Sankheda: Design Optimisation and Production

By Aswin S

156130017

Guided by

Prof. R Sandesh

IDC School of Design

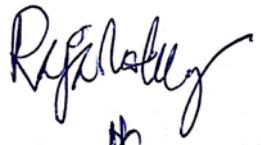
Indian Institute of Technology Bombay

2017

Approval

This project titled "Sankheda – Design optimisation and production" is prepared and submitted by 'Aswin S' in partial fulfilment of the requirement for the degree of 'Masters in Design' in Industrial Design. It has been examined and is recommended for approval and acceptance.

Guide



Chairman

Internal Examiner

External Examiner

Declaration

The work done as a part of the written submission under this report **"Sankheda – Design Optimisation and Production"** is done as project three for post graduate program in Industrial Design Centre, IIT Bombay, India under the guidance of Prof. R. Sandesh.

I hereby declare all the content of this project is an original work with appropriate reference information or links provided wherever due. Any violation of the above will be cause for disciplinary action by the institute.

Aswin S

156130017

Industrial Design Centre

Indian Institute of Technology, Bombay

Acknowledgement

I thank Prof. R. Sandesh who gave valuable guidance throughout the project. I thank Prof. Sreekumar, Head of the Department, IDC for allowing me to work on the project. I also thank Prof. Purba Joshi, Course Coordinator, for the excellent workflow of the project.

A humble thanks to All Product Design faculty, Prof. B. K Chakravarty, Prof. V Bapat, Prof. G.G.Ray , Prof. R. Sandesh, and Prof. Kumaresan and Prof. U Athvankar, Prof. Purba Joshi for their guidance and feedback during the process.

Thanks to Duttaram for the valuable mentoring throughout the project. Thanks to all craftsmen at Sankheda who interacted with me during the field visits. Thanks to all staff in IDC who helped me in carrying out the project.

Thanks to my parents who have been a great mental support, by pushing me further at every milestone. Thanks to all friends in IDC for their support throughout the journey. Many thanks to Noa for all the help and support.

Abstract

Sankheda is a village in Gujarat located in Chhota Udaipur district renowned for its turned wood furniture crafts. The craftsmen of Sankheda follow the traditional working postures in most of their activities adapted to their indigenous machinery and process of manufacturing. Task analysis and interviews with craftsmen reveals the need to design and optimise their workplace for better productivity and health benefits. This project aims at designing a workstation for the craftsmen focusing on reducing drudgery in their work environment and optimising the production process. The final concept can be extended to allied work environments to impart similar benefits.

Contents

Introduction

Sankheda Furniture is a traditionally evolved range of furniture made out of teak wood and finished in a wide variety of colour combinations. The town of Sankheda in Chhota Udaipur district is known for its handcrafted furniture, which is made from teak wood. This furniture is exported to countries all over the world. Sankheda derived its name from 'Sankhedu' the name for lathe in Guajarati language.

Wood turning involves the use of lathe on which a rapidly rotating piece of wood is shaped with a chisel to create cylinders, spheres or cones. The beauty of this craft lies in painting the smooth wooden shapes. Usually, the turned piece is coated with coloured lacquer. But this has changed in recent years and varying colours started to emerge in their products. Today, lacquer ware production has diversified in response to changing markets. It now includes jewellery, decorative pieces, household utility articles and educational articles such as skipping rope handles, chess sets, pen holders, paper weights and rubber stamp holders.

There are many other lac based traditional craft communities in India like the Chanappattana toys of Karnataka and Etikoppakka toys of Andra Pradesh. The softwood lacquer ware toy business is on verge of closure due to government apathy, stringent export norms and rising input costs. The European Union, Australia and the US demand for certifications and ecofriendly compliance markings on this craft.

Meanwhile the Sankheda furniture is exported to different parts of the world. The present market has shown a diminishing value for this furniture due to many reasons. The Sankheda craftsmanship is not restricted to making household furniture. A whole range of decorative artefacts from wall-hangings, pedestal lamps, flower vases and pen stands to beautiful toys, rolling pin for the kitchen and supports for hammocks are produced from the village.

LOCATION

Sankheda is located in Chhota Udepur district of Gujarat, which was created in 2013. It is located 55 km away from Vadodara. The neighbouring towns are Dabhoi (21 km), Bodeli (21 km) and Waghodia (27 km). Sankheda village lies on the banks of the Orsang River which separates it from the nearby Bahadurpur village.

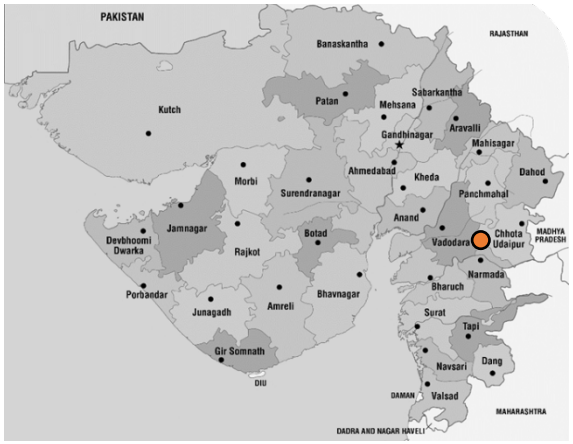


Figure 1

ACCESSIBILITY AND TRANSPORT

Sankheda village is connected to nearby villages and towns primarily by road. It is 1 Km away from Bahadurpur Village near to which the closest local train station is located, which is Sankheda -Bahadurpur Railway Station. The village square has a bus terminal as well as a shared auto stand which takes care of the primary commute to and from the village.

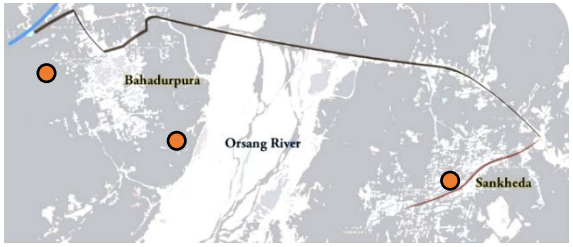


Figure 2

The nearest City Vadodara has fairly good connectivity with the village by means of roadways and railways. From Vadodara bus terminal, State transport buses are available at average intervals of an hour which is headed to this village and nearby areas. Presently, there are 4 trains connecting Vadodara and Chhota Udepur, two each in the morning and evening which has stops at Sankheda Bahadurpur Station.

The local station has shared auto service to Sankheda and Bahadurpur villages. There are no local buses or taxi services in the village. The travel time from Vadodara Station to Sankheda- Bahadurpur station is approximately 1.5 hrs and from the station to the village is approximately 15minutes.

SANKHEDA

Sankheda is a town presently under gradual development. People belong to both extremes in terms of wealth as well as formal education. There are families living in huts without basic necessities to houses with good living conditions. Majority of the families are involved in some business which is evident from the streets of the town.

Development of this town comes from a huge contribution made by Dr. Jethalal K. Parikh, who worked really hard to provide good education and employment to the local community. There are schools and hospitals named after his wife. The local community appreciates his efforts to develop the town. A road was named after him, and there is a statue of him at the entrance to the town. Shri Bhikhubhai Shah, who was a freedom fighter and a lawyer, donated agricultural land in the "Bhumidan Movement" by Vinoba Bhave.

(https://en.wikipedia.org/wiki/Sankheda)

Figure 3

There are different communities inside the village who follows their traditional jobs passed on through generations. The main one of these is the Kharadi Suthar community who make wooden furniture.

There are many public buildings in the town. They include the Sankheda Taluk Office, Sankheda Hospital, Arts College, Public and Private Schools, ITI etc. The town square can be identified by the village gateway that opens to the main Street. The town has many new buildings and shops coming up catering to the necessities of the growing population. The market and the main rickshaw stand also lie near the town square.

Figure 4

Figure 5

Figure 6

PEOPLE AND CULTURE

The language spoken varies from local, charotari, Surti, Kathiyawadi and Kutchi in the Sankheda region. The People wear mostly dhotis, kurtas, bandis. They wear traditional outfits during cultural festivals. Majority of the community people are pure vegetarians. Mainly, the diet consists of dal, roti, rice, vegetables followed by Chaas and sweets.

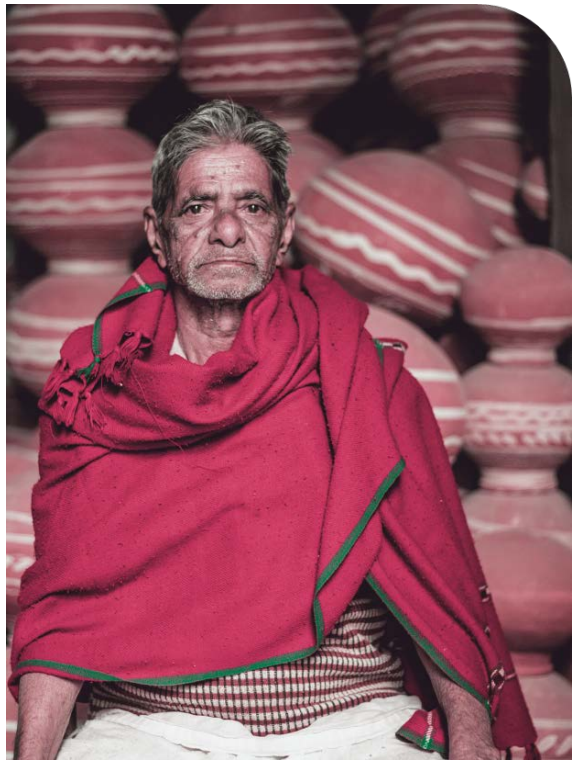


Figure 7

Figure 8

Figure 9

Figure 10


PAINTS
PAINTS

Primary Study

SANKHEDA FURNITURE

To orthodox Guajaratis, Sankheda furniture is considered auspicious and is used in many religious and festive occasions. From being used as sacred pedestals for God's idols in temples and as chairs for the bride and groom in weddings, to cradles and walkers for infants and garden swings that give a fresh touch of breeze in the hot and humid climate, the Sankheda furniture is adopted and loved in its various usages. Erstwhile Gujarati royalty have in the past gifted it to royalty and state-heads of other countries.

HISTORY

According to historical records this type of furniture was reported in the 17th century by George Rocques, a French writer and James Forbes, a British civil servant. At that time teak wood used to make this furniture was transported from Valsad and painted with indigenous colours. The product was then exported from Surat and Khambhat ports.

According to the legend of the saint from Champaner, The holy man, escaping Mughal invaders, had taken refuge in the hut of a lowly wood-cutter in the village. The latter looked after the saint for 110 long years and then, suddenly lost sight of him one day. That very night, as the legend goes, the wood-cutter saw his guest blessing him in his dream and making him a skilled carpenter. Overnight, the man became a gifted craftsman, carving out furniture with the characteristic lacquer coating.

Sankheda furniture is thought to have been produced here from about 1855. 'Ghodiyun'(child's cradle) is believed to be one of the first furniture items produced using this form of expression. It is a prized possession in Gujarati families, and is passed down through the generations as an heirloom.

THE SHIFT

The industry is totally dependent on forests for the primary raw materials. These forest-based products are the wood of the hale tree (or other species like teak, oak, ebony, redwood, rosewood, red cedar, pine, etc.), lac produced by the insect Technadria lacca and the leaves of the talegiri (Pandanus odoratissimus). Synthetic materials used are paints and pigments. Lithophone (compound of barium sulphate and zinc sulphide) is used to give opaqueness to the lac.

For close to four centuries, this cluster which makes Sankheda Furniture has been producing some exquisitely crafted chairs and tables in just two colours — maroon and gold. But today, except for two clusters of houses, Sankheda does not produce such furniture. And the families engaged in keeping this age-old tradition alive have long surrendered to market pressures and are more concerned with "made to order" and "melamine finish" pieces, than retaining the purity of their art.

In effect, Sankheda furniture is now available in a variety of colours from black, blue and green to the currently popular ivory, copper, silver and burgundy. These 'new colours' may not be as durable as the traditional maroon and gold, but with demand for them mounting, nobody seems to complain.

(http://www.tribuneindia.com/2002/20020302/windows/main4.htm)

THE SYSTEM

The Sankheda craftsmen belong to the Kharadi community which still caters to its traditional customers in designing furniture for rituals, weddings and celebrations. The younger generation of craftsmen has a pulse on the commercial requirement of the market and is

producing a variety of furniture for the urban needs and specifics.

For the craftsmen, Sankheda is their bread and butter. About 24 out of the 50 0dd families involved in this craft are doing business while others do labour based on contract. 12 out this whole community can perform all the works involved in the furniture making process and are considered as master craftsmen. Besides workshops, there are display showrooms as wells as furniture outlets along the Sutharwaga. They make use of the infrastructure that has been in existence since many years.

(http://gaatha.com/sankheda-furniture/)

THE CLUSTER

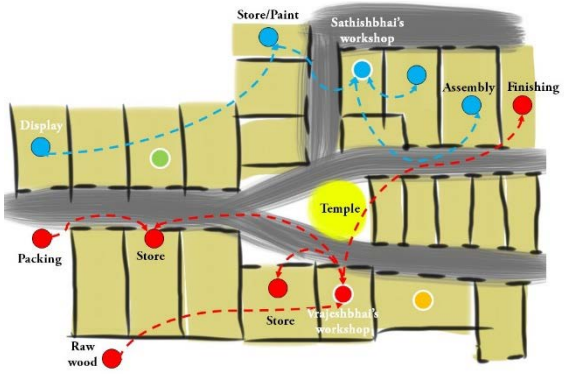


Figure 11

The families who do entrepreneurship make sure they help other families by distributing work and thus obtain good wages. Rs.200/- per day is the minimum wage provided to craftsmen and it increases to Rs. 250/- depending on the quality of work.

This is one of the positive outlooks of the community as it has positive interaction between its families.

WORK CULTURE

The workspaces in Sankheda are essentially their houses itself in which the ground floor space is converted into a suitable work environment. This is also the case of all businesses that run along the streets. In case of furniture manufacturing, people use the room adjacent to street as the main work area as natural light is abundant.

The daily activities at the homes are directly linked with the activities in the workshop as craftsmen may eat, drink, and discuss family matters as the work progresses.

WORK SHOP

Since craftsmen work in their houses, the workshop is their identity as well as their homes. The ground floor is used for working whereas the first floor is where they do other activities. Some homes have kitchen also in the ground floor. The workspace varies greatly in their layout primarily because of the space available and then because of the work flow.

