Optimal Decision Making with Analytic Hierarchy Process for Screw Sustainable Manufacture.

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ABSTRACT

Stately global climate changes due to global warming and the growing rate resource depletion have compelled several researchers to focus their research in the area of sustainable manufacture. This study proposes an approach to select suitable material to the best performance for screw sustainable manufacture by taking into consideration the three sustainability pillars. The three pillars sustainable were environmental, economic, and social impacts and taking screw M5* 0.8 as a case study. The parameters involved were types of material and manufacturing process of screw. The types of material concerned for manufacturing process Ferritic Stainless Steel, AISI 304 Austenitic Stainless Steel, 2024 high strength (Aluminum alloy), Ti-6Al-4v (Titanium alloy) and AISI 1045 Carbon Steel with manufacturing processes were forging and machining. The criteria for social impact were the factor of safety and the data generated by solidworks software. With respect to the economic impact, the cost of production for screw was depended and DFM software used to determine the cost. For environmental impact, the data generated from the Solidworks sustainability tool. The analysis data used in the formation of pair wise comparison matrices for the Analytic Hierarchy Process (AHP). After that, the ranking of global priorities had enabled the determination of suitable material for screw sustainable manufacture. As a result, AISI 1045 Carbon under machining process was the best choice.

ABSTRAK

Perubahan iklim global berlaku secara mendadak berikutan pemanasan global dan jumlah sumber semulajadi yang semakin berkurangan telah memaksa penyelidik menumpukan penyelidikan mereka dalam bidang pembuatan lestari. Kajian ini mencadangkan pendekatan untuk memilih bahan yang sesuai untuk prestasi yang terbaik dalam penghasilan skru secara lestari dimana tiga tunggak kelestarian telah diambilkira. Antara tiga tunggak kelestarian ialah kesan alam sekitar, ekonomi dan sosial dan mengambil skru M5 * 0.8 sebagai kes kajian. Parameter-parameter yang terlibat ialah jenis bahan dan proses pembuatan skru. Jenis-jenis bahan yang akan dipertimbangkan dalam penghasilan skru ialah ferit Stainless Steel, AISI 304 austenit Stainless Steel, 2024 kekuatan tinggi (aloi Aluminium), Ti-6AL-4V gabungan (Titanium aloi) dan AISI 1045 Carbon Steel dengan proses pembuatan secara tempaan dan pemesinan. Kriteria untuk kesan sosial adalah faktor keselamatan dan data yang dijana oleh perisian SolidWorks. Berkenaan dengan kesan ekonomi, kos pengeluaran bagi skru adalah dijada daripada perisian DFM digunakan untuk menentukan kos. Untuk kesan alam sekitar, data yang dijana daripada fungsi kelestarian SolidWorks. Data analisis yang digunakan dalam pembentukan pasangan matriks *pair wise* untuk Proses Hierarki Analitik (AHP). Selepas itu, ranking keutamaan global telah membolehkan penentuan bahan yang sesuai untuk skru pembuatan lestari. Hasilnya, AISI 1045 Carbon bawah proses pemesinan adalah pilihan yang terbaik.

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AHP	-	Analytic hierarchy process
AA	-	Aluminum Alloy
ASS	-	Austenitic Stainless Steel
TA	-	Titanium Alloy.
FSS	-	Ferritic Stainless Steel
CS	-	Carbon Steel
CAD	-	Computer Aided Design
CI	-	Consistency Index
CR	-	Consistency Ratio
λ_{max}	-	Maximum Eigen value
RI	-	Random Index
CO_2	-	Carbon dioxide
PO_4	-	Phosphate
SO_2	-	Sulphur dioxide
LCA	-	Life cycle assessment
DFM	-	Design for manufacturing software
FOS	-	Factor of Safety

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CHAPTER 1

INRODUCTION

1.1 Introduction

Mechanical assembly uses various methods to mechanically attach two (or more) parts together. In Most cases, the method involves the use of discrete hardware components, called Fasteners. Mechanical fastening methods can be divided into two major classes: (1) those that allow for disassembly, and (2) those that create a permanent joint. Threaded fasteners (e.g., screws, bolts, and nuts) are examples of the first class, and rivets illustrate the second [1]. Fasteners (screws, bolts, nuts and rivets) are found in a wide range of applications, from automotive, aerospace and naval vehicles, machinery, electric and electronics, furniture, home appliances and civil engineering structures. They are available in a wide variety of shapes and sizes and their production volume can range from units to millions, depending on specifications and standards [2].

In most of the mechanical assembly method, screw as a kind of threaded fastener is playing a central role. It is used to join one or more parts that can be disassembled easily. For example, many workstations are dedicated to screw fastening. Metal screws are often shown up everywhere, as they are used to fasten and hold securely various fixed and moving components of industrial equipment and machine assemblies.

In between, the screw manufacturing is dealing with a sequence of operations. Each operation transforms the material closer to the desired final state. The two main shaping operations used in industry for screw production are machining and cold heading [3]. Machining is the oldest method of fastener production, and it is still specified for very large diameters and small production runs, although this process is time consuming, wasteful and costly, but lastly, it will end up with an exact shape and dimension with little tolerance [4].

Cold heading is the more common in screw production this is because of it's high production rate, Cold heading has many other advantages such as more economical use of materials, lower scrap, more cost-effective production and fewer secondary operations required. Cold heading transforms wire into the desired shape by applying enough pressure to cause the metal to plastically deform into the die and punch cavities, no preheating the material that is why it is called cold heading.

Due to the dramatic increase of these manufacturing industries, the globe is now confronted with tremendous consumption of natural resources which brings to critical environmental problems. Thus, in order to overcome such problems, the major global challenges are facing today need to be addressed in the multifaceted context of economy, society, environment and technology (ESET). In recent years, the consensus of calling for sustainable development (SD) and implementation has emerged [5]. Sustainability can be defined as having the characteristic of being able to keep up our capacity to endure. Theoretically, although sustainability contains of three pillars, which are economic, environmental as well as social (see Figure 1.1).

As a result, to maintain competitiveness, manufacturers have begun to change the way in designing their product with purpose to cope with the need for sustainable development. Manufacturing itself is the ultimate source of consuming natural resources with toxic by-products and waste, usually detrimental to the environment. Thus, product designers are often being asked to judge the environmental impacts when dealing with the products they designed.

