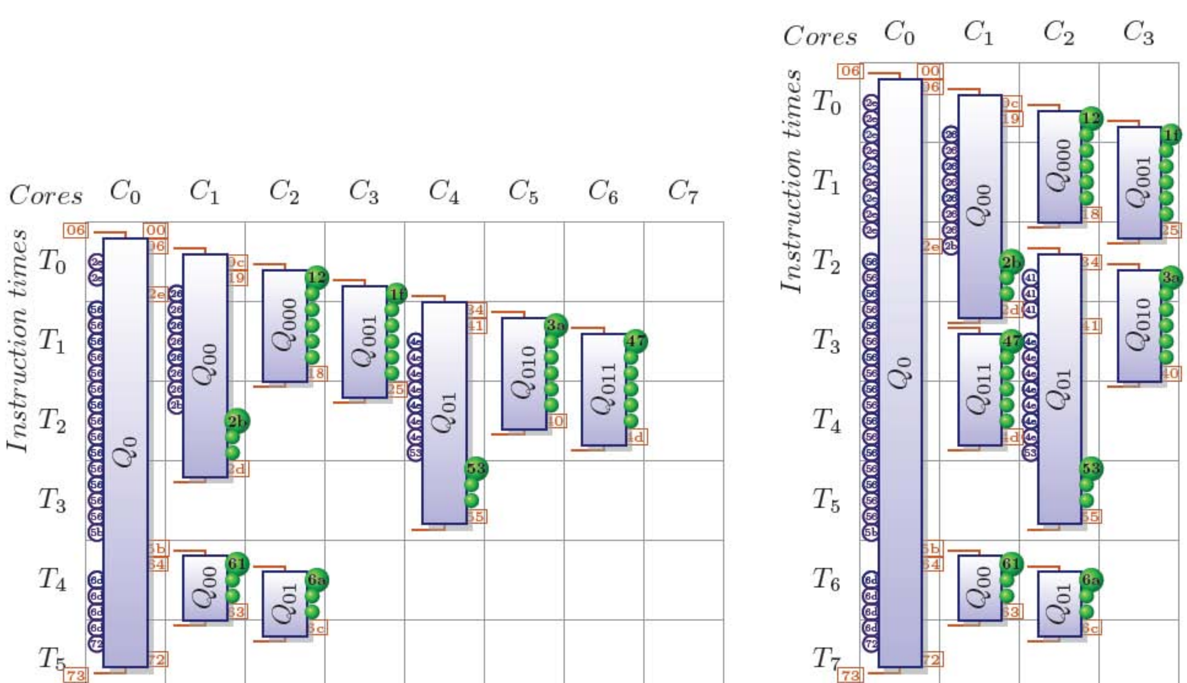

Fig. 3: The processing graphs corresponding to Figure 1, running on an 8-core (left) and 4-core(right) EMPA processor.

VII. The Common Part: Implement Supervised Cooperating Cores, Handling Extra Signals and Storages

From all points of view (the just-a-few and many-many processors, as well as utilizing kernel-mode or real-time services) we arrive at the same conclusion: segregated processors in the many-processor systems do not allow a greater increase in the performance of our computing systems, while cooperating processors can increase the attainable single- threaded performance. Amdahl contented this by a half century ago: "*the organization of a single computer has reached its limits and that truly significant advances can be made only by interconnection of a multiplicity of computers in such a manner as to permit cooperative solution.*" [1]

At this point the many-core architectures have the advantage that they are in the close proximity to one another: there is no essential difference between that a core needing to reach its own register (or signal) or that of another core. The obstacle is actually the SPA: for a core and a process, there exists no other core.

In the suggested new approach, which can be called *Explicitly Many-Processor Approach* (EMPA), the cores (through their supervisor) can know about their neighbours. Today, radical departures from conventional approaches (including rethinking the complete computing stack) are advanced [2], but at the same time a smooth transition must be provided to that radically new technology. *To preserve compatibility with conventional computing, the EMPA approach [9] is phrased using the terms of conventional computing (i.e. it contains SPA as a subset)*.

VIII. How Do Algorithms Benefit From The Empa Architecture?

Some of the above-mentioned boosting principles are already implemented in the system. From the statistics one can see that in some spots, performance gain in the range 3-30 can be reached. The different algorithms need different new accelerator building stone solutions in frame of EMPA.

For example, the gain 3 in an executing loop, when used in an image processing task where for edge detection a 2- dimensional matrix is utilized, means nearly an order of magnitude performance gain, using the same calculational architecture in calculating a new point. And, to consider all points of the picture another double loop is used. This means, that a 4-core EMPA processor can produce nearly 100 times more rapid processing (not considering that several points can be processed in parallel on processors with more cores). This is achieved not by increasing computing density, but by replacing certain non-payload calculations with HW signals, and so executing 100 times less machine instructions.

IX. How Amdahl's Dream Can Be Implemented?

The MC architecture comprising segregated cores is indeed broken. It can, however, be mended, if the manycore chips are manufactured in the form using cooperating cores.

As the first step toward implementing such a system, for simulating its sophisticated internal operation and providing tools for understanding and validating it, an EMPA development system [8] has been prepared. An extended assembler prepares EMPA-aware object code, while the simulator allows us to watch the internal operation of the EMPA processor.

To illustrate the execution of programs using the EMPA method, a processing diagram is automatically prepared by the system, and different statistics are assembled. Fig. 3 shows the equivalent of Fig. 1, running on an 8-core and a 4-core processor, respectively (for legend see [8]). The left hand figure depicts the case when "unlimited" number of processing units are available, the right hand one shows the case when the processor has a limited number of computing resources to implement the maximum possible parallelism.

The code assembled by the compiler is the same in both cases. The supervisor logic detects if not enough cores are available (see right side), and delays the execution (outsourcing more code) of the program fragments until some cores are free again. The execution time gets longer if the processor cannot rent enough cores for the processing, but the same code will run in both cases, without deadlock and violating dependencies.

For electronic implementation, some ideas may be borrowed from the technology of reconfigurable systems. There, in order to minimize the need for transferring data, some local storage (block-RAM) is located between the logical blocks, and a LOT of wires is available for connecting them.

In analogy also with FPGAs, the cores can be implemented as mostly fixed functionality processing units, having multiplexed connecting wires to their supervisor with fixed routing. Some latch registers and non-stored program functionality gates can be placed near those blocks, which can be accessed by both cores and supervisor. The inter-core latch data can be reached from the cores using pseudo- registers (i.e. they have a register address, but are not part of the register file) and the functionality of the cores also depends on the inter-core signals. In the prefetch stage the cores can inform the supervisor about the presence of metainstruction in their object code, and in this way the mixed code instructions can be directed to the right destination. In order to be able to organize execution graphs, the cores (after renting) are in parent-child relation to unlimited depth.

As was very correctly stated [11], "due to its high level of risk, prototype development fits best within the research community." The principles and practice of EMPA differ radically from those of SPA. To compare the performance of both, EMPA needs a range of development. Many of the present components, accelerators, compilers, etc., with SPA in mind, do not fit EMPA. The research community can accept (or reject) the idea, but it definitely warrants some cooperative work.

