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Concrete Frame Structures

Industrial Design Development

Highlights

Productivity of Sewing Section

Development Future Prospect of Silk

Discovering Thoughts, Inventing Future

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Benefits of Titanium Additive Manufacturing for Industrial Design Development. Trends, Limitations and Applications

By Anastasia Kolomiets, Vladimir V. Popov Jr, Evgeny Strokin, Gary Muller & Alexey Kovalevsky

Technion - Israel Institute of Technology

Abstract Direct material deposition (DMD), also called rapid manufacturing (RM), additive manufacturing (AM), or 3Dprinting, brings many changes and opens new ways of production to every industry that it enters [1-4]. DMD-AM is an innovative technology, which layer by layer "prints" objects from a variety of materials, performing shapes that are not achievable by traditional manufacturing technologies. DMDAM, which started as prototyping in plastics, now succeeds in processing metals. DMD-AM in metals, first of all, in titanium alloys, gives a possibility to implicate net-shaped, complex geometrical and light-weight objects. It also provides high mechanical and specific acoustic properties, even better than those obtained by traditional mass production methods, such as casting or machining.

Keywords: *additive manufacturing, 3d-printing, industrial design, titanium.*

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Benefits of Titanium Additive Manufacturing for Industrial Design Development. Trends, Limitations and Applications

Anastasia Kolomiets [α], Vladimir V. Popov Jr [σ], Evgeny Strokin [ρ], Gary Muller [ω] & Alexey Kovalevsky [¥]

Abstract Direct material deposition (DMD), also called rapid manufacturing (RM), additive manufacturing (AM), or 3Dprinting, brings many changes and opens new ways of production to every industry that it enters [1-4]. DMD-AM is an innovative technology, which layer by layer "prints" objects from a variety of materials, performing shapes that are not achievable by traditional manufacturing technologies. DMD-AM, which started as prototyping in plastics, now succeeds in processing metals. DMD-AM in metals, first of all, in titanium alloys, gives a possibility to implicate net-shaped, complex geometrical and light-weight objects. It also provides high mechanical and specific acoustic properties, even better than those obtained by traditional mass production methods, such as casting or machining.

The goal of the current research is to investigate the prospects of 3D-printing as a novel instrument for professional industrial designers developing new products and applications.

However, DMD-AM has limitations that prevent the use of this technology for mass production.

The paper presents examples of successful novel applications of 3D-printing by Additive Manufacturing Center at Technion (Israel).

Keywords: additive manufacturing, 3d-printing, industrial design, titanium.

I. Introduction

The development of DMD-AM processes, includes the development of the process productivity, improvement of material properties, investigation of new alloys and development of modeling and free-form design. Industrial designers, as well as 3D-engineers and product developers, use this technology for making their design prototypes, to solve problems related to shape, lines and structure, together with their usability, mechanical properties, and functionality. The DMD-AM is widely used for presentation of new ideas and concept-designs to clients, to share their concept vision with other departments: sales, management, production or marketing [2, 3].

Moreover, implementation of metals additive manufacturing (M-AM) showed that 3D-printing technologies could be used not only for prototyping but for product fabrication, with required high mechanical properties.

In [5] it is proposed that AM will perform revolution in manufacturing. Some enthusiasts of 3D-printing even predict that this technology will replace other traditional industries like casting and machining. As approval of these statements is the fact of successful application of DMD-AM in such specific life critical spheres as aerospace and production of bio-medical patient-specific titanium implants. In fact, for these applications, the DMD-AM has already become a production tool.

The DMD-AM provides many benefits for industrial design and manufacturing as shape/geometry form freedom, no tooling requirements, on-demand production, no minimum order quantities, extreme complexity, integration of multiple parts into one, no need of high-cost die-forms, and functionally graded materials (FGM).

Papers [5-8] demonstrate remarkable advantages provided by M-AM and its successful application in aerospace, automotive, medical and other specialized industries. Current work aims to show novel applications and potential of this technology for industrial design development and mass production of technologically new products.

a) Direct material deposition (DMD)

The DMD-AM has emerged as an efficient way to produce customized and fully functional parts from various materials [1, 3]. ASTM International (formerly American Society for Testing and Materials) standard defines AM freeform fabrication as: The layer upon layer process of joining materials to make objects from 3D-model, as opposed to traditional manufacturing technologies ascasting or machining [9]. The economic benefits of the use of AM for low series production are substantial as well since customization and single part production are easy to accomplish [10].

Numerous capabilities of M-AM have made it a flexible production method, compared to conventional machining, with enhanced efficiency to produce, for example, personalized bio-medical implants or airspace components.

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At present, the focus has shifted towards manufacturing and production of finished and functionalized parts rather than prototyping [10-12]. Today various materials can be used in AM processes, i.e., metals, polymers, ceramics, organic tissues, and cells.

The benefits of the 3D-printing process summarized from [3, 5, 11] are:

- Waste reduction. For critical raw material, for example, for rare-earth elements it is especially relevant [13];
- No machining is needed, significantly reducing post-processing time and costs;
- An option of small material amount use, important for new materials testing and low-serial production;
- Freedom of rapid design/model development.
- A possibility of function ability / lightweight structure improvement
- Personalized design;
- Manufacturing efficiency: to produce the assembled parts in one build;

However, the capabilities of 3D-printing are still limited due to several reasons:

- High initial costs of 3D-printing professional machines and their maintenance;
- The cost of powder printing materials and complicity and a high cost of their production, for example, gas atomized spheroidal titanium powders;
- For the mass production, 3D-printing is still non-competitive with traditional production methods as casting, because of the relatively low productivity.

b) The additive manufacturing production cycle

An additive manufacturing production cycle starts from the 3D-designer's work, whose task is to realize the CAD-model of the future component (fig. 1).This 3D model is the basis for the production of the part. Initial shape, geometry, and internal properties can be designed directly at this stage. Then the model is transformed into a .stl-file and maybe sliced into layers (.amf format) for further manufacturing. The .stl format converts all internal and external surfaces into an array of triangles.

Components are manufactured by adding thin cross-section layers of a material on a top of each other to grow the parts according to a 3D CAD-model [1, 3].

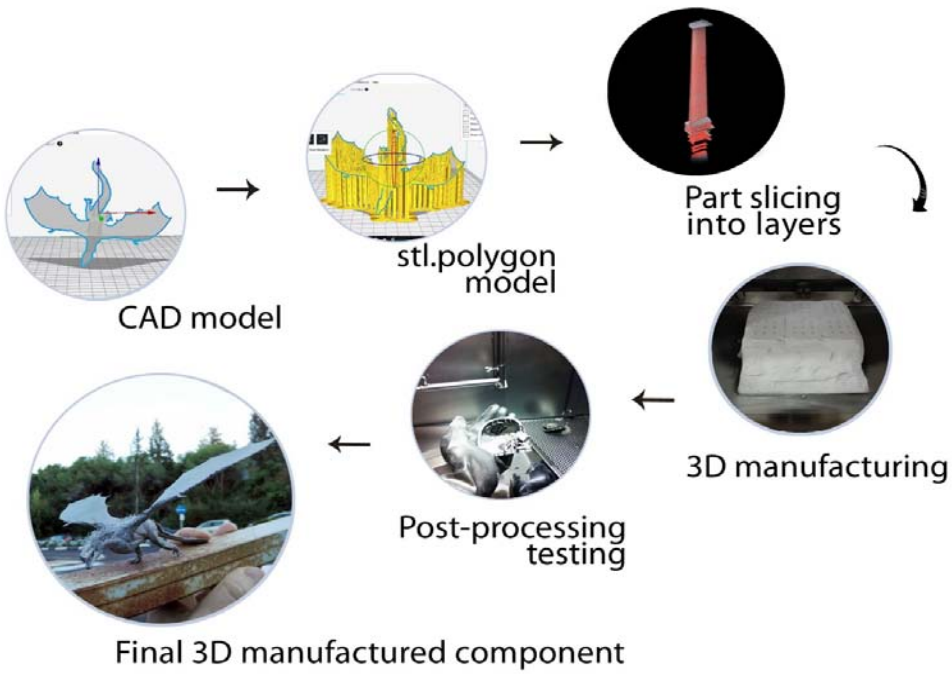

Fig. 1: A visual representation of the additive manufacturing principle

After finishing the building process, the part is removed for post-processing and testing. These procedures vary depending on the used AM process and the final part application. For the M-AM technologies as Selective Laser Melting (SLM) and Electron-Beam Melting (EBM©), the first post-processing

procedure is support structures removal. There are several reasons to apply support structures: for heat transfer from the part and as gravity support.

c) 3D-printing of titanium alloys

Ti-6Al-4V is the most traditional material for SLM and EBM© 3D-printing [15, 16]. It is used in the form of gas atomized spherical powder with the average fraction of 50 microns. High requirements for production and re-use of the powder are aimed to prevent the material oxidation, nucleation of satellites and distortions of the spherical shape of the particles.

Titanium and its alloy Ti-6Al-4V are well-known as structural materials. Such applications as medical technologies, chemical processing, sports, leisure, marine and aerospace all make use of the advantageous combination of properties of titanium materials. Compared to other metals, titanium and titanium alloys exhibit high corrosion resistance and high specific strength-to-weight ratio [14]. Today Ti-6Al-4V is the most widely used titanium alloy [15]. This alloy has a balanced combination of mechanical properties and workability and has been extensively researched [16]. Components from titanium alloys are complicated to process by traditional machining or milling, due to a relatively low thermal conductivity.

II. Application of Titanium Additive Manufacturing in Industrial Design

Due to the material and process benefits, M-AM successfully use in different fields. Today many of them are short series units, with a high level of complexity, and a high level of customization.

a) Patient-specific titanium implants

M-AM techniques are beneficial for the production of patient-specific replacements. The main advantage is the possibility to customize personalized implants. Moreover, the development of lattice structures in medical implants becomes advantageous as it combines the mechanical strength, light weight performance, increases the number of surfaces (for the interaction between titanium implants and muscular tissue), and minimizes replacement/shielding surface.

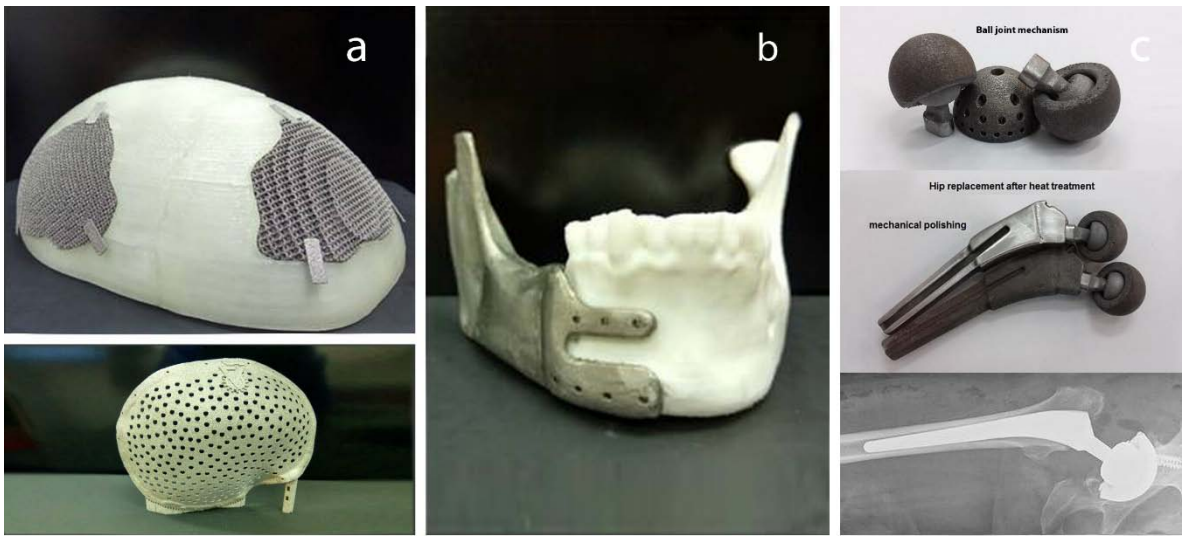

Fig. 2: Examples of EBM© medical implants manufactured by AMC Technion:a -cranial recovery lattice structure inserts; b - preliminary variant of the mandibular implant; c -hip replacement implants

Figure 2 demonstrates the EBM©-manufactured samples of cranial, mandibular and hip replacement implants. The "bone"-part is printed from ABS plastic to provide a surgeon the opportunity to try the implant on a plastic model and see if it fits well, how to fix it, what screws to use, etc.

b) Dental prosthetics

SLM technology has better characteristics than EBM© in surface roughness and accuracy of small parts. Because of that fact, for dental prosthetics manufacturing, such as dental crowns and bridges, braces and aligners, usually use SLM-AM. In the same build, hundreds of personalized prosthetics can be manufactured by cost-efficient SLM-AM. SLM-manufactured dental implants (fig. 3) passed heat treatment and required testing for fatigue resistance.

The manufacturing of titanium dental implants is already serial production for some hospitals.

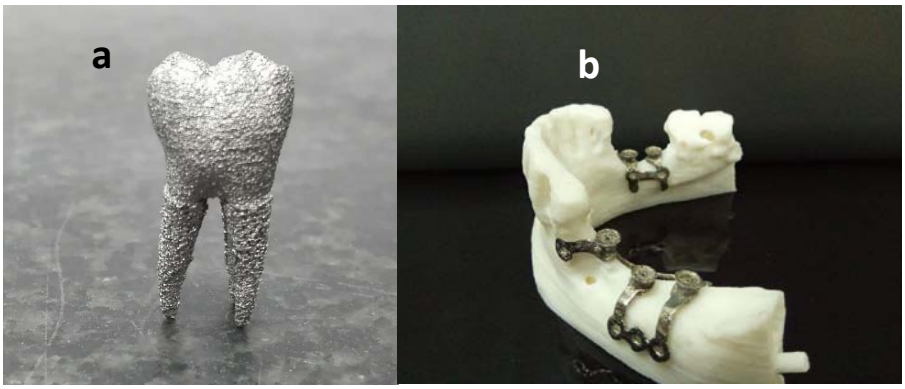

Fig. 3: a - tooth implant with lattice structured basis; b – implant's support system by EBM©

c) Aerospace components

Ti-6Al-4V became a very popular aerospace alloy because of high fatigue resistance. Fatigue resistance is critical for aerospace parts that work under cyclic loadings. Thus, the first goal for a new manufacturing technology was to prove that printed components have the same or maybe better mechanical properties than casted-machined parts.

Today titanium DMD-AM for aerospace application develops rapidly. The components that are already in airplanes are mostly non-critical parts, with light weight design and lattice structure. New bionic shaped parts save weight as the material is put only on stress points.