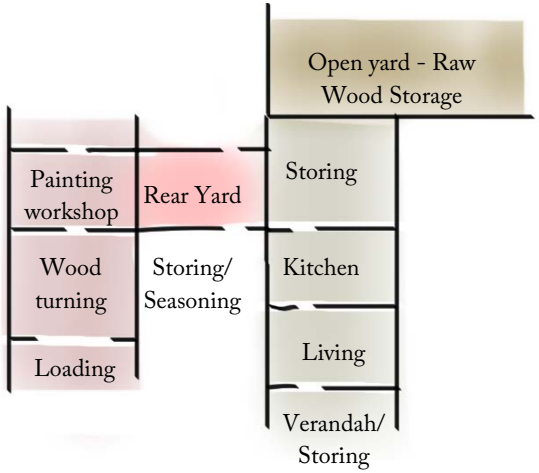


Figure 12

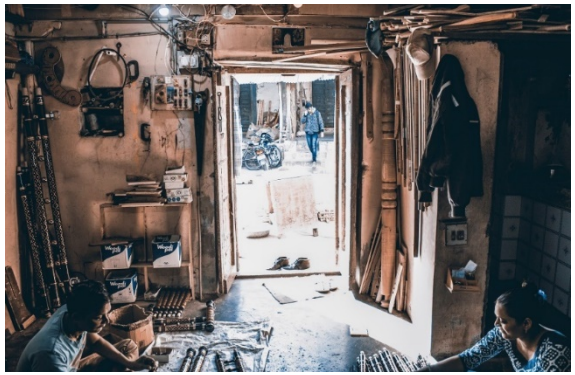


Figure 13

Most of the workshops have lathes in the front room. The verandah is used for loading and unloading wood from the vehicles. Circular saw table is kept outside the building. Chiselled wood is brought into the workshop from the main storage as per requirement. These are stored in upper shelves. Wall shelves are used to store tools and other accessories.

Some have modified the indigenous lathes and circular saw work table according to their convenience. Some have also modified their tools and joineries for ease of use. The two figures below illustrate the layout of two workspaces.

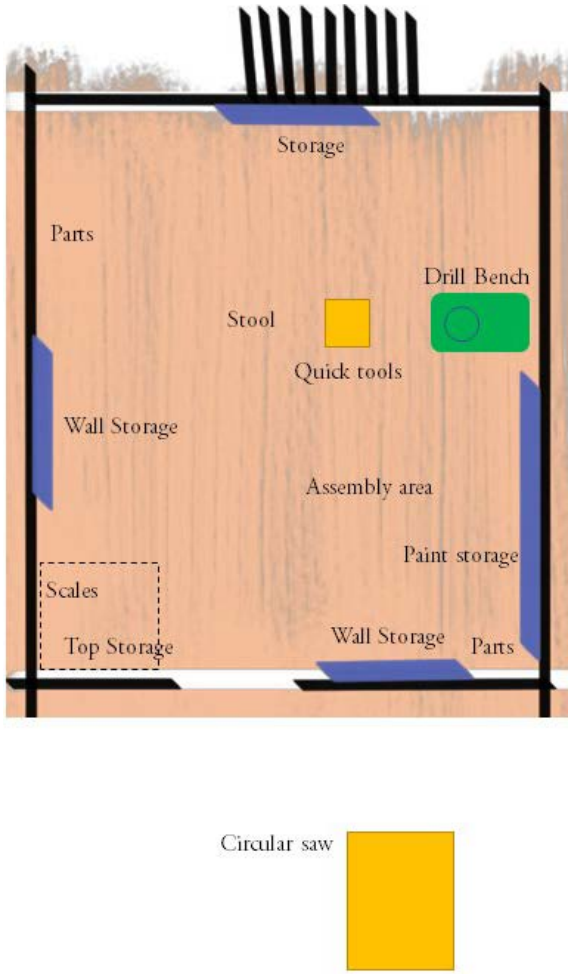


Figure 14

Figure 15

CRAFTSMEN

Both men and women take part in the making of the craft. The children gradually learn the process as they take part in smaller activities of the process. Some craftsmen are capable of all the tasks in the process and are considered master craftsmen.

Figure 16

Figure 17

They work according to the amount of work they have. Sometimes it will be as late as 1 O Clock in the night. These days, they give lot of importance to education and hence send their children to schools as well as higher education. The younger generation also take up other jobs along with helping their parents in making the craft.

SANKHEDA SYSTEM

Interviews were conducted with craftsmen to understand the current scenario in the furniture market as well as in the community level. Few important issues were brought into picture regarding the current situation in market as well as the value of the product.

- Diminishing value of the product.
- Lack of execution of government plans
- Lack of unity among families in support for implementation of actions
- Products compromising quality under business pressure
- Confusion among Customers due to varying costs
- Lack of labourers and their wages
- Practicality in implementing new designs
- Lack of formal education

PRODUCTS

Swings, Pedestal for use in temples, God's sacred pedestal, Chairs for bride & groom in wedding, Garden swings, Jhoolas, Sofa set, Deewan set, Dining Table, Corner Table, Wedding Mandaps, dressing tables

Miscellaneous products include: Mirror Box, Bangle stand, Photo frames, Tops, Toys, Flower vase, dolls. The cradle is considered as the first as well as the prominent of all the products. Pedestal is also considered as one of the important products as it is made and bought in large quantities.

Figure 18

Figure 19

Figure 20

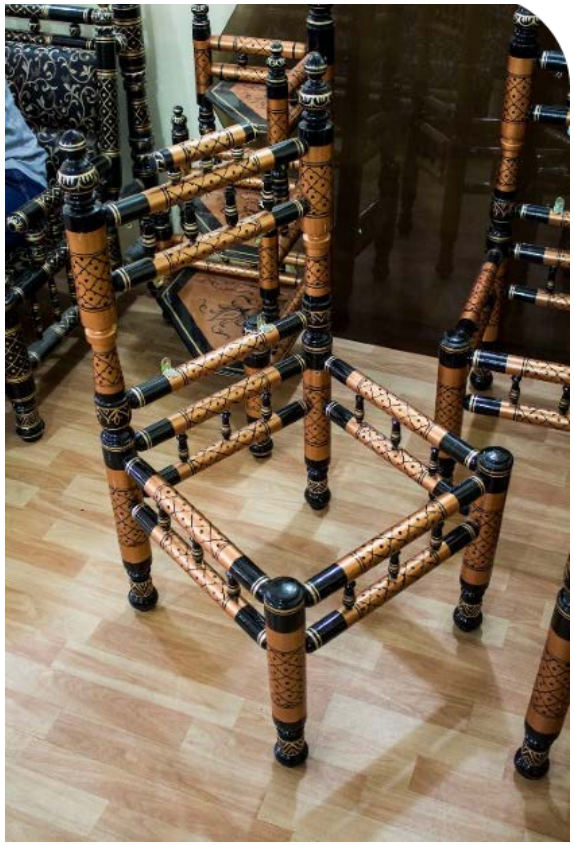


Figure 21

Figure 22

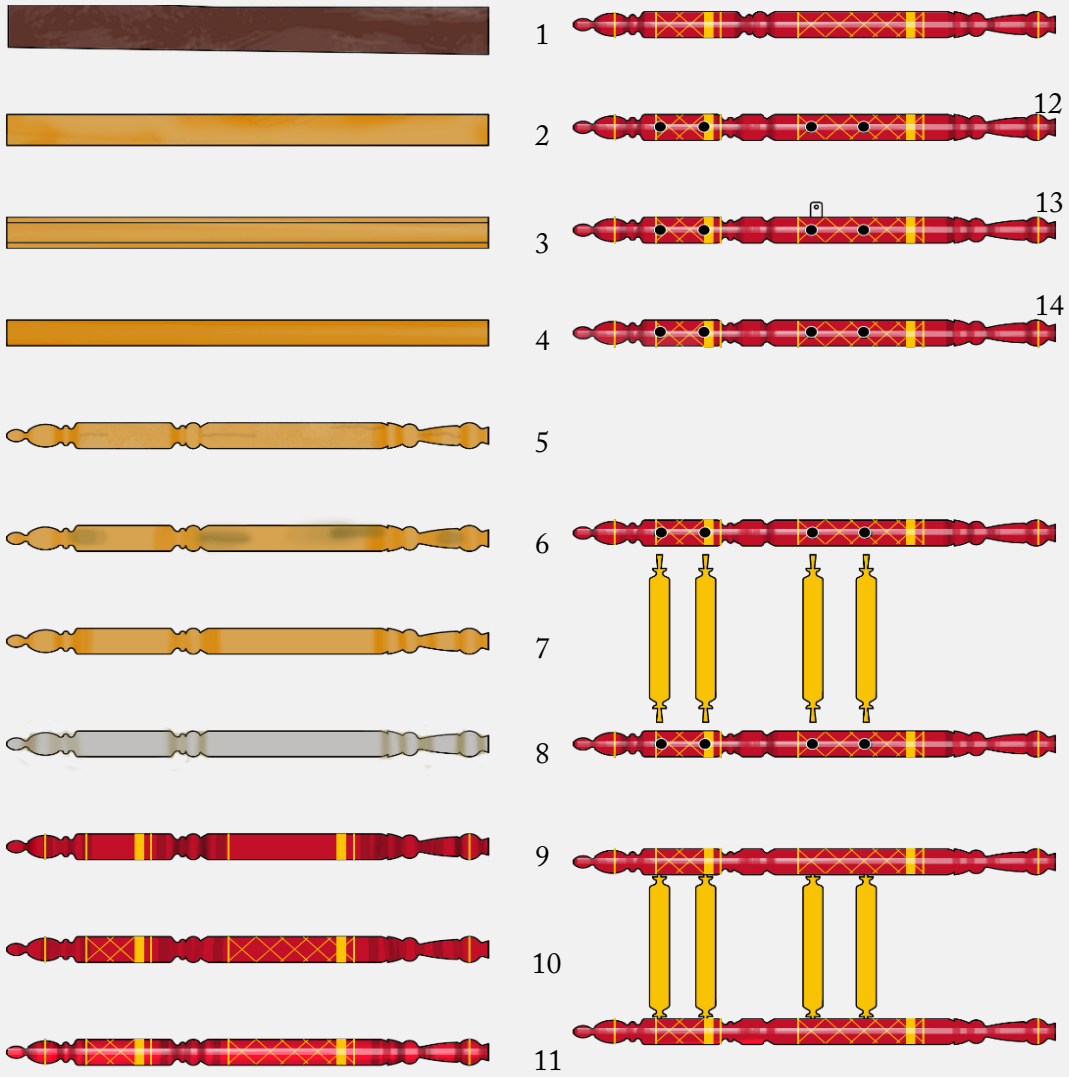
Figure 23

Figure 24

Figure 25

Figure 26

PROCESS



1) Raw wood
2) Making Square Profile
3) Making Octagonal profile
4) Turning
5) Carving
6) Finishing with saw powder
7) Sanding or Smoothening
8) Applying putty
9) Painting with broad brush
10) Painting with fine brush
11) Applying melamine
12) Drilling large holes
13) Fixing clamps
14) Applying glue

a) Wood Cutting

Figure 27

b) Wood Turning

Figure 28

c) Wood Carving

Figure 29

d) Sanding

Figure 30

e) Finishing with wood powder

Figure 31

f) Applying Putty

Figure 32

g) Painting using flat brush

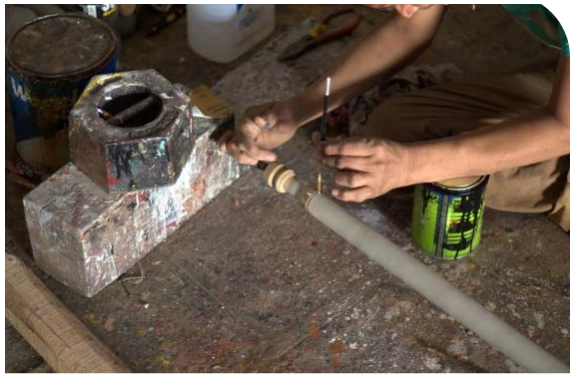


Figure 33

h) Painting pattern

Figure 34

i) Wood Chiselling

Figure 35

j) Drilling

Figure 36

k) Fixing Clamps

Figure 37

l) Drilling large holes

Figure 38

m) Applying glue

Figure 39

n) Hammering

Figure 40

The teak wood pieces are cut as per requirement from the saw mill or using the circular saw. The wood is then chiselled on the edges to assist in ease of lathe work. These wooden blocks are further stacked according to their respective sizes. These pieces are stored in the store area and later taken accordingly by the requirement to the workplace.

The teakwood is first turned into circular profile of required dimension. Then it is carved into respective designs for the furniture. The turned pieces are then finished for the rough wooden burrs, gaps and holes. These gaps are filled with wood dust mixed with adhesives. Then sand paper is applied on these parts to get a smooth finish.

Putty is applied as the next layer to support the paint.

The finished wooden parts are given base paint layer in a variety of combinations. This is done by application of paint by placing the component on a lathe & rotating it while holding a brush dipped in paint.

Various line patterns are created on the earlier parts by holding the brush tip against the rotating turned pieces. The painting varies from geographical shapes to traditional motifs.

Flat parts are made using plywood sheets stacked and glued, later finished to paint. Ornamental Sankheda designs are crafted on the pieces. A wide variety of standard patterns are marked and cut on these plywood sheets. These are fixed on to the furniture to make interesting symmetrical patterns or unique elements on the furniture

All these stages of work are spread among different families in the community.

RAW MATERIALS

Figure 41

Figure 42

a) Wood

Wood is the primary raw material in Sankheda furniture. Teak is specifically used for making Sankheda furniture. Wood is obtained from government licensed dealers who sells it to the manufacturers or mills. These are of varying profiles. The manufacturers buy wood in large quantities and store in their storing yard. Wood is chosen based on the products manufactured which vary widely in their dimensions.

Wood is obtained as per the size of the order, the manufacturer provided the quantity of wood to be cut to the saw mill. Wood is cut into specified dimensions and then edges are chiselled to make it easy for turning. These are stored in the saw mill and further transported to the manufacturer.

b) Plywood

Plywood is used for different products with varying thickness to make flat parts as well as decorative elements.

c) Foam and Textile

Foam is used to make cushions for sofas and chairs.

d) Epoxy adhesives

Adhesives are used to fix parts of furniture as well as other crafts during assembly. It is used along with wood powder for finishing purpose also.

e) Primer and Paint

Putty is used to give smooth surface to the turned wood parts as well as cut plywood surfaces. These are applied using flat brushes and lathe.

TOOLS AND MACHINERY

The craftwork done in Sankheda makes use of machine and hand coordination. Study of the workshop condition was done to understand the different tools used and machineries which take part in the production process

a) Hand Tools

Different types of hand tools are used to process the wood to the final stage. Chisels, Gouges, Hammers, awl and snappers are some of them. Gouges are of three types – Sharp, flat and the curved. Compass is used for measuring radius of the turned wood. Hammer is used for beating and nailing. Sand paper is used for finishing purposes. Chisels and mallets are used while assembling. These tools have longer handles for more leverage, needed to counteract the tendency of the tool to react to the downward force of the spinning wood being cut or carved.

Figure 43

Figure 44

Figure 45

b) Machines

Power Lathe

Lathes are used in Sankheda furniture for wood turning and painting of the turned part.

Increasing market for turned wood products led to the introduction of motor driven lathes in Sankheda. The power lathe is fixed at one end (the headstock) and the other end can be adjusted by shifting the wooden base block. These are connected by a tie member with a sliding lock. The wooden member rotates around a spindle.

The lathe machines are floor based and are unique in that they have no moving parts. The crafts people sit on a low cushioned seat and use both hands and feet when working on the lathe. The motors are placed on as tone pedestal at height of approximately a meter. The motor turns a rope which through a system of pulleys directly turns the wooden member. The tension on the rope is maintained by a system of counter weights. The motor has a stepped pulley which is rarely used.