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Optimization of the Flexible Job Shop Scheduling Problem for Economic Sustainability

Md. Riyad Hossain, Md. Kamruzzaman Rasel, Md. Isanur Shaikh &
Utpal Kumar Dey

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Abstract- The flexible job-shop scheduling problem (FJSP) is one of the challenging optimization problems as they occupy very large search space. Solving this kind of problems with conventional methods are obsolete now as the Internet of Things (IoT) has changed scheduling platform by means of cloud computing and advanced data analytics. Genetic Algorithms (GAs) is a popular modern tool for machine scheduling problems and in this work, a scheduling algorithm has been developed to minimize total tardiness and make span time of parallel machines which is promoting overall economic sustainability. The algorithm consists of a machine selection module (MSM) that helps to select the right machine on the right time with the help of global selection (GS) technique by generating high quality initial population. To represent an optimized solution of the FJSP, an improved chromosome representation is used while adopting uniform crossover and mutation operator.

Keywords: *economic sustainability, flexible job-shop scheduling, genetic algorithm, machine selection module, global search technique.*

GJRE-A Classification: *FOR Code: 091399, 290502p*

OPTIMIZATIONOFTHEFLEXIBLEJOBSHOPSCHEDULINGPROBLEMFORECONOMICSUSTAINABILITY

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Md. Riyad Hossain α, Md. Kamruzzaman Rasel σ, Md. Isanur Shaikh ρ & Utpal Kumar Dey Ѡ

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Keywords: economic sustainability, flexible job-shop scheduling, genetic algorithm, machine selection module, global search technique.

I. Introduction

Nowadays sustainable manufacturing is an important issue for every industry and industries are aiming to achieve triple bottom line (TBL) sustainability for maintaining their competitive benchmark. The triple bottom line sustainability means achieving sustainability in every sector and most specifically achieving sustainability in economic, social and environmental sectors (Islam & AlGeddawy, 2017) (D. Chen, Thiede, Schudeleit, & Herrmann, 2014). Economic sustainability is one of the major pillars of TBL sustainably which is an expression of economic viability of a company (D. Chen et al., 2014; Islam & AlGeddawy, 2017; Kannegiesser & Günther, 2014). In this scheduling problem, the importance of economic sustainability has been highlighted and its mutual relationship between the optimized result has been analyzed.

Scheduling is involved with the proper distribution and availability of resources for accomplishing a set of tasks over a specified time (Roshanaei, Azab, & ElMaraghy, 2013; Shen, Dauzère-Pérès, & Neufeld, 2018). In 1985, Davis first applied Genetic Algorithms (GAs) to scheduling problems (L. Davis, 1991; T. E. Davis, 1991; Kelly Jr & Davis, 1991; Montana & Davis, 1989). While applying GAs to Scheduling problems the main problem is to find a suitable chromosome representation and genetic operators in order to create feasible schedules (Ak & Koc, 2012). The classical method of solving job-shop scheduling problem (JSP) is time consuming and sometimes impossible. The JSP consists of a set of n jobs processed by a set of m machines with the objective to minimize certain criteria (Pezzella, Morganti, & Ciaschetti, 2008). At time zero each machine is fully available, processing only one operation at a time. Each job contains a pre-specified processing order and specific time on the machines that are fixed and known in advance. In modern manufacturing plant, a machine may have the flexible capability to be set up to process more than one type of operations. This leads to a modified version of JSP called flexible JSP (FJSP) (Gen, Gao, & Lin, 2009; Xia & Wu, 2005; Yazdani, Amiri, & Zandieh, 2010). There are two types of FJSP (Brucker & Schlie, 1990) . For type I FJSP, jobs have alternative operation sequences and alternative identical or non-identical machines for each operation (Chan, Wong, & Chan, 2006; J. Chen, Chen, Wu, & Chen, 2008; Fattahi, Mehrabad, & Jolai, 2007). The problem is to select operation sequences for jobs and determine job processing orders on machines (Jahromi & Tavakkoli-Moghaddam, 2012). For type II FJSP, jobs can have only fixed operation sequences but alternative identical or non-identical machines for each operation. The problem is to arrange jobs to machines according to their operation sequences (Chan et al., 2006; J. C. Chen, Wu, Chen, & Chen, 2012; Gen et al., 2009; Xia & Wu, 2005).

In this article, an effective GA is proposed to solve the FJSP. Global Selection (GS) and Local Selection (LS) are designed to generate high-quality initial population in the initialization stage which could accelerate convergent speed (Zhang, Gao, & Shi, 2011). An improved chromosome representation method ‘‘Machine Selection and Operation Sequence” has been introduced to assist the initialization method and to assure the algorithm is performing well (Carlier &

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Pinson, 1989; Moon, Lee, Seo, & Lee, 2002; Prakash, Tiwari, & Shankar, 2008). This method helps to find an efficient coding scheme of the individuals which respects all constraints of the FJSP. At the same time, different strategies for crossover and mutation operator are employed. After that, the computational results show that the proposed algorithm could get good solutions.

II. Problem Definitions

The FJSP consists in performing a set of n jobs $\{J_1, J_2, J_3…., j_i, …… J_n\}$ on a set of m machines $\{M_1, M_2, M_3…., M_k, …… M_m\}$. A job J_i is formed by a sequence of operations $\{O_{i1}, O_{i2}, O_{i3}…., O_{ij}\}$ to be performed one after the other according to the given sequence. Each operation requires one machine selected out of a set of available machines. All jobs and machines are available at time 0, and a machine can only execute one operation at a given time. Preemption is not allowed, i.e., each operation must be completed without interruption once it starts. Machine Setup time and movement time between operations are negligible. The processing time of operation O_{ij} on machine M_m is $P_{ijk} > 0$. Flexibility of FJSP can be categorized into partial flexibility and total flexibility. A system will be called partial if every machine cannot perform every other operation because of some constraint or extremely high cost. Data associated with a partial flexible system are given in Table 1, in which rows stand for operations time and columns is for machines. In this Table, symbol 0 means that a machine cannot be executed the corresponding operation. Problem can be formulated by using following nodes and symbols:

Z is the set of all machines
n is the number of the total jobs
m is the number of the total machines
i is the index of the i^{th} job
j is the index of the j^{th} operation of job J_i
k, x is the index of alternative machine set
O_{ij} is the j^{th} operation of job J_i
P_{ijk} is the processing time of operation O_{ij} on machine k
S_{ijk} is the start time of operation O_{ij} on machine k
E_{ijk} is the end time of operation O_{ij} on machine k

Assumptions made in FJSP as follows:

- All machines are available at time t = 0;
- All jobs are released at time t = 0;
- For each job, the sequence of operations is predetermined and cannot be modified;
- Each machine can only execute one operation at a time;
- Each operation Oij must be processed without interruption on one of a set of available machines;
- Recirculation occurs when a job could visit a machine more than once;
- The objective of the FJSP is to minimize the total completion time;

A basic representation of flexible job shop scheduling is as follows in Table 1.

Job	*O/P*	M_1	M_2	M_3	M_4	M_5
J_1	O_{11}	2	6	5	3	4
	O_{12}	0	8	0	4	0
J_2	O_{21}	3	0	6	0	5
	O_{22}	4	6	5	0	0
	O_{23}	0	7	11	5	8

There are 2 jobs and 5 machines, where rows correspond to operations and columns correspond to machines. Each cell denotes the processing time of that operation on the corresponding machine. In the table, the ''0'' means that the machine cannot execute the corresponding operation, i.e., it does not belong to the alternative machine set of the operation. So this instance is a Partial FJSP.