The next stage for 3D-printing of aerospace components is to perform an approving technology that will enable prediction of mechanical properties and microstructure of the printed products. That will allow manufacturing also critical parts that should be stable under cyclic loadings.

d) New tools manufacturing

Rapid tooling is an M-AM of new or some specific tools. It is a combination of traditional and novel fabrication methods. For example, cutting tools can be printed from tool steels. The main advantage in the fabrication of these tools through the AM is the fast production where the design can be easily changed and improved [5].

DMD-AM maybe also used for specific surgeon tools production. Because of biocompatibility of the material, such titanium-based 3D-printed tools do not need deep sterilization. Moreover, surgeons usually have their techniques, and here 3D-designers can help to produce some new tools for their work.

Benefits of DMD-AM as manufacturing of lattice structures, net-shape surfaces, and internal channels are also relevant for rapid tooling production.

III. Prospects of Additive Manufacturing for Industrial Design

As it was already said above, the critical safety application of 3D-Printing, as bio-medical and aerospace applications, are already well-known and rapidly develop.

To extend the spectrum of M-AM in the current research is presented by the successful examples of implementation of the technology by Additive Manufacturing Center at Technion.

a) Automobile application: passengers and concept cars

The automobile giants like BMW, Nissan, Ford, Rolls Royce, etc. are already utilizing AM for some car components production. Metal and plastic materials are both used.

According to Wohler's Report 2016, motor vehicle sector is already the third one that successfully used DMD-AM as a series production.

However, because of advantages (specific design of unique parts)and disadvantages (low productivity) of DMD-AM, the 3D-printing of parts of concept cars and formula motor cars is rapidly developed.

Figure 4 demonstrates the EBM© manufactured parts of exhaust gases system for Formula Technion cars. The new design and manufacturing technique enabled to decrease weight up to 3 kg.

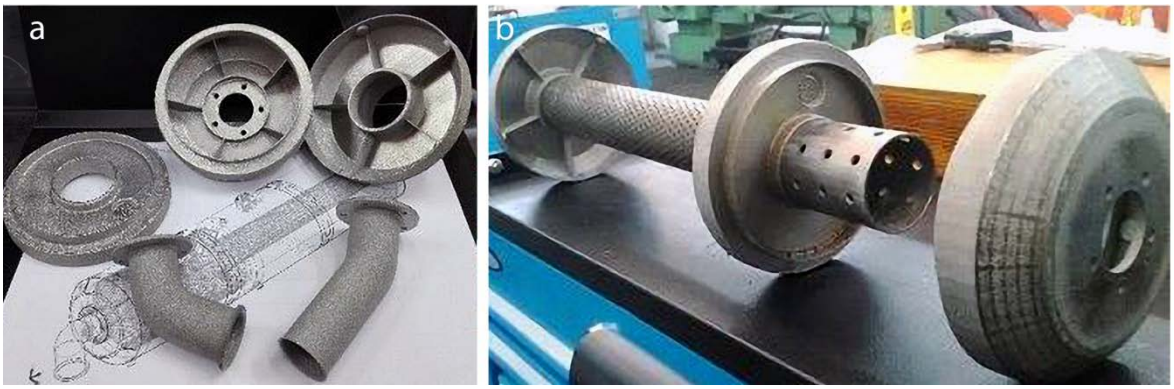

Fig. 4: EBM© manufactured parts of exhaust gases system for Formula Technion car

There are still limitations for mass production by M-AM for automotive application:

- Big volume parts manufacturing. Today ORNL [17] already uses the extrusion jetting technology for big volume parts fabrication from composites. However, EBM©/SLS/SLM metals AM techniques are still limited by the inner chamber size.
- Material price. The high requirements to atomized powders for metals printing make their cost too high compared to materials used in traditional industries.
- Lack of scientific base. Because of novelty of the AM industry, there is a lack of specialists, physicists, engineers, and lack of basic scientific knowledge of physics of the DMD-AM processes.
- Production time. The time of manufacturing by M-AM machines is still uncompetitive with casting. It is a problem for high series production.

b) Electronics and engineering manufacturing

There are several reasons for growing interest in the engineering manufacturing sector to different M-AM technologies. M-AM provides architecture simplification, capability to print integrated parts in one component, no geometry restrictions, and easy manufacturing development. A new product design reduces resources leading to cost reduction.

The case performed in fig. 5 is a newly designed component of a camera for direct nano-motion detection. The chosen material was Ti-6Al-V because of the unique combination of plasticity and strength of this alloy. EBM© process was used for the component manufacturing because of temperature conditions of this type of M-AM, which provide the microstructure of a final component free from residual stresses and martensitic structures.

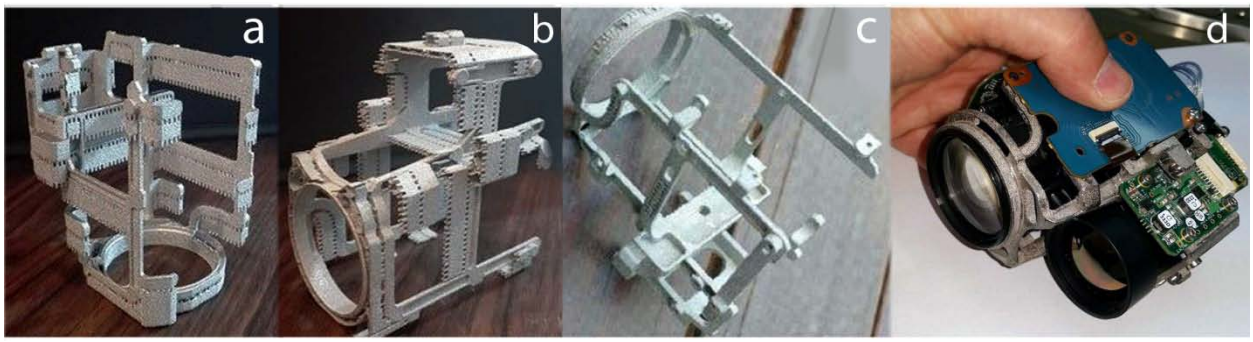

Fig. 5: The titanium EBM© manufactured body of a nano-camera Nanomotion Ltd.:

a – direction of manufacturing; b –component with support structures; c –component without support structures; d – camera assembled in a newly printed titanium body.

After several iterations between 3D-engineer and industrial designer, the optimal light-weight shape was determined. The proposed solution is optimal for the serial production of such type of cameras.

c) Complex research systems

Fig.6 presents the components for the electro-polishing system of titanium EBM©-printed parts for the needs of Corrosion Laboratory at Technion. EBM© has specific advantages:

- EBM© runs in high-temperature and high-vacuum conditions [15,18], which provides material microstructure clean of gas infusions and free from residual stresses. Such production conditions have no need for any post-processing as heat treatment.

- Because of high-temperature conditions, the powder surrounding the printed component is strongly sintered. This phenomenon provides printing with fewer support structures compared to laser printed parts.
- The high-vacuum conditions are critical for production components for working in the aggressive environment. These electrode components are to work in the electrolyte and should have high corrosive resistance.

d) Art and musical instruments

According to successful experience of rapid plastic prototyping of musical instruments, there is a significant potential of titanium DMD-AM for this application. Metal instruments have a more sonorous, piercing sound.

Titanium DMD-AM provides the following benefits:

- Bio-compatible non-allergic material;
- Unique acoustic properties;
- High mechanical properties – lightweight, plasticity, strength;
- Unique design possibilities for development of the product ;
- Personalized instruments: for professional musicians with their specific techniques.

Fig. 6: a - as-built parts of a system with support structures; b - the combined components; c - resolution of lattice structures of an electrode; d - inside the system: the inner dispenser for samples.

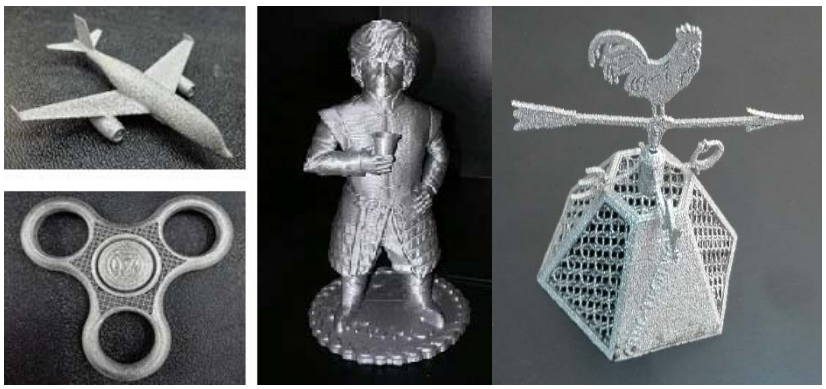

Fig. 7: 3D-printed art-objects and souvenirs.

However, until now there were no widely reported successful experiments in M-AM. It may be explained by the high-cost of the machines and metallic powder for AM.

From the internet search, it may be found just several examples of M-AM of musical parts. One of them laser-manufactured aluminum electric guitar [19]. However, this work is interesting mostly from the esthetic point of view. In this work the advantages of aluminum as a lightweight or non-corrosive material were not utilized. Moreover, electric guitar doesn't use the acoustic properties of the printed metal.

3D-printing in metals allows manufacturing of exclusive souvenirs (Fig. 7), unique art-objects, net-shape art installations (Fig. 8) and even jewelry. Moreover M-AM maybe combined with other techniques as machining, air-brushing (Fig.8b), coating, assembling, etc.

AM gives new ideas to designers, enables the use of 3D-printing for creating final customers products, and also specific printed molding forms, for example, for jewelry production.

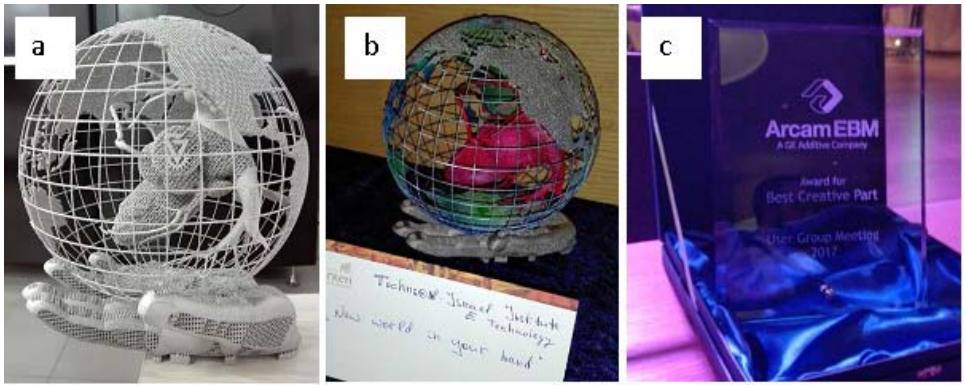

Fig. 8: a - as-built EBM©-manufactured work for Arcam UGM2017 competition; b - the airbrushed final part; c –"Best Creative Part" award for the EBM©-manufactured airbrushed object produced by AMC Technion.

IV. Conclusion

The paper presents the use of the 3D-printing as a new instrument for industrial designers for developing new products and applications. The marketing prediction of the future development of titanium DMD-AM in industrial design is very positive. Today there are decades of 3D-machines producers [20], who provide different processes for different materials.

Titanium alloys, because of the combination of high mechanical properties, fatigue resistance and corrosion resistance, provide interest to titanium 3D-printing not only for medical, aerospace, or automotive applications but also for specific engineering systems, electronics and even for musical instruments.

Many researchers believe [3, 21] that DMD-AM will shape the future of production and will stimulate new development in engineering and manufacturing processes. However, it is already clear that M-AM could not replace traditional fabrication technologies like casting at all. DMD-AM has its niche [3, 21-22] where it is uncompetitive: low-serial production of highly complicated geometrical lightweight parts. And first of all, it is design and development of new products and applications. And here AM becomes an instrument for industrial designers for prototyping new products, and to develop them up to final net-shape products with specific mechanical properties.

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You may contact the corresponding author for any additional information and access to the original tests' results.

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A Potential Approach to Analyze the Optimum Characteristics of Cotton/Modal & Cotton/Viscose Blended Yarn

By Mohammad Rashel Hawlader, Samara Islam Nishi & Md. Nasir Uddin
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Abstract- The demand of blended yarn has been increasing gradually due to some of its distinctive properties. It is a challenging task for textile technologists to ensure the appropriate blend composition and blending ratio for the developments of the spinning industry. We should reduce dependency from natural fiber as their properties are not adequate in advancing textile industry and so they are used together in blends with synthetic fibers to compensate their limitations. The aim of this research work was to study the comparative properties of cotton/viscose and cotton/modal blended yarn. Cotton was blended with viscose and modal fibers separately in 50/50 ratio. Blending was carried out at draw frame, and finally 31/1Ne blended yarns were produced. The yarn properties such as unevenness, imperfection, hairiness, single yarn strength (cN/tex) and bundle yarn strength (CSP) were tested, and their comparative results were analyzed. Cotton/modal 50/50 blended yarn showed significantly better properties than the cotton/viscose 50/50 blended yarn.

Keywords: *blended yarn, IPI, hairiness, SFC, viscose, modal, etc.*

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Keywords: blended yarn, IPI, hairiness, SFC, viscose, modal, etc.

I. Introduction

Blending in the cotton spinning process has the objective to produce a yarn with acceptable quality and reasonable cost. A good quality blend requires the use of adequate machines, techniques to select bales and knowledge of its characteristics [1]. Blending different types of fibers is a widely practiced method of enhancing the performance and the qualities of a fabric [2]. The blending of different fibers is a standard practice in the spinning industries. The blending is essentially done to enhance the characteristics of resultant fiber mix and to optimize the cost of the raw material. The properties of blended yarns generally depend on the properties of the constituent fibers and their compatibility. Moreover, the proportion of fibers in the blend also plays a significant role. [3]. Natural fibers and their blends with synthetic fibers bear valuable characteristics, so at present, there are various products made of these fibers. It determines that absorbing and discharging moisture, non-irritating, anti-bacterial, anti-allergic, protection against the sun's harmful Ultra Violet rays and other valuable properties are better than classic yarns. They may be used for clothing, underwear, socks, hygienic, textile products as well as for composites [4]. The blending of different types of fibers is a widely practiced means of not only enhancing the performance but also the aesthetic qualities of textile fabric. Blended yarns made from natural and synthetic fibers have the particular advantage of successfully combining the satisfactory properties of both fiber components, such as the comfort of wear with easy care properties. It also permits an increased variety of products to be made, yielding a stronger marketing advantage [5]. There is a problem in fiber blending technology of selecting specific types of fibers and blend ratios depending on the final product [2]. There are different types of fibers are used to produce blended yarn. Such as Cotton-Viscose, Cotton-Modal, Cotton-Polyester. The degree of orientation of regenerated cellulose fibers depends on stretching during spinning [6].

