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DESIGN AND DEVELOPMENT OF AN AFFORDABLE LOUNGE SUITE

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We certify that this work has passed the scholastic standards requested by the Information and Communications University as a final year project for the degree of Bachelor

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Dedication

I dedicate this special thesis to my mother Milimo, B. Kapepe for believing in me and ensuring that I complete my studies and my aunties and uncles who gave me the moral support.

Acknowledgement

I would like to thank my supervisor, Dr. Oliver Silumbe for guiding me throughout the production of this thesis document. Secondly i would like to express my appreciation to the management of ICU for having given me an opportunity to study at this great University. I wish also to express my gratitude to Lucheche secondary school for according me chance to carry out my research leading to the production of this thesis.

I am indebted to many people some of whom are not mentioned here helping me produce the final thesis. Special gratitude goes to my family.

Sheila Chiyumu

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FURNCOZ	Furniture Company of Zambia
ICU	Information and Communications University
K	Kwacha (Zambian Currency)
MMD	Movement for Multiparty Democracy
USD	United States of America

Abstract

Comfort is every man's desire to achieve. Every household strives to live comfortably at the level of their social status. Due to liberalization the Zambia's economy by the Chiluba's Movement for Multiparty Democracy (MMD)

Government after coming to power in 1991, major furniture manufacturing companies, such as FURNCOZ went under and the country saw the influx of imported furniture from South Africa, China, Pakistan and other countries.

The primary goal of this study is to design and make a set of comfortable, strong and good-looking lounge suite. The idea was conceptualized after visiting many furniture shops in Lusaka and saw the exploitation of Zambians by importer companies of furniture and the pain customers go through when time to pay comes. Customers buy through higher purchase, a system which makes the price of an item go fourfold in some cases and makes the customers 'pay through the nose'. The majority of them get loans which ends them receiving 'change' on their pay slips at the end of the month for their upkeep. As a result most workers to go into 'Kaloba' (borrow K10 and pay back K20 or more depending on how desperate you look when borrowing). This has made many workers (especially civil servants) live on borrowing and never graduate to enjoy their full salaries.

A lounge suite was designed to sit six people (two single seaters and two double seaters). Each piece was fitted with adjustable leg rest and an adjustable back rest. A study of available leg and back mechanisms was carried out and a simple mechanism to be operated by hand and leg was designed. Several freehand sketches were done and computer aided design software were used which included SolidWorks, AutoCAD and Sketch Up.

The research exposed the designer to different designs and materials and covering techniques. Different resistant materials are used in this trade and these include wood, metal and thermosetting plastics. Cloth, Rexene and leather were some of the covering materials considered.

Having learnt some fashion and fabric in the secondary school, adequate skills were acquired to enable the writer cut and join upholstery fabric using a sewing machine. With these skills, high quality products would be produced.

Metal was chosen for the main frame because the designer was an expert in manipulating metals by training. In addition steel is locally produced at Kafue Steel Industry located near Lusaka and it is affordable. This in turn will help promote the growth of our local industry.

The concept was inspired after seeing the gap in quality between locally produced sofas by our carpenters and those imported. Our carpenters use unseasoned (wet) timber which distorts in service and make the finished product weak and unsightly. Carpenters roughly nail their frameworks and use nails too for tacking covering materials. The newly designed and made lounge suite would have an improved appearance, comfort and strength to match the imported ones but priced reasonable enough for the Zambian worker. This will save more employees from the embarrassing situations at the end month.

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Chapter 1

1.0. Introduction

1.1.History of the lounge suite

A lounge, business or office suit is a set of garments which are made from the same cloth usually in dark colours. . (Simmel (1958) affirms that the current styles were founded in a period of the sartorial revolution during the early 19th century. The search for more comfort gave rise to the loosening of rules in the late 19th century to the modern lounge suite.

> *"It was originally a traditional form of 'men's formal clothes in the Western world. The earliest women's suits were for riding, which consisted of a jacket and matching skirt from the 1660s and those not intended for riding appeared in the later 19th century under the influence of Dress for Success"*(Simmel, 1958).

A working woman's uniform of skirted suit evolved in the 1970s and 1980s. Women's suits with trousers were introduced but were only gradually accepted as formal business attire. Simmel, (1958) indicates that for some four hundred years, suits of matching coat, trousers, and waistcoat have been in and out of fashion. The single breasted suits came in style throughout the 1920s and the double-breasted suit was mainly worn by older and more conservative men. In the 1920s, very fashionable men would often wear double-breasted waistcoats (with four buttons on each side) with single-breasted coats. They continually changed their preference from double-breasted suit, to three-piece suits, two pieces single-breasted and the three-button two-piece suit exchanging fashion popularity for decades.

The use of the matching materials in suits gave rise to the lounge suite where the colours of sofas, curtains and the lady's attire would match in the lounge (living room). The set of sofas were then referred to as a 'Lounge Suite'.

1.2. Background information

Chiyumushe Design Limited is a company specializing in design and manufacture of lounge suites in conjunction with the Information and Commination University. The Company appreciates the many advantages metal as an engineering material presents over other resistant materials. The following are advantages of metal when used in production; availability in different sections; ease machinability; its ability to bend under heat; the easiness in joining; takes finishes easily and its durability in service.

1.3. Problem statement and problem analysis

1.3.1. Problem statement

To produce a lounge suite with mechanism to make it act as bed to help people who have been working for long hours to relax. When they come home from work, they can sit and rest in the lounge suite which can also be used as a bed and the leg rest by use of hand operated mechanisms.

1.3.2. Problem analysis

A trial and error method might consist of constructing different shapes numerically and a process to try a lounge suite. In practice this would be very difficult to implement. Fortunately a much easier method can be found using a simple change of perspective. Indeed, for any given path of motion the ellipse can take around the lounge suite the intersection of the set of lounge suite parts at least as large as any shape it could have passed.

The lounge suite size is given by the maximum area over all possible continuous paths of the intersection of this set. It is worth noting that in this form the moving lounge suite problem can be seen to fall into a general class of problems that require finding the maximum intersection or minimum union of a set of shapes under some allowed sets of transformation. For example Lebsgue's universal covering problem seeks the minimum convex union of all shapes of diameters, allowing them to be rotated, translated or reflected. To construct the lounge suite numerically we can divide the path into angular steps of size and form. The intersection of shapes where the first and last shape is replaced with just a single long straight line whose position can be taken as fixed. The remaining positions are then varied iteratively to find the maximum area of the intersection shape must then be taken appropriately large to give the shape to the required accuracy. It should be noted that a number of assumptions are being made to decide that this method gives the required solution including the following: That the finest shape must actually turn through a right angle while going round the corner (This is not a trivial assumption since a unit square can get round the corner without turning at all.) The limit of the isolated path which is continuous and that the shape of maximum area formed from the intersection is connected in order that the solution is unique.

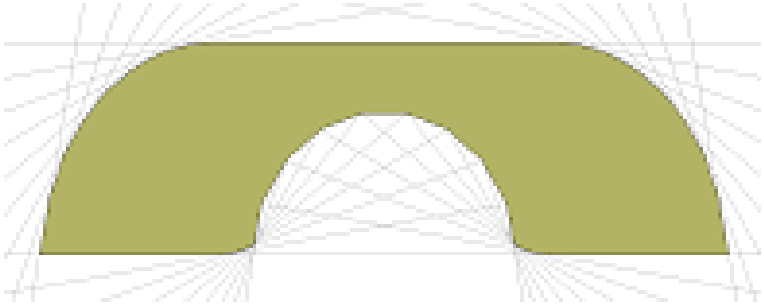


Figure 1: Shape design

1.4. Situation analysis / inventory

The study area in this design paper is Mbala district. Due to the increase levels of poverty residents sit on stools and traditional chairs and a few sit on poorly made sofas which are not comfortable at all. Comfortable chairs are imported and cost much. A visit at Mikalile shop in Lusaka reviewed that the cheapest sofa was going for K 25, 000 a price too inflated for an ordinary citizen especially middle income earners and subsistent farmers.