III. Algorithm for Flexible Job Scheduling

The proposed algorithm is developed according to the concept of the genetic algorithm. The detailed procedure of the proposed algorithm is as follows:

a) Determining operation sequence

The sequence of operation should be arranged on that way so that every other operation of an individual job must be accomplished before processed to next immediate operation. For example, to perform the job j_2 of table 1 the sequence of operations O_{21} 0_{22} should be maintained i.e. $O_{21} > O_{22}$

b) Global selection

We define that a stage is the process of selecting a suitable machine for an operation. Thus this method records the sum of the processing time of each machine in the whole processing stage. Then the machine which has the minimum processing time in every stage is selected. In particular, the first job and next job are randomly selected. Detailed steps are as follows:

1. Create a new array to record all machines' processing time, initialize each element to 0;
2. Select a job randomly and insure one job to be selected only once, then select the first operation of the job;
3. Add the processing time of each machine in the available machines and the corresponding machine's time in the time array together;
4. Compare the added time to find the shortest time, and then select the index k of the machine which has the shortest time. If there is the same time among different machines, a machine is selected randomly among them;
5. Set the allele which corresponds to the current operation in the MS part to k;

6. Add the current selected machine's processing time and its corresponding allele in the time array together in order to update the time array;
7. Select the next operation of the current job, and execute Step 3 to Step 6 until all operations of the current job are selected, then go to Step 8;
8. Go to step 2 until all jobs are all selected once.

The implementation of GS is given in Fig. 1.We assume that the sequence of job is $J_1 > j_2 > j_3$ from table 1, as mentioned earlier processing time '0' means the machine is unable to perform the operation. So, we easily see that the processing time on M_4 is the shortest in the alternative machine set of operation O_{11}. Hence, machine M_1 is selected to process the operation O_{11} of job J_1, and set corresponding allele in MS to the index of M_1 .Then the processing time is added to the corresponding position in time array. The selection process continued till finding a new chromosome as described above 8 steps.

(a) O_{11}

Time array	0	0	0	0	0
Operation			O_{11}		
Available machines	M_1	M_2	M_3	M_4	M_5
Processing time	2	6	5	3	4
Added time	2	6	5	3	4
Shortest time	2				
Selected machine	M_1				
Update time array	2	0	0	0	0
Machine Selection	1				

(b) O_{12}

Time array	2	0	0	0	0
Operation			O_{12}		
Available machines		M_2		M_4	
Processing time		8		4	
Added time		8		4	
Shortest time				4	
Selected machine				M_4	
Update time array	2	0	0	4	0
Machine Selection	1	4			

(c) O_{21}

Time array	0	0	12	13	0
Operation			O_{21}		
Available machines	M_1		M_3		M_5
Processing time	3		6		5
Added time	5		6		5
Shortest time	5				
Selected machine	M_1				
Update time array	5	0	0	4	0
Machine Selection	1	4	1		

Fig.1: The global selection technique for operation (a) O_{11} (b) O_{12} (c) O_{21}

Finally, the selected machines of operations O_{11} O_{12} O_{21} may be M_1-M_4-M_1 and chromosome is 1-4-1.

c) Generate the Initial Population

As shown in Fig 1, the structure of the chromosome used in this paper consists of two components. The first component of the chromosome represents the list of machines while the second component contains the sequence of operations to be processed used in executing the operations in the first component.

For example, consider the 3-job, 5-machine problem given in Table 1. Initial chromosomes are randomly created as shown in Fig 1. Each chromosome contains 10 genes. The numbers 1 and 2 which appear in the first component of the chromosome stand for jobs J_1 and J_2 respectively. According to the chromosome in Fig 2, the second component is [1 1 2 2 2 ...]. The first gene in the second component 1 means that the 1st operation of the 1st job is to be processed by the machine M1. Here, Ch. = chromosome

Ch.	Machine selection					Operation sequence				
	1	4	1	3	2	1	1	2	2	2

Fig. 2: Schematic representation of the chromosome structure

d) Crossover operation

The goal of the crossover is to obtain better chromosomes to improve the result by exchanging information contained in the current good ones. In our work we carried out uniform crossover operator to generate new chromosomes.

i. *Machine Selection part*

The crossover operation of MS is performed on two Machine Selection parts and generates two new Machine Selection parts each of which corresponds to a

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new allocation of operations to machines. Each machine of the new Machine Selection parts must be effective, i.e., the machine must be included in the alternative machine set of the corresponding operation. We adopt uniform crossover (Gao, Sun & Gen, 2008). MS crossover operator only changes some alleles, while their location in each individual i.e., their preceding constraints are not changed. Therefore, the individuals after crossover are also feasible. The procedure could be illustrated in Fig. 3.

ii. *Operation Sequence part*

The crossover operation of OS is different from that of MS. During the past decades, several crossover operators have been proposed for permutation representation. Here we apply a Precedence preserving order-based crossover (POX) for the Operation Sequence. Detailed implementing steps of POX are as follows:

1. Generate two sub-job set Js1/Js2 from all jobs and select two parent individuals as p1 and p2;
2. Copy any allele in p1/ p2 that belong to Js1/Js2 into two child individuals c1/c2, and retain in the same position in c1/c2;
3. Delete the alleles that are already in the sub-job Js1/Js2 from p2/ p1;
4. Orderly fill the empty position in c1/c2 with the alleles of p2/p1 that belongs to in their previous sequence. In Table 1, there are only four jobs. So it is difficult to present the process of POX clearly.

P_1	1	4	1	3	2	1	1	2	2	2
P_2	1	3	4	2	4	2	2	1	2	15
C_1	1	3	1	2	2	2	1	1	2	15
C_2	1	4	4	3	4	1	2	2	2	2

Fig. 3: MS uniform crossover operator

e) *Mutation operator*

Mutation introduces some extra variability into the population to enhance the diversity of population. Usually, mutation is applied with small probability. Large probability may destroy the good chromosome.

i. *Machine Selection part*

The machine selection mutation operation is performed by following steps:

1. MS mutation operator only changes the assignment property of the chromosomes. We select the shortest processing time from alternative machine set to balance the workload of the machines. Taking the chromosome from Fig. 3 for example, MS mutation is described as follows: Select one individual from the population;
2. Read the chromosomes of the individual from left to right and generate a probability value randomly; if all the chromosomes have been read, then end the procedure;
3. If the probability value is less than or equal to the mutation probability then go to Step 4; otherwise, go to Step 2;
4. Select the shortest processing time from the alternative machine set and assign it to the mutation position;

An illustrative instance is shown in Fig. 4. Suppose the mutative operation is O_{23}, before the mutation, O_{23} is processed on M_2, which is the fourth machine in the alternative machine set, so the allele is 2. In the mutation, the rule that selecting the machine of the shortest processing time is obeyed, so M4 is selected, and the allele in the chromosome changes into 4.