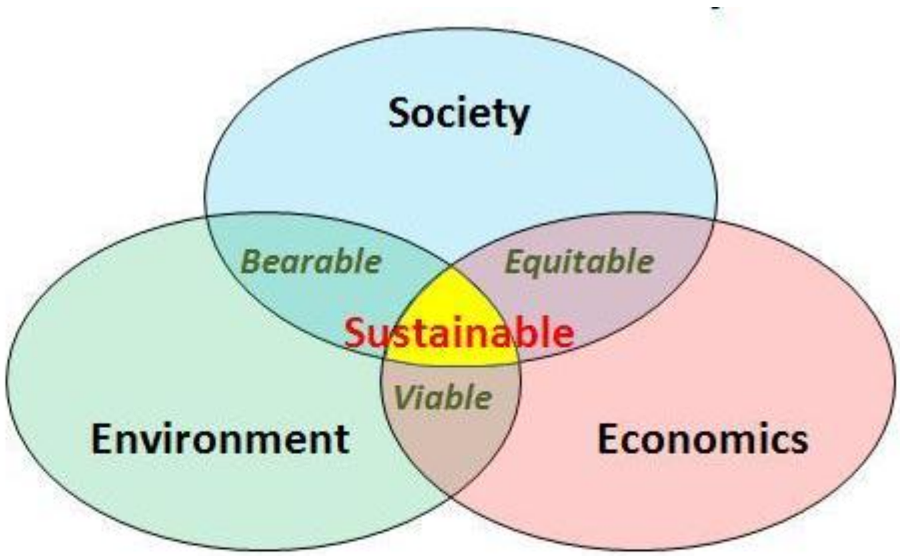

Figure 1.1: Venn diagram of sustainable development: at the confluence of three constituent parts. [6]

In short, with the increase of screw manufacturing industries, our world is confronted with tremendous consumption of natural resource which will bring environmental problem if proper selection of material is not taken into account. Besides economic and social aspects priority must be given to select material that gives minimal impact to the environment. The depletion of global resource, climate change and environment pollution problem are getting worse, so it is a challenge and responsible for manufacturer to include sustainability in their product design, thus, the significance of this study will contribute to investigate three pillars sustainability environment, economic, and social in manufacturing of screw.

1.2 problem statement

Substantial global climate changes due to global warming and the growing rate resource depletion have compelled several researchers to focus their research in the area of sustainability. Ensuring a sustainable future requires a systems approach. Sustainable systems are characterized by interlinked interactions at various levels spanning economic, ecological and societal issues. Emphasis on interactions within and across these levels is critical to the fundamental understanding of sustainable design and manufacturing systems, because tackling any one of the issues in isolation can result in unintended consequences along other dimensions. Sustainable systems are best understood in terms of information across products, processes and management (operational) aspects.

Almost all types of industry will bring impact to the natural environment and its sustainability. The vigorous growing of company numbers in the manufacturing industry has resulted in the implementation of sustainable and green manufacturing lately. The interrelated subjects that relate to the design of a manufacturing system are tooling strategy, material-handling methods, system size, process and material flow configuration, flexibility needed for future engineering changes, production methods, capacity adjustment, and also production floor layout strategy [7]. Therefore, optimizing these parameters may greatly reduce the consumption of natural resources. Suitable material and appropriate manufacturing method will bring screw manufacturing to achieve the minimal level of environmental impact and indirectly preserve the ecological system. Sustainability is the key to preventing or reducing the effect of environmental issues, effort is needed to return human use of natural resources to within sustainable limits.

1.3 Objectives

The goals of this study are:

i- To determine the three pillars sustainability, environment, economic, and social in manufacturing of screw.

ii- To choose suitable material with select manufacturing process of screw for the best performance in the screw sustainable manufacture.

1.4 Scope of study

To achieve the objectives of this study, the scope listed as below:

i. This study will focus deeply on the three pillars sustainability (environmental, economic, and social pillars) and taking screw M5* 0.8 as a case study.
ii. The main manufacturing processes of screw selected include forging and machining process.
iii. The types of material concerned for manufacturing process Ferritic Stainless Steel, AISI 304 Austenitic Stainless Steel, 2024 high strength (Aluminum alloy), Ti-6Al-4v (Titanium alloy), AISI 1045Carbon Steel (Medium carbon steel).
iv. Use CAE software (Solidworks 2014) to sketch the 3D drawing of the screw. Then, the tool which named Solidworks sustainability is applied to measure the four environmental impacts such as carbon footprint, water eutrophication and air acidification as well as total energy consumed.
v. The hexagonal machine screw (M5*0.8) is selected as an example in this study.
vi. The location of manufacture and distribution is assumed at Asia region.
vii. The decision making method to selection material being by using Analytic Hierarchy Process (AHP).

1.5 Expected results

Throughout this study, the expected results are:

i. Select the appropriate material with the manufacturing process of screw for the best performance in environmental, social and economic impacts.
ii. Implementation of sustainability in manufacturing of screw.

CHAPTER 2

LITERATURE REVIEW

2.1 Manufacturing industry and its impact

Manufacturing is defined as the application of mechanical, physical and chemical processes to modify the geometry, properties and appearance of a given starting material in the making of new, finished parts or products [8]. In modern context, it involves making products from raw material by using various processes, by making use of hand tools, machinery or even computers. Modern manufacturing operations are accomplished by automated machines, and it is supervised by workers [9]. Manufacturing is the production of goods, in which raw materials are transformed into finished goods or products on a large scale. Finish goods or product will be used for other manufacturing or directly sold to wholesalers.

For any manufactured products, the product life cycle, including manufacturer's economic benefits, environmental impact of a product as well as the society must be considered in the first place. Recently, the overall growth in manufacturing industry seems aggressive and astonishing. However, this incident has driven many natural systems to a near collapse stage. Some of the obvious signs that show ecological distress are ozone depletion, global warming happening, depletion of aquifers, critical species extinction, and collapse of fisheries, soil erosion and air pollution problem [10]. Thereafter, this issue has led to numerous studies regarding to the environmental sustainability of products being carried out separately.

Environmental pollution getting serious during the industrial revolution, with the emergence of large factories and consumption of large quantities of coal and other fossil fuels gave rise to unprecedented air pollution. Growing load of untreated human waste also rise during this era. Research done on 2005 shows that manufacturing industry are no 1 in global total final energy consumption with 33%, and they are also no 1 in total global direct and indirect C02 emissions with 38%, as shown in Figure 2.1. With the statistic as a proof, there for there is an urgent need for green manufacturing; in product life cycle consideration for environmental aspect must also be taken seriously, mostly manufacturers only looking at economic benefits. Nowadays, prerequisite for manufacturers to survive in the competitive market is the ability to cope with the needs of sustainable development.