Figure 2: Sample of imported suite

1.5. Justification

We need something to provide comfort to people which can be affordable to buy instead of those in town costing between K25 000 and K30 000, which is beyond most citizen's reach. Locally lounge suits can be made and sold at a cheaper price so as to enable these households have good lounge suites.

1.6. Objectives

1.6.1. Broad objective

To design and make a lounge suite that would be affordable by many households.

1.6.2. Specific objectives

The specific objectives include the following;

1. To review existing sofas in the district.
2. To utilize high quality local materials for cushions and covering in order to resemble imported lounge suites.
3. To hire experienced professionals to train local craftsmen to make improved products.

1.7. Statement of the scope

The designed lounge suite will have four pieces comprising two single seaters, and two double seaters, sitting a total of six people at one time. It will have adjustable back rest and extended leg rests for total relaxation. The improper seat sizes, seat height, backrest height will result in discomfort of the user. The mechanisms used will be simple to operate and fitted to the sofa to suit the average sized user.

Chapter 2

2.0. Literature review

In the seated posture, it is desirable that as much contact is made with the chair's support surfaces in order to provide maximum stability to facilitate function. However in a back less seat or in right angled backrest seating, it is difficult to achieve this and often results in a person acquiring a slumped posture to compensate for fatigue and discomfort.

Figure 3: Example of backless seat

The pictures below show three examples of chair designs

Design 1 - Ottoman Seat

The chair is comfortable with good seat height. The chair has good casing shapes for seat, arm and back rests. The materials are aesthetically contrasted. The leg rest is provided for full relaxation. Good workmanship is evident though the main frame stand may get damaged easily.

Design 2 – The Lunar Sofa

The modern lunar sofa has good curvature and adequate cushioning for comfort. The combination of materials makes the design elegant. The covering material looks strong but the choice of colour is questionable as it can get dirty easily especially for most Zambian households. Arm rest is inclined away from the user and may force the user to lean side wards. The legs though metallic look proportionally small and may continually slide on a smooth concrete floor.

Design 3 – The Short Back

The overall design does not look appealing to the eye. Choice of covering material colour is good as dark materials are locally liked by most households because they do not show dirt easily. The addition of adjustments for back rest and leg support are a good advantage to the user. The arm rests appear to be lower that the level expected.

2.1.Sofa Techniques

2.1.1. Seat

Extensive study gathers generally valid knowledge which is true for most of the studied objects, furniture inclusive, because there is much variance in sizes of users. Ergonomically, the standard sofa seat is 510 x 510 mm, cushioned with a minimum of 100 mm cushion thickness for comfort purposes. It is recommended that the most preferred joint angle should range between 79^{o} and130^{o} (Schmidt, Amereller, Matthias, Kaiser & Schwirtz, 2013:254).

Free space of 10 cm is left between legs and the front of the seat, to avoid pinching the nerves and enough space for moving the legs, Schmidt et al (2013) advises.

Openshaw & Taylor (2006) say that the height of the seat must be adjustable to allow a height of 2 cm under knee joint and not be slippery. A suitable inclination is about 3 degrees.

It should be possible to push the chair back and forward. Rollers should be avoided however; the seat must be a little wider than the pelvis. It must allow for moving the posture and can be flat or a little concave.

2.1.2. Mechanism

The mechanism responds to the hand control commands to position the lounge suite in the sit stretch and stand positions. These mechanisms will provide the power needed to return the lounge suite to an upright or semi upright position. The leg rest mechanism is stored internally with external leg levelers manually pulled in order to adjust the chair.

The chair height can be adjusted to suit user's preference. Simply rotate the lever wheel clockwise to lower or anticlockwise to raise the chair.

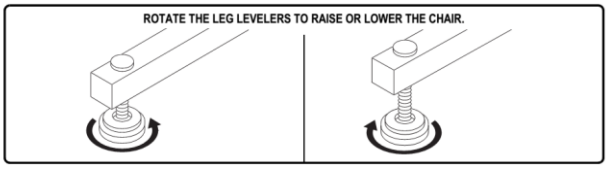


Figure 4: Chair height adjustment

2.1.3. The Frame

The frame is the base upon which a sofa or other upholstered piece of furniture is built. A strong base generally means a long-lasting product. The frame must be able to carry any universal user

load for which it is designed. It needs to take an elegant shape in order to attract attention of the buyers, but this should not compromise the strength of the product. Frames may be made of wood, metal, molded plastic or fiberglass.

2.1.4. The back rest

The first aspects to be dealt with were ergonomics aspects and dimensions. Shoulders must be free to move. Top and bottom edges of the backrest must be comfortable - no sharp edges. When the person leans backwards the backrest should give support to the lower chest and it should be inclined at 15 degrees, Openshaw & Taylor (2006) write. It should not be too wide and restrict moving the arms. When seated upright or a little inclined forward, backrest should give support to the backbone. Backrest should be cushioned and give support to the upper part of the pelvis but open space should be left between backrest and seat.

2.1.5. Webbing Technique

Putting of appropriate webbing materials especially on the seat for comfort is very important. There are several materials used for webbing which include; metal straps, rubber straps, denim straps, ropes and springs. Three types of springs are often used in upholstered furniture, the sinuous (S-shaped) springs being the most used. Springs provide upholstery furniture with an added measure of bounce, but not all upholstered furniture has springs. In many cases, polyurethane filling alone provides enough spring. Coil springs are one of the most used webbing techniques as it provides a very strong seat.

S-shaped spring

Denim straps

Synthetic material straps

Figure 5: Webbing techniques

2.1.6. Padding

Padding is the fitting of soft materials over the framework and webbed parts of the upholstered furniture and is very important for comfort. It may be easy to overlook since it is hidden beneath the fabric and often difficult to see. However, if you see two pieces of furniture with the same cover fabric and a comparative large price difference, the reason could be either the frame or the padding. “Padding with good, high quality polyurethane foam is able to provide 20 years of service” (Adler & Fackler, 2014).

2.1.7. Covering Fabrics

The fabric on any upholstered piece is the most visible sign of quality and style. Upholstery fabric also is the part most likely to show wear and soil. When choosing upholstery fabric, you should be aware of its durability, cleanability, and resistance to soil and fading. Consider how your upholstered pieces will be used in your home? Sofas and chairs receiving only moderate amounts of wear will do fine with a less durable fabric. However, pieces subjected to daily heavy wear need to be covered in tough, durable, tightly woven fabrics. Adler & Fackler (2014) advise that when purchasing upholstery fabrics, be aware that the higher the thread count, the more tightly woven the fabric is, and the better it will wear. Thread count refers to the number of threads per square inch of fabric.

Examples of fabric designs

Figure 6: Examples of upholstery fabric designs

Fabrics may be natural or synthetic. According to Adler & Fackler (2014) natural fabrics, include linen, leather, cotton, wool, silk and vinyl, while synthetic fabrics include acetate, acrylic, nylon and polyester.

Natural Fabrics

Linen is best suited for formal living rooms or adult areas because it soils and wrinkles easily and does withstand heavy wear. However, linen does resist pilling and fading. Soiled linen upholstery must be professionally cleaned to avoid shrinkage.