Similar lathes are also used for painting which is again of varying sizes. Some are motorised while others are manual. Flat and small brushes are held against the wooden part to finish.

Figure 46

Figure 47

Table Saw

Table saw is primarily used in cutting smaller turned parts from a long turned part. It is also used to create cuts on turned parts to fix joineries. It is also used to cut the edges of square wood logs to make it easy for wood turning. It basically consists of a standard 10" saw blade attached to rotating shaft fixed below the table top. Few cutting work stations also have an extendable top which can be folded up to support longer work pieces.

Figure 48

Figure 49

Drill bench

It is used to make large and small holes on the turned wood parts to assist in assembly of furniture. Hand held drill machines are also used in assembly process with the help of bits and chucks of various sizes.

Figure 50

Situation Analysis

PROJECT DIRECTION

An initial idea was put forward to design and develop the work environment of the craftsmen. Thus the work environment comprising their activities, postures and workstations were studied to arrive at practical design opportunities.

ACTIVITY PLOTTING

An activity analysis was done to understand and standardise the workflow in the manufacture of furniture. Classification of work was done on the basis of following parameters:

- Activity
- Tool/ Workstation
- Posture
- Type of Work

These were compared with each other based on the average time taken. Since the time taken can vary with the product or the work piece, a 3 feet long work piece which is part of a dining chair is considered for comparison.

Constraints

Since Sankheda furniture involved multiple work clusters and associated designs, a standard was to be achieved in comparing the activities.

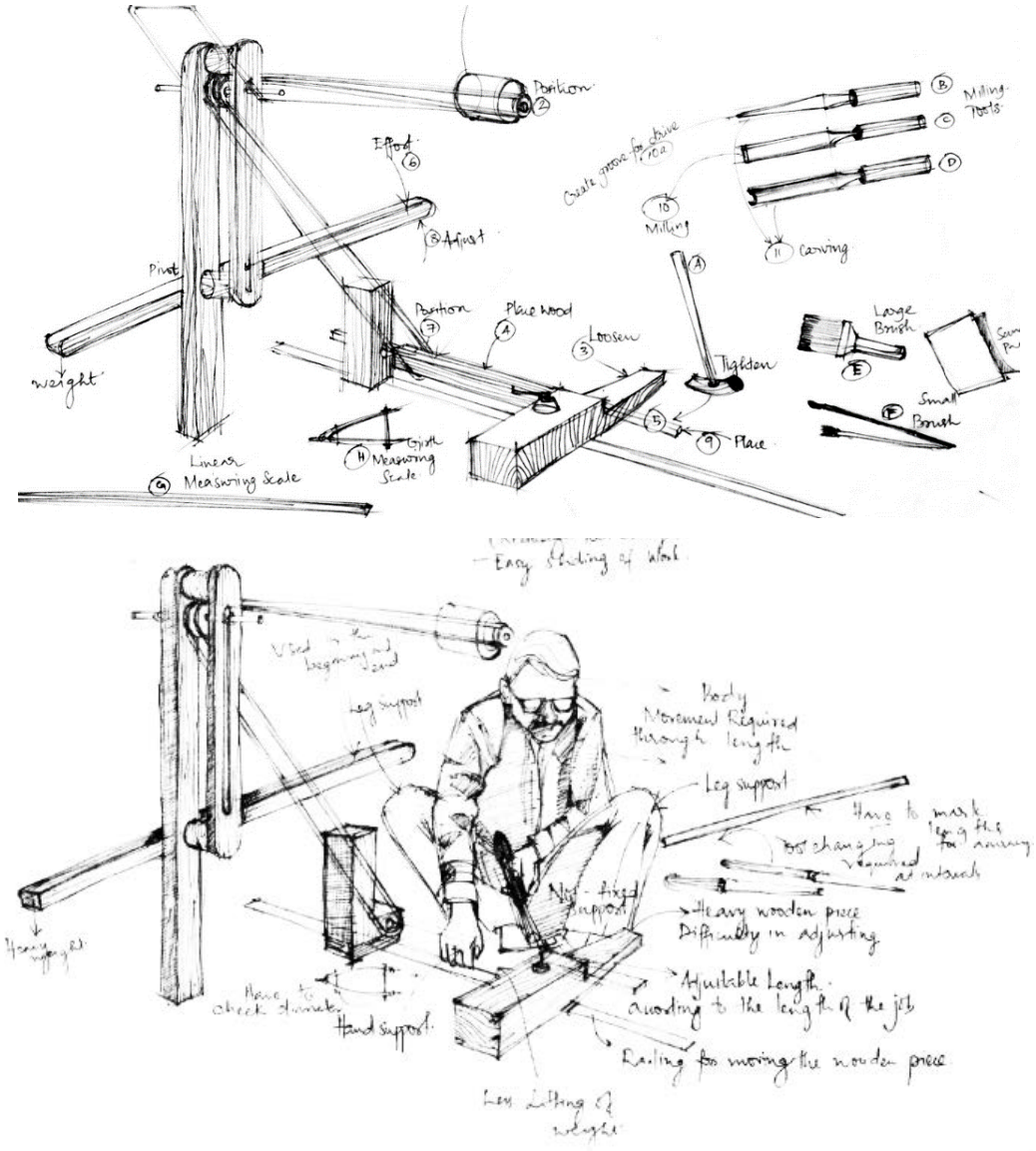
- The study is aimed at all furniture which constitutes only turning of wood, thus eliminating the design which adds plywood parts and decorative elements. This also helps to focus the project only on wood turning and thus reduce the scope of the project.
- Furniture parts that constitute foam and textile are not used for the study as the process becomes more complex. Here also it helps to streamline the scope to just turned wood parts in furniture making.
- All these activities are meant for a single person even though multiple persons might involve in supporting the task.

The table below shows the activities involved in turned wood furniture making process in Sankheda. The time taken here can vary with the craftsman or the working condition and should be considered as a close depiction of the real situation.

Furniture Type 1						
No	Process	Activity	Tool/Workstation	Posture	Type	Average Time
Making of Parts						
1	Wood Working	Wood Cutting	**Circular Saw**	Standing	Repeating	6 min/ job
					Non- precise	
2		Wood Turning	**Lathe**	Sitting	Repeating	9 min/ job
			Chisel		Non- precise	
3		Wood Carving	**Lathe**	Sitting	Repeating	7 min/ job
			Chisel		Non- precise	
4	Finishing	Sanding	**Lathe**	Sitting	Repeating	10 min/job
			Sand Paper		Non- precise	
5		Applying Putty	**Lathe**	Sitting	Repeating	7 min/job
			Brush		Non- precise	
6		Painting	**Lathe**	Sitting	Repeating	7 min/ job
			Flat Brushes		Non- precise	
7		Painting	**Lathe**	Sitting	Repeating	3 min/ job
			Thin Brushes		Moderately precise	
8		Painting	**Manual**	Sitting	Repeating	30 min/ job
			Thin Brushes		Precise	

Assembly of Furniture						
9	Fixtures	Wood Chiselling	**Circular saw**	Standing	Non-Repeating	1min
					Precise	
10		Drilling	Drilling machine	Sitting	Non-Repeating	2min
					Moderately precise	
11		Fixing Metal Clamp	Hammer	Sitting	Non-Repeating	2min
					Non- precise	
12	Joining	Edge Finishing	Chisel	Sitting	Non-Repeating	1min
					Non- precise	
13		Drilling Large holes	**Drill Bench**	Standing	Non-Repeating	2min
			Stool		Non- precise	
14		Applying Glue	Stick	Sitting	Non-Repeating	1min
					Non- precise	
15		Hammering	Mallet	Sitting	Non-Repeating	1min
					Non- precise	

Table 1



Wood turning - Step by step actions

1. Switching on the power.
2. Positioning the belt on to the driving pulley of the motor.
3. Loosen the tail stock by unscrewing it from the bottom guide
4. Move it by hitting using the hammer.
5. Place the wood in between the mandrel.
6. Tighten the tailstock using hammer and align the wood piece.
7. Tighten the screw to fix the position of the tail stock.
8. Push the handle to loosen the belt.
9. Position the belt on an appropriate position on the wood.
10. Position the tool rest on both ends of lathe
11. Create a pulley on the wood piece to position the rope (belt)
12. Position the rope.
13. Turn the wood piece (Involves multiple change of chisels)
14. Push the handle to loosen the belt and stop turning.

TAKEAWAY

After studying the work culture of the craftsmen and the process of making furniture using turned wood, an activity analysis was done to identify the different patterns in the process.

It was understood that majority of the time in the process is used in manual work using hand tools as well as lathe. Most of this is done by sitting on the floor, but in varying postures.

It was inferred that most work done in lathe are repetitive tasks like wood turning, finishing, painting etc.

Machines like Saw and Drill bench are used mostly during assembly and help in changing the continuous sitting posture.

To understand why craftsmen use these basic postures during working, the advantages and drawbacks of the existing tools, machinery and environment were identified

ADVANTAGES OF CURRENT SYSTEM

- Working on the floor helps the craftsmen with lot of space in circulation as well as in storing the unfinished and finished parts. The parts spread over the floor makes it easy for assembling.
- Existing lathe is designed to work by sitting and all tools are designed for working in the same posture.
- Frequent used tools are kept on the floor and are accessible quickly.
- Indigenous methods of working and modification of parts for ease of use.
- Working on floor helps by reduction in lifting of weight of parts to be made.

DRAWBACKS OF CURRENT SYSTEM

- Lack of storage spaces of tools to be quickly used.
- Lack of proper seating.
- Lack of awareness of possible health consequences due to bad posture.
- Drudgery in work associated to repetitive tasks especially lathe.
- Less area for support in performing tasks in lathe.
- Heavy wooden parts
- Multiple tools used and frequent change of tools of milling and carving
- Exposed sharp parts of Circular saw
- Improper wiring and electrical fixtures of Circular saw

USER STUDY

Figure 51

Interviews were done with the craftsmen to understand their issues in the workshops. Health issues were found in relatively older craftsmen.

Figure 52

Most of the lathes are positioned in such a way that it is away from the wall making it difficult for using wall as back rest. One person said he used to work continuously for an hour or two and then lean on to the wall, raising his legs on to the pedestal he uses to perform the work. Every now and then they stop the work or get up and perform some other task. This is one reason which affects the productivity.

Precision works are another area where the craftsmen need relatively more support for working. This includes painting pattern using fine brush on flat or round wooden parts. They use small stools for raising the work for better precision. But staying in these difficult postures creates pain in their body.

PROBLEM IDENTIFICATION

- Drudgery in work environment
- Storage in work environment
- Usability of existing work stations
- Storing of existing tools
- Safety in workstations

After identifying the problems in the work environment, various design opportunities were identified to take forward the project, which included system design as well as product design options.

DESIGN OPPORTUNITIES

Considering the initial system study and further the process study, two areas were understood as areas of design opportunity.

a) System design:

- Design of a system to improve demand of the crafts in Sankheda.

b) Product design:

- Workstation design: Design for craftsmen to increase productivity and reduce drudgery in work environment.
- Furniture design: Design to evolve according to current trends in market.

Due to lack of awareness among craftsmen, a system design which changes the entire workflow of the manufacturing process is not feasible in the current scenario as it will disrupt the social and economical system too. The infrastructure to be provided has also to be designed which is out of scope of the project.

After discussions with guide, it was decided to work on the productivity issues in the work environment and develop a new workstation design for the craftsmen. This was based on the feasibility of the project and the availability of time for project.

PROJECT LIMITATIONS

- Again due to lack of awareness on health issues related to musculo-skeletal disorders, a new design of work station may or may not be acceptable to the craftsmen, as they have been using the current system for many years and might

Design Brief

Design of workstation for Sankheda craftsmen to reduce drudgery in work environment by ergonomic and user friendly optimisation of wood turning, painting and assembly in manufacture. This initiative can lead to standardised, ergonomic and production friendly workstations for allied turned wood crafts and other production units

FUNCTIONAL REQUIREMENTS

a) Primary Functions

There are primarily two functions for a workplace in the process of crafts making. They are:

i. Assist craftsmen in the manufacture of furniture parts – The furniture parts in Sankheda are made of wood as well as plywood. Both are cut to required sizes. Wooden parts undergo turning before proceeding to the finishing and painting steps. Plywood parts are cut in required shapes out of large sheets and then finished.

ii. Assist craftsman in the assembly of furniture – This involves crafting of details in the finished parts and fixing them with appropriate joinery details and glue. Holes are either drilled or chiselled out in turned wood parts.

b) Secondary functions

iii. Storage of tools – There are multiple tools associated with the different processes involved in making of parts and assembly.

iv. Storage of Accessories – These include nails, clamps and similar metal parts which are used in assembly.

v. Storage of material – Paint and glue has to be stored as well as used during the manufacturing process.

c) Other functions

vi. Provision for storing personal items like phone as well as tea cups can enhance the usability of the workplace.

PRIMARY OBJECTIVES

- The design should be ergonomic
- The design should accommodate existing machinery
- The design should increase productivity

SECONDARY OBJECTIVES

- The design should suit existing wok environment.
- The design may be extended to other similar crafts or work.

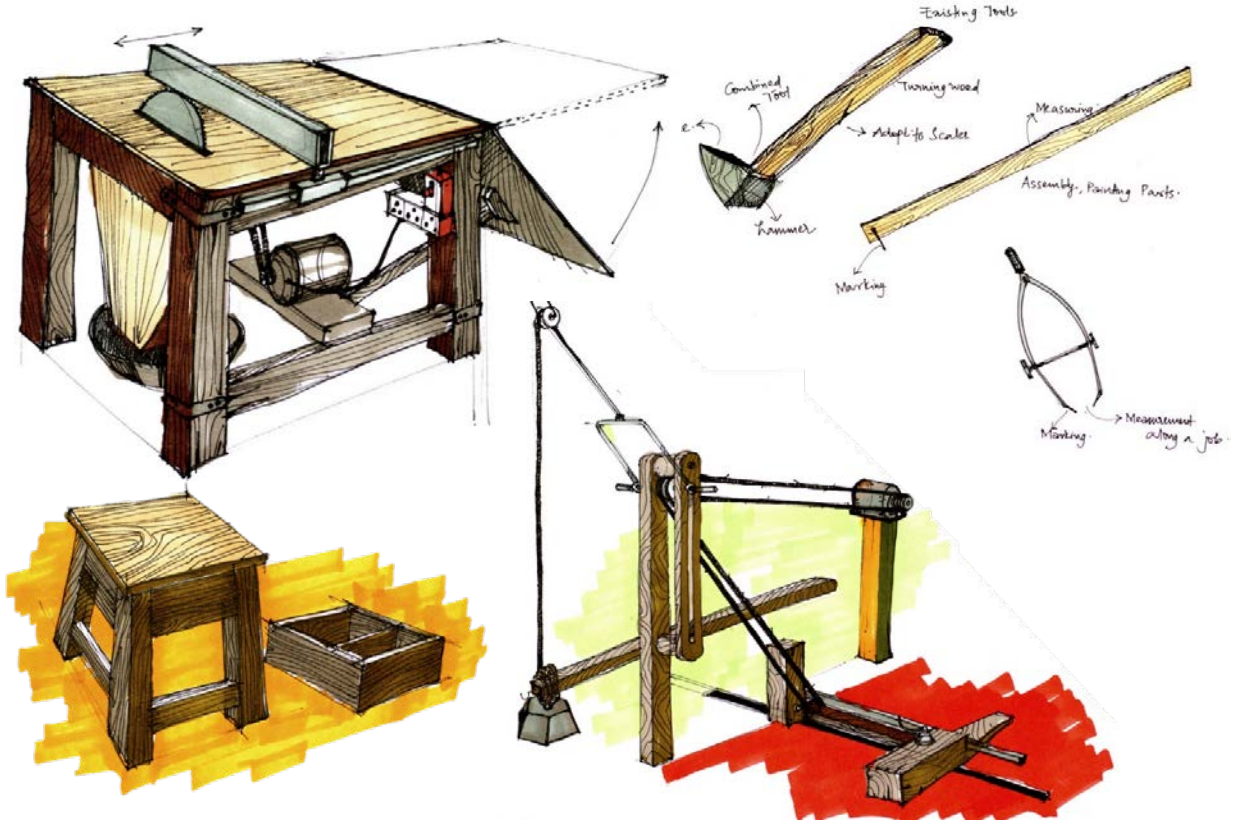
DESIGN CONSTRAINTS

- Non-standardized existing work environment.
- Non-standardized tools and machinery used by craftsmen.
- Varying designs and multiple products under Sankheda.
- Modification of existing machinery may not be feasible.