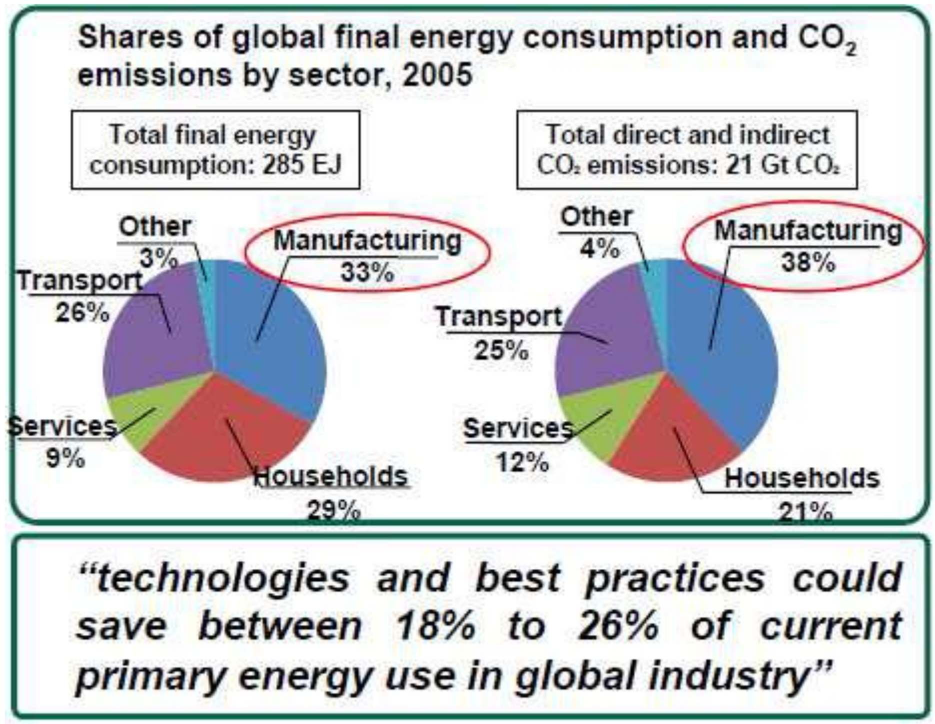

Figure 2.1: Shares of Global Final Energy Consumption and CO2 Emissions by Sector, 2005 [11]

2.2 Screw

There several kinds of common Mechanical fastening such as bolts and nuts, screws and rivet, Screw can be consider the most versatile fastener and the most common uses of screws are to hold objects together in position required. A screw is an externally threaded fastener capable of being inserted into holes in assembled parts, of mating with a preformed internal thread or forming its own thread, and of being tightened or released by torturing the head [12]. Screw and bolt look alike and to differentiate it a bolt is normally intended to be tightened or released by torquing a nut, screw stands alone meanwhile bolt is paired with nut.

Screw consists of two main parts that is head and shank as stated Figure 2.2. Screw head, is specially formed section it allows screw head to be turned by screw driver or wrench. The cylindrical portion of the screw from the underside of the head to the tip is known as the shank; it may be fully threaded or partially threaded [14].

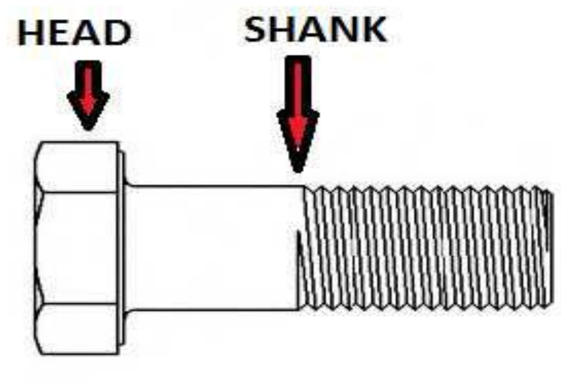

Figure 2.2: Screw parts

The screw is one of the versatile fasteners. To a significant degree, the screw manufacturing industries are widely established and cannot be underestimated. Perhaps the screw production fund is nearly all associated with mass production. Mass production refers to the situation where the production rate is high due to high demand rate, and manufacturing system is completely dedicated to the production of that single item [12].

2.2.1 Screw types

There are many types of screw available is the market, normally they are categorized by types of head, shape of the screw head, types drive, and types of material. There few common types of screw found are cap screw, wood screw, machine screw and self-tapping screw as stated in Figure 2.3. Cap screw normally has hexagonal shape head, designed to be driven by a spanner or wrench), Wood screw, designed for wood has a tapered shaft allowing it to penetrate, Machine screw has a cylindrical shaft and fits into a tapped hole and lastly self-tapping or self-drilling screw has a cylindrical shaft and a sharp thread that cuts its own hole normally used for sheet metal.

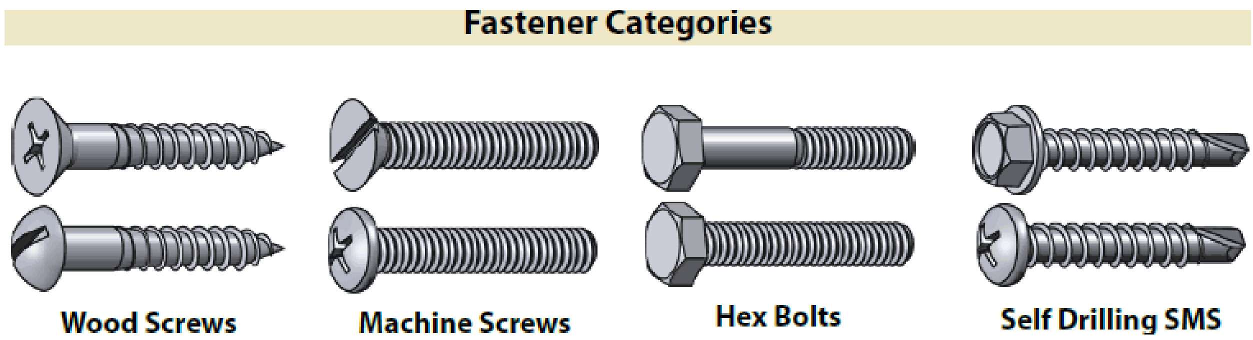

Figure 2.3: Fastener categories [14]

If categorized by shapes of screw head, common screw types found are flat head, oval head, pan head, hex head, socket cap, button and countersunk as shown in Figure 2.4. A variety of tools exist to drive screws into the material, they are flat screwdriver, Phillips screwdriver, Allen key, spanner, wrench and some special tool.