II. Material & Methods

Cotton is the common blending component used here. Variable elements used here with cotton were viscose and modal fiber. The fiber parameters were tested in AFIS & HVI machine in a standard testing condition (Temperature $20^0 \pm 2^0$ C & Relative Humidity 65±2 percent) [7]. Fiber properties and country of origin shown in table 1.

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Table 1: Fiber properties and country of origin of cotton, viscose, and modal fiber

Properties	Cotton	Viscose	Modal
Fineness	4.30 µg/inch	4.31 µg/inch	4.31µg/inch
Upper quartile length(UQL)	28 mm	38 mm	38 mm
Strength	28.83 gm/tex	15gm/tex	30 gm/tex
Country of origin	Mali & Senegal	Indonesia	Thailand

Here, Draw frame blending was applied. Sliver blending gives excellent blending evenness along the length of the product [8].

III. Result and Discussion

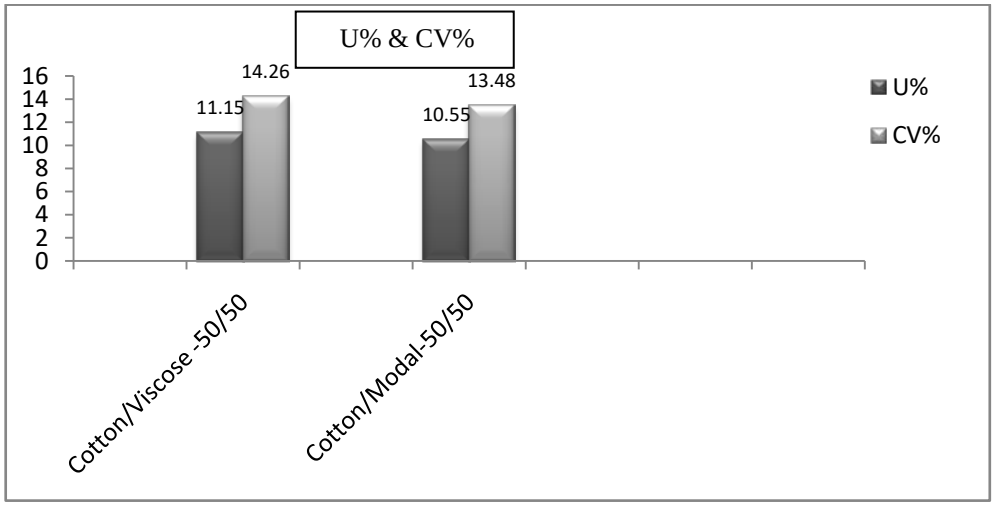

Fig. 1: Unevenness (U% & CV %) of cotton /viscose & cotton /modal blended yarn

The strength of viscose fiber is lower than modal fiber. It creates short fiber which leads to more unevenness in cotton/viscose blend yarn. As the strength of the modal fiber is same as cotton fiber, so unevenness found lower in cotton /modal blend yarn. The short fiber content in different stages is given in fig. 2

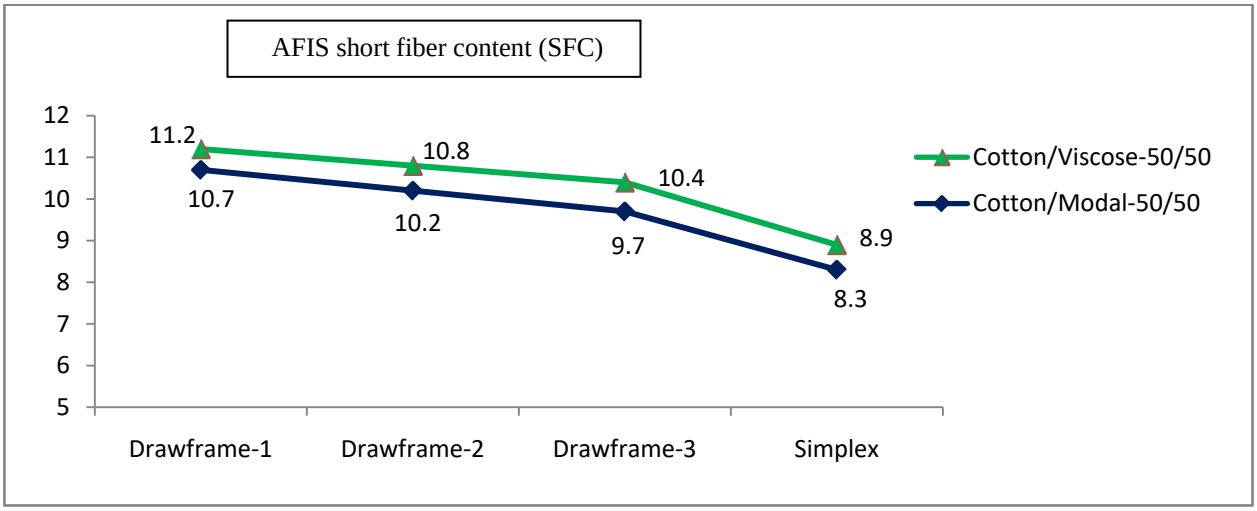

Fig. 2: AFIS short fiber content SFC (n) at the different stage of blending

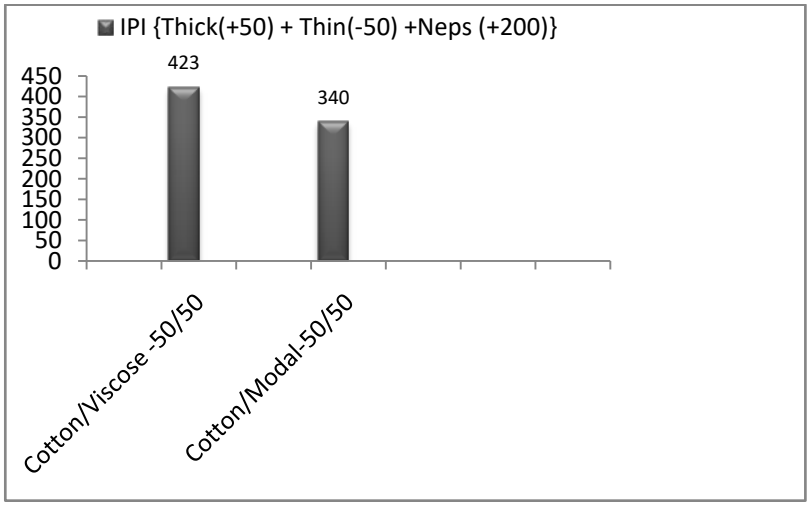

Fig. 3: IPI comparison of cotton /viscose and cotton /modal blended yarn

Thick place, thin place, and neps found higher in cotton/viscose blended yarn. As the strength of viscose fiber is less than modal so it creates more short fiber and neps during processing which creates more imperfection in cotton/viscose blended yarn than cotton/modal blended yarn. Neps generation percentage in different stages shown in fig. 7

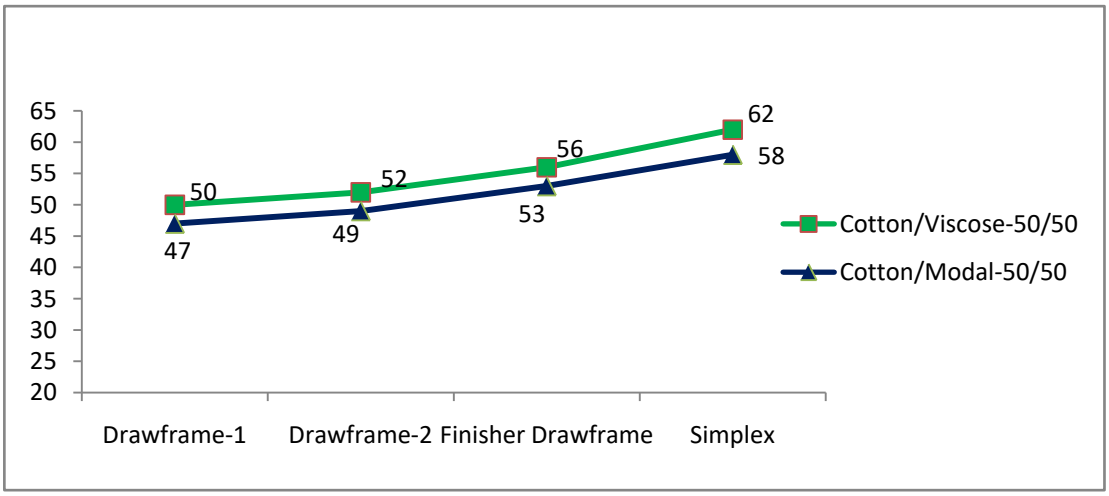

Fig. 4: AFIS neps content per gram at the different stage of blending

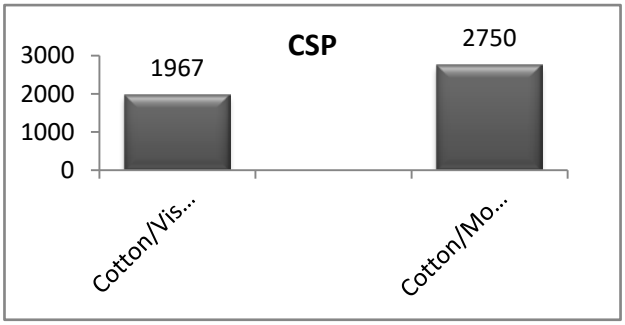

Fig. 5: CSP comparison of cotton /viscose and cotton /modal blended yarn

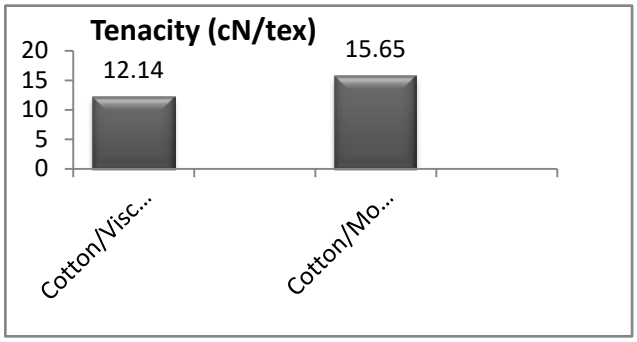

Fig. 6: Tenacity comparison of cotton /viscose and cotton /modal blended yarn

Modal fiber strength is higher than viscose, so cotton /modal blended yarn showed greater strength than cotton /viscose blended yarn.

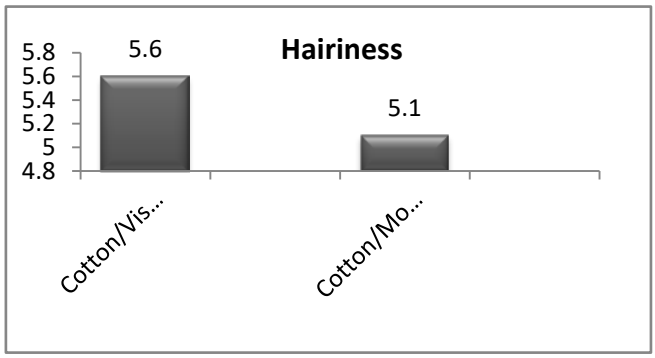

Fig. 7: Hairiness comparison of cotton /viscose and cotton /modal blended yarn

Viscose creates more short fibers while processing, so hairiness of cotton/viscose blended yarn is more than cotton/modal blended yarn. Short fiber content of different stages is showed in fig. 2

IV. Conclusion

The results of this work reveal that cotton/modal blended yarn shows better properties than cotton/viscose blended yarn. Though viscose and modal both are regenerated cellulosic fiber, the strength of viscose fiber is lower than modal due to the higher molecular weight of modal. When viscose blends with cotton, it creates short fibers and neps during the spinning process. Apart from these, the movement of viscose fiber during drafting is not as much controllable as in case of modal fiber. For the above-mentioned reasons, the cotton/modal blended yarn quality is better than cotton/viscose blended yarn.

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Drawbacks, Necessary Development and Future Prospect of Silk in Bangladesh

By Md. Sanaullah Murad, Md. Ebrahim Shaikh, Nazmul Islam & S.M. Tufazzal Haider
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Abstract- Bangladesh is an underdeveloped and agro-based country. Silk industry has a long and glorious past history but the growth and market share is not satisfactory of this industry to the national and global context. It is an urgent need to mark the existing problem and future expectations of silk industry in Bangladesh. So, it is essential to make effective plan and proper execution of that plan to get back the glorious position of our silk industry as well as to help the economical development of our country.

Keywords: *silk, sericulture in bangladesh, silk industry, silkworm breed.*

GJRE-J Classification: *FOR Code: 291899*

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Md. Sanaullah Murad [α], Md. Ebrahim Shaikh [σ], Nazmul Islam [ρ] & S.M. Tufazzal Haider [ω]

Abstract- **Bangladesh is an underdeveloped and agro-based country. Silk industry has a long and glorious past history but the growth and market share is not satisfactory of this industry to the national and global context. It is an urgent need to mark the existing problem and future expectations of silk industry in Bangladesh. So, it is essential to make effective plan and proper execution of that plan to get back the glorious position of our silk industry as well as to help the economical development of our country.**

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I. Introduction

Silk production is a very complicated process. Silk is made by silkworm, the caterpillar of the flightless silk moth, whose only food is fresh mulberry leaf. Silkworms are hatched from eggs and end their existence by encasing themselves in cocoons from which they emerge as silk moths. Several steps are required for silk filament manufacturing.

The production of cocoons for their filament is called sericulture. Experiments have proved that the cocoon of the Bombyx mori, a species of moth, produces the finest quality of raw silk.

The silk-moths cannot fly because their bodies are too heavy in relation to their wings. Male's silk-moths die soon after mating while one single female silk-moth lies from 300 to 500 tiny eggs before she dies. Silk moths lay eggs on specially prepared paper by using paper card method. After hatching, larva (caterpillar) comes out.

These caterpillars are very delicate and require the utmost care. When first born, they are dark green in color and have a voracious appetite.

The larva is fed mulberry leaves which are taken from the mulberry trees. At the 1st stage, the larva is fed tender mulberry leaves and this stage lasts for two days. At 2nd stage, the larva is fed mulberry leaves which are taken from the middle part of the trees and are more matured than tender leaves. This stage lasts for 2.5-3 days. At 3rd stage, the larva is fed mulberry leaves which are taken from the lower middle part of the mulberry trees. This stage lasts for 2.5-3 days. At 4th stage, the larva is fed more matured mulberry leaves which are taken from the lower part of the trees. This stage lasts for 3-3.5 days. After 3.5-4 days, the silkworms stop having leaves and their skin turns into yellowish color from white color and secrete saliva which is a Protein based substance.