Leather is a tough material and can be gently vacuumed, damp-wiped as needed, and cleaned with leather conditioner or saddle soap.

Cotton provides good resistance to wear, fading, and pilling though not resistant to soil, wrinkling, and fire. Surface treatments and blending with other fibers often atone for these weaknesses.

Wool is strong and durable and offers good resistance to pilling, fading, wrinkling, and soil. Wool can be blended with a synthetic fiber to make it easier to clean.

Silk is delicate fabric and is only suitable for adult areas, such as formal living rooms. It must be professionally cleaned if soiled.

Vinyl is easy-care and less expensive than leather and are ideal for busy family living and dining rooms. Durability depends on quality.

Synthetic Fabrics

Acetate is developed as an imitation of silk and can withstand decay, pilling, and shrinking. However, it offers only fair resistance to soil and tends to wear, wrinkle, and fade in the sun.

Acrylic is synthetic fiber developed as imitation wool. It resists wear, wrinkling, soiling, and fading. Low - quality acrylic may pill excessively in areas that receive high degrees of abrasion.

Nylon is rarely used alone but usually blended with other fibers to make it one of the strongest upholstery fabrics. Nylon is very tough; in a blend, doesn't readily soil or wrinkle, but it tend to fade and pill.

Polyester is rarely used alone in upholstery but blended with other fibers to add wrinkle resistance, eliminate crushing, and reduce fading. When blended with wool, polyester worsens pilling problems.

All these steps can be summarized from as presented by Johnson (2012) who wrote;

> *"Two other components essential to upholstery foundation included … were padding for the chairs… which included the two layers of linen that enclosed the padding. After tacking the girt webbing to the seat frame, upholsterers covered it with a coarse layer of linen called "sack cloth." Because the strips of webbing were spaced so far apart, sack cloth served to provide additional support, as well to create a base for the stuffing to rest upon'(p20).*

2.1.8. Arm Rest

The sofa should have an arm rest conveniently positioned to provide comfort to the arms of any adult user. The armrest will also act as a guard system to the user.

2.1.9. Leg Rest

The leg rest helps the leg to be stretched in a straight line. By pulling the mechanism it comes out. Make sure you lift leg before adjusting, as it come with force and can cause an injury if not carefully pulled. The second point is the back rest which acts as a bed .For back rest operation, just press the number that at which you want the bed to be formed.

2.2. Another big thing:

2.2.0. Tools of the trade

Upholstery requires the use of several specialized tools and equipment to carry out the operation smoothly. These are briefly outlines below.

2.2.1. Webbing Stretchers and Webbing Puller Stretcher

Webbing stretchers help to pull webbing materials which may include leather, fabric, steel bands, sisal strings/ropes, rubber or synthetic strands. When springs are involved, a webbing puller stretcher becomes handy.

Figure 7: Webbing Stretchers and Webbing Puller Stretcher

2.2.2. Staple gun

The staple gun is very useful and is fast to use. It is used to staple fabric or thin foam to wood frames of the chair. It may use electricity or compressed air.

Figure 8: Staple gun

2.2.3. Staple lifter hammer

Staple lifter hammer is used to lift staples that have not been fixed properly. It may also be used to tack in material where the fingers may be too big to pass.

Figure 9: Staple lifter hammer

2.2.4. Staple remover

It is a handy tool which is used to remove staples when placed in wrong places.

Figure 10: Staple removers

2.2.5. Nail removers

Nail removers are used to remove nails that have bent or are wrongly placed.

Figure 11: Nail removers

2.2.6. Assorted tools and equipment

These tools include wooden and rubber mallets, pairs of scissors, needles and sewing machines.

Figure 12: Assorted tools and equipment

2.3. Theoretical framework

In most engineering, the word 'theory' means general knowledge often called invariance which is common to all or most of the objects in the class - for example in the class of beds. Typical for this type of study is a great number of objects and the study is extensive. From these researched records and analyses only those attributes of the objects that one judges important and interesting are chosen. This approach is often preferred in technology and in engineering.

To the contrary when one is studying furniture or other products of human culture it is often not enough to study only a few properties of the products. In order to understand the objects and

their meaning in the engineering and cultural context it may be necessary to study them thoroughly in their genuine environment with all their relevant properties and relationships.

The design of this lounge suite will be done using locally available materials and it is expected to be cheaper. For the sofa to last longer, strictly observe that only one person seats on a single seater and respectively. Some engineering design factors such as tensile forces, compressive forces and bending moments will be taken into consideration.

The leg for instance, will be under compression when the user sits on the sofa, thus;

$$\text{Compression stress in the leg} = \frac{Applied force}{Cross section Area} = \frac{F}{A} \quad \text{(i)}$$

Where area of a round bar is given by

$$A = \frac{\pi d^2}{4} \quad \text{(ii)}$$

Young modulus of a material is the ration between stress and strain

$$E = \frac{Stress}{Strain} \qquad E = \frac{\sigma}{\tau} \quad \text{(iii)}$$

But the young modulus of mild steel is 207 000 MPa, then strain (τ) will be;

$$\tau = \frac{\sigma}{E} \quad \text{(iv)}$$

Chapter 3

3. Design methodology

3.2.0. Collection of data/needs

The principal aspect in many normative studies about furniture, especially during the latter half of the 20th century, after the breakthrough of the 'Functionalist Style' of architecture professed that function must be the starting point for all design. One pioneering country was Sweden where the research center for furniture Möbel institute was formed in 1967 with financing mainly from the state. The first projects dealt with ergonomic aspects and dimensions, and on the basis of these studies recommendations were given and disseminated effectively.

Kroemer & Robinette (1968) write;

> *"Researchers generally agreed that the trunk, including neck and shoulders, should be in natural, upright, but relaxed position. The seated person must be able to select and change his body position from time to time. Weight transfer through the thighs should be avoided; body weight should be transmitted mainly through the buttocks. The height of the seat should be adjustable so the individual's feet can be placed firmly on the floor, while the thighs remain horizontal. A back rest should be provided on all chairs to allow temporary relief of weight from the spinal column" (p. iii).*

Seat should be cushioned. Free space of 10 cm is left between legs and the front of the seat, to avoid pinching the nerves and enough space for moving the legs.

It should be possible to push the chair back and forward. Rollers should be avoided however; the seat must be a little wider than the pelvis. It must allow for moving the posture and can be flat or a little concave.

Quality of materials

Today, the results of many years of ergonomic research in several countries are published not only as standards but also as handbooks for the design of many types of furniture. The concepts, models and methods in the study of the usability of furniture do not much differ from their counterparts in the study of other products.

Furniture belongs to those products that function as a "second skin" of people in the same sense as clothes, chair and homes. Furniture associates closely with its user or owner, and when selecting furniture, the owner can define the picture that other people shall have of him or her.

What people want to say about themselves, depends above all of the local social structure. In a traditional rural community a peasant perhaps wishes to be seen simply as worthy of his fathers. Accordingly, he has all reason to stick to ancestral vernacular furniture .On the other hand; Western urban societies have a strong legacy of social rank-order. Many people would like to ascend to a higher social class or, should an immediate ascent seem infeasible, they want to show

at least that they are worthy and prepared to such a rise. Furniture, as well as clothes, is well suited to indicate social status and also the owner's competence for an eventual ascent of status. That is the reason why the furniture styles of European aristocracy have long been imitated by coexistent lower classes.