PROJECT SCOPE

- Considering time allotted for the project, the type of products as the output of the design had to be limited. Hence only turned wood parts are primarily taken into consideration for the design of workplace. The design at a later stage may or may not evolve to accommodate all types of products.
-

EXISTING WORKSTATIONS



The illustration represents the existing workstations used by the craftsmen. The main machinery to be accommodated is:

1. Table saw
2. Lathe
3. Drill bench

Tools used:

1. Chisels
2. Wooden mallet
3. Spring divider
4. Measuring scales
5. Painting brush
6. Markers
7. Metal hammer
8. Screw driver
9. Hand drilling machine
10. Wrenches

Accessories used:

- Drill bits of varying sizes
- Nails and screws
- Clamps
- Central bolts
- Wooden jigs

According to the stated objectives, detail guideline for design have to be listed down by studying the ergonomic requirements, existing machinery and methods to increase productivity, prior to ideation.

ERGONOMIC DESIGN GUIDELINES

a) Adjust the working height for each worker at elbow level or slightly below it.

- Seated workers - around elbow level. Slightly below elbow level if forces need to be exerted downward
- High precision work - Slightly above elbow level - to see the fine detail. Provide armrests. A jig may also be required to support the object.
- Standing workers - the hand height should be a little or somewhat below elbow level. For work requiring accuracy, elbow height can be chosen. Light assembly work or packing of large items, the hand height should be about 10–15 cm lower than elbow level. When the use of very strong force is needed, an even lower height is appropriate so as to allow the use of body weight.
- Use an adjustable work table wherever possible.
- Use a platform or a similar flat structure under tables, work surfaces or work items to raise the working hand height. Use platforms under the feet or chair to lower the actual working height in relation to elbow level.

b) Make sure that the workplace accommodates the needs of smaller workers.

- Purchase machines and equipment with adjustable work surface height. Then adjust the height to suit smaller workers.
- Replace controls (although this might be relatively difficult once machines are bought) and materials so that they are within easy reach of smaller workers. If the same controls and materials are dealt with by taller workers, make sure that they are still within easy reach of taller workers.
- Use platforms for smaller workers so that the hand position of these workers becomes higher and can easily reach controls and materials. Ensure that the stand does not present a tripping and falling hazard.
- Use a foot-stand or a mobile platform to enable workers to reach particular controls or materials which are difficult for them to reach.

c) Make sure that the workplace accommodates the needs of taller workers.

- Check overall space clearance of all workstations and passageways for the largest worker, and increase clearance where necessary.
- Check knee and leg clearance of workstations used by the largest worker. If knee and leg clearance is too narrow, consider how the clearance can be expanded. Raise the work-table height or expand the work-table size, for example.
- Mark all unsafe clearances with bright colours and warning signs.

d) Place frequently used materials, tools and controls within easy reach.

- Place frequently used tools and controls within the primary hand movement area. This is between 15 and 40 cm from the front of the body and within 40 cm from the side of the body at elbow height.
- Place all frequently used materials within this primary hand movement

area or at the margin of this area. When materials are supplied in boxes or bins, or on pallets or racks, they should be placed within easy reach and at around elbow height.

- For similar workstations, organize the placing of tools, controls, materials and other work items in a good combination with each other. For example, when several kinds of material are collected at the same time or one after another, place them in the same area in different bins. Standardize the location of all these items based on the opinions of the workers.
- If appropriate, divide the work-table surface into subtask areas so that different operations are done sequentially.

e) Provide a stable multi-purpose work surface at each workstation.

- At each workstation provide a stable work surface of appropriate size where a variety of tasks can be done, including preparation, main tasks, recording, communication and maintenance-related tasks. Such a surface is usually available when the work requires a work table, but tends to be neglected when the main operations do not require a table.
- Avoid a makeshift work surface or an unsteady surface. Work done on it becomes frustrating and of low quality.
- The thickness of the work surface should be not more than 5 cm. This is necessary to secure knee space underneath. Therefore, avoid putting drawers or under-table shelves in front of the seated worker where the legs are positioned.
- In the case of a visual display unit (VDU) workstation, a work surface is needed, in addition to the keyboard space, for preparation, document holding, writing and maintenance.

f) Make sure that workers can stand naturally, with weight on both feet, and perform work close to and in front of the body.

- Arrange all important and frequent operations so that they are carried out close to and in front of the body, and around or slightly below elbow level. Make sure that the work table or working height close to and in front of the body is free from obstacles.
- Make sure that these frequent operations can be performed without raising the elbow high or bending or twisting the body long enough to cause discomfort.
- Provide adjustable workstations when used by different workers or where different tasks are carried out. If adjustable workstations are impractical, provide platforms or other means to adjust the working height to each worker. Use lifting and tilting arrangements if needed.

g) Allow workers to alternate standing and sitting at work as much as possible.

- Provide sitting workplaces for workers performing tasks requiring precision or detailed inspection of work items, and standing workplaces for workers performing tasks requiring body movements and greater force.
- Assign work tasks so that the worker can do these different tasks by alternating standing and sitting while at work. For example, preparation while standing and sitting, power tool work while standing, inspection and recording while sitting.

- If the main tasks are done at standing workstations, then allow for occasional sitting (e.g. for watch keeping, recording or at the end of a series of work tasks).
- If the main tasks are done in a sitting posture, then opportunities should be provided for occasional standing, e.g. for collecting materials from storage, communicating with other workers or monitoring work results, or after completing one or a few work cycles.
- If appropriate, organize job rotation so that the same worker can go through different jobs alternating standing and sitting.
- If alternating standing and sitting at work is not at all possible, insert short breaks to allow for the change.

h) Provide standing workers with chairs or stools for occasional sitting.

- Provide a chair or stool near each standing worker. If there is no immediate space for this purpose near the workstation, put chairs or stools or a bench near a group of workers.
- See if workers are using makeshift chairs for occasional sitting. Formally allow workers to use chairs when they need it.
- Check if part of the tasks assigned to the standing worker can be done while sitting (e.g. some preparatory tasks or keeping watch over the machine operation). Arrange for occasional sitting work, where possible.

i) Provide sitting workers with good adjustable chairs with a backrest.

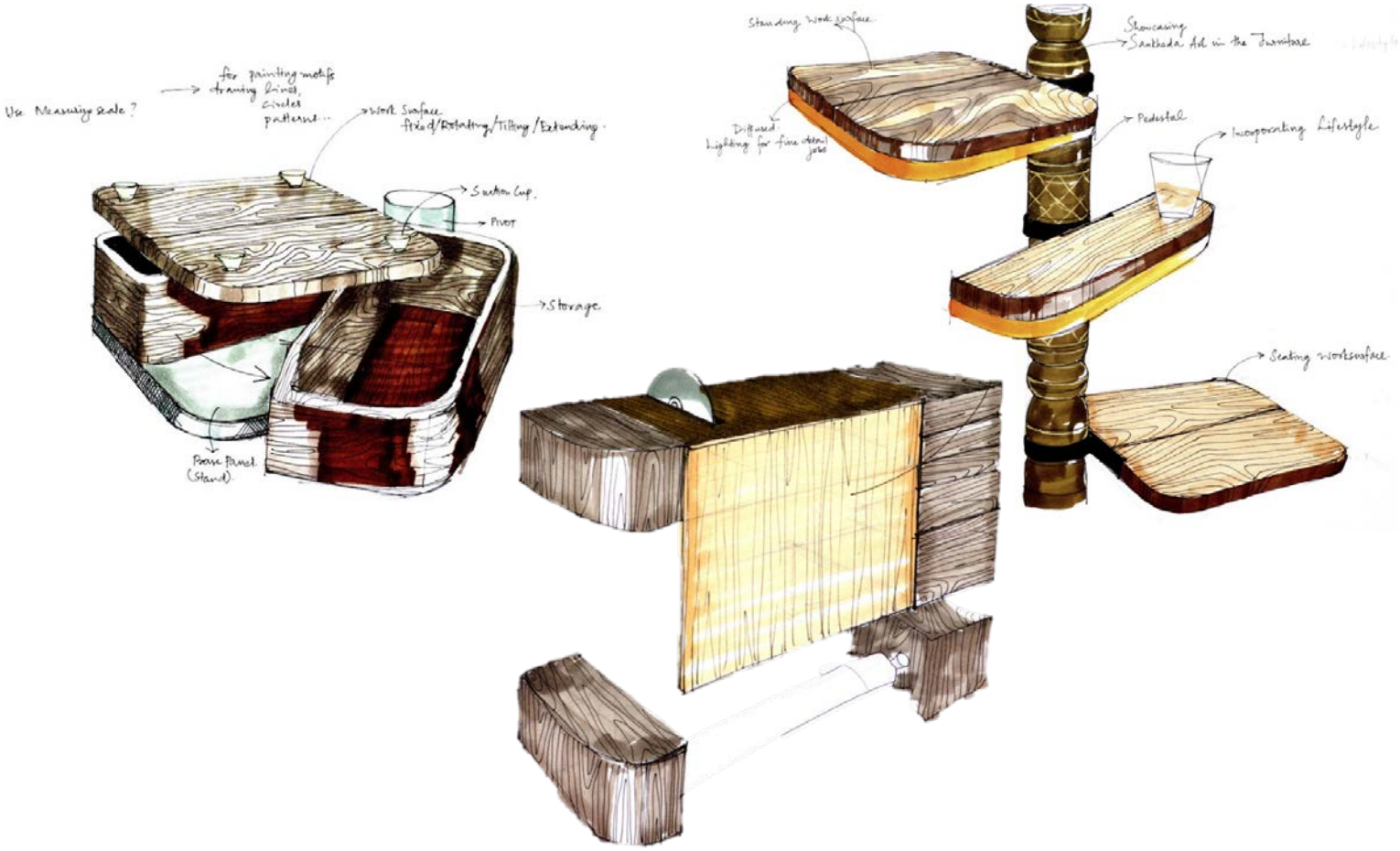
- A suitable seat height is the height at which the worker can sit with the feet placed flat and comfortably on the floor and without any pressure to the back of the lower thigh. Provide a chair with adjustable height. Height adjustment should be very easy while sitting on the chair.
- If an adjustable chair is not feasible, each worker should use a chair of correct height, or alternatively use a footrest or seat cushion in order to attain the correct floor/seat height difference.
- Use a padded backrest that supports the lowest part of the back (often called the lumbar area) at waist level (about 15–20 cm above the seat surface) as people will lean both forward and backward in the chair. The backrest should also support the upper back for occasional leaning backward.
- Provide a good seat surface with some padding, neither too hard nor too soft, so that the worker can easily change the sitting posture in the chair.
- Ensure good mobility required for the work and for occasional changes of the sitting posture while in the chair. Five-leg chairs with castors are good for many seated tasks.