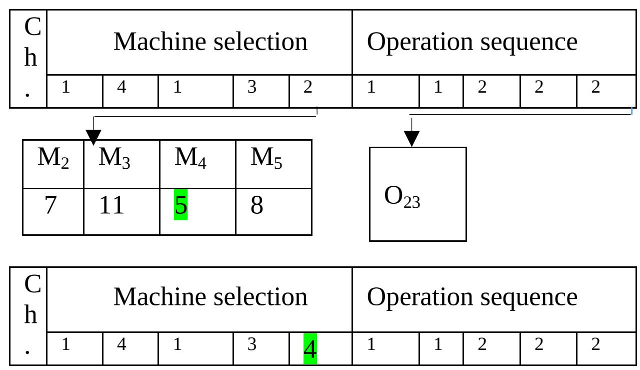

Fig. 4: MS after mutation operation.

IV. Numerical Illustration and Computational Result

The genetic algorithm was coded in ANSI C++ programming language using only simple array data structure and implemented on a PC (Intel(R) Pentium(R), CPU B960 Intel processor of 2.20 GHz).

Table 2: Shows a sample output data set for a flexible job shop scheduling problem

Generation Number	Average Objective Function value (min)	Best Objective Function value (min)
1	113.433	107
2	111.76	103
3	111.375	103
4	111.1	103
5	115.88	103
6	108.21	103
7	107.35	103
8	105.21	103
9	104.83	103
10	104.83	103
11	104.83	103
12	104.16	103
13	103.5	103
14	102.83	101
15	102.85	101
20	101	101

Firstly, we tested the performance of the algorithm using GS method. In Fig. 6 we draw the generation vs time completion curve that shows the decreased average time required to complete each and every operation. The optimal solution for a 4×5 problem can be achieved at 17th generation. In order to obtain meaningful results, we ran our algorithm for several times on different instance. The parameters used in this GA are chosen experimentally in order to get a satisfactory solution in an acceptable time span.

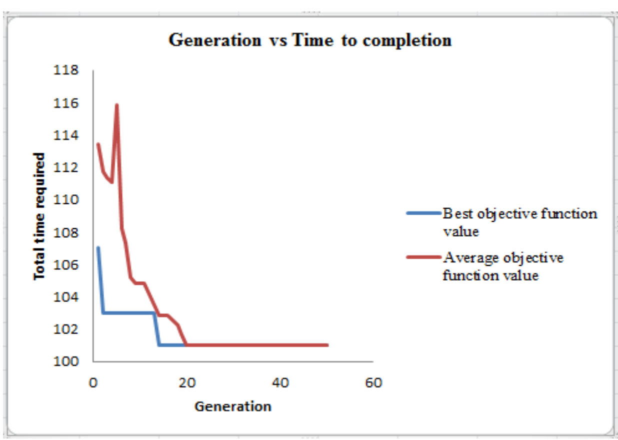

Fig. 6: Decreasing of the total time required

V. Conclusion And Future Study

In this paper, a genetic algorithm for solving the flexible job-shop scheduling problem (FJSP) is proposed. A new chromosome representation scheme is proposed and an effective decoding method interpreting each chromosome into a feasible active schedule is designed. In order to enhance the quality of initial solution, a new initial assignment method i.e., global search technique is used to generate high-quality initial population integrating different strategies to improve the convergence speed and the quality of final solutions. Then different strategies for crossover, selection and mutation operator are adopted. This makes it possible to solve the problem of trade-off resources allocation. Some realistic problems are solved by using this new algorithm. The computational results show that the proposed genetic algorithm leads to an effective scheduling considering time and quality compared with other genetic algorithms which is an indicator of gaining economic profit. The proposed algorithm can enhance the convergence speed and the quality of the solution. This algorithm can be used in solving large size flexible job shop scheduling problem with a focus on achieving economic sustainability throughout the system. In future, it will be interesting to investigate a better search technique which can be developed along with global search technique to generate better results. Also, there is more scope of adjusting an appropriate relation between crossover and mutation probability to enhance the chance of better solution.

Author Declaration

Authors declare that we don't have any conflict of interest. This work has been funded by the Department of Industrial Engineering and Management of Khulna University of Engineering and Technology. All the data and information were collected through the existing lab facilities from this department.

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Energodynamic Theory of the Shawyer's Engine

By V. A. Etkin
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Annotation- It is shown that Shawyer's electromagnetic engine doesn't break the law of conservation of momentum as for gravitational energy of the closed systems doesn't exist. The emergence of the draft in the Shawyer's propeller is explained from positions of the entrgodynamics as a result of the interaction of gravitational field with the vortex electromagnetic field in the resonator. The existence of such interaction and emergence at the same time of specific gyroscopic forces is proved mathematically thanks to obvious account in energodynamics of spatial heterogeneity of the studied systems. Experimental confirmations of the existence of gyroscopic forces are presented.

Keywords: shawyer's and fett's engines, thrust, gyroscopic forces, experimental confirmationlaws.

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Strictly as per the compliance and regulations of:

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I. Introduction

In August 2013, the official website of NASA, there was a report on testing the model of the space engine "Cannae Drive" American inventor Guido Fett [1]. A year later, at a conference on the reactive movement, a report was made by a group of NASA employees who experienced this engine for 8 days in various modes and was convinced of its efficiency. Test tests showed that Fett's microwave engine generates a thrust of (30-50)$\cdot 10^{-3}$ N.

The author of the idea of creating traction due to directed microwave radiation, British engineer Roger Shawyer in 2003, designed a series of demo-tion devices called "EmDrive" and did his best to attract attention to his invention [3-6]. In 2006, his electromagnetic engine was introduced to the world and during the demonstration created a thrust of 16$\cdot 10^{-3}$ Newton. R. Shawyer even received a state grant for his EmDrive, but nothing convinced the critics: they denied the theoretical part of the work and insisted that the EmDrive engine is a closed system and, according to the law of conservation of momentum, can not work. The appearance of the generator Shawyer is shown in Fig.1. Its device is quite simple: the magnetron generates microwaves, and the energy of the oscillations accumulates in a high-Q copper resonator. The resonator is made in the form of a copper container in the form of a truncated cone and closed on all sides. The microwave generator (from the left) directs the radiation into the resonator, where it is repeatedly reflected from the walls of the hollow vessel and, due to the effect of the light pressure, creates a thrust from the side of the base of the cone. Thanks to this engine do not need traditional rocket fuel. Microwave radiation is generated solely by electric energy, which will feed the EmDrive engine from solar batteries, from thermoelectric radioisotope generators or from miniature nuclear reactors.

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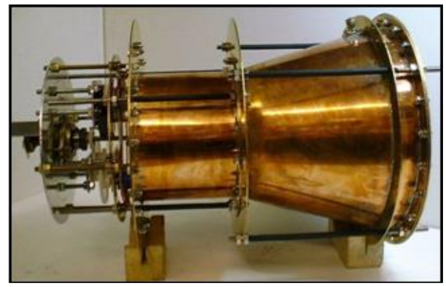

Fig. 1: Appearance of "EM DRIVE"

In 2009-2010, a Chinese research team from North Western Polytechnical University (Xi'an, China) built an analog "EmDrive" and confirmed that the thrust of the engine reached 720$\cdot 10^{-3}$ N [7]. This is quite enough to practically use the device to adjust the orbits of communications satellites and other spacecraft. However, these experiments did not attract convincing physicists, the overwhelming majority of which recognize this idea as unscientific. Indeed, classical mechanics argues that to create a movement it is necessary "to push something off". Since the Scheuer engine "does not leave anything," its momentum must remain zero. This explains why the experts literally took up arms against Shawyer, calling his idea unscientific and even fraudulent. This reaction put the EmDrive testers in a difficult position, forcing them to express very vague considerations, such as the fact that the device Shawyer "demonstrates the interaction with the quantum vacuum of virtual plasma" [8]. The objections of Shawyer, based on the fact that the laws of physics, and their interpretation by physicists, are not mistaken, were not taken into account, as usual. He is meanwhile right, and this can be justified from the standpoint of energodynamics [9] as a more general theory from the viewpoint of which the Shawyer's device is not a closed system.