Imitation of the higher classes explains how furniture styles propagate through society, but it also explains why new styles come into existence repeatedly. The reason is that the reigning aristocracy cannot afford to adhere long to any single style. Should they do so, the imitators would sooner or later reach equal perfection of style. The upper-class must continuously develop their extravagant style onto a new, more refined level. In this way the imitators are forever condemned to have a slightly old-fashioned, hence inferior, style.

The above socio-psychological mechanism by Simmel (1923) first exposed the fashions of chairs. Strickfaden and Heylighen (2007) cleverly examined Bourdieu's book, 'The Distinction', which explains much of the development of new styles of furniture, at least in Europe until well into the 19 century. The workings of the mechanism are also reflected in the fact that French period styles still bear the names of the reigning monarchs, for instance, style Louis.

Even today, when aristocracy has lost its position as the most enviable social class, many people still fetch the model for their habitus and furniture from one or another ostensibly more distinguished group in the society. Today it might be the new class of technocrats, the homes of which are published in coffee-table periodicals.

A great difference to earlier generations is that today people, especially the younger ones, are free to select their models for habits. They can now consider and select into which group of people they want to be associated with and what style of furniture is their proper surrounding. Moreover, the traditional status or group membership symbol is today only one of many possible alternative messages. Other alternatives are attitudes, moods and sentiments which can today be propagated through suitable selection of furniture, clothes and other personal belongings. Fun-loving or imaginative people can today create for themselves or find in the shops amusing products which, placed in suitable contexts, can transmit various messages, either vague or

subconscious or clear. Some products have even been given a name that indicates what it symbolizes, for example, the 'Ant' chair by Arne Jacobsen, on the right.

The great diversity of messages that the public today wants to deliver makes it almost impossible to compose a semiotic theory of furniture. The normal method when a designer wishes to communicate a message in his work is simply to do it by trial and error. The public will then decide either to take it or leave it.

Aesthetics of furniture

We all agree that it is a pleasure to see beautiful objects around us and that some pieces of furniture are more beautiful than others, but it is difficult to give grounds for our preferences and discuss them, let alone of knowing how a designer could attain beauty when creating new products. In such a situation, one normally expects that basic research, in this case the study of aesthetics, would help us by providing concepts and models which designers, manufacturers and the great public could use when discussing questions of beauty, when setting targets for it and when trying to fulfill these in new furniture.

Indeed, there is a tradition of more than two millennia of studying the beauty of works of art and other objects. From the point of view of the designers and users of furniture, perhaps the most interesting findings of these studies concern the process of gradual comprehension of works of art. According to the hypothesis of gradual comprehension, aesthetic pleasure is a sensation which is felt when a person discovers something of interest in the work of art. This discovery produces a gratifying sensation of highness which is more intensive if the discovery has been preceded by a few seconds of perplex ion. As contrast, if there is no enigma and the work of art reveals its content simply, the sensation of beauty remains flat. An important aspect in the aesthetic discovery is that for a human it is not possible to receive great amounts of information in one shot because there is a quantitative limit in the 'input' capacity of human cognition. However, great aesthetic values a work of art may contain, the public never can receive them as one single flash. The reception must always take place bitwise or slowly.

Typical of a great work of art is thus a multi-layered content. To begin with, it must have superficial content or decoration immediately appealing to the senses, otherwise the public would not more than glance at the work. Moreover, to qualify as competent art, the work must be able to offer also a deeper content. Finding this deeper content will then produce the pleasant feeling of highness once more. As a contrast, if the work offers no deeper layers of interpretation, or if discovering them is too easy, the aesthetic pleasure remains brief and thus such a small low feeling and the work of art will be classified as worthless or in bad taste!

The perception of a profound work of art proceeds in the several step-by-step phases. According to the findings of quantitative perception psychology, the aesthetic pleasure is greatest when the flow of new information remains long near the maximum of human abilities of perception or understanding. The most rewarding work of art is one where the process of discovery can take place several times successively. Such a multi-faceted work of art can be looked at over and over again. In each new vista the observer finds something new; each phase of observation leads to more profound comprehension and thus increases the aesthetic value of the work. When no more discoveries are made, the spectator loses his interest in the work.

Trying now to apply the theory of gradual comprehension to the art of furniture design, the first question will be, what could be those hidden structures or messages that could coax a spectator to meditate and examine a piece of furniture? It is to be admitted that furniture seldom can display such dramatic focal points of interest as can a painting or a novel. Nevertheless, even a piece of furniture can include elements that sometimes invite a spectator to look closely at them.

The product will usually be more interesting if it can be used in several ways, or the user can modify it by adjusting, for instance, the size of a seat or the inclination of a backrest. Here there has not been much research on these techniques for creating aesthetic interest in a piece of lounge suite and the few studies that have been made have stayed on a case study level, not on a general level. In other words there is not much theory of these questions yet. In practical product development, the designer thus has to rely just on the examples given by earlier products and his own aesthetic judgment. The use of lounge suite entails risks of accident, especially to small

children and elderly people. However, there are serviceable methods for studying, systematizing and analyzing the accidents related with lounge suite and for defining necessary measures for avoiding them.

Many investigation projects around accidents include proposals for improving the design of subsequent furniture. As a summary of all the preceding we can say that normative general theory, in other words explicit recommendations for design, exists today only for a few properties of furniture, notably on their usability, economy and safety. Regarding other properties, such as beauty, nearly all the studies until now have been of the descriptive and intensive type, i.e., in either case studies or historical studies where the objects have been studied these or holistic entities. Intensive approach means that general theory has not been produced.

In practice intensive research seldom is free from all normative bias. The reason is that researchers tend to select their objects among "interesting" cases which quite often are better than average is some respects. A quite usual finding of such a study is one or a few exemplars, reports on earlier produced meritorious artefacts. This is no bad thing, however, because exemplars can in practice substitute theory in questions where it is difficult to develop more explicit doctrines, like for example in questions of beauty and message. Exemplars can provide useful points of reference in various stages of product design project, particularly when preparing a detailed product concept. They are published in professional journals and exhibitions, and they are also much used in the education to the profession.

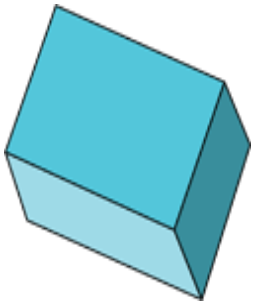
Selection of exemplars can be done by the researcher, or they can be selected by juries for exhibitions, by steering groups for professional journals or by other committees consisting of respected members of the profession. In any case they do not directly reflect the opinions of the users of the products, which naturally is a disadvantage as compared to proper research.
In the future, when descriptive research uncovers more of the relationships between various factors pertaining to furniture, it is probable that these findings will be used for normative purposes as well.

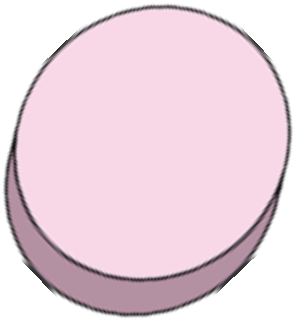
Foam

The largest solid foam size available is 1900 x 2050 mm. When any one piece of foam is ordered larger than that, it will be glued together with another piece. There are no additional gluing charges for oversized cushions though. The largest solid thickness available is 150mm. When any one piece of foam is ordered at a greater thickness than that, it will be glued together with another piece. Foam is a great way for padding on any furniture that you make for as much comfort as it has to be.

To make your foam cushions, we need form cushion measurements, a tape measure, a long straight edge and a sharp carving knife. The blade of your cutting tool must be longer than the foam's thickness to allow you to cut through completely.