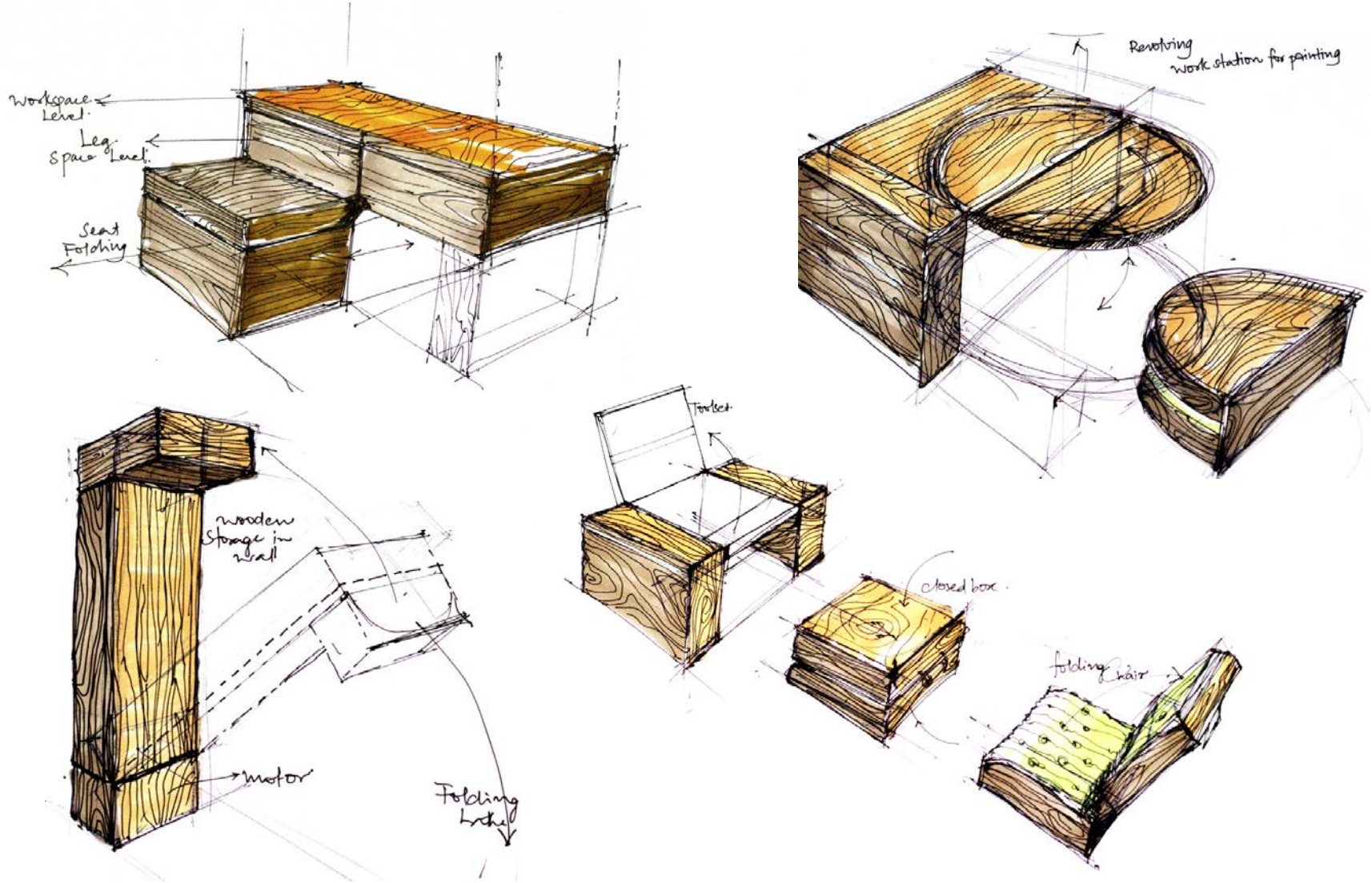
(ILO, IEA) – Ergonomic Checkpoints

Ideation

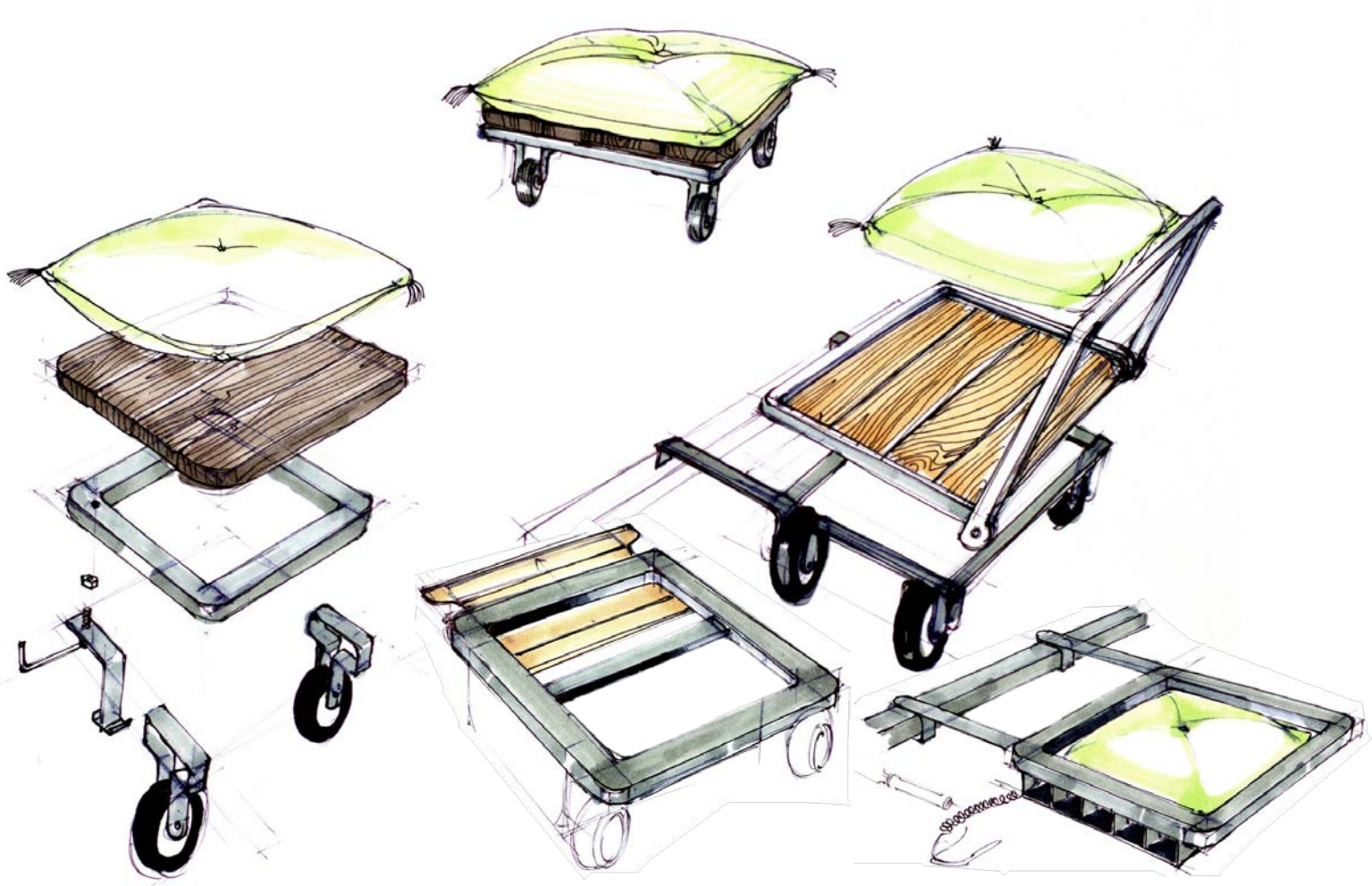
INITIAL IDEAS

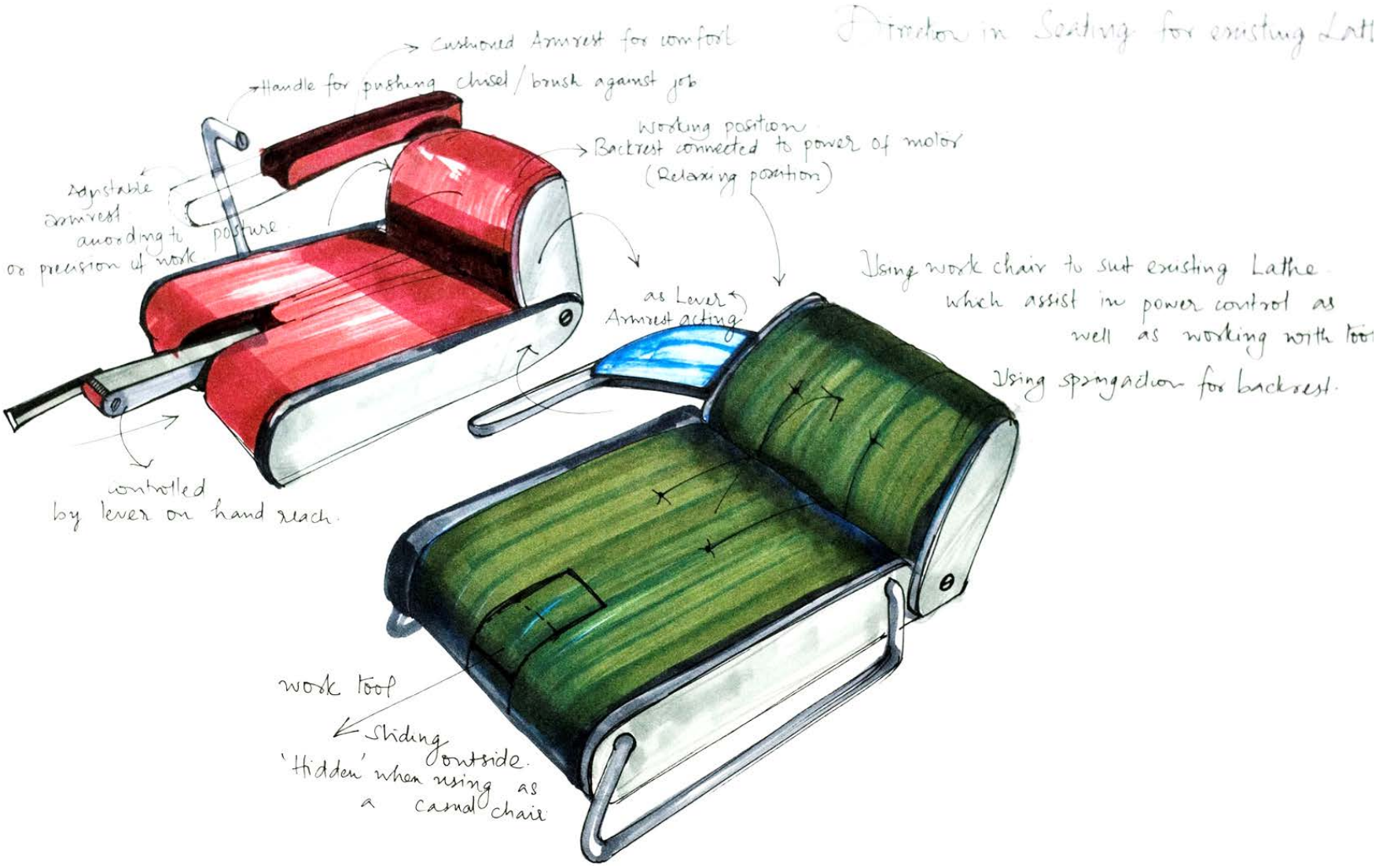
a) Modifying the existing work environment

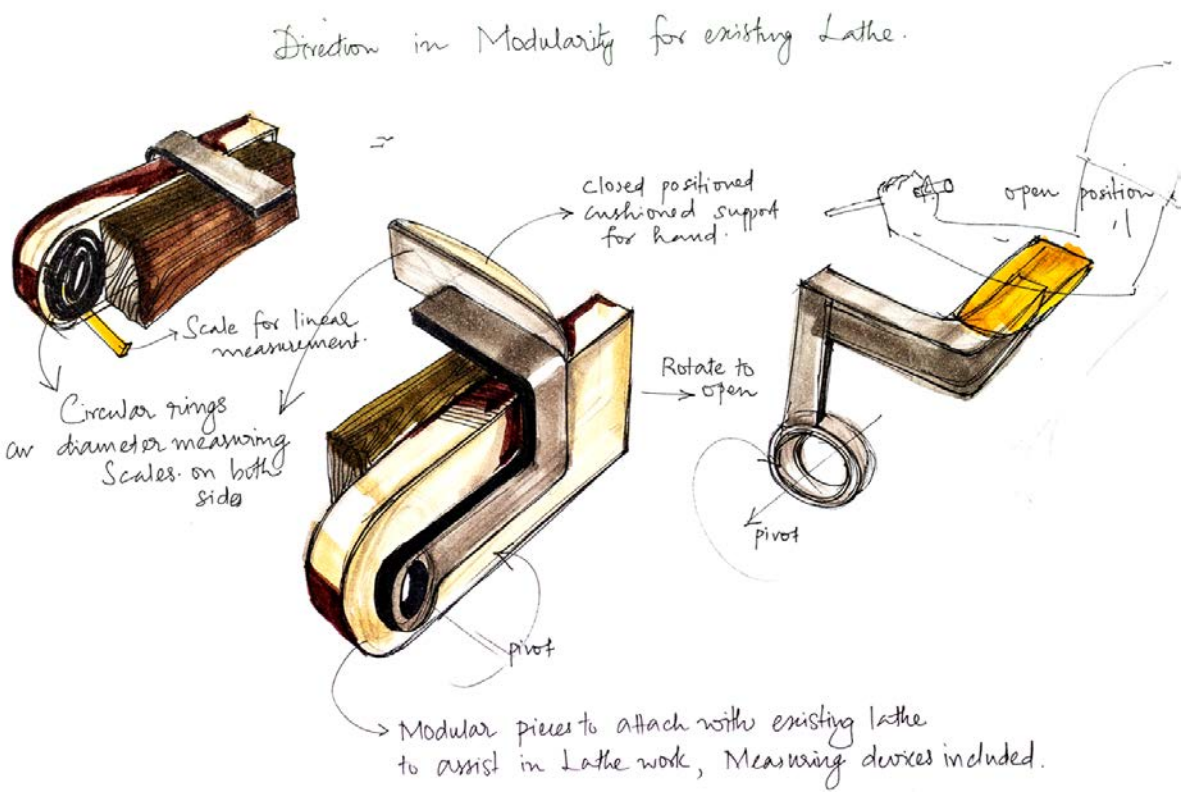



Workspace Level
Leg Space Level
Seat Folding
Revolving work station for painting
wooden storage in wall
motor
Folding
Footrest
closed box
folding chair

b) Assisting the existing work environment




Direction in Seating for existing Lath
Cushioned Armrest for comfort
Handle for pushing chisel / brush against job
Working position
Backrest connected to power of motor
(Relaxing position)
Adjustable armrest according to posture or precision of work
as Lever Armrest acting
Using work chair to suit existing Lathe which assist in power control as well as working with tool
Using springaction for backrest.
controlled by lever on hand reach.
work tool
Sliding outside
'Hidden' when using as a casual chair



TAKE AWAY:

- Existing functions can be combined to increase the productivity of the work.
- Use of sliding and folding mechanisms can increase safety as well as improve space inside the work space.
- The guides on the floor can be used to design the new workstation.
- Use of movable chairs will only provide a comfortable seating posture and won't help in productivity
- There are multiple constraints involved in the design and has to be look into before designing the product.

REFINED DESIGN GUIDELINE FOR WORKSTATION DESIGN

In the initial ideations, focus was given on the position of the existing machinery, and designs were developed accordingly. Seating with lumbar support that has provisions for tool support was one such idea. A second idea of attachment to the existing lathe was thought of.

It was observed that this does not change the posture of the craftsmen and may not be an ideal solution as long term work spaces as well as workspaces to be extended to other crafts. These designs become specific to the current machinery and also will not help to improve the productivity.

On further reading on anthropometric and ergonomic guidelines it was understood that:

"In any system, the person who performs the work would be the prime consideration. Accessories, machines and other work equipment are aids. The work space should make it easy to use all these facilities." (Chakrabarti)

This led into developing a new approach for further design process.

REDEFINING BRIEF WITH NEW CONSTRAINTS

The initial brief with a wider scope which was developed from including storing was refined as:

Design of a workstation for Sankheda craftsmen to reduce drudgery in work environment in the selected areas:

- Turning
- Painting
- Drilling
- Cutting

DESIGN METHODOLOGY

IDEATION LEVEL 1

These ideations were based on the idea of changing the existing posture of the craftsmen to a more ergonomically comfortable posture. This was made possible by elevating the current work surface of Lathe to a higher level and adding features and accessories to the workplace. Storing and transporting of wood parts, drying of painted parts are also considered as part of the process. Ideations were lacking clarity in frame of the structure. More importance was given to the outer shell of the workstation. Hence ideations of frame were made to add a structure to the form. Line drawing of frames was made according to functional requirement. This also considered various processes like transporting of wooden parts as well as storing.

To understand how productivity can be achieved as well as to understand the different features that can be incorporated, study of existing products have to be done.