II. Energodinamics As A Unified Force Theory

Energodynamics generalizes the thermodynamic method of investigation to nonthermal forms of energy and continuous media with distributed parameters. The specificity of this method consists in considering the system as a whole, without the usual division of such a system into an infinite number of conditionally equilibrium elementary volumes. This required the introduction of specific "heterogeneity parameters" of the systems under study, capable of repelling the removal of them as a whole from an equilibrium of any kind. These parameters are the moments of the distribution $Z_i = Θ_iΔR_i$ of the known thermodynamic parameters Θi (mass *M*, entropy *S*, charge *З*, number of moles k-th substances N_k, their momentum P_k, its moment L_k, etc.). These moments arise when the system deviates from a homogeneous state due to the displacement $ΔR_i$ of the radius vector of the center of these extensive R_i values from its equilibrium position R_{io}. This position is determined in a known way

$$\mathbf{R}_i = Θ_i^{-1} \int ρ_i(\mathbf{r},t)\, \mathbf{r} dV \,; \mathbf{R}_{io} = Θ_i^{-1} \int \bar{ρ}(t)\, \mathbf{r} dV, \qquad (1)$$

where $ρ_i$(r, *t*), $\bar{ρ}(t)$ - - size density $Θ_i$ and its average value; r - the "running" (Euler) coordinate of a point of the field; *i* = 1,2,…, *n* – the number of forms of energy in the system; *t* – time.

From here directly follows that the shift of energy carriers $Θ_i$ is followed by the emergence of "the distribution moments" [9]:

$$\mathbf{Z}_i = Θ_i Δ\mathbf{R}_i = \int_V \left[ρ_i(\mathbf{r},t) - \bar{ρ}_i(t)\right] \mathbf{r} dV. \qquad (2)$$

with the arm $ΔR_i = R_i - R_{io}$, which we called the "displacement vector" [10].

Thus, the moment of distribution Z_i of each *i*-th form of U_i can change in the course of two independent processes, the coordinates of which are the parameters $Θ_i$ and $ΔR_i$. This means that the total energy differential of the system $U = Σ_iU_i(Θ_i, ΔR_i)$ can be represented in the form of the identity [9,10]:

$$dU \equiv Σ_i Ψ_i dΘ_i - Σ_i \mathbf{F}_i \cdot d\mathbf{R}_i, \qquad (3)$$

where $Ψ_i \equiv (∂U/∂Θ_i)$ are the averaged over the system values of its generalized potentials (absolute temperature *T* and pressure *p*, chemical $μ_k$, electric φ and gravitational $ψ_g$ potentials, the components $υ_α$ and $ω_α$ (α = 1,2,3) of the vectors speed of translational and rotational motion **υ** and **ω**, etc., $F_i \equiv -(∂U/∂R_i)$ - forces in their general physical meaning.

In this expression, the terms of the first sum characterize the effects that do not violate the distribution of the parameters $Θ_i$ in the volume of the system *V*, including the nonequilibrium heat transfer, the all-round deformation of the system, its mass exchange with the environment, the diffusion of kx substances through its boundaries, the electrization of the system, the translational and rotational acceleration of it as a whole, etc. The second sum of this expression, on the contrary, characterizes the work connected with the redistribution of the parameters $Θ_i$ by the volume of the system and performed by the forces F_i "against equilibrium" in it. In isolated systems, where all processes are internal, identity (4) vanishes, but its terms still describe the energy exchange between its parts (components) and its interconversion. This allows us to expand the scope of the applicability of thermodynamic methods to isolated systems.

Fundamentally important for the energodynamic determination of the energy *U* is the uniform dimension of forces of any nature F_i and a unified method for their determination as functions of the nonequilibrium state of the system. This allows directly summing up forces of a different nature, determining their resultant, finding equilibrium conditions from the condition of their balance, and so on. This energy dynamic differs from other fundamental disciplines operating in terms of the electric and magnetic fields E and H, the thermodynamic forces $X_i = F_i/Θ_i$, surface tension, etc. Since the partial derivative $(∂U/∂R_i)$ is in the constancy of all variables $Θ_i$ and in the absence of displacements $Δr_j$ of all other energy carriers ($j \neq i$), then $dU = dU_i$ and $dR_i = d$r. Consequently, the forces $F_i = -(∂U_i/∂\mathbf{r})$ are gradients of the "partial" energy U_i taken with the opposite sign. Thus, the notion of force known as mechanics as a gradient of potential energy extends not only to inertial forces and centrifugal forces, but also to any (scalar, vector and tensor) fields, including vortex fields and temperature fields, pressures, chemical potentials, velocities, etc. [11]. These force fields are not reducible to the four known types of interaction. This, in particular, is the "spin-spin" and "orientational" interaction that causes the ordering of spin systems and rotation axes of celestial bodies [12], or an interaction that generates attractive or repulsive forces between rotating bodies [13].

It is in this unity of forces and interactions of a different nature that the "key" is to understand the "mechanism" of the interaction of the vortex electromagnetic field in the resonator of the Shawyer propulsor with a gravitational field, from which, as is known, no isolation exists.

III. How To Create Traction In The Shawyer's Engine

From the point of view of energodynamics, the Shawyer's engine is a device whose magnetron, with the help of a waveguide, creates a vortex electromagnetic field (EMF) in the resonator that has a certain kinetic energy of the vortex motion $dU_ω = \mathbf{ω} \cdot dL_ω$. This energy is distributed unevenly in the resonator due to the difference in its diameter and the angular velocity **ω**. As a result, the EMF acquires an inhomogeneous "vorticity" inside the resonator, characterized by a gradient of the angular velocity **∇ω**. The non-uniform distribution of the amount of rotational motion (angular momentum) in the installation causes the displacement of its center ΔRω, which generates the "vorticity distribution moment" Zω. It is one of the parameters of the spatial inhomogeneity of the system considered above and characterizes the removal of the system from the state of "homogeneous vorticity. If we are only interested in the component of the tensor Zω =ΔRω×Lω, which is directed along the resonator axis, then the value of Zω can be found from the expression analogous to (2):

$$\mathbf{Z}_\omega = L_\omega \Delta \mathbf{R}_\omega = \int [\rho_\omega(\mathbf{r}, t) - \bar{\rho}_\omega(t)]\mathbf{r} dV , \qquad (4)$$

where ρω(r, t), (t)$\bar{\rho}_\omega(t)$is the local and average density of the amount of this motion in the resonator; *L*ω
is the axial component of Lω.

As in other cases, the appearance of an inhomogeneous vorticity produces a force

$$\mathbf{F}_\omega \equiv -(\partial U/\partial \mathbf{R}_\omega), \qquad (5)$$

called earlier *gyroscopic* due to the fact that it appears in gyroscopes and any other rotating bodies [13]. It is directed toward the base of the cone since the angular velocity of the vortex EMF rises with distance from it. Thus, we come to the conclusion that there is another kind of force in media with an inhomogeneous vorticity that is not reducible to its known species.