Plotting cushions





Marking the foam

Using the measurements, begin to mark the shape of the foam within its designated boundary area. Whenever possible, the outside edge of the foam sheet is used as an edge for the cushion to reduce the number of cuts made. For square or rectangular cushions, design is created in the corner of a sheet, which meant that there are already two sides cut. It is important that design is laid out to share a cutting edge. A single mistake can ruin two cushions with this layout, while having room around each form can make a mistake manageable.

With the edge of the foam facing the operator, begin marking the foam using a straight edge, as seen in the picture below. Tick marks are made with a marker, spread apart at a comfortable distance without drawing lines yet, in case a measurement error was made. Work is double checked to ensure the measurements are straight and correct and that they fall within the cushion's boundary area. When this is confirmed, the straight edge and marker are used to connect the dots taking care not to tear into the foam with the marker tip.

.

Cutting the foam

Before beginning to cut the foam it must be checked that the work surface is stable, flat and could not be damaged by the knife. If a carving knife is used, make gentle back-and-forth sawing motions letting the blade to do the cutting.

……. (2013) advises;

> *Do not compress the foam and attempt to slice through quickly. The less the foam is during cutting, the more control the user has. Softer foams compress more easily during cutting. Taking caution to minimize pressure while cutting will result in cleaner edges. Medium and firm foams will hold their shape better during cutting, but do not use this as a reason to apply extra force".*

Cut it as if you were slicing freshly-baked bread. The picture below depicts the ease with which a sharp blade can cut foam without compression. If you use an electric knife, do not force the blade through the foam. The slower you cut the more control you have and the cleaner the cut will be. Whenever possible, begin cuts from the sheets' outside edge.

Making a cutting layout

There are three different ways to do a planned layout. For each of the pattern pieces just make a rectangle. Don't worry about shapes or darts at this point.

Pencil and paper

Use a large piece of paper, card board or hard board and draw out a large rectangle, to scale, to represent the fabric size. Then lightly pencil in the various pattern sizes, with identification marks and measurements, in the middle of the large rectangle. Erase and rearrange as necessary to get the best use of the fabric.

On graph paper, scale down your measurements so that 25 mm equals one square (or something similar). Tape together enough sheets of graph paper to the size of your fabric. Lay the graph paper on a large flat piece of cardboard or a corkboard and use thumbtacks to attach the graph paper. You can lay board flat or put it up on the wall. Then, for each fabric piece, draw a dark line around the edges of each pattern piece, following the lines of the graph paper to mark each piece to scale. As you cut each piece, mark it (i.e. IB for inside back, IA for Inside arm, OA for outside arm, etc.). Also mark the L x W size on each piece. When you have all the patterns cut. Rearrange then on the fabric graph paper base to get the best fit. As we put everything in place, use thumbtacks to hold the small rectangles of graph paper onto the large piece of graph paper. Rearrange the cut pieces to get the best use of fabric.

Drawing or CAD software

This is the method that is mostly used though many people find it hardest to learn, but is the easiest and most efficient to do once you have mastered it. It works similar to the graph paper, except on the computer. You draw one large rectangle to represent the roll of fabric. Then, using the measures from your sofa, you make rectangles to represent the cut sizes of the different parts of the sofa. Dimensions lines are attached to each rectangle and each rectangle labelled for each sofa part (i.e. Inside Arm (IA), Inside Back (IB), etc.) Arrange the labeled rectangles on top of the large rectangle to get the best use of the fabric. The finished drawing is then printed out and use as a guide to mark and cut the fabric. As you cut each piece, transfer the identification marks from the drawing to the back of the fabric.

Cutting the fabric

Assuming that plain fabric was to be used, you can railroad the fabric (cut from the side). Since you may have already done a fabric layout, just mark and cut the fabric following your plan. You can use a carpenter's framing square to square up the fabric. As you cut out each piece of fabric, draw a line along the top edge to identify which is the top of the fabric. Also mark an id mark on the back side of each piece taking care to use a marker that won't bleed through the fabric.

Fitting the cover

For any pieces that need to cut to shape, lay the precut pieces upside down on the corresponding pieces, check all around the edges that everything has enough for at least a 12mm seam allowance and pin it in place. Once the fabric is anchored in place with the pins, use a marker to

draw on the back side of the fabric along the seams. Wherever appropriate, draw a line around those fold lines. Then, before cutting it, add a 12 mm seam allowances to all seam areas.

Sewing the cover

The inside arms and the inside back need special consideration. First you need to determine whether or not you will be using a stretcher cloth at the bottom of these. If so, then you will add about 75 mm or 100 mm at the bottom of each of these.

French Seams

French seams have been one of the best ways to finish the inside of any project. They are perfect for children's clothing, making the garment durable because all seams are sewn twice. French seams were especially useful for uniforms. The uniforms held up extremely well due to these sturdy seams. They are best used for straight seams and are not recommended for curved seams. They work best on light weight woven fabrics and are ideal for pure fabrics.

If the inside back has a cording around the front, then when you sew the cording onto the IB piece, center the cording so that the cording will protrude about 125-250 mm past the bottom edge of the IB. You will need this extra cording sticking out when you attach the IB to the frame.

Notching or clipping a curved seam

When making an outward-curved seam, (as is the case on the sofa being made) the material will have reduced bulk and lie flat if notches are cut into the seam allowance. Alternatively, when making an inward-curved seam, pins are cut into the seam allowance to help the seam lie flat with reduced bulk in the fabric[-]

Once seam allowances are pinned they are often pressed flat with an iron before sewing the final seam. Pressing the seam allowances makes it easier to sew a consistent finished seam. Clipping is done along the seam allowance of an inward-curving seam. Notches cut into the seam allowance of an outward-curved seam.

3.3.0. Design of project

3.3.1. Design considerations

- The parameters considered in the design of a lounge suite include the following;

- The thickness of the sheathing form
- The seat height to be between 300 and 350 mm for comfort
- The arm rest to be between 220 to 260 mm above seat
- Weight of the sofa for portability
- Adjustments of back rest and leg rest

3.3.2. Working principles of the lounge suite

The work of lounge suite is to help the workers who come home tired and need some things to stretch their bodies on. It is designed in a special way with mechanism to stretch the legs and the backrest which is adjustable to form like a bed like. Usually this can be used on occasions when you have visitors or at parties. One can even sleep in a lounge suite without getting to the bedroom, unlike the Zambian sleeping culture.

Ordinary hand pulling force is what is needed to operate the backrest and leg rest mechanisms.

3.3.3. Design specification

The lounge suite is made in a special way that the seat carries a cushion to support and provide good comfort to a person reclining. The leg rest will be added to provide a platform for stretching the legs. The product will also have an adjustable backrest to enhance further support to the upper part of the body. Hence when fully adjusted it will function like a bed. Chain and hook mechanism is suitable for the back rest while the tray type mechanism is for the leg rest.

Safety is very important in every product. Being aware that one is free from accident the user is at peace. The framework components will be welded and clean by grinding machine to remove sharp edges which can cause accident to users.

Cost

The product cost in the range of K4 000 - K6 000 to manufacture.

The material should be strong durable and can stay for years with little maintenance. The materials should be easily cleaned, and can take mostly used cleaning materials to keep the attractive and shiny and the material is leather.

The overall dimension for a single seater is 1510mm x 910 mm x 1460 mm and 2120mm x 910mm x 1460 mm for a two seater.