The liquid silk is contained in two glands inside the silkworm. From these glands it flows in two channels to a common exit tube, called the spinneret, in the silkworm's head. As it emerges, the liquid silk hardens into very fine filaments and these are coated and stuck together by a gummy substance called sericin which comes from two other glands nearby.

The silkworms are transferred to Chandraki as they start spinning cocoon around themselves and they are kept 6-7 days. The formation of cocoon needs 6-7 days and the Worm inside it is called Pupa.

The purpose of sericulture is to harvest the cocoons and collect the raw silk from these cocoons. Therefore, before it becomes a moth and tears out the cocoon to come out, the chrysalis is killed by exposing it to a temperature of 70-80 °C for 7-8 hours.

The silk fiber, as it is spun by the silkworm, consists of two triangular filaments of fibroin, stuck together with a gum called sericin.

The silk farmers heat the cocoons to kill them, leaving some to metamorphose into moths to breed the next generation of caterpillars. Harvested cocoons are then soaked in boiling water to soften the sericin holding the silk fibers together in a cocoon shape. The fibers are then unwound to produce a continuous thread. Since a single thread is too fine and fragile for commercial use, anywhere from three to ten strands are spun together to form a single thread of silk.

Most of the silk gum is not removed to give protection of the delicate filament. Cocoons are boiled into hot water until yarn comes out of cocoons and when the yarn comes out it is transferred to the reel by some manual and mechanical process. Transferring the

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yarn from reel to hank is known as re reeling which is done to overcome the reeling defects like yarn breakage, uneven Winding etc. Then the yarn is prepared for fabric production.

II. Materials and Methods

In our study we find out some problems of silk industry in Bangladesh like old technology, poor advertising, limited showroom, shortage of raw materials, inadequate capital, insufficient governmental facilities etc. We also find out some prospects of this industry like growth of sales and market share, low cost of labor, increasing demand, good geographical location, employment opportunity etc.

a) Present Status of Mulberry Trees in Bangladesh

In our study we find out some problems of silk industry in Bangladesh like old technology, poor advertising, limited showroom, shortage of raw materials, inadequate capital, insufficient governmental facilities etc. We also find out some prospects of this industry like growth of sales and market share, low cost of labor, increasing demand, good geographical location, employment opportunity etc.

Cultivation of mulberry plants is referred to as moriculture. Mulberry is a perennial plant and, once established in the field, continues to produce in full form for at least 15 years.

Mulberry leaf is the food on which the silkworm lives on. So production of raw silk directly depends on the production of this leaf. Bombyx mori which produces the silk cocoons therefore research on conservation of genetic stock of mulberry, development of high yielding mulberry varieties, appropriate technology of mulberry cultivation and control of diseases and pests of mulberry are being conducted.

Improvement of crop productivity primarily depends on the level of conservation of genetic maerial. BSRTI is maintaining 60 mulberry varieties in its germplasm bank out of which 36 are indigenous and 24 are exotic in origin. Among the 24 exotic varieties,17 Indian, 4 Chinese and 3 Japanese. Recently 4 exotic varieties have been collected.

BSRTI has developed 9 high yielding mulberry varieties (BM-1 to BM-9). The leaf yield of the developed varieties is 30-40 metric ton/hectare/year as against 12-18 metric ton/hectare/year. Among the developed BM-1, BM-3,BM-4,BM-5,BM-6 and BM-8 has been transferred to the field for commercial leaf production. The rest are in the pipeline for exploitation to the field level.CPH-91 and CPH-167 these two varieties are in the multiplication stage. The varieties were selected on the basis of biometrical, biochemical and bioassay studies, diseases etc. The varieties BM-4 and BM-3 are found to be resistant to drought and water logging conditions respectively. The variety BM-4 is recommended for practice in water stress conditions and BM-3 water logging conditions.BM-8 and CPH 167 are found to be tolerant to drought and disease specially Tukra and Leaf curl.

b) Present status of sericulture in Bangladesh

BSRTI has fabricated low cost mountage made of straw and bamboo, which has the facilities for both side mounting. This type of mountages helps to produce quality cocoons at cheaper rate. The collection and maintenance of silkworm breeds of tropical and temperate regions are important for development of high yielding breeds and hybrids of silkworm. 85 multivoltine and bivoltine silkworm strains are being maintained in the institute. This include indigenous multivoltine, Indian multivoltine, Chinese multivoltine, Chinese bivoltine, Korean bivoltine etc.

The institute has formulated package of practices required for Chawki silk worm (young age) as well as late age silkworm rearing in tropical and subtropical condition. This include handling of silkworm eggs maintenance of proper temperature(23-28°C) and relative humidity (70-90 %) providing adequate spacing for silk worm (400-600 sqft for 50,000 larvae in 5th stage), maintenance of leaf freshness to preserve moisture and nutrient content, careful handling of worms in moults and spinning.

Silkworm genes could be altered to increase their tolerance of hot climates, allowing more widespread global cultivation.

Bangladesh is growing mainly BSRTI mulberry varieties for bush and tree plantations; silkworm races are both bivoltine hybrids (BSRTI series) and hybrids of poly-voltine breeds evolved throuth crossbreed of Nistari, a traditional Bangla strain and the hardy other races.

Table 1: Newly invented silkworm breed by BSRTI

SL No.	Code Name of Race	Full Name	Year of Development
1	F.T.B	Field Trial-B	2004
2	H.T.H.R.B-3	High Temp. High Humidity Resistant Breed-3	2004
3	95/14(P)	Improve multivoltine(Plain)	2004
4	95/14(M)	Improve multivoltine(Mark)	2004
5	ISK.	Indian Silkworm, Karnataka	2002
6	N(I)K(P)	Nistari(India) Karnataka(Plain)	2003
7	BN(P)	Brac Nistari(Plain)	2004
8	(P)	Nistaari B-2(Plain)	2005
9	(M)	Nistaari B-2(Mark)	2005
10	BN(M)M	Brac Nistari(Mark)	2004
11	BB	Bangladesh Bivoltine	2004

III. Results and Discussion

a) Present Status of Mulberry Trees in Bangladesh

In 1993 our Finance Minister M. Saifur Rahman accepted the World Bank 1990 open market policy which is the main reason for the destruction of our silk industry. In open market policy people did not have to pay tax on the import of silk yarn .so people of our country started to import of silk yarn from china which was economically & in quality better than ours. Bangladesh became the transit point for the import of silk yarn which not only affected Bangladesh but also India and Vietnam. Many people in Indian boarder started seasonal business of silk product which came to our country cheaply & hampered our farmers & industrialist. As a result the Mulberry tree farmers and silkworm producers can't make profit by selling their products. So People are reluctant to cultivate Mulberry trees now days because there is no guarantee that if anyone has a Mulberry tree, he can sell its leaves to the market.

Another reason is there are hybrid crops from which they can earn much more than selling leaves of Mulberry trees. Now days, people can get crops all over the year from the hybrid crops & the crops amount is much more than previous period. For this reason there is acute shortage of Mulberry trees and silkworm. As a result many of our silk industries have been shut down so the number of Mulberry trees is decreasing day by day. The weather of country is changing day by day so the suitable environment for the cultivation of silk worm is reducing day by day. Many people have diverted their occupation to other sector from this sector and our rural areas people forgot about the cultivation of silk worm which is another reason for the destruction of this sector.

[11] Silk is a very fine, regular, translucent filament. It may be up to 600m long, but averages about 300m in length. Depending upon the health, diet and state under which the silk larvae extruded the silk filaments, their diameter may vary from 12 μm to 30 μm.

Our silk worm lays egg from which we can get only 400-500 yarn which is much lesser in comparison with china where from a silk worm egg they can get 1400-1600 m yarn. As long as our silk yarn is not so good as compared with China, we can't compete with them in international market. Our local market is now reluctant about silk product. People are now buying Indian synthetic product which are cheaper & don't have any crease or wrinkle after washing. So, people are refusing silk products eg. saree, salwar kameez etc.

In 2001 China created embargo to the export of silk yarn because they found producing fabric & garment more profitable than selling silk yarn. Recently china is reluctant to export silk yarn to other countries. Our sericulture research board & institute are corrupted & there is acute shortage of skilled & trained manpower. People working here very few of them have knowledge about sericulture. Lack of govt. subsidy & attention is another reason for the destruction of our silk industries.

b) Future prospect of silk weaving in Bangladesh

The present situation of silk weaving sector in Bangladesh is not very much congenial. If the current situation continues, our silk industries will be demolished in the near future. If our silk research board & institute work together & give appointment the skilled people here then we may hope a bright prospect in this sector. We need better silk worm & tooth tree in respective to our weather. If we can do so, we may certainly hope a better prospect in our silk sector. If the Government patronize to this sector & give incentive to the people of this sector then we can hope a bright prospect of this sector. People of our country should be getting acknowledged of this sector & new investment will certainly help to boost this sector. The farmers of our

country should be trained how to cultivate silk worm & tooth trees & if this happened we can certainly hope a better prospect of this sector.

c) Way to restore our previous glory of silk product

First reopening of the mills is needed. People can't overcome loss without subsidies from the govt. Govt. should create awareness to the farmers about Mulberry tree cultivation & the leaves should be bought by the govt. of its own care so that the farmers don't have any fear about loss. Embargo should be given on the import of silk yarn. Local market of silk product should be regenerated by creating awareness among people.

Our silk worm egg is not necessarily so big that can give 1400-1600 m yarn to compete with China. So, it is the research institute's duty to invent highly developed silk worm which can give 1400-1600 m yarn from its egg. Necessary developments of Mulberry tree should be done so that it can grow everywhere such as low lying land & in the front of free land of home.

IV. Conclusion

Bangladesh is a developing and small country. Silk industry plays a vital role in our national economy. It has a remarkable goodwill but the growth and market share is not satisfactory of this industry to the national and global context. Many people get employment opportunity from this industry and Govt. is getting huge income tax from the silk mills. In the present study we find out some problems of silk industry in Bangladesh like old technology, poor advertising, limited showroom, shortage of raw materials, inadequate capital, insufficient governmental facilities etc. Besides this we also mark some prospects like growth of sales and market share, low cost of labor, increasing demand, good geographical location, employment opportunity etc. So, it is essential to make effective plan and proper execution of that plan to get back the glorious position of our silk industry as well as to help the economical development of our country. For this purpose some recommendations have been proposed for silk industry of Bangladesh in the study. We believe that if the industry follows that recommendation, it will be benefited and able to gain more profit and overcome all of its obstacles.

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Increase the Efficiency and Productivity of Sewing Section through Low Performing Operators Improvement by using Eight Wastes of Lean Methodology

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Keywords: workstation layout, low performer, sewing section efficiency, worker capacity, time study, eight wastes of lean, performance%, line balancing, bottleneck, productivity.

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Sohel Ahmed[α] & Md. Shafiqul Islam Chowdhury[β]

Abstract- This paper represents the use of some tools and techniques to increase the efficiency and productivity of an apparel sewing section through low performing operators' improvement. Now a day's apparel manufacturing industries are trying to develop their current production system and situation and continuously looking for new production tools and techniques to keep swiftness with the rapid changes of the trend in consumers of apparel products. To deal with the current situation and fulfill customer demand within lead time, whole production system should be more capable and efficient. Full apparel is produced based on the performance and contribution of individual workforce. There is no doubt that operators are selected and appointed on the specific tasks based on their evaluation and performance level where they are capable. But with the rapid changes of apparel products style, excessive pressure on sewing floor & imbalance in the sewing section, sometimes some operators can't keep pace with the desired production processes. If we observe a garments production line, we will see that there are lots of in-process inventories and wait time between almost every sequential operation. The materials used to travel an extensive distance from the input receiving to needle check and disposal. Many movements and handlings are practiced by the operators which are unnecessary. Sometimes reworks are increasing the total completion time. As a result, the productivity is hampering in the sewing section. In this paper, the wastes firstly found out from some selected operations, and then some tools and techniques have been implemented to eliminate those wastes, and by applying these techniques, significant improvements in the sewing section have been achieved. The manufacturers of homogeneous apparel industries can expand the findings in future.

Keywords: workstation layout, low performer, sewing section efficiency, worker capacity, time study, eight wastes of lean, performance%, line balancing, bottleneck, productivity.

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I. Introduction

The Ready Made Garments (RMG) industry is the significant export – base (77%) for Bangladesh and it has a major impact on country's economy, as well as on society, because of a substantial number of worker involvement [8]. The RMG industries are continuously providing the single source of growth in Bangladesh's rapidly developing economy. Because of being technologically labor dependent, it has a large number of worker involvement, and most of them are female workers, so it helps in socio-economical development of the poverty-stricken fraction of the population of the country. Many reputed buyers prefer this country for manufacturing for lesser labor cost with high quality of products [2]. The RMG industries are getting very competitive to attract the well-known buyers, and in today's competitive era, the manufacturers mainly need to be concerned about time, cost, quality, and delivery [10]. It is obvious that assembling apparel is a highly laborious process where a great number of people participate. But it is a matter of consideration that all the labors performance and capability are not same. So capacity variation occurs very frequently as working capacity differs from man to man. As a result, the production system often gets very problematic to ensure its smoothness. In case of running the smooth production, sometimes some operators have been highlighted as the low performers who are producing less as well as creating problems for the others. The combination of the machines to the operators is needed to specify to make the best use of both of them. Taiichi Ohno, considering the father of Toyota Production System, created a lean manufacturing framework, which was on the basis of the idea of preserving (or increasing) value with less work. Anything that doesn't increase profit in the eye of the customer must be considered waste, or "Muda," and every effort should be made to eliminate that excess [9]. The acronym for the eight wastes is TIM WOODS. TIM WOODS stands for: Transport, Inventory, Motion, Waiting, Overproduction, Over-processing, Defects & Skills. Elimination of these eight wastes from production

floor can help the manufacturers to produce the quality product with less material, higher efficiency, shorter lead time, and in a timely manner. The manufacturers can reduce approximately 43% lead time by implementing the lean technique in the sewing industry [1]. This paper addresses the application of these eight wastes of lean to identify the reasons for being a low performer and then the implementation of necessary tools and techniques to eliminate those findings.