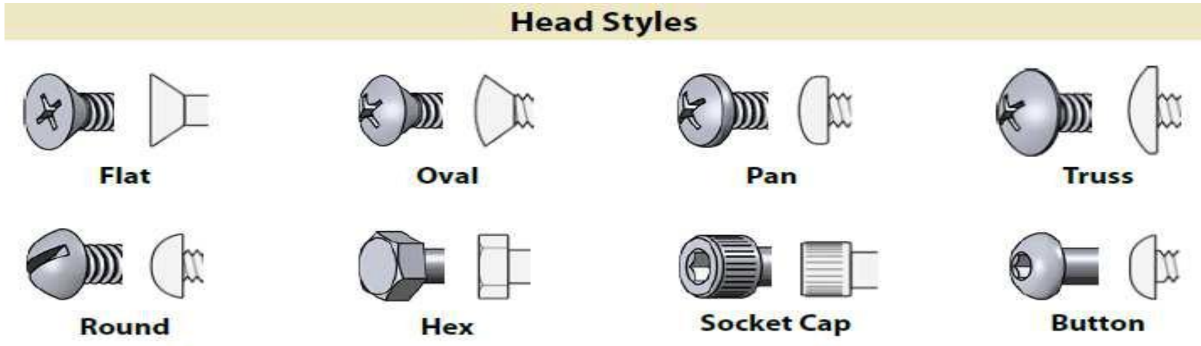

Figure 2.4: Screw head style [14]

Screws and bolts are threaded fasteners that have external threads. There is a technical distinction between a screw and a bolt that is often blurred in popular usage. The screw is an externally threaded fastener that is generally assembled into a blind threaded hole. Some types, called self-tapping screws, possess geometries that permit them to form or cut the matching threads in the hole. A bolt is an externally threaded fastener that is inserted through holes in the parts and ‘‘screwed’’ into a nut on the opposite side. A nut is an internally threaded fastener having standard threads that match those on bolts of the same diameter, pitch, and thread form. The typical assemblies that result from the use of screws and bolts are illustrated in Figure 2.5.

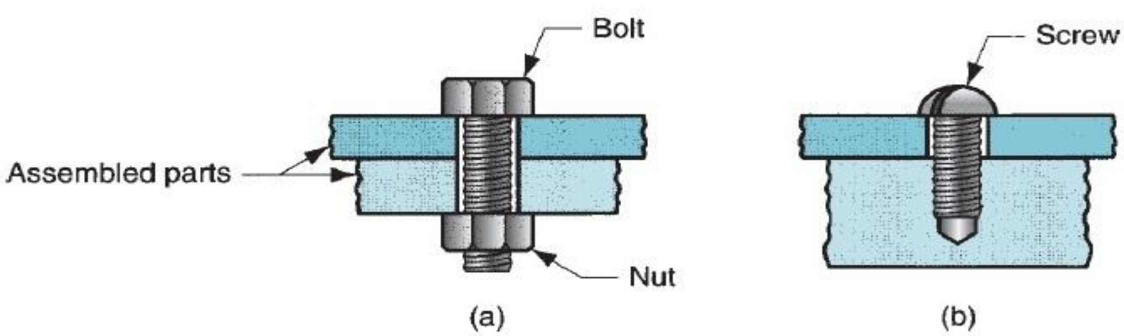

Figure 2.5: typical assemblies using: (a) bolt and nut, and (b) screw

2.2.2 Screw material

Selecting appropriate material of screw for intended application is an awesome task. There are various factors that can influence the material selection of screw such as environmental circumstances, presence of corrosive elements, physical stress requirements and overall structural stability. Screw can be made from ferrous, non ferrous and also non-metallic (plastic). However, the screw is usually produced from aluminum, brass, certain synthetic non-metals and various grades of steel and stainless steel. Steels especially carbon steel is indeed the most commonly selected material in screw production as it is workability and relatively inexpensive to fabricate.

For an aim of weight saving, aluminum is selected. Although titanium has specific application in a narrow range of fields, but sometimes it is being used as well. Besides, since alloy steel has low corrosion resistance, therefore it is typically benefiting from additional coating. These steels are extremely strong, but can be rigid and brittle. By the way, the screw that made from stainless steel has a high degree of corrosion resistant, which suitable for long term uses purpose. Bronze and brass also perform good corrosion resistant characteristic [15].

2.2.3 Screw manufacturing process

There are three steps in manufacturing a screw: heading, thread rolling, and coating. Screws are normally made from wire, which is supplied in large coils, or round bar stock for larger screws. The wire or rod is then cut to the proper length for the type of screw being made; this workpiece is known as a blank. It is then cold headed, which is a cold working process. Heading produces the head of the screw. The shape of the die in the machine dictates what features are pressed into the screw head; for example a flat head screw uses a flat die. In between, the screw head can be formed by two alternative methods before screw thread is continued; they are metal forming and machining method [16].

For metal forming approach, the metal work piece is subjected to plastic deformation circumstances where the changing of shape takes place due to the applying of compressive force. The compressive force is usually in the form of hammer blows that using a power hammer or a press. Although metal forming can be classified into several processes such as extrusion, rolling, forging, bending, shearing, wire and bar drawing, but only both forging and rolling processes are probably applied in screw manufacturing. Besides, the forging processes that are used in screw production are cold forging and hot forging [17].

So far, cold forging is the most economic way to manufacture screw. This is because it is commercially produced with batches in a big volume. Stated that cold forging is a process where the work piece is forged in a die through a series of blows at room temperature that yields products with a shape similar to the inner surface configuration of the die [18]. This process is said has undergone the plastic deformation circumstance at room temperature and the materials that are suitable for cold forging process include non-alloy steel, case hardening steel, quenched and tempered steel, copper, brass and aluminum alloys [16]. Normally, cold forging will require heat treatment at the end of the process in order to achieve the desired mechanical property of the material. The Figure 2.6 below illustrates an upset forging operation to form the head of the screw.

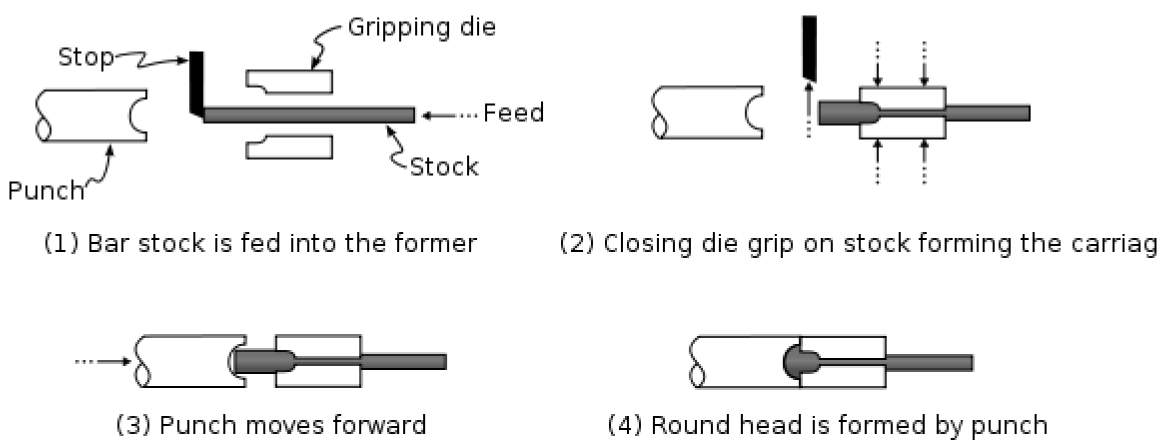

Figure 2.6: An upset forging operation to form the head of screw [17]

Hot forging is not as famous as cold forging. In most instances, the cold forging is used to substitute the hot/warm forging as per cold forging is likely to offer a good surface finish with better mechanical properties in the forged products compared to hot/warm forging . The hot/warm forging is only an option when the deformation ratio is too high. Hot forging machines work alongside a furnace, one end part of the bar is heated for some length, then heated end of the bar is then fed into the dies in forging machine. With the help of dies and a heading tool, screw head is forged by upsetting process. Illustration in Figure 2.7 shows the sequence of process for screw upsetting sequence, after head forged; shearing process will cut the length of the screw. Then, the bar is sent for heating again and the whole process is repeated. The hot forming manufacturing technique is an option only when the number of parts is too low for the cold forming process.