3.3.4. Design diagram

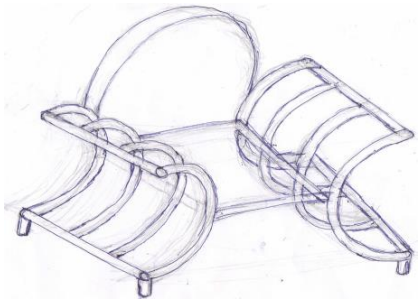


Figure 13: Frame design

3.3.5. Complete single seater chair

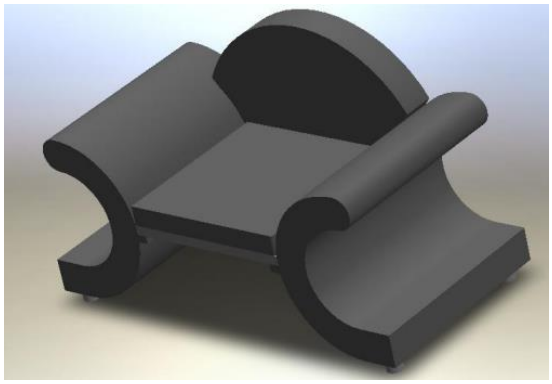
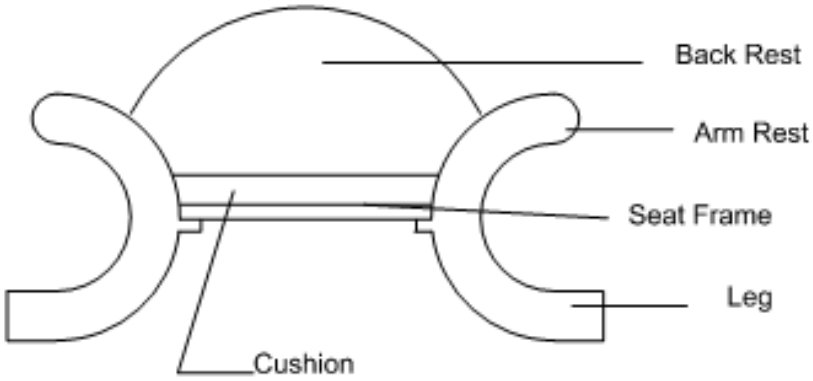


Figure 14: complete single seater chair

3.3.6. Components of the design

Figure 15: Components of the design

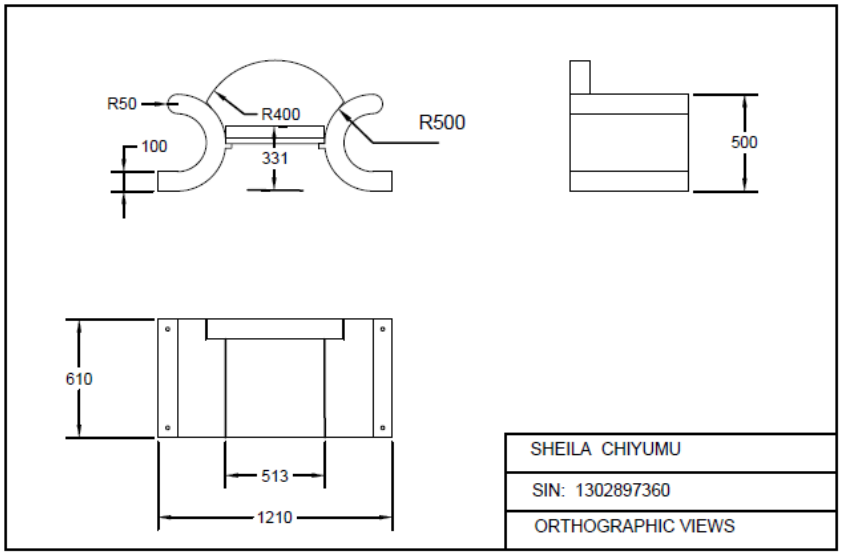
CAD WORK



3.3.7. Design analysis

Figure 16: Orthographic views

3.3.8. Design parts / sections



The back rest is hinged on its lower part to the frame and allows it to swing, thus creating different slants. Three adjustment stations are provided to give user options on which slant to use.