We now apply the identity (3) to the set of electromagnetic and gravitational fields of the Universe (i = 1,2), referring the terms with i = 1 to the EMF, and the terms with i = 2 to the gravitational field. Then it becomes obvious that for the universe as a whole, $\Sigma_i \mathbf{F}_i \cdot d\mathbf{R}_i = 0$ for the isolated system, since $dU = 0$ and $d\Theta_i = 0$. Hence, the forces $\mathbf{F}_i$ are interrelated, so that the interaction of electromagnetic and gravitational fields is inevitable, even if the eddy EMF is enclosed in a cavity closed for him. Thus, the appearance of thrust in experiments with the engines of Shawyer and Fett does not contradict any laws of physics [14]. It remains to confirm the reality of gyroscopic forces.

IV. Experimental Confirmation Of The Existence Of Gyroscopic Forces

Back in 1974, E. Latewaite (Eric Laithwaite) publicly demonstrated a spiral rotation of a gyroscope weighing 10 kg, suspended at one end of the rotor [15]. A very important addition to its results was the experiments of GA. Golushko [16], in which the gyroscope was isolated from the environment by paper screens of conical shape. In these experiments, thanks to a laser pointer attached to the free end of the gyroscope, it was possible to fix the trajectory of the gyroscope's rotational motion and to detect oscillations of the gyroscope rotation speed caused by a change in the direction of the gyroscopic traction vector. These experiments confirmed that the gyroscope is an open system whose vector of thrust is directed along the axis of the gyroscope.

Another effect - the apparent "weight loss" of rotating masses - was confirmed by precision measurements of the weight of rotating gyroscopes, performed in 1989 by Japanese physicists H. Hayasaka and S. Takeuchi [17]. Their studies showed that at speeds of ~ 12 · 103 rpm the 175 g gyroscope loses in weight up to 10 milligrams, and the gyroscope, rotating clockwise, is lighter than the counter-clockwise gyroscope by an amount of the order of $7 \cdot 10^{-8}$ %.

In 2001, in the experiments of A.L. Dmitriev and her co-workers [18] found a systematic increase (up to 10 ± 2 cm/s^2) of the free fall acceleration of the container with two coaxial gyroscopes with a horizontal axis rotating at an angular velocity of 20,000 rpm.

S.V. Plotnikov performed very detailed studies of the interaction of rotating masses [19]. In his experiments, a smooth increase in weight was observed as the standard aviation gyroscopic autopilot with a mass of 540 grams was rotated to $20 \cdot 10^3$ rpm, and the difference in weight gain with the rotation of the gyroscope in the direction coinciding with the direction of rotation of the Earth and against it (520 and 430 mg, respectively).

The presence of the interaction of rotating bodies was demonstrated by a series of experiments by V.N. Samokhvalov [20] with two closely spaced (with a gap of 2-3 mm) discs 165 mm in diameter, fixed at the ends of the rotors of two coaxial DC motors. In his experiments, the appearance of torque during the unscrewing of one of the disks was measured by the magnitude of the braking torque of the other electric motor. These experiments revealed an increase in the torque of the "driven" disk by two orders of magnitude as the vacuum deepened in the container containing the device. This seemingly unexpected result also follows from the identity (5), according to which the potential of any force $\mathbf{F}_i \equiv -(\partial U/\partial \mathbf{r}_i)$ is determined under conditions of constant volume of the system V. In this case, the specific value of the force $\mathbf{F}_i/M = \mathbf{X}_i$ in [14, 15] by the thermodynamic force, can be expressed in terms of the density $\rho_u = (\partial U/\partial V)$ of the energy of the system U by the simple expression:

$$\mathbf{X}_i = -\nabla \rho_u/\rho \qquad (6)$$

According to this expression, the intensity $\mathbf{X}_i$ of any force field increases as the density ρ of the material medium decreases with the same value of the energy gradient. This consequence of the energy dynamics is directly related to the Shoyer's engine, indicating that its thrust in outer space can be even higher than that achieved in laboratory experiments.

Thus, the recognition of the existence of hidden matter as an all-pervasive environment from which all forms of matter of the Universe were formed, makes it possible to explain the appearance of thrust in the engine of Scheuer, without going beyond the framework of classical physics. The existence of gyroscopic forces may be an alternative to the reactive motion. Together with the lowering of the launch weight of spacecraft, more than 90% of which is fuel, the possible acceleration will also increase by an order of magnitude. The duration of flights, even within the solar system, will be reduced. It will become easier and cheaper to adjust the orbits of satellites and orbital stations. All this opens up new prospects for the exploration of outer space.

V. Conclusion

1. The apparent violation of the law of conservation of momentum by the Shawyer's engine is due to the limited nature of the concepts of classical mechanics about closed systems. There are no closed systems for gravitational systems.
2. Introduction of parameters of spatial heterogeneity of the studied systems finds the dependence of any form of internal energy of such systems on the position of the center of her material carrier. It allows finding the internal forces and the moments characterizing their nonequilibrium state earlier not giving in to the definition.
3. In non-closed systems, the appearance of such forces is equivalent to the acquisition by the system of additional external energy, which becomes, therefore, dependent on the internal state of the system. A consequence of this is the existence of a new form of interaction with the external environment, not accounted for by mechanics. This, in particular, is the interaction of rotating bodies.
4. Among the additional forces of interaction with the external environment, arising from the inhomogeneity of the system, there is a gyroscopic force due to the inhomogeneity of the vortex electromagnetic field created in the Shawyer's engine by the magnetron. This force also generates its thrust, found in the experiment.
5. The validity of the conclusions of energodynamics is confirmed by the fact of the existence of gyroscopic forces, found in a variety of experiments and observations. This allows us to explain the thrust of the Shawyer's electromagnetic motors, without going beyond the framework of classical physics.

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Automatic Street Light Control System using Light Dependent Resistor and Motion Sensor

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Abstract- Automatic street light control system is used in modern world for energy savings by using Light dependent Resistor (LDR).Nowadays the human has not enough time, and he/she is unable to find time even to switch the lights on or off. This new system can be used more effectively in case of street lights. In proposed system, the street lights will be switched on just before the sun sets and are switched off the next day morning when there is sufficient light on the road. The proposed model also uses motion sensor to control the intensity of light. Huge power is consumed when most the vehicles don't move during the late. This paper shows that the proposed System is relatively low cost, efficiency is better than the existing system.

Keywords: automation, LDR, motion sensor, relay switch.

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AUTOMATICSTREETLIGHTCONTROLSYSTEM USINGLIGHTDEPENDENTRESISTORANDMOTONSENSOR

Strictly as per the compliance and regulations of:

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Md. Sazol Ahmmed [α], Tanzima Zoha Chowdhury [σ] & Sourav Kumar Ghosh [ρ]

Abstract- Automatic street light control system is used in modern world for energy savings by using Light dependent Resistor (LDR).Nowadays the human has not enough time, and he/she is unable to find time even to switch the lights on or off. This new system can be used more effectively in case of street lights. In proposed system, the street lights will be switched on just before the sun sets and are switched off the next day morning when there is sufficient light on the road. The proposed model also uses motion sensor to control the intensity of light. Huge power is consumed when most the vehicles don't move during the late. This paper shows that the proposed System is relatively low cost, efficiency is better than the existing system.