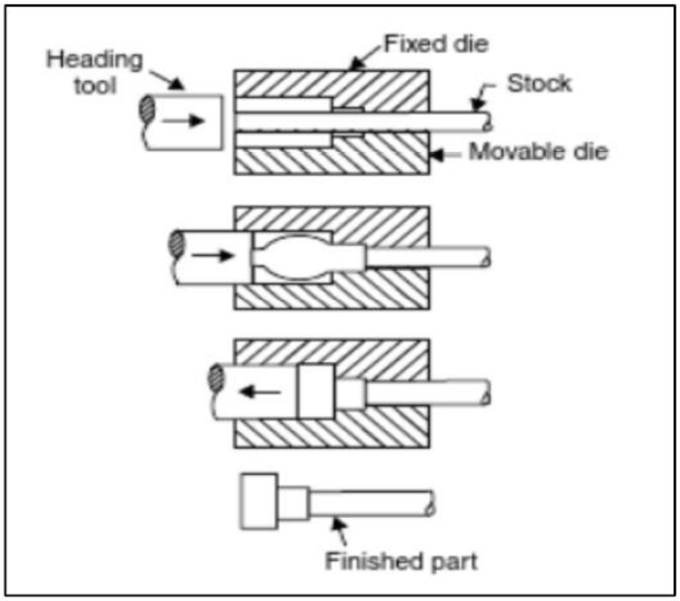

Figure 2.7: Hot forging processes for a screw [19].

Some fasteners like screws are also manufactured as machined parts, it is suitable for machining with parts with special profiles, small radius or intentionally sharp edges, there are also some special materials that cannot be formed without machining. Shaping is performed by machining with the turning and milling tool, forging improves the finished part’s grain structure by making it conform to the flow of the design. Machining is not only used to obtain cylindrical shapes by turning, but also implies processes such as milling of flat areas, drilling, grinding and similar fine work, e.g. to achieve a specified degree of roughness [20].

Subsequently, the thread cutting operation of screw is continued after the screw head is done by forging or lathe turning. This is the next stage of screw production chain. The screw cutting lathe with a single edge cutting tool is the most desirable option for special screw thread [21]. On the other hand, the ordinary external screw thread can be made by either thread rolling process or manually through material removal process using dies. The dies specifically used are solid dies, split dies, spring dies and pipe dies. They are shown in Figure 2.8 below [22].

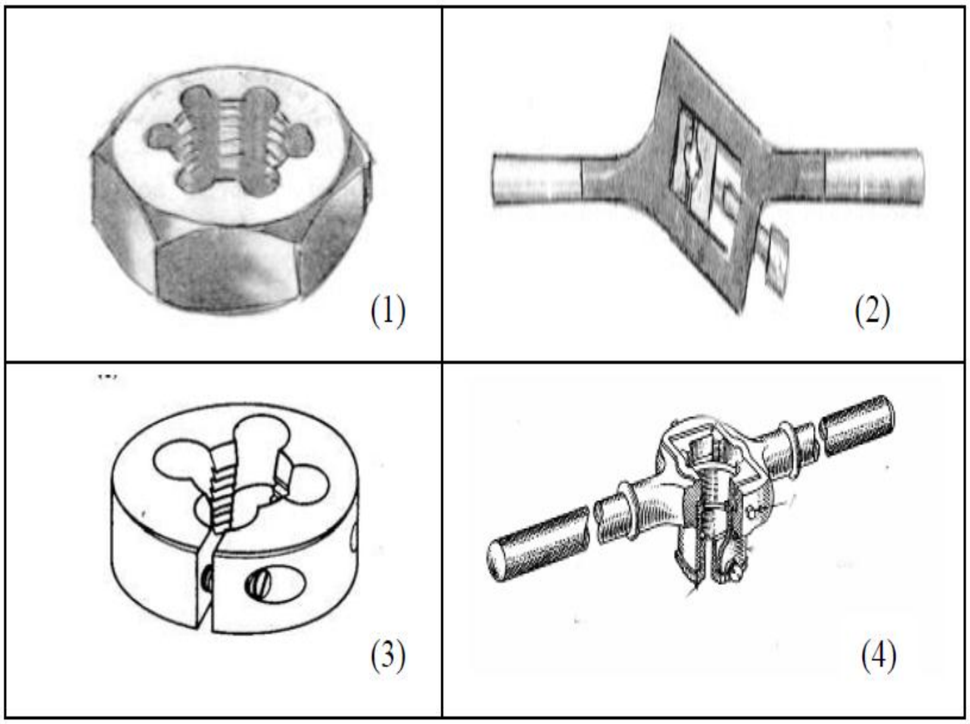

Figure 2.8: (1) Solid die (2) split die (3) spring die (4) pipe die.

The Figure 2.9 has displayed an alternative way to produce screw thread, which is by rolling with flat dies. Through this rolling process, the material is extruded from its initial diameter (rolling diameter) by forcing it radically into the negative profile of the die. This process does not cause any metal material to loss and is better than machine cut method [17]