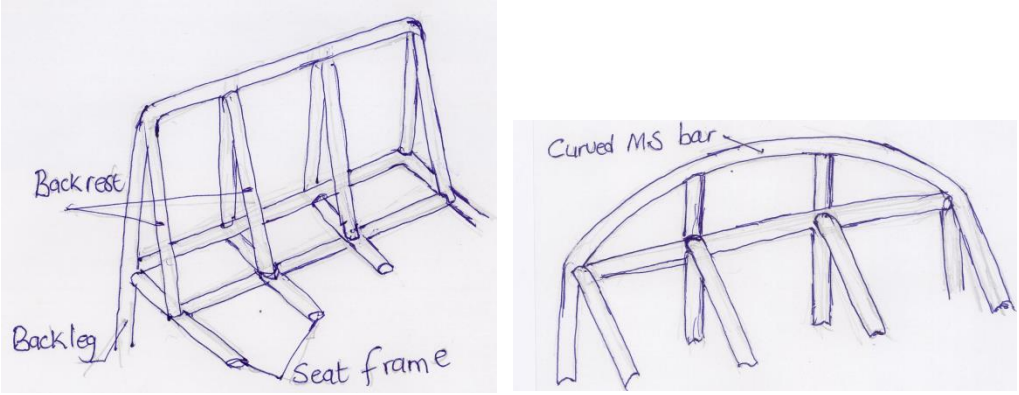


Figure 17: Back rest design

Seat design

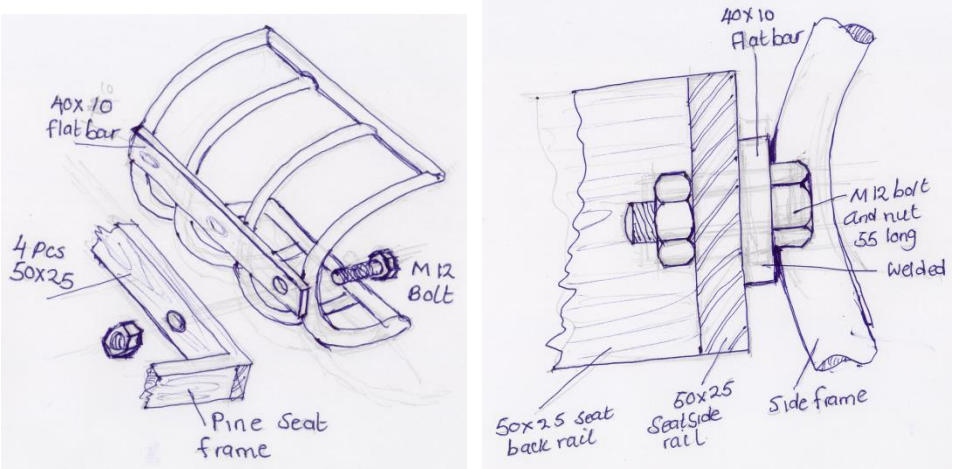


Figure 18: Seat design

Webbing technique used

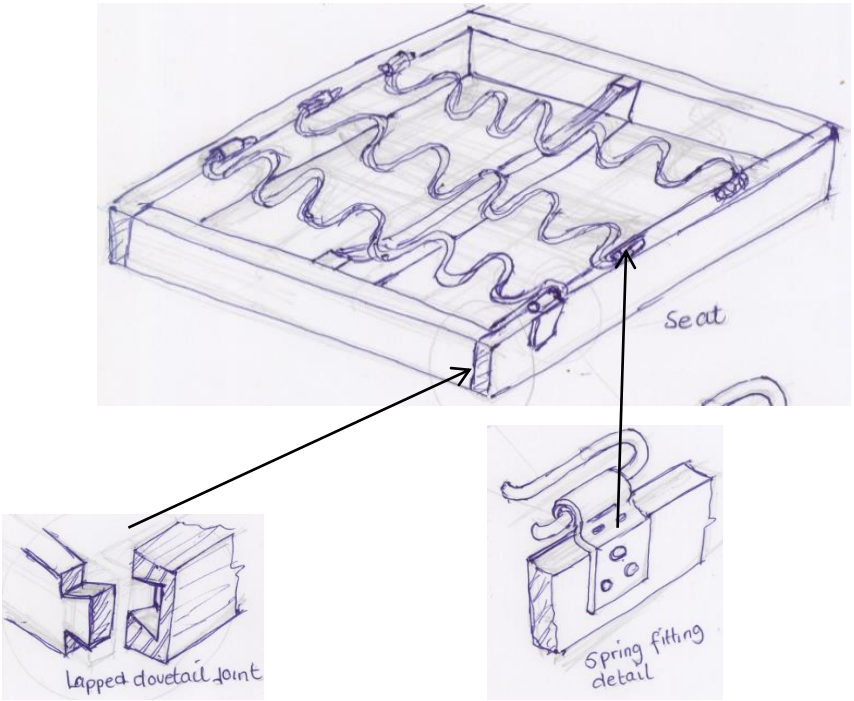
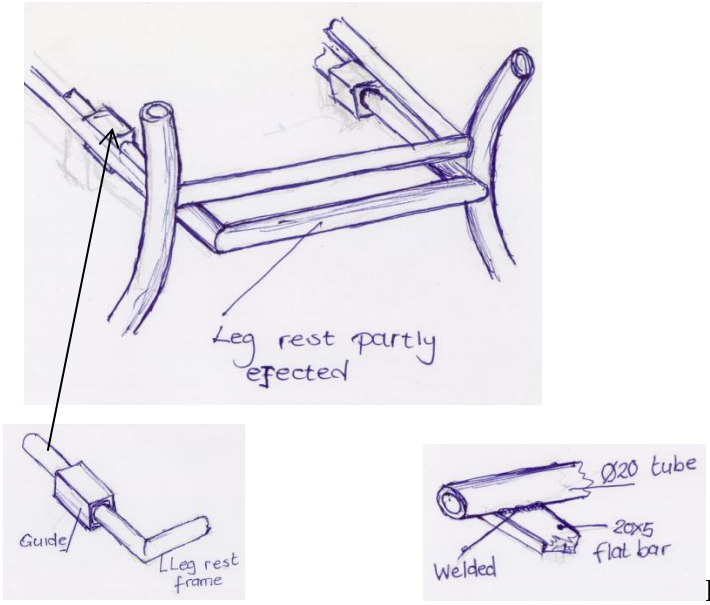


Figure 19: Webbing techniques used

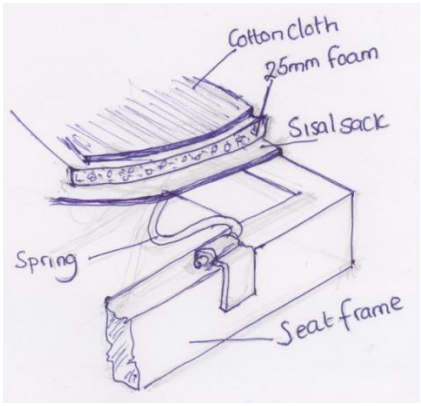


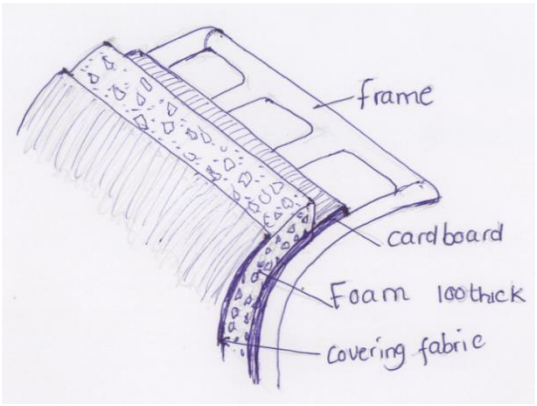
Leg rest design

Figure 20: Leg rest design

The diagram above shows the leg rest mechanism which is fitted under the chair frame in front. The guide is welded to the frame and allows the leg rest frame to slide through when operated.

Upholstery work





Upholstery work on seat *Upholstery work on arm rest*

Figure 21: Upholstery work

3.3.2. Other design considerations

The parameters considered in the design of this lounge suite include the following;

1. The Centre of gravity of the product when framing be appropriate to ensure no toppling over when back rest is pushed far back.
2. Welding to be expertly done to have a strong product ready for use by differently built users.
3. Joints to be cleaned off so that they do not tear off upholster padding.
4. As the frame is made from rods, the padding should be thick enough to eliminate discomfort as a result of the framing.
5. Put rubber shoes to the legs of the sofa to reduce the impact to the floor and to guard against slipping.

Chapter 4

4.0. Design calculations, results and discussion

4.1.1. Design calculations

The diameter of the rods used for the project is 16 mm.

Compression stress in the leg $= \frac{Appliedforce}{CrosssectionArea} = \frac{F}{A}$

Where area of a round bar is given by

$$A = \frac{\pi d^2}{4}$$

$A = \frac{3.142x16^2}{4}$ Area = 201.15 mm^2 $2.0115x10^{-4}$ $0.0002012\ m^2$

One single seater sofa used four (4), diameter 16mm, six metre long mild steel rods. The volume of a single rod is $\pi r^2 h$ 3.142×0.008^2 m x 6m $0.00121\ m^3$

But 4 rods are requires for this purpose, thus; 4 x 0.00121 $= 0.00483\ m^3$

Density of mild steel is 7850 kg/m^3

Therefore the mass M = density x volume

$M = 0.00483m^3$ x 7850 kg/m^3 = 37.9155kg = 37.92 kg

Expressed as a weight 37.92 kg x 9.81 371.995 372 N

Assuming that the person sitting on this chair has a mass of 70 kg and that all the body weight is on the chair, thus 70kg x 9.81 = 686.7 N

The total force then 372 N + 686.7 N = 1058.7 N

Therefore stress in the four legs will be 1058.7 N / (4 x 1. 0.0002012) m^2

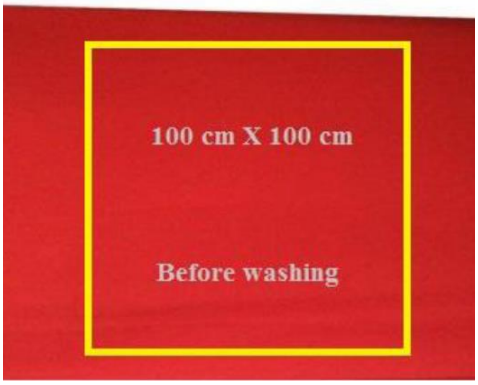
1 315 482.12N/m^2 1 315 482.12 Pa 1.32 MPa

Given the young modulus of mild steel is 207 000 MPa, then strain (τ) will be;

$\tau = \frac{\sigma}{E}$ $\tau = \frac{1.32MPa}{207000MPa}$ $= 6.38x10^{-6}$ = 0.00000638

Textile fabric has a common feature that it shrinks in wet processing. Shrinkage means the length of the fabric get shorten after wash. So prior to cutting fabric for bulk production, you must check its shrinkage percentage in washing. The shrinkage percentage needed to add to the production pattern. Otherwise you would not get garment of correct fit and measurement could not match the specification sheet.