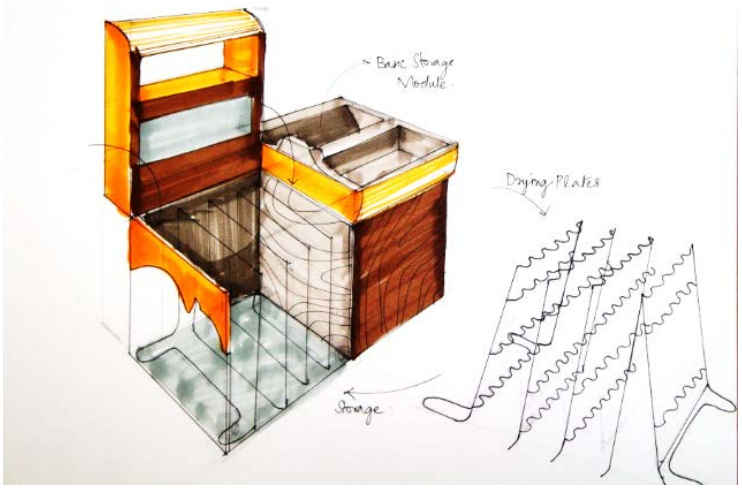


Figure 53

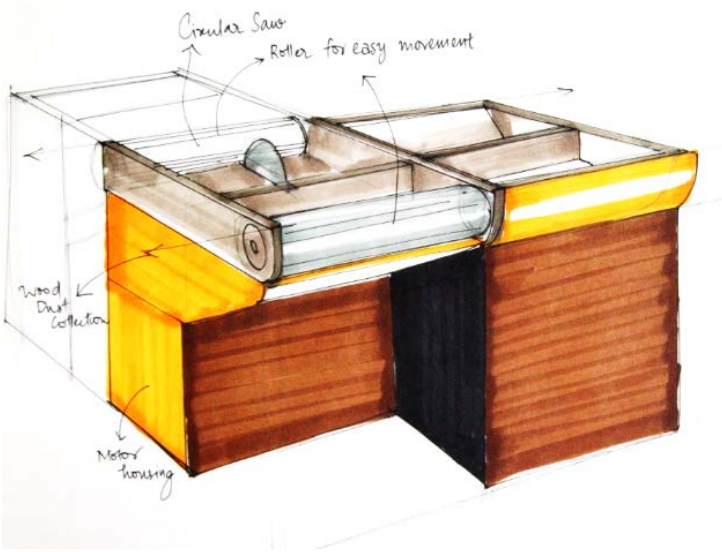


Figure 54

Figure 55

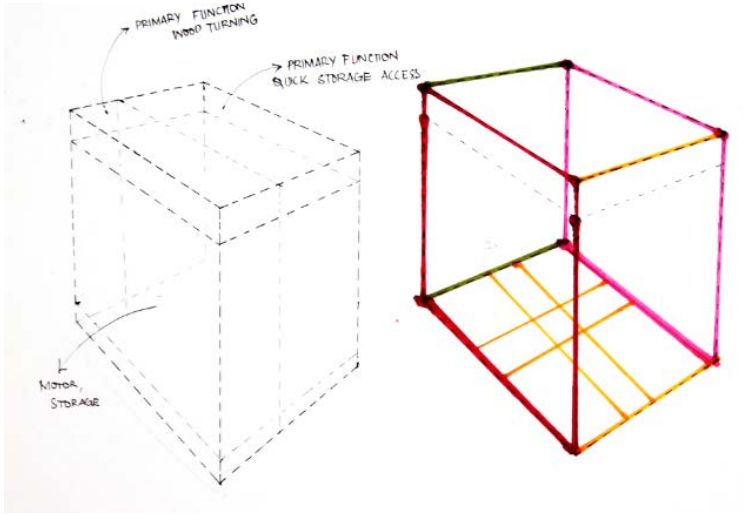


Figure 56

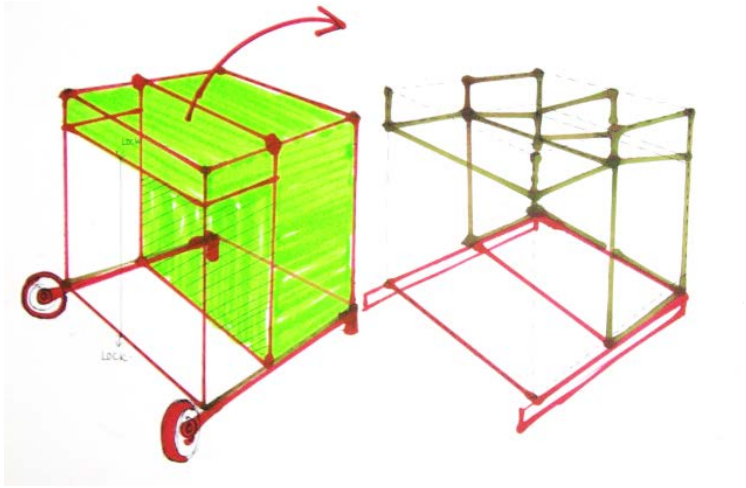


Figure 57

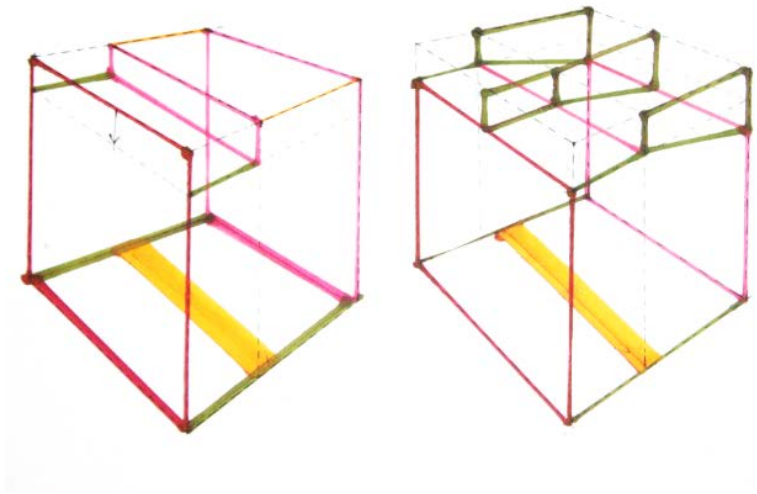


Figure 58

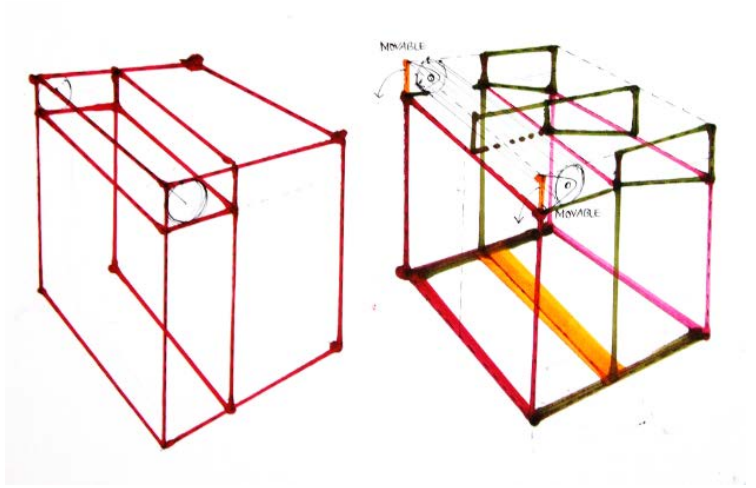


Figure 59

STUDY OF SIMILAR PRODUCTS

c) Woodworking Tables

Figure 60

Figure 61

Figure 62

Figure 63

Figure 64

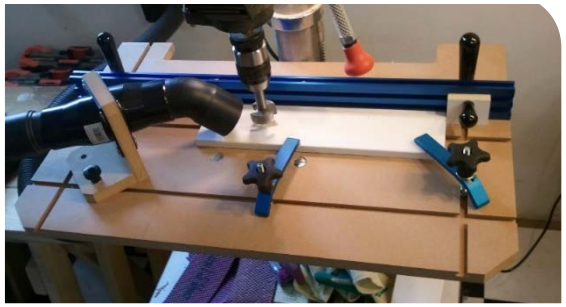


Figure 65

Figure 66 –

Figure 67 –

Figure 68 –

Figure 69

Figure 70

Figure 71

Figure 72

Figure 73

Figure 74

Figure 75

Figure 76

Figure 77

Figure 78

The study included a wide variety of workstations as well as work benches with a variety of functions as well as features. Many videos were referred to understand their construction and assembly.

TAKEAWAY

a) Functions and their attributes

- Workstation Chassis – Wooden, Cast Steel, Steel Sections
- Drawers – Single/ Double/ Multiple
- Shelving – Laminated Metal/ Solid Metal/ Wire gauge/ corner Shelving
- Work surface – Wooden, laminated metal, Metal

b) Features and types

- Integrated Lighting – Fluorescent/ LED/ under shelf
- Parts Cup accessory – Rail/ Rack/ Swinging Arm/ Tiered/ Bin
- Pegboard/ Document Holder/ Extension
- Sliding Rails for Assembly
- Utility Accessories – Duct/ Trough
- Privacy and Support Components- Isolating Screens and Channels
- Speciality Work Surface – Adjustable Tilt tops/ Indexing Rotary surface
- Ergonomic Foot rest – Bent metal pipe, Industrial with adjustments
- Speciality tool holder
- Electrical Outlets/Electrical Channels

c) Details

- Grommets

- Power Distribution System/ Chords
- Joinery

A new set of guidelines were created for the ideation of the workstation

DESIGN BASIS

a) Primary guidelines

- Number of products the workstation can produce
- Number of craftsmen who use the workstation
- Postures of working
- Assistance to primary functions
- Storage Capacity of the workspace
- Method of accessing the existing machinery
- Shape and Size of the Workspace
- Flexibility in Workspace position and height
- Flexibility in accessories and attachments
- Stability and strength of the system
- Usability of parts and accessories
- Robustness

b) Secondary guidelines

- Electrical requirements of the machinery
- Safety requirements for machinery
- Visibility in the work area
- Lighting requirements in the workspace
- Electrical requirements of the workspace
- Power outlets requirements of the workspace
- Types of storage according to process
- Privacy requirements in workspace
- Safety requirements in workspace
- Seating or standing requirements
- Supports for sitting and standing
- Supports while doing work

METHODOLOGY OF IDEATION

Further Ideations were done based on proper classification of functions

IDEATION LEVEL 2

In this level, the design of workstation was directed in two ways and carried out together:

1) Ideation of Worktop
2) Ideations of framing

Work Top – These ideations were based on the different machineries or tool used in the process of furniture making. Hence the work surfaces adapt to the machinery and have features adapted to that particular function. These ideations, illustrate the use of guides for sliding of lathe, Rotating work surface for painting, Roller feature for Circular saw along with guides and supports and Clamping facility for Drilling machine

Frames - These ideations were based on the type of steel sections used and the configuration along with a feature identified by studying the existing products. Ideation 1 used angle sections and flats with mountable parts, Ideation 2 used angle sections with foldable work surfaces and Ideation 3 used Large Channel Sections and angle sections with fixed parts. Figure 79-82 shows these ideations.

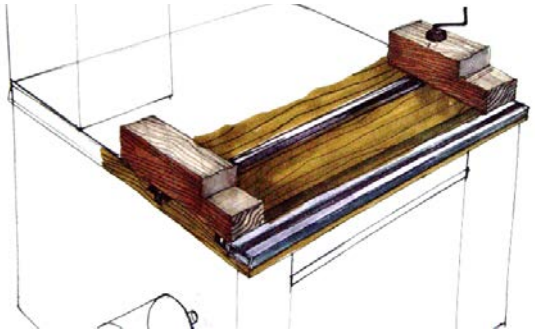


Figure 79

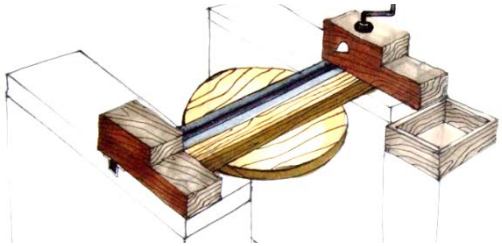


Figure 80

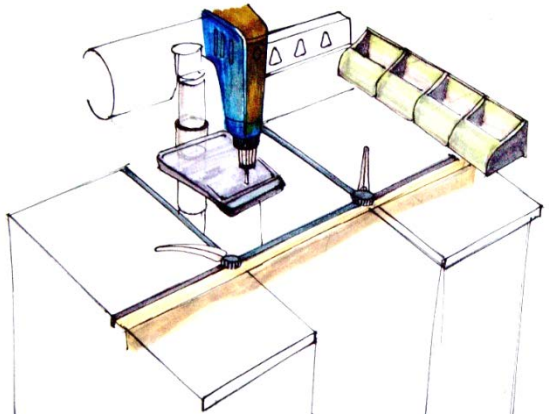


Figure 81

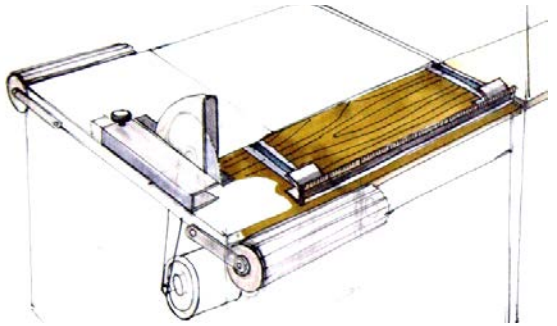


Figure 82

TAKEAWAY:

- Use of steel channels for guides in lathe for moving tail stock
- Frame that provides continuity is required in case of lathe.
- Integrating different levels on the work surface is important.
- Different shapes of the surface
- Access to machinery is important and accessories should not conflict with the movement of parts.
- The position of the motor is critical to design the workstation for lathe as well as saw.
- Use of guides for sliding scales as well as jigs.
- Use of rollers for supporting wood pieces need to be aligned according to work.
- Details need to be work out to understand whether the design is feasible or not.

DEVELOPING FRAMES

Option 1 – This frame design indicates the possibility of modularity in design by making modular frames for machinery or work surfaces. The frame uses the combination of equal angle sections and flat bars to derive a sleek and simple design. Wooden parts can be bolted or simply paced on these frames.

Option 2 – This option uses angle sections which forms a frame that can be folded or take apart to provide a lower work surface for sitting and working. This can also be used to do painting using a manual lathe.

Option 3 – This option uses larger channel sections for the base for high stability. The secondary frames are made in angle sections for easy joining of parts. It also helps in placing wooden surfaces on top without sliding away.