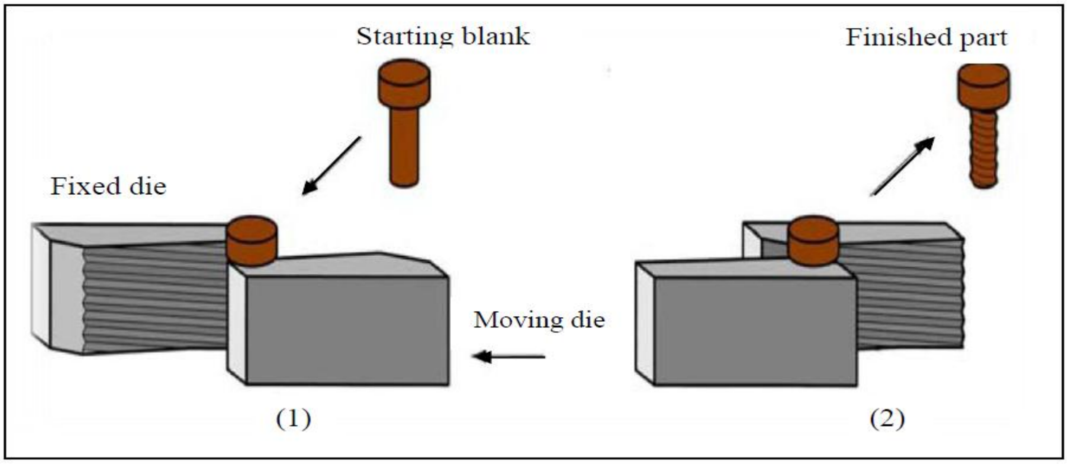

Figure 2.9: Thread rolling to flat dies (1) start of cycle (2) end of the cycle

Machining screw threads on lathes are also produced in normal lathe, special purpose lathes and CNC lathes. Two method external threads are produced in center lathes they are by a single point and multipoint chasing as shown in Figure 2.10 (a) & (b).Single point is the most basic threading method using the machine but it can provide high quality. Multipoint chasing gives more productivity, reduce threading, but at the cost of quality to some extent. Machining of external threads on semi-automatic lathes for batch or small lot production in capstan. External threads on a capstan lathe by self-opening die as shown in Figure 2.10 c).

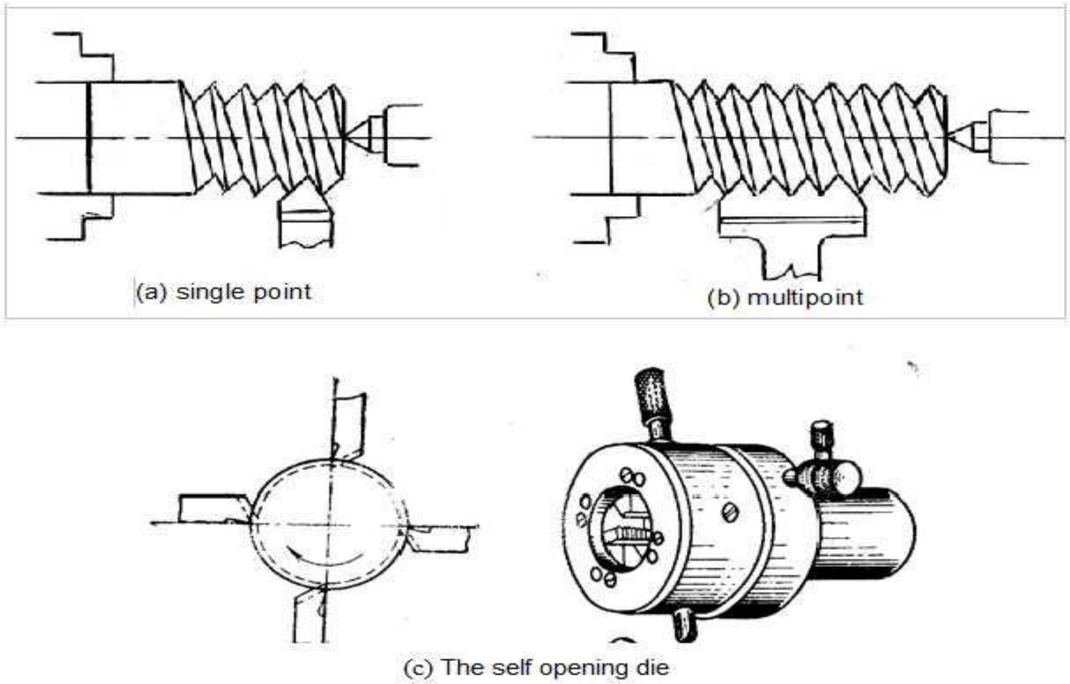

Figure 2.10: (a) single point (b) multi point (c) self-opening die [23]

Hexagonal machine screw is selected for this study, for a hexagon head bolt or screw, the manufacturing stages are arranged in the following order: Cutting the bar stock, pre-upsetting and ironing of the shank, upsetting a round head, trimming the head to a hexagonal shape, forming the bolt or screw end, and finally, on a separate machine, forming the screw thread by means of a flat or cylindrical die. Hot forging and cold forging are two different metals forming process that delivers almost similar results. Forging is the process of deforming metal into a predetermined shape, the main benefits of forging process are savings in material and machining costs are significant and forming complex shapes are possible [16].

Screw manufacturing process mainly are divided into forging process and machining process, although they different kinds of process at the beginning at least both of screw manufacturing method must go through threading, heat treatment and coating process as stated in figure 2.11.