II. Literature Review

a) Productivity

Productivity is the measure of output per unit of input [3]. In garments sewing section, the operation breakdown of a garment consists of several long, medium and short operations and operators also allocated on those specific operations based on their performance and grade. Generally, critical procedures are taken care of by grade – A operators while semi-critical by grade – B and the grade – C operators appointed to other types of working. The productivity of them can be measured by how they are using their allocated resources in a worthwhile manner e. g. time, energy, skill, etc. to achieve established goals based on the relationship between inputs and outputs. If operators don't make the best possible use of those resources skillfully and wisely, they can't get the results and accordingly line's total production and efficiency will fall. So, productivity improvement of individual operators is very superior.

b) Line Layout

The sewing line layout is a formation where sewing workstations are placed on the sewing floor to form a line (or batch) that works on a single style. Materials start flowing from the back to the front in a sequential order. All part sub-assemblies are started at the right time to be ready at the required time and kept moving until the finished product is available at the end of the assembly line. The line to be followed by the product during travel may be straight, U-shaped, circular or zigzag and the machines lay in the order in which they are to be used [3].

c) Workstation Layout

Workstation layout is the arrangement of the required items in a specified way at a designated area where specific job or jobs are performed. To do the operations within the least possible time, their handling movement needs to be the minimum. The components need to place within the nearest hand distance to the operators so that they can pick them simply. In the apparel industry, an ideal workstation layout should consist of minimum picking and disposal area, least movements and minimum length of every action.

d) Line Balancing

The total work to be performed at a workstation is equal to the sum of the tasks assigned to the workstation. Balancing the line means jobs assigned to the workstations in a specified way so that each workstation has no more than can be done in the workstation cycle time, and so that unassigned (idle) time across all workstations minimizes. In a balanced line, materials will flow smoothly and no time will be lost in waiting for work. An appropriate balancing of a sewing line depends on the mechanism of work cell deign and it needs to be linked with the other decisions to function well.

e) Time Study

Time study is a method of measuring work for recording the times of accomplishing specific tasks or its elements carried out under specified conditions. An operator does same operation throughout the day. Time study helps to define how much time is necessary for an operator to carry out the job at a defined rate of performance. The aim of time study is to establish a time for a qualified worker to do definite work under stated conditions and at a stated amount of working.

f) SMV (Standard Minute Value)

SMV stands for Standard Minute Value, which indicates a standard period, and within that a required amount of work needs to be done through following the standard procedure with worker's "standard performance". For measuring how much time is required for doing a definite amount of workload, proper SMV set up is needed in garments production floor.

Standard Time = (Average observed time X Rating %) + Allowance%

g) Progressive Bundle System

Bundles consist of garment parts need to complete a specific operation of garment component [11]. In readymade garment manufacturing plants, the manufacturers install various types of sewing systems. Operation head chooses these systems depending on the volume of production, product categories and cost-effectiveness of high tech machines. Among those "Progressive Bundle System (PBS)" is mostly installed sewing system till date. In this production system, bundles of cut pieces (bundle of 5, 10, 15, 20 or 25 pieces) are moved manually to feed the line. Then inside the line, an operator himself drags the bundle from the side table and transfers the bundle to the next operator after completion of the work. Quality inspectors track the bundles if they are coming sequentially.

h) Bottleneck in Production Line

In a production sewing line, where supply gathered, production goes under capacity and lots of

garment's parts on specific workstation remain unattached, those areas are termed as bottleneck areas and which works as a constraint for smooth flow of production is termed as bottleneck [2].

i) Low Performers

A company's overall performance depends on the contribution of every employee, and a company is only as strong as its lowest-performing employees. Low performers are those who struggle to do his/her job according to the standard method and who is causing problems to the other operators in the whole section. The operators who normally take more time than established, produce lesser than target and causing bottlenecks, causing defects while doing the operation and reworks needed to be done, etc. are termed as low performers. Operation management can improve the low performers through identifying the causes they are facing and eliminating those and giving them the proper training so that they can understand their job very well.

j) Eight (8) Wastes/Mudas of Lean

There are eight types of wastes which are following:

i. *Transportation*

Waste caused by moving things around. Too much transportation tends to increase costs, wastes time, increases the likelihood of product damage and deterioration and can result in poor communication. Limiting transportation waste can be easily addressed by sound judgmental efforts such as simplifying processes, repairing physical layouts, handling products less often, and making distances between workstations as short as possible.

ii. *Inventory*

Work in Process (WIP) Inventory is material between operations due to large lot production or processes with long cycle times. This waste occurs when there is supply more than real operators' demand, which masks real production. Approximately 60% of wastes occur in garments industry due to inventory [5].

iii. *Motion*

Any excess movement that doesn't add value to the product, service or process [9]. The motion includes any unnecessary physical motions or walking by workers which diverts them from actual processing work.

iv. *Skill*

Not or under-utilizing peoples' talents, skills, and knowledge can have a detrimental effect on an organization. Companies can experience great benefits when recognizing the value of skills and breakthrough performances from all levels and can suffer when not effectively engaging in the process.

v. *Waiting*

This occurs whenever work has to stop for some reasons: because the next person in line is overwhelmed, because something broke down, because operators are waiting for approval of materials, or because they've run out of something.

vi. *Overproduction*

Unnecessary production of more quantities than required can be termed as overproduction [1]. In some organizations, workers just blindly keep producing, even when those who receive their output either aren't ready for it or don't need it. Line balancing and improved work design can contribute primarily to reduce the waste of overproduction.

vii. *Over-processing*

When a revise or redone of procedure or product happens for something because it wasn't correct at the first time or taking unneeded steps to process the parts, inefficiently processing due to the poor tool and product design, causing unnecessary motion and producing defects [10]. In the apparel industry, this waste relates to defects because operators often produce alterations on their operations and so rework needed to be done regularly.

viii. *Defects*

Mistakes that require additional time, resources, and energy to fix. In a manufacturing process, a defect might involve a defective part that worker has to redo. Production of faulty parts or correction, repair or rework, scrap, replacement production, errors in paperwork, provision of incorrect information about the product, late delivery, and inspection mean extravagant handling, time, and effort.

III. Methodology & Experimental Work

This study was carried out in a reputed woven (top) garment industry situated at My mensingh in Bangladesh. In this study, a woven shirt (Men's Flannel shirt with two pockets and flaps) was analyzed, and the critical points were identified. There a line was selected where production was minimum compared to the others.

a) Data Analysis of the experimented sewing line

Here ten cycle times for each operation was recorded, and at the same time, the name of the operator or helper, attachment used and machine type was recorded in a time study template sheet. Before starting the time study, the breakdown of the progress of operation was done. After recording ten cycle times; average cycle time was calculated from which basic time or cycle time was found. Then from cycle time, the potential capacities per hour and performance% were calculated.

b) Identification of low performers

The calculated data visibly highlighted the low performers based on their performances and capacities and bottleneck areas were found out. Analyzing the data, seven (7) operators were selected for whom bottlenecks creation and less production were happening. They were selected for the further experimentation to be improved. The picked seven low performers with their potential capacity and performance against standard time data are given below:

Table 1: Low performers with potential capacity and performance% against standard time

Sl. No.	Operator Name	Operation Name	Machine Code	SMV	Capacity CT	Capacity/Hr	Performance%
1	Julekha	Attach Collar Band to Collar	1N2TLS-EC	0.56	0.85	71	65.88%
2	Khaleda	Make Front Left Placket (Top Placket)	4N8TCS-Kan	0.35	0.69	87	50.72%
3	Nasrin	Press Pocket (Auto)	Creasing m/c	0.41	0.83	72	49.40%
4	Lily	Attach Pocket to Front	2N4TLS-UBT	1.22	2.45	24	49.80%
5	Sharmin	Attach Pocket to Front	2N4TLS-UBT	1.22	2.59	23	47.10%
6	Rokeya	Attach Sleeve to body	2N4TCS	0.93	1.83	33	50.82%
7	Tahmina	Attach Cuff with 2 Pleats	1N2TLS-UBT	0.81	1.46	41	55.48%

c) Implementation of tools & techniques to find out the reasons for low performance

For the improvement purposes, low performers can be defined as someone who is not achieving necessary QUALITY or QUANTITY; this could be either a trainee or a line machinist. An action flow chart is followed to observe what needs to take into consideration of the performing procedures. The flow chart is in the following:

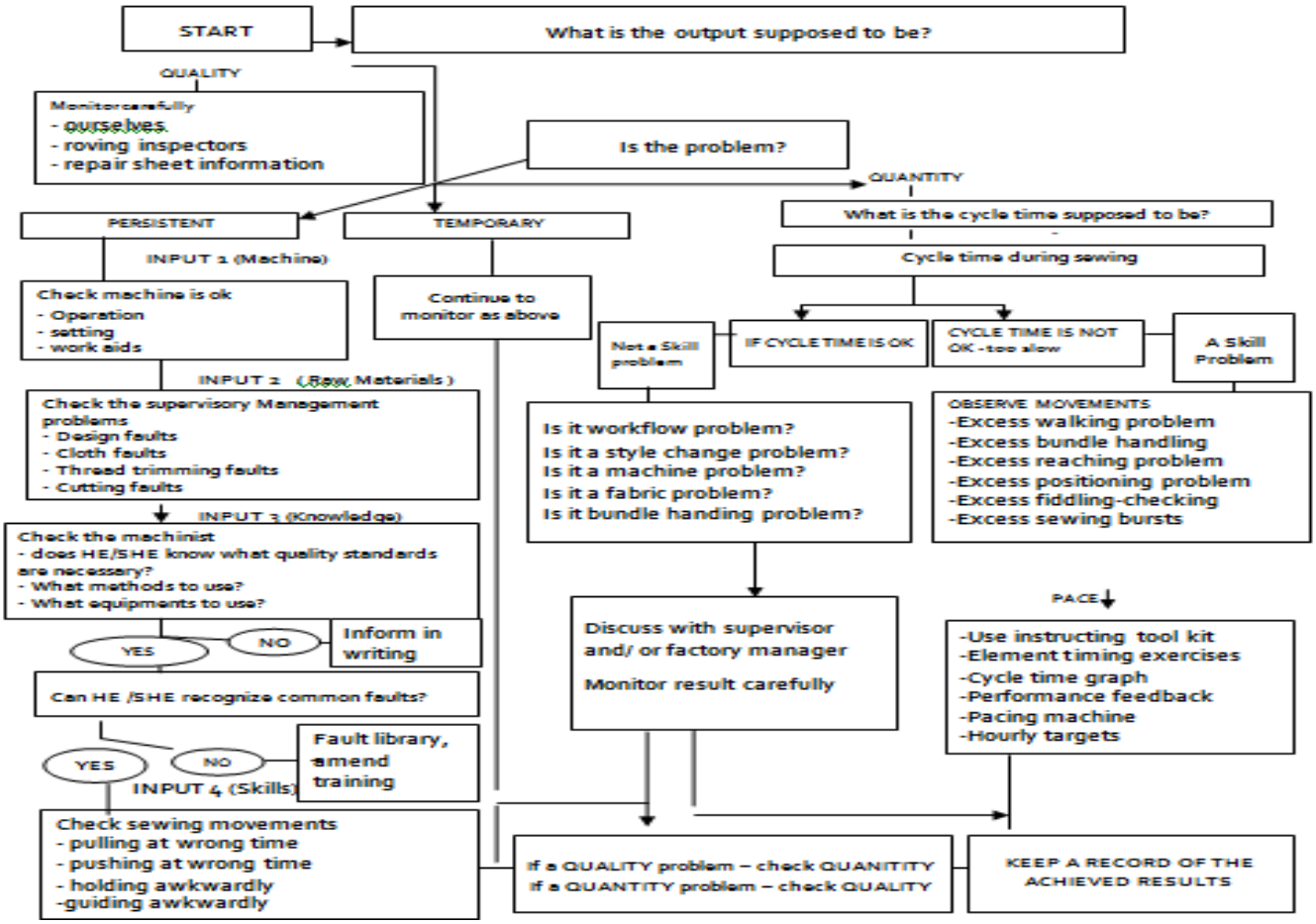

Fig. 1: Low performing operation monitoring chart

After that lean tool of wastes has been applied and the findings of every operation are listed below:

Table 2: The findings after implementing lean tool of wastes for low performers

Sl. No.	Operator Name	Operation Name	8 Wastes of Lean	Effective (Y/N)	Findings
1	Julekha	Attach Collar Band to Collar	Transportation	Y	After 2-3 bundle completion, operator herself needs to go to the collar band rolling operator to collect the next bundles
			Inventory	Y	The made collars from collar make operator and the lower part from cutting section stored beside her on the center table
			Motion	Y	Using trimmer 4-6 times for levelling the parts accordingly during the operation
			Waiting	N	
			Over Production	N	
			Over Processing	Y	As the bundles parts remain randomly on the center table, operator is matching the all 3 parts with one to another according to the cutting serial no. and bundle no.
			Defects	Y	Notch uneven
			Skills	N	
2	Khaleda	Make Front Left Placket (Top Placket)	Transportation	N	
			Inventory	Y	Front parts directly coming from the cutting department gathered right beside her
			Motion	Y	Approximately taking 5 bursts to complete each operation
			Waiting	N	
			Over Production	N	
			Over Processing	Y	Operator has to control the fabric during operation because the fabric is slipping out from the machine and affter completion of every bundle, she is checking if the check matches with each other
			Defects	Y	Raw edge out, Check match uneven, High-Low
			Skills	N	
3	Nasrin	Press Pocket (Auto)	Transportation	Y	At the end of bundle completion, operator has to stand & move towards the center table to dispose the pressed parts.
			Inventory	Y	Approximately 3-6 bundles stored on her side from pocket hemming operator
			Motion	Y	She is picking the pocket parts from the inside of the body parts and also disposing it into the front body parts after the operation
			Waiting	N	
			Over Production	N	
			Over Processing	Y	At the end of every pocket pressing, she is unwrapping paper or tissue everytime
			Defects	N	
			Skills	N	
4	Lily	Attach Pocket to Front	Transportation	N	
			Inventory	N	
			Motion	Y	Excess movement to check match and to match the diamond shapes
			Waiting	Y	Waiting to recieve bundles from the pressing operator
			Over Production	N	
			Over Processing	Y	Bundles coming to her by being half folded, she needs to open up, take the pocket parts, straighten the front parts, align & then sew
			Defects	Y	Check mismatch, High-Low in pockets, Slanted in diamond shapes etc.
			Skills	N	
5	Sharmin	Attach Pocket to Front	Transportation	Y	Far from pressing operator and so relying on the other operator to pass her the next bundle
			Inventory	N	
			Motion	Y	Taking 7 instead of 4 standard bursts
			Waiting	Y	Waiting to recieve bundles from the pressing operator
			Over Production	N	
			Over Processing	Y	Bundles coming to her by being half folded, she needs to open up, take the pocket parts, straighten the front parts, align & then sew
			Defects	Y	Check mismatch, Pocket alignment uneven etc.
			Skills	N	

Sl. No.	Operator Name	Operation Name	8 Wastes of Lean	Effective (Y/N)	Findings
6	Rokeya	Attach Sleeve to Body	Transportation	N	
			Inventory	N	
			Motion	Y	Excessive handling motion where she doesn't follow the basic instructions
			Waiting	N	
			Over Production	N	
			Over Processing	Y	Cutting the sleeve pair for separation before starting the operation
			Defects	Y	Pleated, Down Stitch etc.
			Skills	N	
7	Tahmina	Attach Cuff with 2 Pleat	Transportation	N	
			Inventory	Y	Center table beside her gathered fully with unattached cuffs
			Motion	Y	Slow hand movement and excessive motion taken
			Waiting	N	
			Over Production	N	
			Over Processing	Y	Cuffs arent's sorted out according to sizes and numbers, operator needs to find out the right cuff pairs
			Defects	Y	Lob uneven, Pleat depth uneven etc
			Skills	N	

The above study elucidated information that operators are working with many types of wastes in their workstations. The primary problems came out from the research were excessive motion, poor methods following and line unbalancing, unorganized workstation layout and high defect rates, etc. By using the lean tool, the wastes which were unnecessary in the sewing section had been found out. Those wastes were working as barriers against faster and improved production. By eliminating of those wastes, operators overall performance improvement, their capacity enhancement, performance improvement can be perceived, and with the improvement of those individual operators, the ultimate line's productivity could be increased. But after finding the wastes, then some steps needed to take into action to remove those specific problems and operators also should know those barriers what were hindering themselves not to reach to their goals.

d) Actions taken to eliminate wastes

Several actions were taken to rectify the problems from each operator.