To test the shrinkage rate you firstly prepare the wash test sample. This is done by cutting a piece of fabric specimen of 110 cm x 110 cm taking a sample from each lot. Then measure before washing and mark a square of 100 cm x 100 cm before wash measurement of fabric length and width. Use fabric marker to mark the fabric. Wash the specimen following dip wash or machine wash as needed following standard washing method to find the shrinkage percentage to washing. Dry the fabric specimen either using line dry or tumble dry as specified in test method as specified. Measure after washing



Lay the specimen on a flat table and remove creases but don't stretch the fabric. Measure the fabric length and width following marking points and note it.

For example, if the new length measurement is 95 cm and the new width measurement is 97 cm, the shrinkage percentage of specimen fabric is calculated using following formula;

Fabric Shrinkage % = (Length before washing - length after washing)*100/Length before washing.

$$Fabric\ shrinkage\ (\%) = \frac{Length\ before\ washing - length\ after\ washing}{length\ after\ washing} \text{ x } 100$$

Using data from the above example:

Fabric Shrinkage

Length wise $= \frac{100-95}{95}$ x 100 = 5.26 % = 5.3%

Width wise $= \frac{100-97}{97}$ x 100 = 3.09 = 3.1%

In some fabrics instead of fabric shrinkage you may get fabric growth in length wise or width wise or in both directions. This is known as fabric growth percentage which is calculated using the formula;

Fabric growth% = (Length after washing - length before washing) x 100 / Length before washing

If the fabric length increases after washing and the measurement after washing is 106 cm. Fabric growth percentage will be $= \frac{106-100}{100}$ x 100 = 6%

> *"Please remember to check shrinkage for the fabric you have chosen. If the fabric shrinks normally the natural fibre does shrink - please wash the fabric before cutting it. Some natural fibre fabrics can shrink up to 10% which makes a huge difference if the fabric is ever washed"* (Makkonen, 2014).

4.2. Discussion

4.2.1. Discuss results

Looking at the total force from both static and dynamic loads of 1058.7 N, the use of diameter 16 rods is sufficient to be used to make the frame of the lounge suite. Even when you look at the calculated stress of 1.32 MPa the material would overcome such stress. But because the rods provide a small surface area of contact with the floor, the ends of the legs will be fitted with rubber shoes to increase the contact surface areas.

Since this lounge suite is manually operated, it involves two operations; its work output will depend on the design of the lounge suite. The user will set the mechanism alone by stretching out

the hand and pull the leg rest in front just below the seat. To return it, the user will push the mechanism using the legs.

Improper lounge suite height will result in discomfort to the user. It is for this reason that this design is based on the standard measurements for lounge suites in terms of length, depth and height. Ergonomics data on lounge suites have been taken into consideration to enhance proper and comfortable sitting postures.

4.2.2. Review existing techniques

Lounge suite in Zambia are available in simple as well as complicated commercially made designs with prices for modern and imported ones ranging from K 25,000 to over K 30,000 while lounge suites will produce similar results choice of material finishing techniques, addition of other functions and the location of where it is bought from a source of prestige for many. This depends on the class of the people though others tend to break away from their class in to impress.

4.2.3. Effectiveness of lounge suite design

With the recent swell in the cost of lounge suites, the renewed interest in home and eco-friendly living with increased number of the urban area is discovering the use of lounge suite. Hence the requirement for the design of a lounge suite with the needs of people as presented by the one described in this paper. Also the mechanism part had problems due being a manually operated, else need to work on it.

4.2.4. Performance analysis

The lounge suite was tested by several people and me. It was able to work effectively though the mechanism was not running smoothly because there was no lubrication. The back rest were

adjusted to the required inclinations using chain and hook and this performed exceptionally well. When seated on the chair, the legs of lounge suite were sliding on the smooth concrete floor because of the spring type of the material for the frame. This was an indication that more railing was required underneath to make the product rigid.

Figure 22: Product testing

Chapter 5

5.0. Conclusion and recommendations

5.1. Conclusion

Self-reliance is a major driver of development and vibrant economy. The lounge suite has been designed to be fabricated with the use of locally available materials. It is simply bulky and the ergonomics consideration in the design would allow for its comfort in a sitting posture.

The lounge suite produced displayed several positive attributes such as;

- The choice of materials was good.
- The metal size was good as it did not add too much weight to the chair.
- The black coloured leather covering material was neutral looking and texture was good.
- The heights of the seat, backrest and arm rests were appropriate.
- The design of the frame looked elegant and made the chair quite executive.

On the other hand there were some negative attributes which were noted as follows;

- The covering of the arms was some-how not properly done as it did not get the shape as expected. The cushions too were loosely covered.
- The buckling of the frame when chair was seated on indicated some weakness on the railing.
- Mechanism for leg rest worked but with some little jamming sometimes.

5.2. Recommendation

To improve on the upholstery work, experience tailor is needed to do the sewing of the covering material .To eliminate the buckling of the frame when chair is seated on, rail have to be added to the under frame (in front and back) to make it rigid.

To eliminate the jamming of mechanisms, either use readymade runners from hardware shops or provide lubrication to fabricated ones.

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APPENDICES

Appendix A

Existing Chairs

Appendix B

Gantt chart

STAGES OF WORK TO BE DONE		S	O	N	D	J	F	M	A	M	J	J	A	S
Identification of thesis study topic														
Submission to supervisor for advice														
Preparation of a research proposal														
Existing ideas														
Research on resistant materials														
Designing the product														
Ideas														
Identification of mechanisms														
Testing mechanisms														
Design sketches														
Development of chosen idea														
Presentation drawings														
Working drawings														
Material lists														
Production planning														
Manufacturing														
Finishing														
Testing and evaluation														
Suggestions for improvement														
Preparation of PowerPoint and book														
Presentation of thesis														

Appendix C

Material requirements

S/N0	DESCRIPTION	LENGTH	WIDTH	THICK
1	Curved Arms	6.5m	Dia 20	Dia 20
2	Arm rails	5.5m	Dia 20	Dia 20
3	Seat rails	2m	Dia 20	Dia 20
4	Back frame	1.8 m	Dia 20	Dia 20
5	Back rest middle bars	6 m	Dia 20	Dia 20
6	Legs	0.2 m	Dia 20	Dia 20
7	Runners housings	0.6 m	Sq. 24	Sq. 24
8	Runner	1.6 m	Dia 20	Dia 20
9	Chain	0.2m		
10	Hook	0.2 m	Dia 16	Dia 16
11	Upholstery material	6.6m		
12	Foam	1.8 m	1200 mm	100mm
13	Paint	2 cans		

Appendix D

Costing

Description	**SIZE**	**TOTAL**
Curved Arms	6.5m	227.49
Arm rails	5.5m	195.00
Seat rails	2m	69.99
Back frame	1.8 m	63.00
Back rest bars	6 m	210
Legs	0.2 m	6.99
Runners housings	0.6 m	21.00
Runner	1.6 m	56.01
Chain	0.2m	30.00
Welding rods	15 kg	150.00
Upholstery material	36m	237.60
Foam	4	1400
Paint	2 cans	150
Fabrication labour		400.00
Upholstery labour		300.00
Rent a workshop		500.00
Transport to UNZA		150.00
TOTAL		**4167.08**

Appendix E

The product