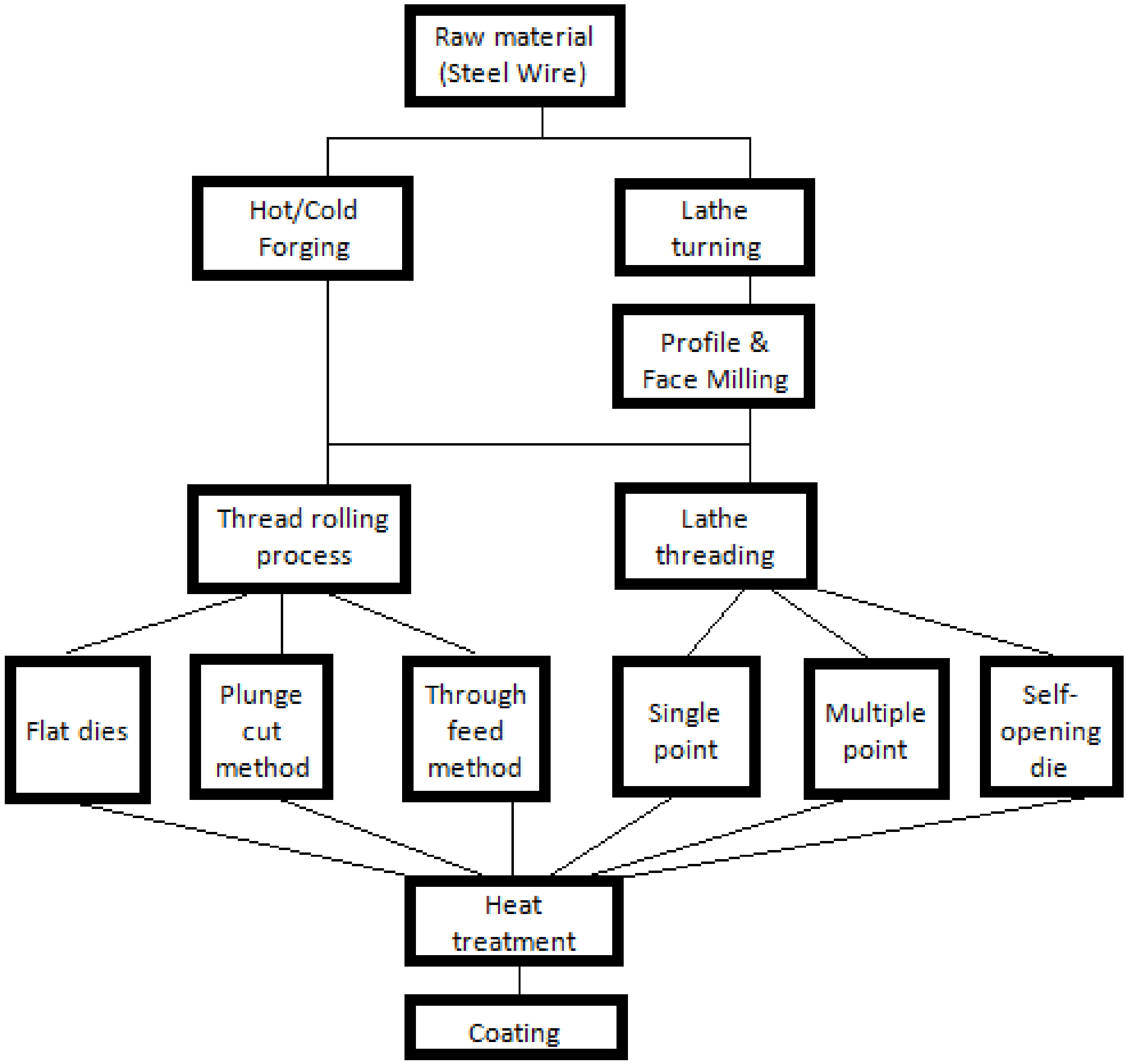

Figure 2.11: Flow chart of hexagonal head screw manufacturing process

2.3 Material selection

Material selection can be defined the importance of material selection job, perhaps the appropriate selection of material and manufacturing process is also essential to achieve sustainability of a product [25]. The altering of material has shown higher impact over the manufacturing process in reducing the environmental impacts. In between, this intricate task is often dominated by production methods, function and structural demand, market or user demand, design, price, environmental impact and lifetime [26].

Most engineering materials can be classified into one of three basic categories: (1) metals, (2) ceramics, and (3) polymers. Their chemistries are different, their mechanical and physical properties are different, and these differences affect the manufacturing processes that can be used to produce products for them [1].

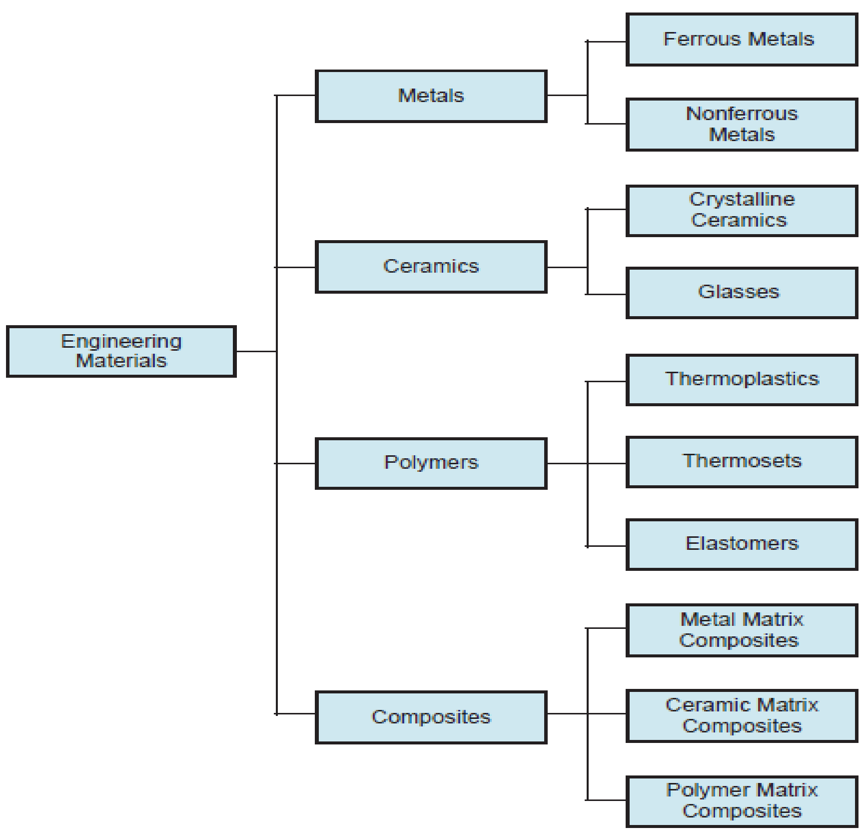

Figure 2.12: Classification of the four engineering materials.

Thanks to advances in material science, today's engineers and designers have more options for choosing greener materials. Choosing more sustainable materials often means making informed tradeoffs. To make an informed choice you need good data on a material's environmental impacts, and you need to consider that data alongside other design requirements [27]. During product design when considering the environment properties of materials, look for materials that are abundant/rarely used, non-toxic, have low embodied energy, and meet regulations. Green design is now a major trend in product design, more manufacturers are looking into these matters.

2.4 Sustainability

This word is occurring more and more. *Sustainability* can invoke fundamental yet complex concepts. **What is** *sustainability*? The word is derived from the Latin *sustinere (tenere*, to hold;*sus*, up). Dictionaries provide many meanings for *sustain*, the main ones being to "maintain", "support", or "endure". The most frequently used professional definition states: "Sustainable development *is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*" This comes from the 1987 report of the World Commission on Environment and Development (also known as the Brundtland Report), an early landmark in developing **what sustainability is today**. At larger scales, sustainability refers to attaining and ensuring a long-term balance among complex social, economic, and environmental systems. The goal of *between-generation transfer* of our current quality of life is fundamental; this requires thinking about *present resource consumption* - in terms of *future resource needs.* There are dozens of examples: many involve the adoption of *best management practices* - routines that improve near-term efficiency and long-term production [28].

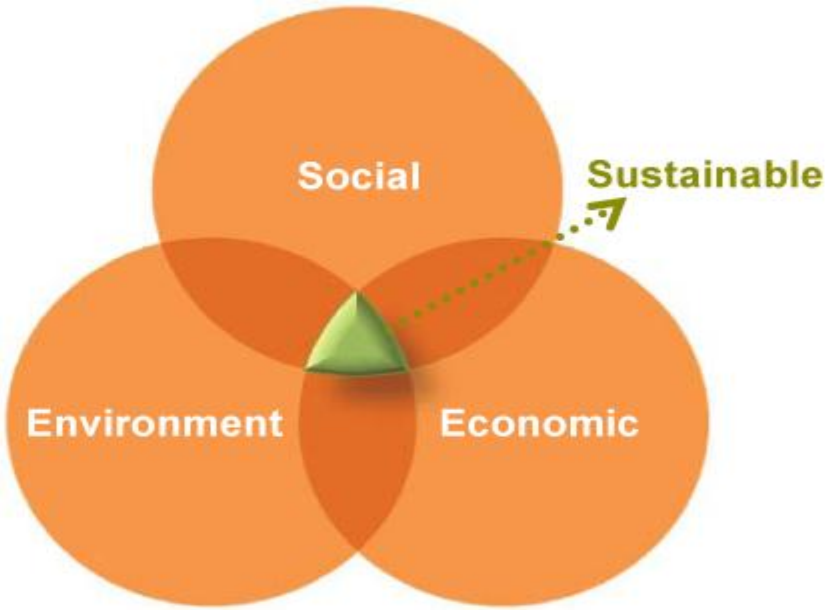

Figure 2.13: Venn diagram of sustainable development: at the confluence of three constituent parts.