To remove the wastes, the applied actions are presented in the following table.

Table 3: Actions were applied to remove the wastes from the low performing operations

Sl. No.	Operator	Operation	Actions Taken
1	Julekha	Attach Collar Band to Collar	1. Change the Line Layout where the band hemming operation is placed beside Collar band attach operation in a zigzag way.
			2. A stand placed at the operators right side
			3. Fix the standard of using 2-3 pokes by trimmers for alignment during the operation
			4. The extra capacity of the Collar Band Hemming operator & Collar Midline T/S is used to match the all 3 parts
			5. Trained the standard method by trainer & technician and bigger pattern is introduced instead of shorter one to the operator and check the next 20 pieces if the same defect comes again
2	Khaleda	Box Placket	1. Supervisor instructed to place only 5 bundles beside that operator in order to keep the workstation free and clean
			2. A special attachment of rubber mat is attached on the m/c so that fabrics can't slip out and operator doesn't need to pay extra attention to control the fabric during her operation
			3. This operator is mainly facing problem because of her coming defect rates. She is struggling to match the horizontal and vertical checks and thats why she is confused and taking extra time also to check after the operation. So she is again sent to the training room for relearning.
3	Nasrin	Pocket Press	1. Two stands at operator's both side are placed; one for the pocket parts placement and the other for disposal
			2. Change in method: Previously she has to take the pocket parts from the inside of the bodies where bodies being half folded & has to dispose like the same way. The new method involves body parts directly will go to pocket attach operation after top & bottom placket operation. So, pocket press operator will receive the pocket parts only from the pocket hemming operator.
			3. Operator previously responsible to unwrap the paper after pressing. Now according to new way, operator won't unwrap the paper, it will directly go to pocket attach operators & they will responsible for unwrapping by themselves.

Sl. No.	Operator	Operation	Actions Taken
4	Lily	Attach Pocket to Front	1. Operator previously received bundle in a randomly manner where body parts being half folded consisting of pocket parts inside. Now, they will receive pocket parts only from pressing operator according to bundle number where front parts will be received from the Top & Bottom Placket operators in a straight formation according to the sizes and same bundle no.
			2. The extra capacity of side label attach operator sometimes used to unwrap the paper from the pocket parts.
			3. This operator's wrong handling movement causing defects sometimes. Besides extra time is taken to align the parts. So standard method & operational breakdown time is ensured.
5	Sharmin	Attach Pocket to Front	1. Change in line layout and workstation layout to fix the operator's position nearer to the pocket pressing operator so that she doesn't have to wait so long to receive.
			2. Operator previously received bundle in a randomly manner where body parts being half folded consisting of pocket parts inside. Now, they will receive pocket parts only from pressing operator according to bundle number where front parts will be received from the Top & Bottom Placket operators in a straight formation according to the sizes and same bundle no.
			3. The extra capacity of side label attach operator sometimes used to unwrap the paper from the pocket parts.
			4. This operator is also performing low because of high defect rates. So she is instructed by the trainers, technician & line quality controller.
6	Rokeya	Attach Sleeve to Body	1. The operator is taking approximately 18-20 bursts to do one operation. So she is instructed where she is taking the extra bursts & how can she reduce them.
			2. Previously operator has to cut the sleeve pairs firstly before starting the operation. Now sleeve match operator is instructed to do it.
			3. A trainer is allocated there to teach her the proper instruction
7	Tahmina	Attach Cuff with 2 Pleat	1. One rack is arranged where all unattached cuffs will be gathered accordingly.
			2. The sleeve placket attach operators instruected to stitch one tack at sleeve and then cuff join operator has to stitch one tack only with joining
			3. The extra capacity of cuff top st. Operator is used to sort out the cuff with bodies according to sizes and numbers.
			4. Sleeve match operator is instructed to give a mark in the sleeve pairs so that cuff join operator can join the cuffs with sleeves evenly.

e) Workstation layout standardization

A well-designed workstation is essential for productive work. Most garment workers repeat the same or similar tasks throughout each shift, which, if performed efficiently and quickly, can result in higher productivity. Further, each workstation should be designed to suit the needs of the particular worker (dependent upon height, reach, size, etc.) and take into account the types of machine they are using and the works they are performing [4]. A well-organized workstation (and workplace) that is well-lit, free from chemical hazards and noise, and that minimizes material handling, will improve efficiency and reduce worker fatigue. Sometimes even minor ergonomic changes in the design of equipment, workstations or job tasks, which cost very little can make significant improvements in worker comfort, health, safety, and productivity. The most workstation layouts of the low performing operators were unorganized and to improve their productivity, workstation layout must need to be updated. The changes in workstation layouts with upgraded methods for low performing operators are attached below:

i. *Operator – Julekha, Operation- Attach Collar Band to Collar*

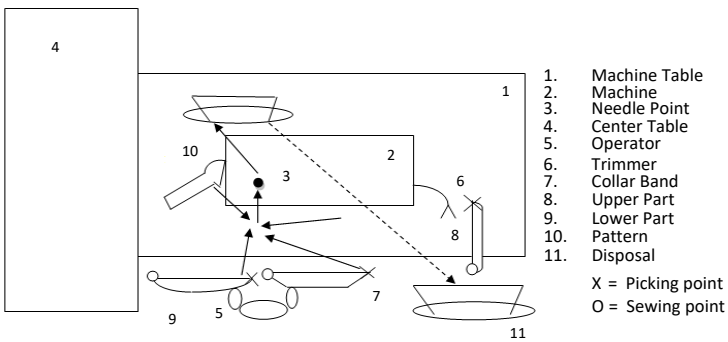

Fig. 2: Previous Layout

Previous Method Operator followed –

1. Pick the lower part
2. Pick the collar band
3. Pick the upper part
4. Pick the pattern
5. Align
6. Sew
7. Align
8. Sew
9. Turn the Pattern
10. Align
11. Sew
12. Trim
13. Dispose

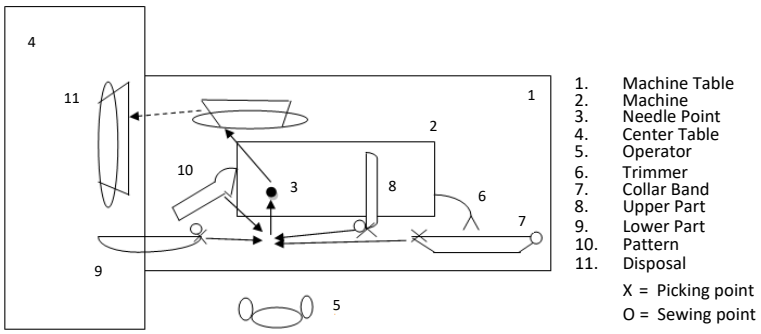

Fig. 3: Updated Layout

Updated Method –

1. Pick the Collar Band with right hand & the lower part with the left at a time
2. Pick the upper part
3. Pick the pattern
4. Align
5. Sew
6. Align
7. Sew
8. Turn the pattern
9. Align
10. Sew
11. Trim
12. Dispose

ii. *Operator – Khaleda, Operation – Top Placket*

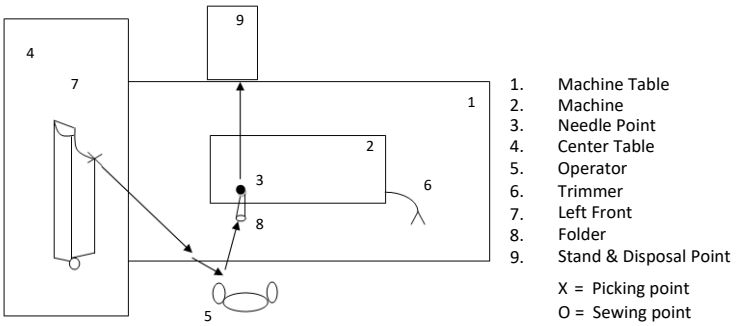

Fig. 4: Previous Layout

Previous Method –

1. Pick
2. Turn the front part
3. Insert the front part into the folder
4. Sew
5. Align
6. Sew
7. Align
8. Sew
9. Align
10 Sew
11. Trim
12. Dispose

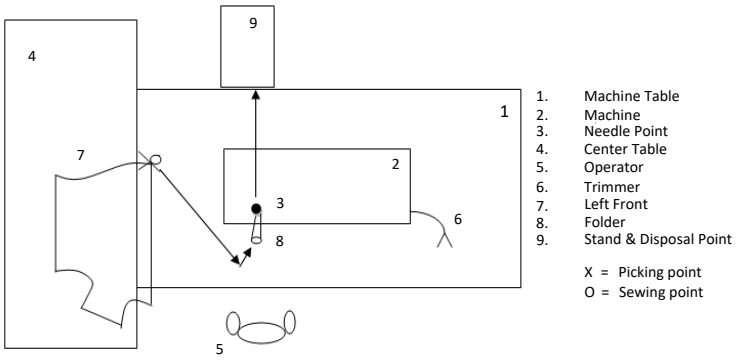

Fig. 5: Updated Layout

Updated Method –

1. Pick
2. Insert the front part into the folder
3. Sew
4. Align
5. Sew
6. Trim
7. Dispose

iii. *Operator – Nasrin, Operation – Pocket Press (Auto)*

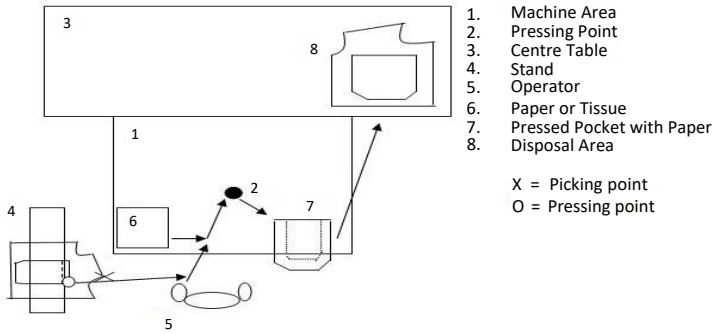

Fig. 6: Previous Layout

Previous Method –

1. Pick the pockets from the inside of the front part
2. Pick the paper
3. Align the pocket with paper
4. Press
5. Unwrap the paper
6. Place the pressed pocket inside the front part
7. Dispose

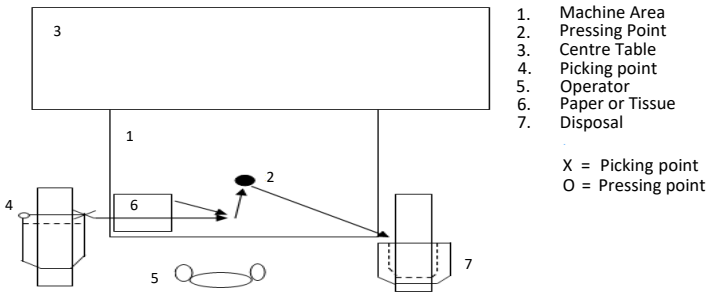

Fig. 7: Updated Layout

Updated Method –

1. Pick the pocket & paper at a time using both hands
2. Align
3. Press
4. Dispose

iv. Operator- Lily & Sharmin, Operation – Attach Pocket to Front

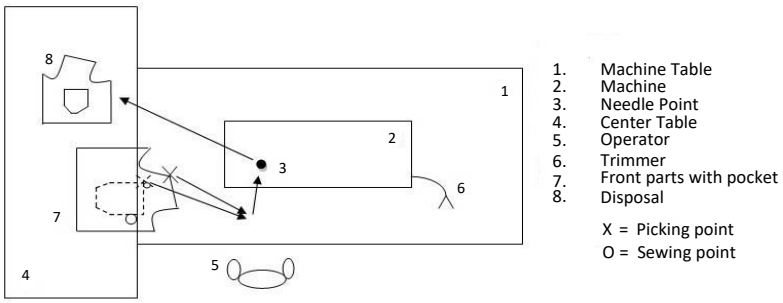

Fig. 8: Previous Layout

Previous Method –

1. Pick the front part & pocket
2. Turn the front part
3. Align
4. Sew
5. Align
6. Sew
7. Align
8. Sew
9. Align
10. Sew
11. Align
12. Sew
13. Align
14. Sew
15. Trim
16. Dispose