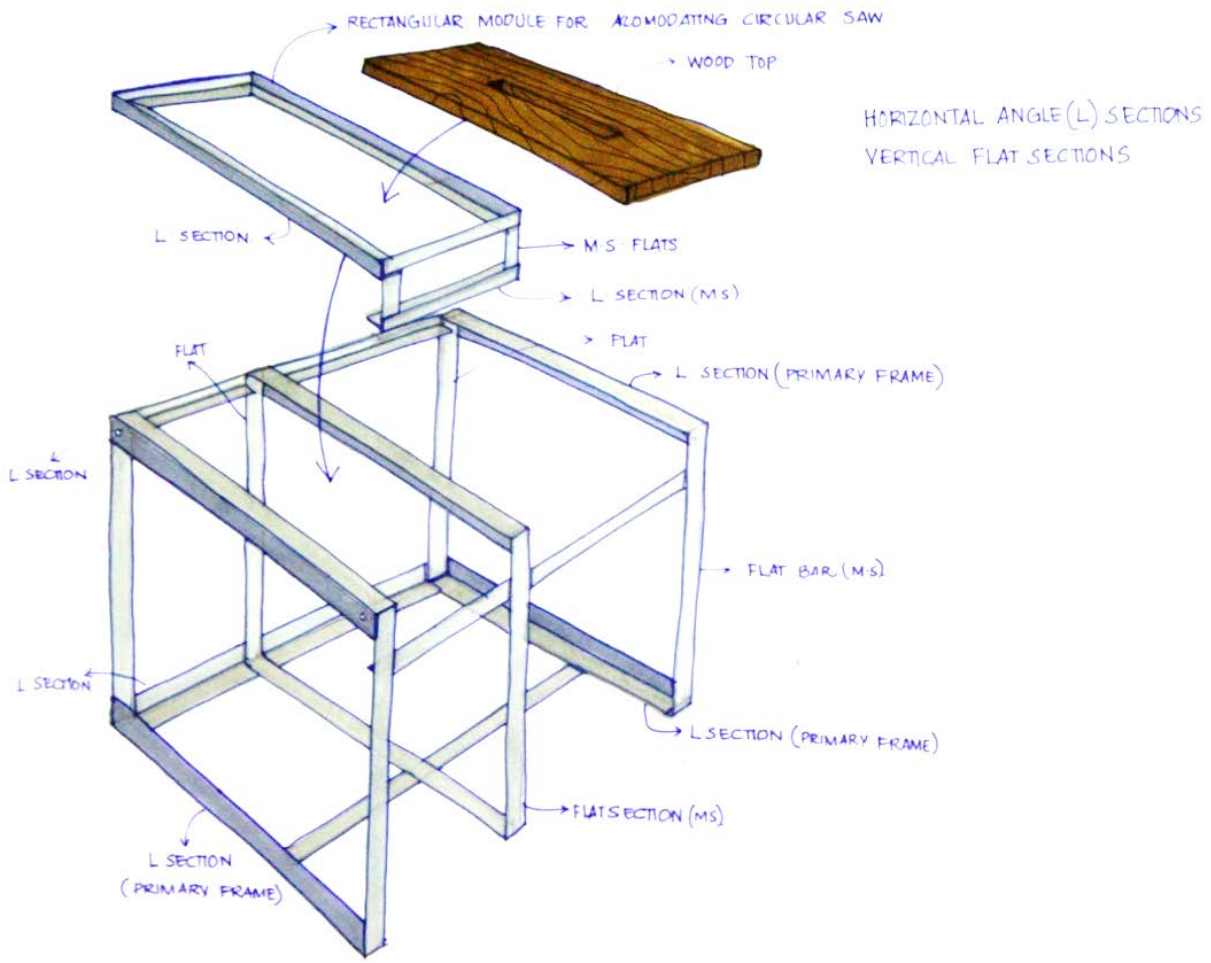

RECTANGULAR MODULE FOR ACOMODATING CIRCULAR SAW
WOOD TOP
HORIZONTAL ANGLE (L) SECTIONS
VERTICAL FLAT SECTIONS
L SECTION
M.S FLATS
L SECTION (M.S)
FLAT
FLAT
L SECTION (PRIMARY FRAME)
L SECTION
FLAT BAR (M.S)
L SECTION
L SECTION (PRIMARY FRAME)
FLAT SECTION (MS)
L SECTION
(PRIMARY FRAME)

Figure 83

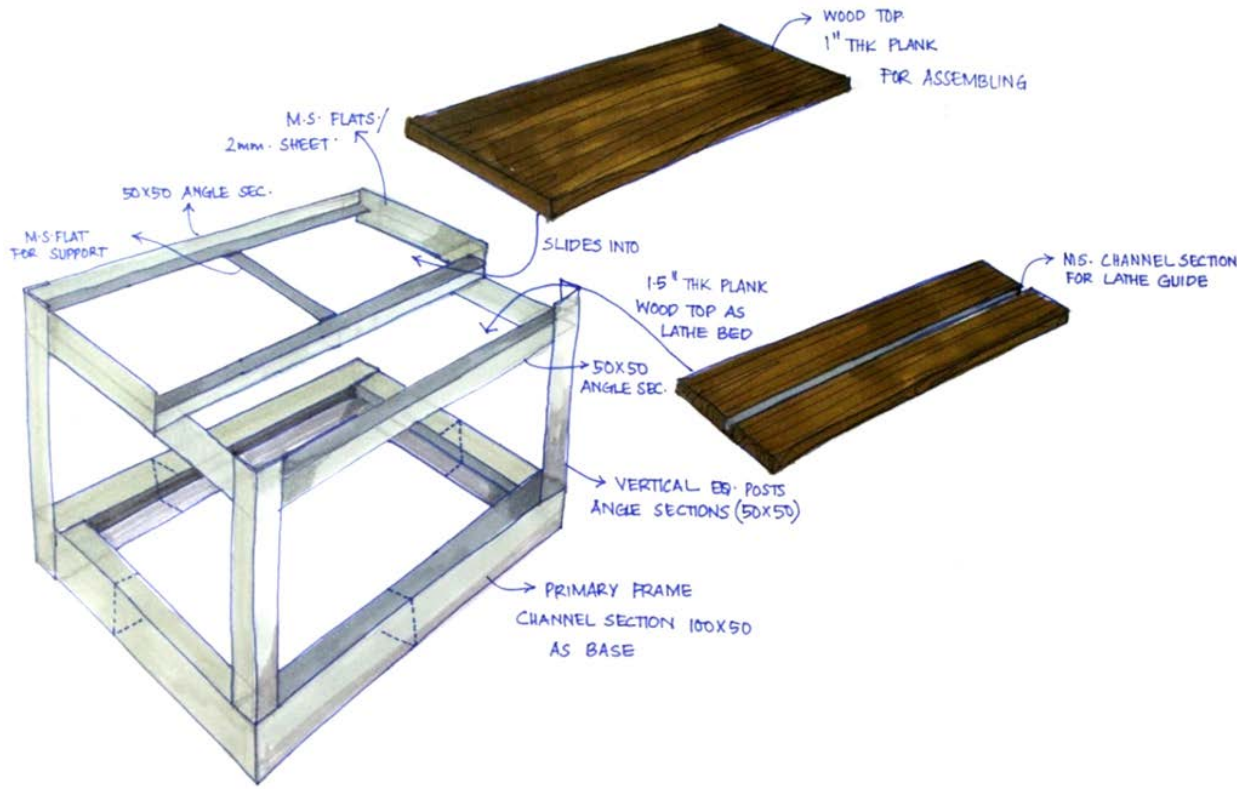

WOOD TOP
1" THK PLANK
FOR ASSEMBLING
M.S. FLATS/
2mm. SHEET
50X50 ANGLE SEC.
M.S FLAT
FOR SUPPORT
SLIDES INTO
1.5" THK PLANK
WOOD TOP AS
LATHE BED
M.S. CHANNEL SECTION
FOR LATHE GUIDE
50X50
ANGLE SEC.
VERTICAL BG. POSTS
ANGLE SECTIONS (50X50)
PRIMARY FRAME
CHANNEL SECTION 100X50
AS BASE

Figure 84

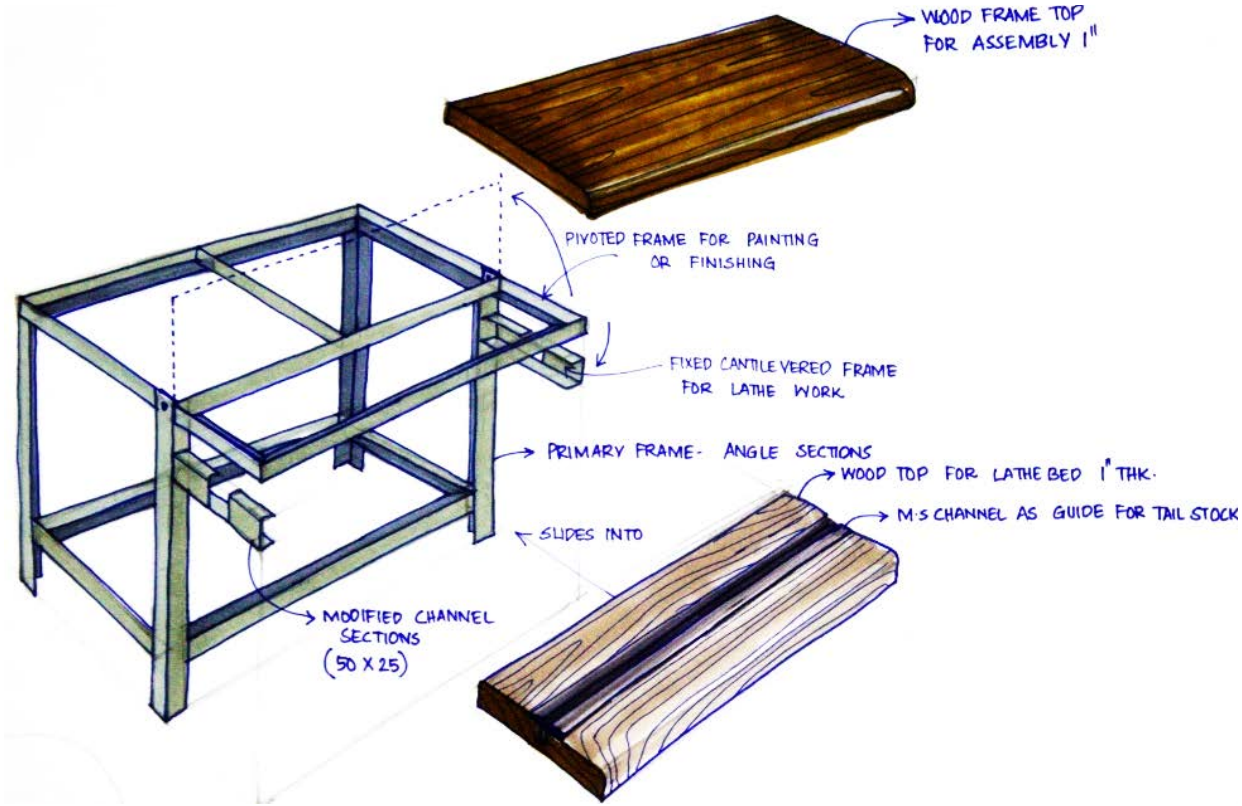

WOOD FRAME TOP
FOR ASSEMBLY 1"
PIVOTED FRAME FOR PAINTING
OR FINISHING
FIXED CANTILEVERED FRAME
FOR LATHE WORK
PRIMARY FRAME- ANGLE SECTIONS
WOOD TOP FOR LATHE BED 1" THK.
M·S CHANNEL AS GUIDE FOR TAIL STOCK
SLIDES INTO
MODIFIED CHANNEL
SECTIONS
(50 X 25)

Figure 85

a) OPTION 1

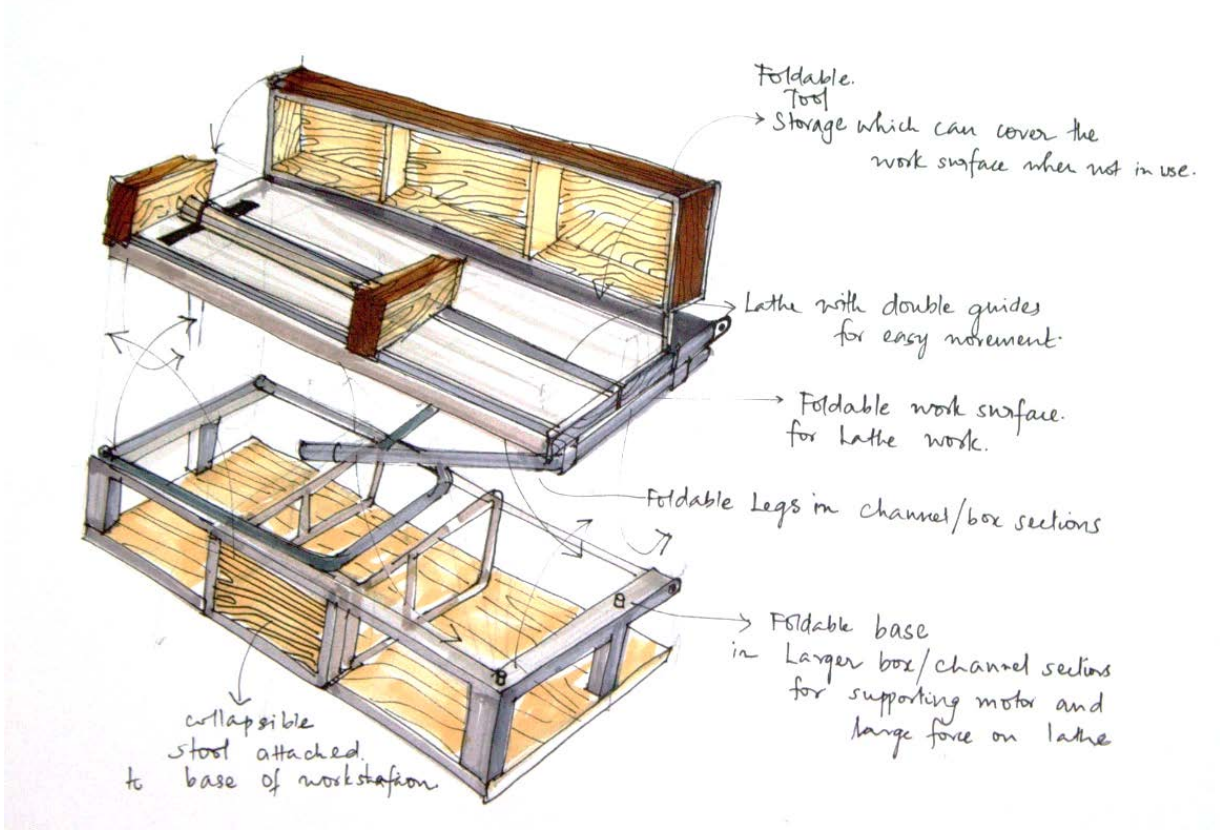


Figure 86

These ideations were a refined version of the second level ideations but with better detail on features as well as combine both work surface as well as frames to get a better idea of the design.

Option 1:

This design makes use of the existing work environment. In this case, there are two foldable structures which can be fixed to the wall. During the time of usage, this can be opened up and developed to function as the main work surface.

The design offers foldable storage which can be closed when not in use. The foldable legs can be attached to the bottom panel to make the work surface stable. The bottom flat wood panel has a stool which can be taken to sit during work.

The main drawback of the design is that it may not be a good option in terms of stability and usability.