2.4.1 Sustainable production

Sustainable production is defined as the creation of goods and services using processes and systems that are non-polluting, conserving of energy and natural resources, economically viable, safe and healthful for employees, communities, consumers and socially and creatively rewarding to all working people [29].Thus, a sustainable product is denoted as a product that gives a little impact on the environment as possible during its life cycle.

The critical factors that causing those environment impacts in manufacturing industries are the design of the product, the material selection and the production method and in fact, these factors must be emphasized during the design stage rather than production stage [30]. sustainable manufacturing can be addressed as the creation of manufactured products with processes that have minimal negative impact on the environment, conserves energy and natural resources, are safe for employees and communities, and are economically sound [31].

Hence, the optimizations of ecological and economical of products are necessary to be implemented by all manufacturers. The ecological optimization includes all life cycle stages of the product while economical optimization is limited to the responsibility of the manufacturers [32]. In this circumstance, the efforts to preserve the environment do not rely on the responsibility of single party and the most important stages of the product life cycle are manufacturing, service/usage and recycling/reuse.

Figure 2.14 has depicted an example of sustainability indicator hierarchy which was developed by using category framework and the relationship with the product life cycle [33].

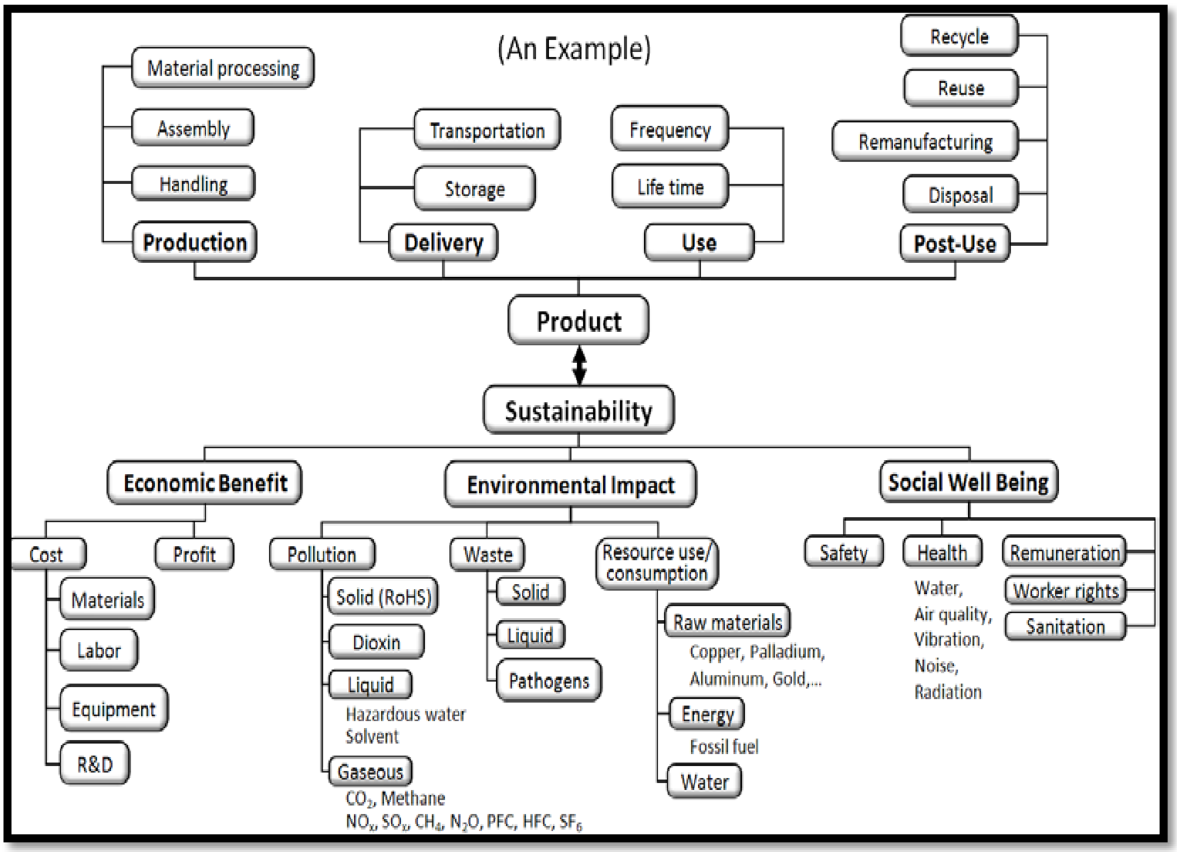

Figure 2.14: An example of indicators and product life cycle [33].

2.4.2 Social aspect of sustainability

The general definition of social sustainability is the ability of a social system to function at a defined level of social well-being indefinitely. That level should be defined in relation to the goal of mankind, which is to optimize quality of life for those living and their descendants. Social dimension of sustainable development indicates that the socially sustainable system must achieve fairness in the distribution and opportunity, adequate provision of social services which including health and education as well as gender equity and political accountability and participation [34].

Social sustainability is an important aspect of sustainable development that is concerned with personal and communities' well-being. Social development usually refers to improvements in individual well-being and also the overall social welfare, that result from increases in social capital, the accumulation of capacity for individuals and groups of people to work together to achieve shared objectives[35].

Assessing the social aspects of product sustainability is not an easy task. First, the social dimension of sustainability is a complex issue. Second, in addition to questions on assessment methods, there are very practical obstacles, such as the availability of data and the consensus on the procedure by industry and the public.

A basic problem is that many of the social aspects – such as ensuring safe working practices, provision of high-skill employment, or absence of child or forced labor in the supply chain – are qualitative aspects covered at the level of the company, rather than quantitative measures that can be attributed to individual products. Data on environmentally relevant inputs and outputs related to one product unit (usually 1 kg or 1 MJ) can be found in life cycle assessment databases, but so far there are no similar databases for social aspects [36].

The factor of safety from the social aspects that can be measured .In this study will take the factor of safety for screw as an important factor in the social aspect of sustainability in terms of reliability in the screw is utmost importance to save lives of people as screw is used in connecting structure of bridges, buildings, structures, aircraft, vehicles etc.

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