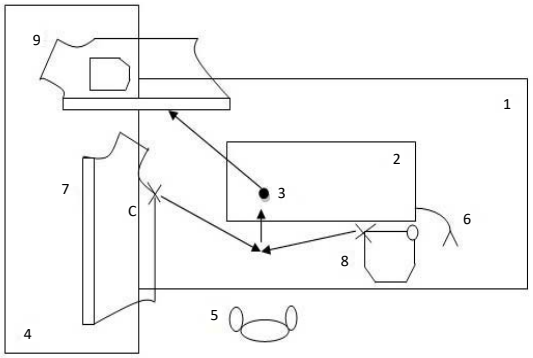

Fig. 9: Updated Layout

Updated Method –

1. Pick the front part with left hand & pocket part with the right hand
2. Align
3. Sew
4. Align
5. Sew
6. Align
7. Sew
8. Align
9. Sew
10. Align
11. Sew
12. Trim
13. Dispose

v. *Operator – Rokeya, Operation – Attach Sleeve to Body*

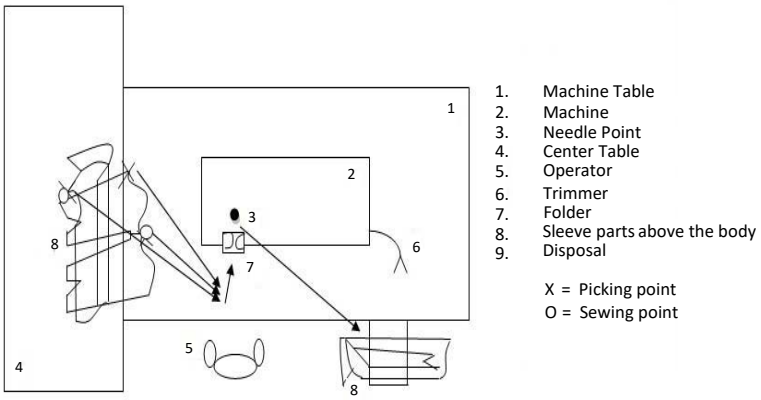

Fig.10: Previous Layout

Previous Method –

1. Pick the sleeve pair
2. Trim the link
3. Pick the body part
4. Place inside the folder
5. Sew
6. Align
7. Sew
8. Trim
9. Dispose

Note: Sew & Align continue for several times

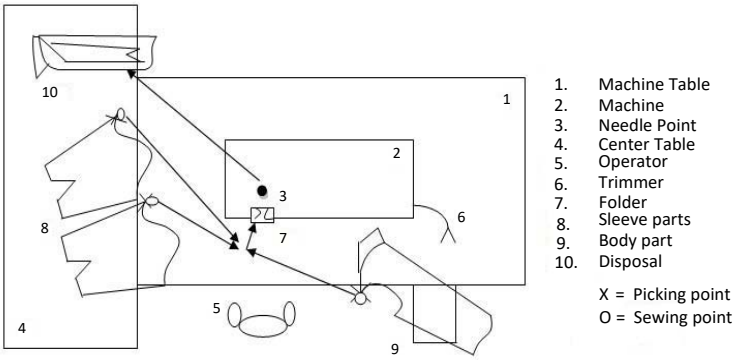

Fig. 11: Updated Layout

Updated Method –

1. Pick the sleeve & Body
2. Place inside the folder
3. Sew
4. Align
5. Sew
6. Align
7. Sew
8. Align
9. Sew
10. Trim
11. Dispose

vi. *Operator – Tahmina, Operation – Attach Cuff with 2 Pleat*

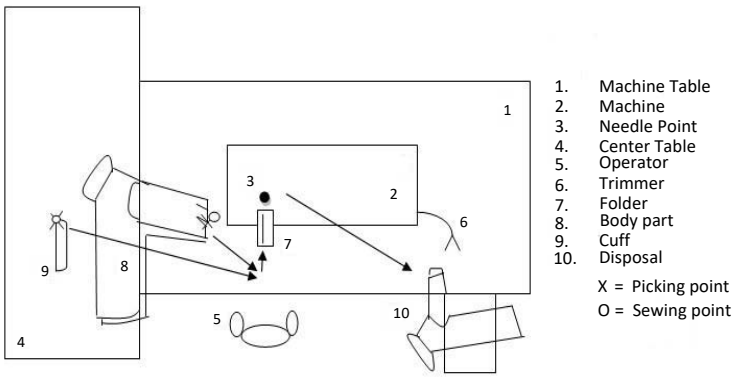

Fig.12: Previous Layout

Previous Method –

1. Pick the body
2. Pick the cuff
3. Align
4. Place into the folder
5. Sew
6. First pleat & Align
7. Sew
8. Second Pleat & Align
9. Sew
10. Trim
11. Dispose

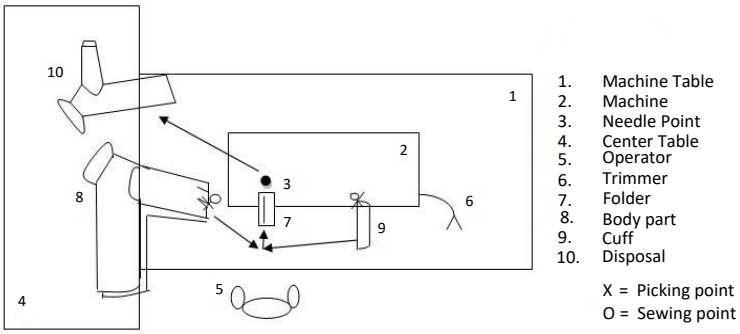

Fig.13: Updated Layout

Updated Method –

1. Pick the body & Cuff
2. Align
3. Place into the folder
4. Sew
5. Make the second pleat of the cuff & Align
6. Sew
7. Trim
8. Dispose

Here with changing operator's workstation layout, they also sent to training to improve their performance and handling movement and also motivation was done to improve their activity level. A change in operation breakdown & line layout was also done. Finally to improve their working condition and to increase the overall sectional productivity, some workloads were given to the higher capacity workers considering the layout. Thus the bottlenecks were solved; the changes improved the performance and capacity of those low performers because of the reduction of their working operation time and the enhancement in productivity. The following tables in result & discussion section show the updated outcome of the examined operators, the summary of the operators' performance & capacity improvement and overall line's productivity and efficiency improvement.

IV. Results & Discussion

By analyzing the sewing line's condition and operator's psychology, training arranged to motivate the workers as well as they trained on how to work consciously and efficiently. On that training, they learned about the reasons for being low performers and what steps to take to avoid the condition. Operators were taught about the operational procedure standardization, maintain the quality and quantity on the required time and how to reduce the excessive movements to avoid fatigue. Supervisors also trained on understanding operational breakdown, operation bulleting, line balancing and the ways to monitor the operators effectively.

a) Calculations

Here the improvements regarding capacity, efficiency, productivity and performance of the operators as well as the sewing line after the actions of method standardization, process improvement, line balancing and training took place are stated in the following.

b) Calculation of Sewing Line Efficiency

Line Efficiency = (Total Production X SMV X 100) / (No. of Operator X Working Hour X 60)

Before improvement line efficiency:
= (58 X 28.38 X 100) / (51 X 1 X 60) = 53.79%

After improvement line efficiency:
= (66 X 28.38 X 100) / (51 X 1 X 60) = 61.21%

Efficiency improved through the rise of the production/hr by improving the operator; balancing the line and reducing bottleneck.

i. *Calculation of Sewing Productivity*

Productivity = (Output amount / Input amount) X 100%
Before Improvement Productivity = (58 / 200) X 100%
= 29.00%
After Improvement Productivity = (66 / 150) X 100%
= 44.00%

With the improvement of line's productivity and efficiency, operators per hour production capacity

increased. Besides, operators defect rates also reduced. Rework times for fixing the defects was also decreased and thus operators could use the maximum time provided to her to reach their goals. Summaries based on time study charts before and after the actions, changes due to the improvement to the line as well as operators and bar chart on the low performing operator's performance improvement are shown in the following.

Table 4: Previous time study chart (Yellow marks indicating the low performers)

Sl. No.	Operator Name	Operation Name	S.M.V	M/C	Capacity Cycle Time	Potential Capacity/Hr	Performance (%)
1	Rozina	Collar Make	0.45	1N2TLS-UBT	0.58	103	77.59%
2	Tanzina	Trim, Turn & Press Collar	0.35	Collar Press	0.4	150	87.50%
3	Rubina	Collar Top St	0.34	1N2TLS-UBT	0.37	162	91.89%
4	Ruzina	Hem Cuff	0.45	1N2TLS-UBT	0.56	107	80.36%
5	Ruzina	Hem Collar Band	0.26	1N2TLS-UBT	0.35	171	74.29%
6	Rima	Cuff make	0.55	1N2TLS-EC	0.72	83	76.39%
7	Robina	Press Cuff	0.26	Cuff Press M/C	0.29	207	89.66%
8	Rohima	Cuff top st.	0.39	1N2TLS-UBT	0.47	128	82.98%
9	Julekha	Attach Collar Band to Collar	0.56	1N2TLS-EC	0.85	71	65.88%
10	Taslima	Collar Midline top st. with turn	0.44	1N2TLS-UBT	0.48	125	91.67%
11	Nurunnahar	Trim excess collar	0.16	1N3TOL	0.19	316	84.21%
12	Shanta	Mark at Collar Band	0.17	Collar Notcher	0.21	286	80.95%
13	Abdul Alim	Press Front Flap	0.5	Press M/C	0.59	102	84.75%
14	Moriom	Flap top st	0.88	2N4TLS-UBT	1.19	50	73.95%
15	Ruma	Flap top st	0.88	2N4TLS-UBT	1.32	45	66.67%
16	Suma	Bottom placket	0.3	1N2TLS-UBT	0.43	140	69.77%
17	Kohinur	Attach Side label	0.39	1N2TLS-UBT	0.44	136	88.64%
18	Khaleda	Box placket	0.35	4N8TCS-Kan	0.69	87	50.72%
19	Sabina	Press Front Right Placket	0.16	FUMC	0.18	333	88.89%
20	Mala	Pocket hem	0.35	1N2TLS-UBT	0.45	133	77.78%
21	Nasrin	Press Pocket	0.41	Creasing M/C	0.83	72	49.40%
22	Eity	Attach Pocket to Front	1.22	2N4TLS-UBT	1.65	36	73.94%
23	Sharmin	Attach Pocket to Front	1.22	2N4TLS-UBT	2.45	24	49.80%
24	Lily	Attach Pocket to Front	1.22	2N4TLS-UBT	2.59	23	47.10%
25	Lakhy	Flap attach	0.42	2N4TLS-UBT	0.69	87	60.87%
26	Romicha	Attach Back Yoke with Pleat use folder	0.65	2N4TLS-UBT	0.78	77	83.33%
27	Chameli	Attach Main Label	0.39	1N2TLS-UBT	0.52	115	75.00%
28	Moriom	Join Shoulder by Folder	0.72	2N4TLS-UBT	0.95	63	75.79%
29	Asma	Join Shoulder by Folder	0.72	2N4TLS-UBT	1.02	59	70.59%
30	Taslima	Attach Collar to Body	0.56	1N2TLS-UBT	0.71	85	78.87%
31	Papiya	Collar close to Body	0.59	1N2TLS-UBT	0.79	76	74.68%
32	Fatema	Attach Sleeve Tape	0.28	1N2TLS-UBT	0.39	154	71.79%
33	Amena	Tack Sleeve Tape with Cut Excess	0.26	1N2TLS-UBT	0.3	200	86.67%
34	Sabrina	Press Sleeve Placket	0.2	FUMC	0.24	250	83.33%
35	Amina	Attach Sleeve placket	0.49	1N2TLS-UBT	0.55	109	89.09%
36	Moushumi	Attach Sleeve placket	0.49	1N2TLS-UBT	0.58	103	84.48%
37	Asha	Match Sleeve to Body	0.23	Plain Table	0.29	207	79.31%
38	Rokeya	Sleeve attach	0.93	2N4TCS	1.83	33	50.82%
39	Marufa	Sleeve attach	0.93	2N4TCS	1.42	42	65.49%
40	Fahima	Side seam	0.88	2N4TCS-FOA	1.23	49	71.54%
41	Ojufa	Side seam	0.88	2N4TCS-FOA	1.42	42	61.97%
42	Momena	Bottom Hem	0.69	1N2TLS-UBT	0.89	67	77.53%
43	Mahmuda	Bottom Hem	0.69	1N2TLS-UBT	0.95	63	72.63%
44	Tahmina	Cuff join	0.81	1N2TLS-UBT	1.46	41	55.48%
45	Monira	Cuff Join	0.81	1N2TLS-UBT	1.33	45	60.90%
46	Jesmin	Button Hole	0.66	1N2TLS-BH	0.71	85	92.96%
47	Kona	Collar and Placket holing	0.67	1N2TLS-BH	0.73	82	91.78%
48	Rukhsana	Bartack	0.48	1N2TLS-BT	0.53	113	90.57%
49	Tulshi	Mark Button Attach	0.38	Plain Table	0.42	143	90.48%
50	Akhi	Button Attach	0.68	1N2TLS-BA	0.74	81	91.89%
51	Ruma	Button attach on neck and sleeve placket	0.63	1N2TLS-BA	0.69	87	91.30%

Time study chart after the improvement:

Table 5: After improvement, time study chart

Sl. No.	Operator Name	Operation Name	S.M.V	M/C	Capacity Cycle Time	Potential Capacity/Hr	Performance (%)
1	Rozina	Collar Make	0.45	1N2TLS-UBT	0.58	103	77.59%
2	Tanzina	Trim, Turn & Press Collar	0.35	Collar Press	0.4	150	87.50%
3	Rubina	Collar Top St	0.34	1N2TLS-UBT	0.37	162	91.89%
4	Ruzina	Hem Cuff	0.45	1N2TLS-UBT	0.56	107	80.36%
5	Bilkis	Hem Collar Band	0.26	1N2TLS-UBT	0.39	154	66.67%
6	Rima	Cuff make	0.55	1N2TLS-EC	0.72	83	76.39%
7	Robina	Press Cuff	0.26	Cuff Press M/C	0.29	207	89.66%
8	Rohima	Cuff top st.	0.39	1N2TLS-UBT	0.47	128	82.98%
9	Julekha	Attach Collar Band to Collar	0.56	1N2TLS-EC	0.73	82	76.71%
10	Taslima	Collar Midline top st. with turn	0.44	1N2TLS-UBT	0.48	125	91.67%
11	Nurunnahar	Trim excess collar	0.16	1N3TOL	0.19	316	84.21%
12	Shanta	Mark at Collar Band	0.17	Collar Notcher	0.21	286	80.95%
13	Abdul Alim	Press Front Flap	0.5	Press M/C	0.59	102	84.75%
14	Moriom	Flap top st	0.88	2N4TLS-UBT	1.19	50	73.95%
15	Ruma	Flap top st	0.88	2N4TLS-UBT	1.29	47	68.22%
16	Suma	Bottom placket	0.3	1N2TLS-UBT	0.43	140	69.77%
17	Kohinur	Side label	0.39	1N2TLS-UBT	0.44	136	88.64%
18	Khaleda	Box placket	0.35	4N8TCS-Kan	0.53	113	66.04%
19	Sabina	Press Front Right Placket	0.16	FUMC	0.18	333	88.89%
20	Mala	Pocket hem	0.35	1N2TLS-UBT	0.45	133	77.78%
21	Nasrin	Press Pocket	0.41	Creasing M/C	0.62	97	66.13%
22	Eity	Attach Pocket to Front	1.22	2N4TLS-UBT	1.65	36	73.94%
23	Sharmin	Attach Pocket to Front	1.22	2N4TLS-UBT	1.85	32	65.95%
24	Lily	Attach Pocket to Front	1.22	2N4TLS-UBT	2.18	28	55.96%
25	Lakhy	Flap attach	0.42	2N4TLS-UBT	0.69	87	60.87%
26	Romicha	Attach Back Yoke with Pleat use folder	0.65	2N4TLS-UBT	0.78	77	83.33%
27	Chameli	Main Label	0.39	1N2TLS-UBT	0.52	115	75.00%
28	Moriom	Join Shoulder by Folder	0.72	2N4TLS-UBT	0.95	63	75.79%
29	Asma	Join Shoulder by Folder	0.72	2N4TLS-UBT	1.02	59	70.59%
30	Taslima	Attach Collar to Body	0.56	1N2TLS-UBT	0.71	85	78.87%
31	Papiya	Collar close	0.59	1N2TLS-UBT	0.79	76	74.68%
32	Fatema	Attach Sleeve Tape	0.28	1N2TLS-UBT	0.39	154	71.79%
33	Amena	Tack Sleeve Tape with Cut Excess	0.26	1N2TLS-UBT	0.3	200	86.67%
34	Sabrina	Press Sleeve Placket	0.2	FUMC	0.24	250	83.33%
35	Amina	Attach Sleeve placket	0.49	1N2TLS-UBT	0.63	95	77.78%
36	Moushumi	Attach Sleeve placket	0.49	1N2TLS-UBT	0.69	87	71.01%
37	Asha	Match Sleeve to Body	0.23	Plain Table	0.38	158	60.53%
38	Rokeya	Sleeve attach	0.93	2N4TCS	1.59	38	58.49%
39	Marufa	Sleeve attach	0.93	2N4TCS	1.42	42	65.49%
40	Fahima	Side seam	0.88	2N4TCS-FOA	1.23	49	71.54%
41	Ojufa	Side seam	0.88	2N4TCS-FOA	1.42	42	61.97%
42	Momena	Bottom Hem	0.69	1N2TLS-UBT	0.89	67	77.53%
43	Mahmuda	Bottom Hem	0.69	1N2TLS-UBT	0.95	63	72.63%
44	Tahmina	Cuff join	0.81	1N2TLS-UBT	1.08	56	75.00%
45	Monira	Cuff Join	0.81	1N2TLS-UBT	1.33	45	60.90%
46	Jesmin	Button Hole	0.66	1N2TLS-BH	0.71	85	92.96%
47	Kona	Collar and Placket holing	0.67	1N2TLS-BH	0.73	82	91.78%
48	Rukhsana	Bartack	0.48	1N2TLS-BT	0.53	113	90.57%
49	Tulshi	Mark Button Attach	0.38	Plain Table	0.42	143	90.48%
50	Akhi	Button Attach	0.68	1N2TLS-BA	0.74	81	91.89%
51	Ruma	Button attach on neck and sleeve placket	0.63	1N2TLS-BA	0.69	87	91.30%

c) Effects of implementing the tools & techniques

From the above discussion and time study charts, it is noticeable that by improving the low performers, manufacturers can achieve the overall line's progress.

By applying time study technique, method improvement, balancing techniques, and training the bottleneck operations were developed as well as the line efficiency improved from 53.79% to 61.21%. Line's productivity previously was 29%,

which lately upgraded to 44%. Besides, lines sewing operators & helper's average capacity & performance also increased through those improvements. The following table with bar chart shows a comprehensible indication:

Table 6: Changes due to improvement actions were taken to the line

Parameter	Before	After
Line Efficiency	53.79%	61.21%
Line Productivity	29%	44%
Operators Avg. Performance	76.16%	77.05%
Bottleneck	5	0

Summary of the improvement of the low performing operators:

Table 7: Low performers improvement regarding operational time, performance% & capacity

Sl. No.	Operator Name	Operation	Cycle Time (in second)		Performance Improvement %	Potential Pieces	
			Before	After		Before	After
1	Julekha	Attach Collar Band to Collar	51	43.8	10.83%	71	82
2	Khaleda	Box Placket	41.4	31.8	15.32%	87	113
3	Nasrin	Press Pocket	49.8	37.2	16.73%	72	97
4	Sharmin	Attach Pocket to Front	147	111	16.15%	24	32
5	Lily	Attach Pocket to Front	155.4	130.8	8.86%	23	28
6	Rokeya	Sleeve Attach	109.8	95.4	7.67%	33	38
7	Tahmina	Cuff Join	87.6	64.8	19.52%	41	56
Average Improvement					13.58%		

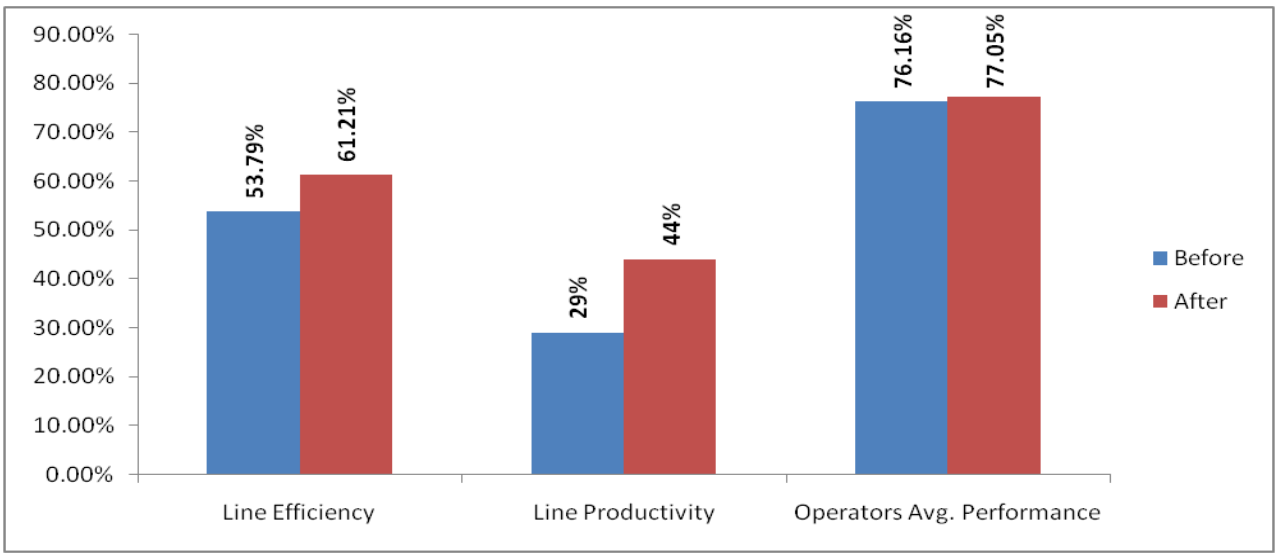

Fig. 14: Bar chart showing the improvement of the line

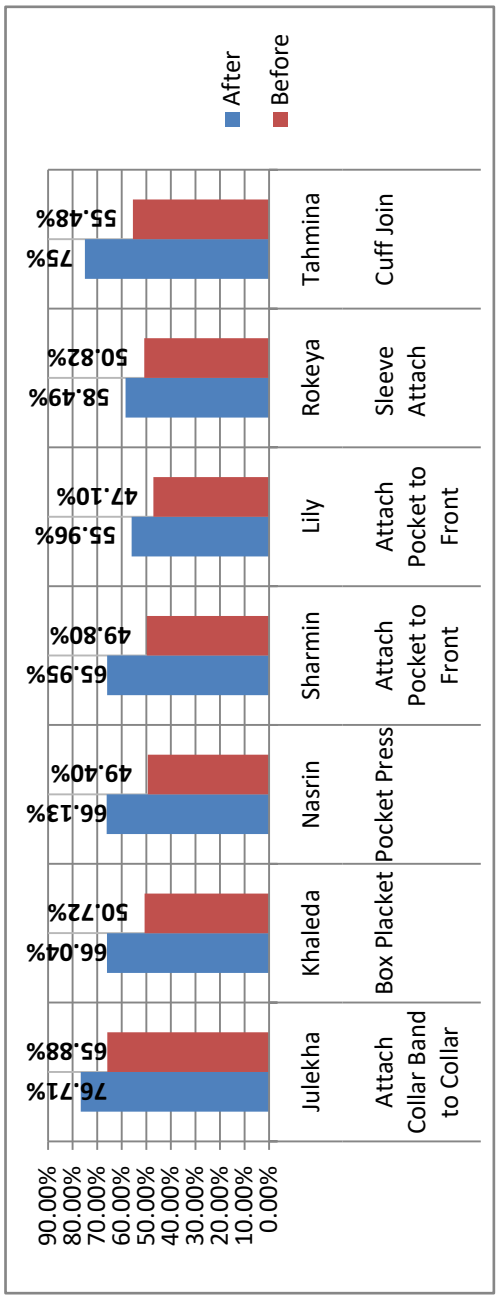

Fig. 15: Bar chart showing the individual operators performance before & after the improvement

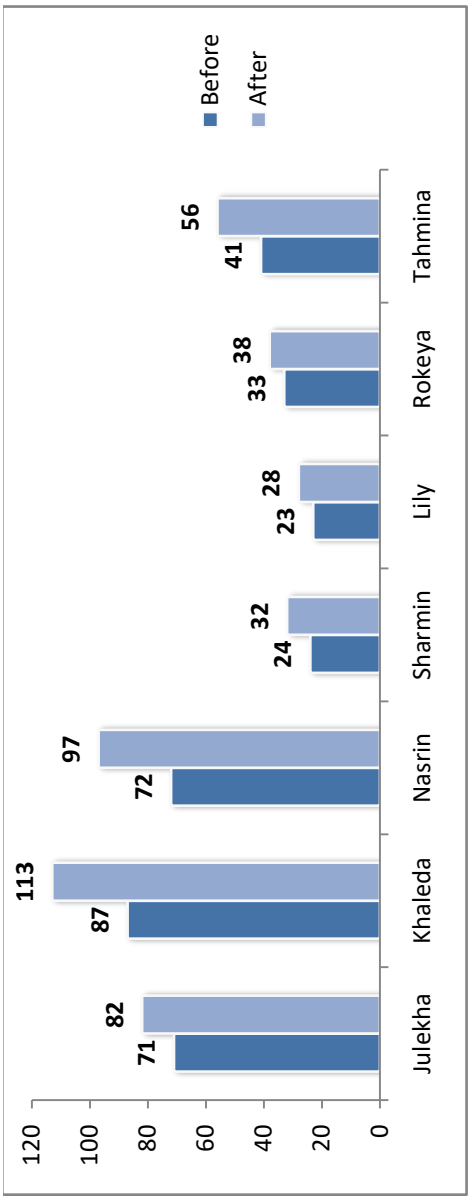

Fig. 16: Bar Chart showing low performing operators improvement based on potential capacity per hour

V. Conclusion

In apparel industries, it is sometimes very complicated to identify the causes behind the low performance of the operators, and also the key areas to select and improve, which can change the current system and process. In today's competitive world, delivering the high-quality garments at low cost in shorter lead times are the uppermost challenges faced by apparel manufacturers [6]. So the maximum capacity utilization of the operators needs to be ensured to meet the target. Generally, operators have to do their operations in a hurry and mostly by being in a fixed position, which is unlike from their natural life [7]. So the work environment needs to be suited and well-organized to them as much as possible. Considering these facts, working station standardization to make operators comfortable and feel them free to work is very much necessary to receive the maximum output with acceptable quality from them. In addition to these, sewing line also needs to be very much balanced to maximize hourly production capacity. By ensuring the proper work distribution among the operators, the targeted output can be achieved without having

overtime. Even a minor policy change to the sewing floor or any specific operation can result in very positively. Therefore, the similar type apparel industries, those who want to recognize and rectify their problems, and expect for the better production efficiency through the improvement of the low performing operators, the research outcomes can be worthwhile and beneficial to them.

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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 FARSE can go through standards of OARS. You can also play vital role if you have any suggestions so that proper amendment can take place to improve the same for the benefit of entire research community.

As FARSE, you will be given a renowned, secure and free professional email address with 100 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders,Auto-Responders, Email Delivery Route tracing, etc.

The FARSE will be eligible for a free application of standardization of their researches. Standardization of research will be subject to acceptability within stipulated norms as the next step after publishing in a journal. We shall depute a team of specialized research professionals who will render their services for elevating your researches to next higher level, which is worldwide open standardization.

The FARSE member can apply for 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 FARSE, 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. After certification of all your credentials by OARS, they will be published on your Fellow Profile link on website https://associationofresearch.org which will be helpful to upgrade the dignity.

The FARSE members can avail the benefits of free research podcasting in Global Research Radio with their research documents. After publishing the work, (including published elsewhere worldwide with proper authorization) you can upload your research paper with your recorded voice or you can utilize chargeable services of our professional RJs to record your paper in their voice on request.

The FARSE member also entitled to get the benefits of free research podcasting of their research documents through video clips. We can also streamline your conference videos and display your slides/ online slides and online research video clips at reasonable charges, on request.

The FARSE is eligible to earn from sales proceeds of his/her researches/reference/review Books or literature, while publishing with Global Journals. The FARSE can decide whether he/she would like to publish his/her research in a closed manner. In this case, whenever readers purchase that individual research paper for reading, maximum 60% of its profit earned as royalty by Global Journals, will be credited to his/her bank account. The entire entitled amount will be credited to his/her bank account exceeding limit of minimum fixed balance. There is no minimum time limit for collection. The FARSE member can decide its price and we can help in making the right decision.

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.

AUXILIARY MEMBERSHIPS

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.

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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.

Policy on Plagiarism

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

Authorship Policies

Global Journals follows the definition of authorship set up by the Open Association of Research Society, USA. According to its guidelines, authorship criteria must be based on:

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.

Copyright

During submission of the manuscript, the author is confirming an exclusive license agreement with Global Journals which gives Global Journals the authority to reproduce, reuse, and republish authors' research. We also believe in flexible copyright terms where copyright may remain with authors/employers/institutions as well. Contact your editor after acceptance to choose your copyright policy. You may follow this form for copyright transfers.

Appealing Decisions

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

Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

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:

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

Introduction:

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

The following approach can create a valuable beginning:

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

Approach:

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

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

Procedures (methods and materials):

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

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

Materials:

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

Methods:

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

Approach:

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

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

What to keep away from:

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

Results:

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

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

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

Content:

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

What to stay away from:

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

Approach:

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

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

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

Figures and tables:

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

Discussion:

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

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

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

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

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

Approach:

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

Describe generally acknowledged facts and main beliefs in present tense.

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Topics	Grades		
	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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