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I. Introduction

In 21st century it is quite impossible to avoid accident during night without lights. So street light is the essential part in our busy life for safety purposes. But the manpower required for controlling the light cuts a huge cost .So in this situation this project helps to reduce the cost of man power and reducing power Consumption. During day time there is no essence of street light so the LDR keeps the street light off. As soon as the light intensity is low then the LDR is started working and the light is switched on. Motion sensor has a huge indoor and outdoor application. Very common application of motion sensor is activation of automatic door opening. Motion sensor also used instead of convention sensor because of its accuracy. Motion sensor also used as an alarm when it detects the motion of a possible intruder.

II. Literature Review

Bangladesh faces major problem regarding electricity i.e. its rate of generation of electricity is less than rate of consumption. Even small implementations can make large contributions on large scale. We know in this area of development more and more numbers of highways, expressways etc. thus an automation is needed to improve this condition [1].In the prior automation system i.e. only using LDR the system could only reduce the manual switching, but power saving could not be handled[2].Itcan control (on/off) distribution line of a specific region based on the intensity of the daylight was implemented by [3]. The circuit was built by providing some special features so that it can withstand or adjustable if the intensity of light varies with some others factor. The microcontroller based control systems are more reliable, accurate and easily programmable to perform data transfer, data security, design the control system and tracking the changes in the system.[4].Street lights are controlled by photocells. These have only one function, which is switching lights on and off according to factory-fixed, light-level thresholds. Telensa's proposed system operates by replacing the traditional photocell with an 'outstation'. This performs the lamp switching and monitoring functions [5].

III. System Components

It consists of nine main components. These are LDR, LM 358, Diode, BC 547, Relay, Voltageregulator, Bulb, Motion sensor, Resistor, Adapter.

a) Design of system components

i. Automatic switch on off control system components

Light-dependent resistor (LDR): Photo resistor or light-dependent resistor (LDR) or photocell is a light-controlled variable resistor. The resistance of photo resistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. Photo resistor can be applied in light-sensitive detector circuits, and light- and dark-activated switching circuits.

The electrons are liberated when the light falls on the sensor. The photons absorbed when the light intensity exceeds a certain limit. For these reason lots of free electrons and hole are released and resistance is decreased dramatically. The equation to show the relation between resistance and illumination can be written as

$$R = A*E^{a}$$

The value of 'a' depends on the CdS used and on the manufacturing process. Values are usually in between 0.7 and 0.9.

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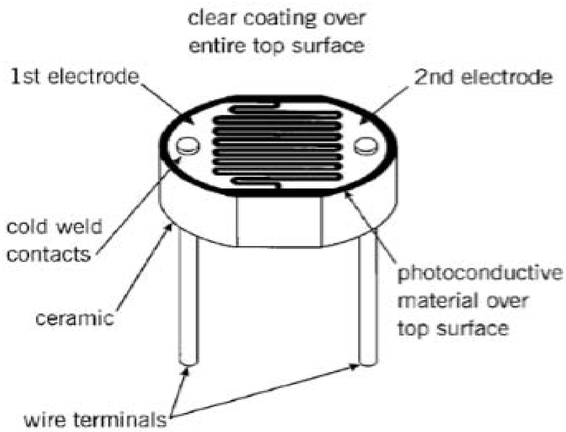

Fig. 1: Light Dependent Resistor

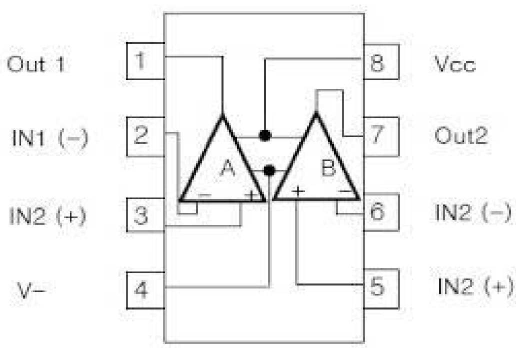

Fig. 2: Pin configuration of IC

LM 358: LM358 consists of two independent and high gain operational amplifiers. It is not require independent power supply for each comparator for wide range of power supply. LM358 may be used as transducer amplifier, DC gain block etc. It consists of dc voltage gain of 100dB. The power supply requires from 3V to 32V for single power supply or from ±1.5V to ±16V for dual power supply.

ii. *Light intensity control system components*

Motion sensor:

Motion sensor has an optical, microwave, or acoustic sensor. However, a *passive* sensor only senses a signal emitted by the moving object itself. Changes in the optical, microwave, or acoustic field in the device's proximity are interpreted by the electronics based on one of the technologies listed below. Motion detectors can detect in variable distances depends on their cost. In this project we use passive inferred ray motion sensor to detect the arrival of vehicle.

Fig. 3: PIR Sensor

Relay switch:

A relay is an electromagnetic switch operated by a relatively small electric current that can turn on or off a much larger electric current. Many relays use an electromagnet, but other operating principles are also used such as solid-state relays.

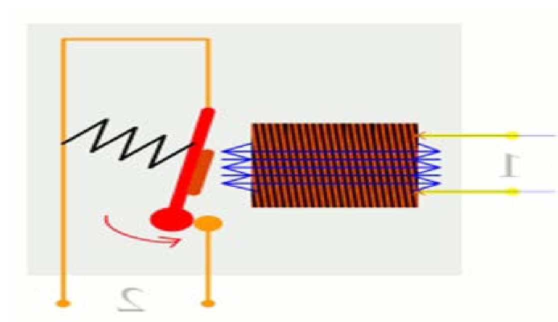

Fig. 4: Relay

IV. Working Procedure

This circuit uses divider circuits connected as comparator; the output goes high when the trigger pin 2 is at lower then 1/3rd level of the supply voltage. Conversely, the output goes low increasing its power supply. So small change in the voltage of pin-2 is enough to change the level of output (pin-3) from high to low and high to low. The output has only two states high and low and cannot remain in any intermediate stage. It is powered by a 6V battery for portable use. The circuit is economic in power consumption. Pin 4, 6 and 8 is connected to the positive supply and pin 1 is grounded. To detect the present of an object we have used LDR and a source of light.

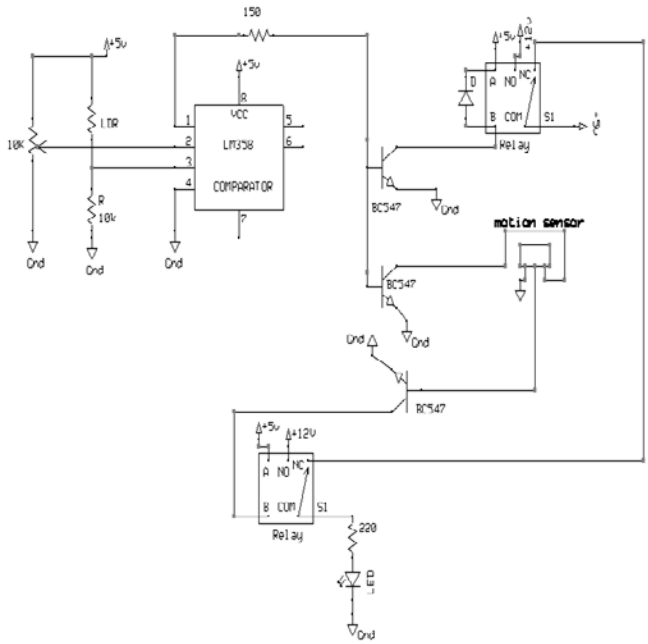

Fig. 5: Main circuit diagram of automatic light on–off and light intensity control.

LDR is a special resistance whose value depends on the intensity of the light which is falling on it. It has resistance of about 1 mega ohm in case of total darkness, but a resistance of only about 5k ohms when brightness illuminated. It responds to a large part of light spectrum. We have built divider circuit with LDR and 100K variable resistance connected in series. It is well known that that voltage is directly proportional to conductance. This divided voltage is given to pin 2 of IC 555. Sensitiveness can be adjusted by using variable resistance. As soon as LDR gets dark the voltage of pin 2 drops 1/3rd of the supply voltage and pin 3 gets high and LED which is connected to the output gets activated. When the switching circuit is activated, the motion sensor circuit will not work, so when light is fall in the LDR that means in day-night motion sensor will not work.

V. Design Analysis

The lamp power rating was 3 WATT and its working voltage is 12v.

The current rating of the lamps is calculated as follows:

I (amp) = POWER/VOLTAGE
=3 /12 A
= 0.25A

Therefore, the current rating used in lamps is 0.25A. The bulb number used is 20.Therefore, the current consumption of the lamps used = (0.25 x 20)A. I(amps) = 5.Since the current consumption used is 5A. A Relay of 10A contact current is used for the control circuit of the lamps.

Proper Selection of transistor for the Relay:

Since the voltage rating of the D.C. power supply used for the lamp is 12v. A. 12v D.C. Relay is selected for automatic switching ON/OFF. The coil resistance of the relay used is 82Ω.Relay working voltage = 12v, Resistance of the Relay = 82Ω
Therefore, I(relay) = 12/82 A = 0.15 A

Since the current consumption used is 0.15A, a BC 547 transistor with collector current rating of 0.8A, collector to base voltage of 11v, collector to emitter voltage of 7v and emitter to base voltage of 4v is considered suitable to drive the relay used in the output of the control circuit.

VI. Cost Analysis

The present situation if the night time is 12 hours and the 300 lights are working under 220 volts, and the power of the light is 60 watts .the road distance consider 1 kilometer, the unit is calculated below

Unit =p*T/1000
=60*12/1000
=0.72Units per day per lamp

Let the cost of electricity per unit is5.50 taka then the total cost per month =0.72*5.5*30=118.8 taka per month per light The Total amount for all light is=118.8*300=35640 Taka Using automatic intensity control circuit The vehicle moves late night small number, so the lamps do not get voltage 220 volt all time .In small-town For the automated system lets consider 2 cases heavy traffic and very light traffic.

Case 1: Heavy traffic, the road is continuously having vehicles; power consumption will be,

Total=0.72Watts per month per vehicle
=216 watt per month
Total cost =35640 taka

Case 2: Light traffic, a very few vehicles pass by this road, For a highway minimum speed can be considered as 30 kilometer per hour, So it will take 2 min to cover the stretch of 1km for light traffic of 100 vehicles it would take 200 minutes i.e.3 hours 20 minutes

Unit =30*p*T/1000
=30*60*4/1000
=7.2Units per month per lamp
=2100 unit per month for all lights

Total cost=7.2*300*5.5=11800 taka

For Thus in any of the cases, the system in this paper is capable of saving electricity.

VII. Conclusion

This project is automatic street light control system. It is very economical because it is a very cheap budget project. So it can play an important rule to save energy consumption. As a product design engineer we are trying to analyze the product in such a way that it will be less costly, good appearance, user-friendly, economical improved performance & after all satisfy customer's requirements. But our effort will be successful if the customers satisfy to get this project benefit. We think post survey is required among the customers to find out further improvement in design.

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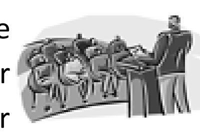

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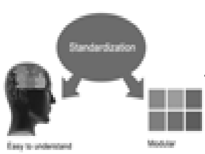

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The FARSE member is eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get remuneration of 15% of author fees, taken from the author of a respective paper. After reviewing 5 or more papers you can request to transfer the amount to your bank account.

MEMBER OF ASSOCIATION OF RESEARCH SOCIETY IN ENGINEERING (MARSE)

The ' MARSE ' title is accorded to a selected professional after the approval of the Editor-in-Chief / Editorial Board Members/Dean.

The “MARSE” is a dignified ornament which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., MARSE or William Walldroff, M.S., MARSE.

MARSE accrediting is an honor. It authenticates your research activities. After becoming MARSE, you can add 'MARSE' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, Visiting Card and Name Plate etc.

The following benefitscan be availed by you only for next three years from the date of certification.

MARSE designated members are entitled to avail a 25% discount while publishing their research papers (of a single author) in Global Journals Inc., if the same is accepted by our Editorial Board and Peer Reviewers. If you are a main author or co-author of a group of authors, you will get discount of 10%.

As MARSE, you will be given a renowned, secure and free professional email address with 30 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders,Auto-Responders, Email Delivery Route tracing, etc.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time.This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The MARSE member can apply for approval, grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.

Once you are designated as MARSE, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria.

It is mandatory to read all terms and conditions carefully.

Institutional Fellow of Open Association of Research Society (USA)-OARS (USA)

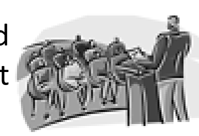
Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as "Institutional Fellow of Open Association of Research Society" (IFOARS).

The "FARSC" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as "Institutional Board of Open Association of Research Society"-(IBOARS).

The Institute will be entitled to following benefits:

The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA) The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.
The author fees of such paper may be waived off up to 40%.



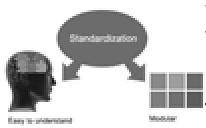
The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of "Open Association of Research Society, U.S.A (OARS)" so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.



After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.

Disbursement of 40% Royalty earned through Global Journals : Researcher = 50%, Peer Reviewer = 37.50%, Institution = 12.50% E.g. Out of 40%, the 20% benefit should be passed on to researcher, 15 % benefit towards remuneration should be given to a reviewer and remaining 5% is to be retained by the institution.

We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth $ 2376 USD.

Other:

The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.

- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10%discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone. "

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

Before and during Submission

Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

1. Authors must go through the complete author guideline and understand and *agree to Global Journals' ethics and code of conduct,* along with author responsibilities.
2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

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Plagiarism is not acceptable in Global Journals submissions at all.

Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
- Ideas
- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

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1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

Changes in Authorship

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

Declaration of funding sources

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Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for Writing a Good Quality Engineering Research Paper

Techniques for writing a good quality engineering research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of research engineering then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

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 though 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:

- o Single section and succinct.
- o An outline of the job done is always written in past tense.
- o Concentrate on shortening results—limit background information to a verdict or two.
- o 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:

- o Explain the value (significance) of the study.
- o 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.
- o Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- o 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.

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	A-B	**C-D**	**E-F**
Abstract	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
Introduction	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
Methods and Procedures	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
Result	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
Discussion	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
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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