Meanwhile, this put forward the idea of foldable parts which can be wisely used in design to increase the usable work area.

b) OPTION 2

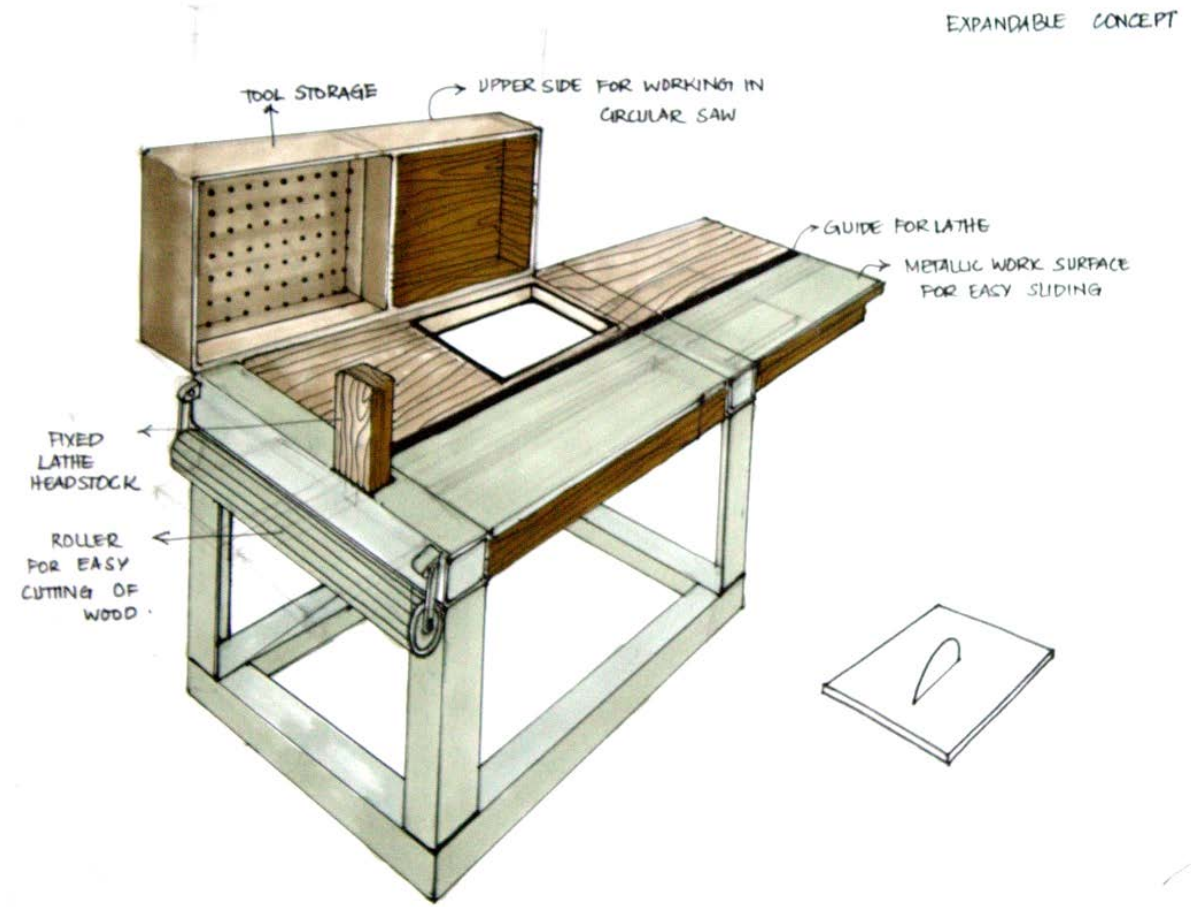


Figure 87

Option 2:

This is a multifunctional design which uses large steel channel sections as the main frame to which wooden work surface is fixed. The surface is finished with two types of panels for using the lathe for the less resistance in sliding the tail stock.

Both the circular saw and the lathe can be used on the same workstation. The worktop provides a cut out to which a circular saw module can be attached on use.

The table length can be extended by the use of a foldable work surface. The roller is attached to the work surface in such a way that it can be folded down when not in use. There is a central guide for the movement of the tail stock.

The storage unit is foldable with pegboard for holding tools in order to provide safety from saw blade.

The design explains the idea of combined work surfaces which can be used in turn or simultaneously if designed accordingly.

c) Option 3

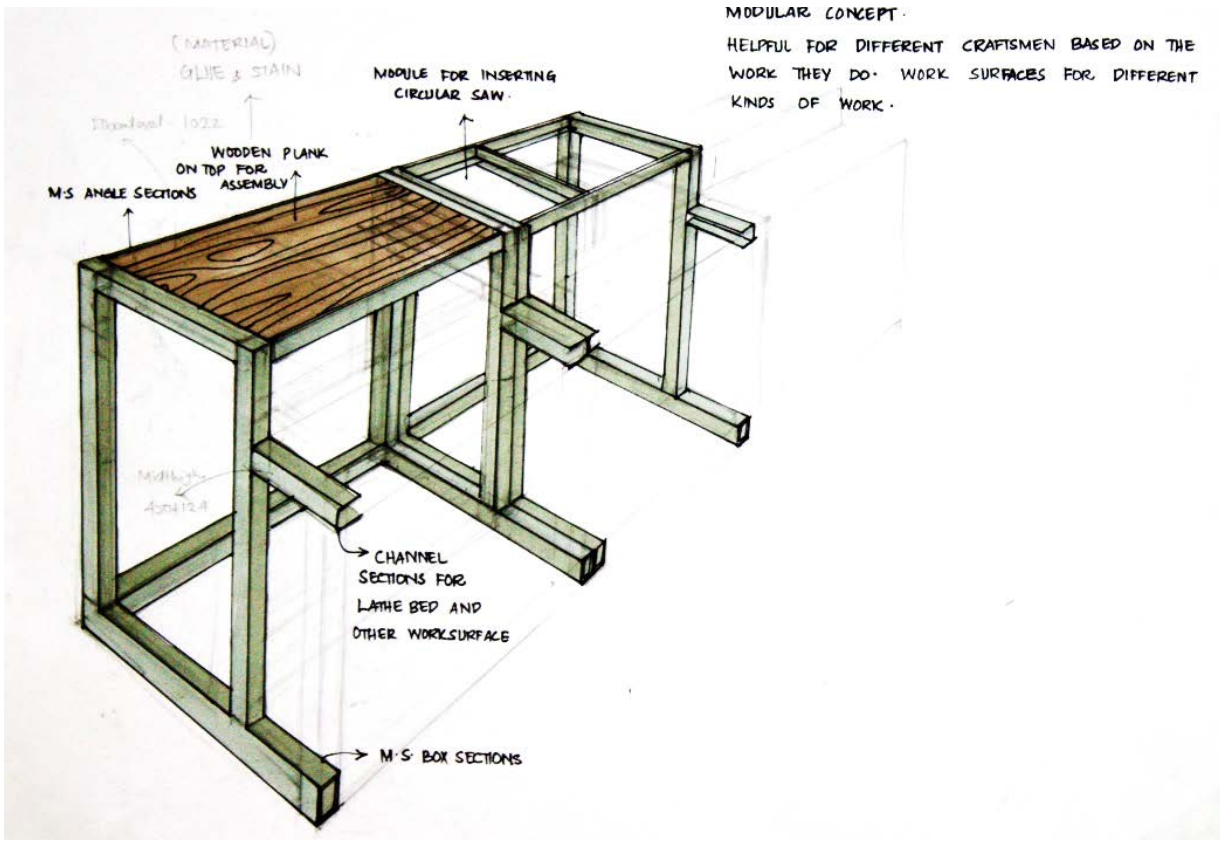


Figure 88

Option 3:

This option makes use of modularity in frame design to come up with an extendable work surface for multiple applications. The frame can be linearly arranged so that the user can choose the number of units he need to buy according to the work he does.

The workstation module can be designed in a way to incorporate all the functions it needs to address. This illustration shows a plain wooden top which can be used for assembly. The same frame is shown in the adjacent work surface with the worktop interchanged with a table saw module.

The channels at the lower side provide provision for seated work which can be done when the user feels to change work.

The frame makes use of Mild steel box sections and designed in a way to provide leg clearance for sitting as well as for standing.

It was also understood that for proper detailing of the workstation, dimensions need to be provided to the design ideas.

DIMENSIONAL GUIDELINES

The dimensions of the existing products being manufactured are to be known to understand the requirements of the work surface. Hence the following furniture are taken into consideration for design to know the dimensions of turned parts.

- Jhulla -
  - Part 1 – 02 X ~1950mm
  - Part 2 – 02 X ~1800mm
  - Part 3 – 10 X ~1500mm
  - Part 4 – 04 X ~1350mm
  - Part 5 – 02 X ~1200mm
  - Part 6 – 04 X ~900mm
  - Part 7 – 36 X ~300mm
  - Part 8 – 20 X ~150mm
- Sofa –
  - Part 1 – 1X 1000mm
  - Part 2 – 4 X 450mm
  - Part 3 – 4 X 300mm
  - Part 4 – 2 X 200mm
- Dining table
  - Part 1 – 04 X ~1500mm
  - Part 2 – 26 X ~900mm
  - Part 3 – 06 X ~600mm
  - Part 4 – 06 X ~500mm
  - Part 5 – 32 X ~400mm
- Chair
  - Part 1 – 4 X 1650
  - Part 2 – 8 X 650mm
  - Part 3 – 12 X 1000mm
  - Part 4 – 60 X 500mm
  - Part 5 – 12 X 450mm

TAKEAWAY

- For making Jhulla the required work surface is approximately 2 metres. A work surface of 1500mm can make most of the parts of the Jhulla Set.
- For making Sofa set the required work surface is approximately 1metre. A work surface 450 mm can make most of the parts of the Baby Jhulla.
- For making Sofa set the required work surface is approximately 1.5 metres. A work surface 900 mm can make most of the parts of the Sofa set.
- For making Sofa set the required work surface is approximately 1.7 metres. A work surface 500 mm can make most of the parts of the Dining Set.

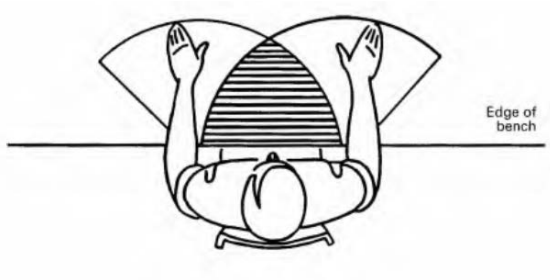


Figure 89

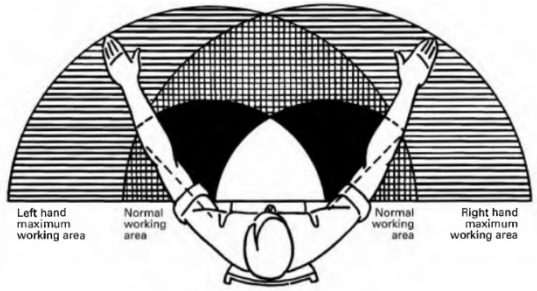


Figure 90

ANTHROPOMETRIC STANDARDS

a) Heights and Clearances

- Standing Elbow Level – Male and Female Combined – 5th percentile – 908mm - **Top**
- Sitting Elbow Level – 450mm(Seating)+124mm (Thigh-95th percentile)
- Thigh Clearance – 644mm (95th percentile) – **For table top at lower level**
- Forward arm reach – 700mm (5th percentile) – **For shelf and storage.**

(Chakrabarti) *Indian Anthropometric Dimensions*

b) Area of Workspace

The area of workspace or position of tools can be limited by the optimal as well as the maximum reach of hands. But this is also controlled by the size of the products and hence is overridden by the length of wooden parts to be made.

DIMENSIONS OF WORK SURFACE

Two dimensions are identified as optimal lengths for workstation based on the type of work

- 1500 mm workspace
- 900mm workspace

DIMENSIONS OF MACHINERY

- Circular saw –The design of Circular saw workstation is decided by taking saw blade of 10" diameter as the standard.
- Drill press – Floor mounted drill bench with a 30cm X 30cm metal work surface is used for the design process.
- Lathe – The dimensions of the lathe was measured on site and is taken as the standardised and used in the further development and design of the workstation.

(Chakrabarti) *Indian Anthropometric Dimension*

DIMENSIONS OF TOOLS

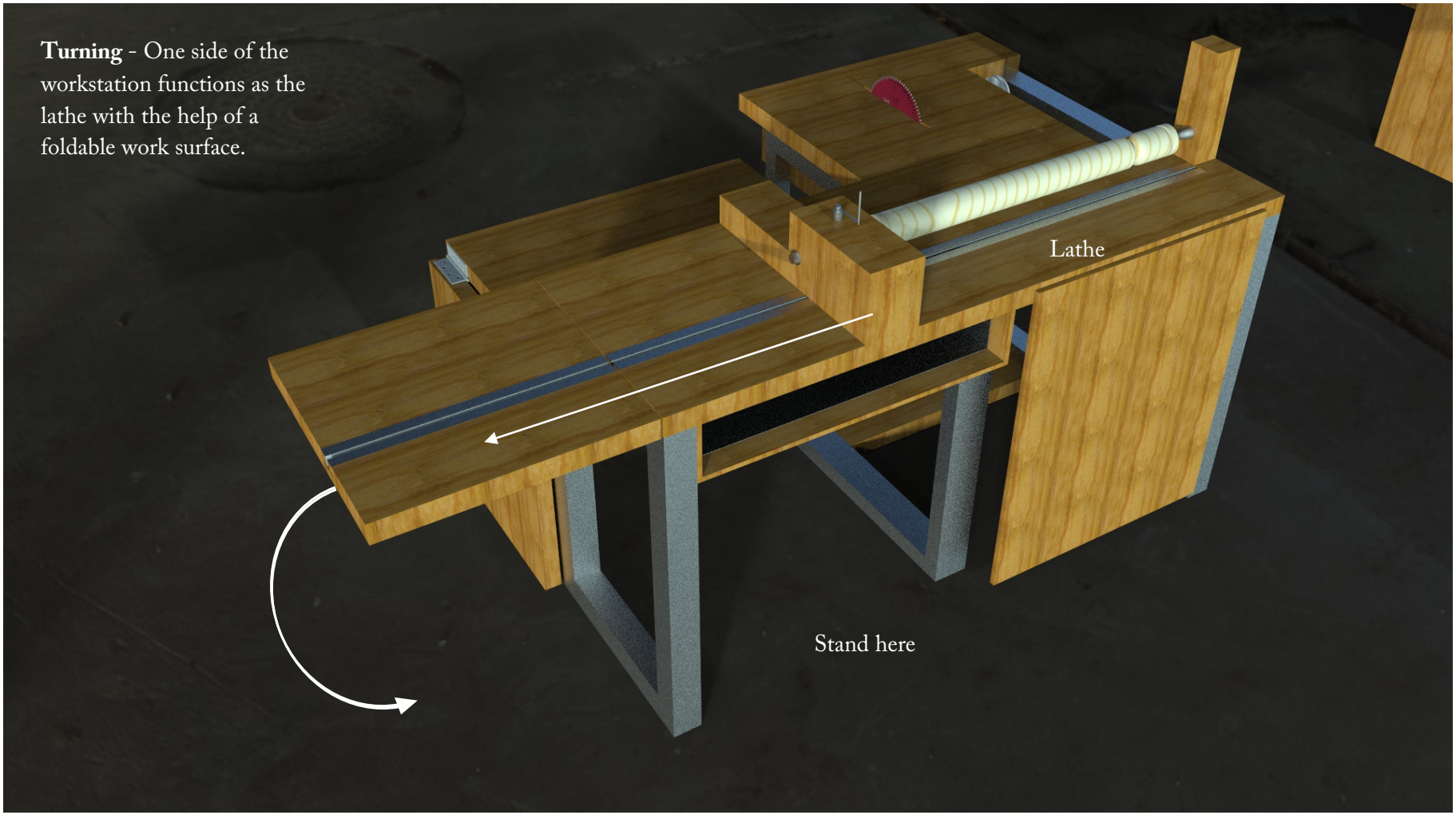
Few approximate dimensions of the tools are taken to facilitate initial design process.

Concepts

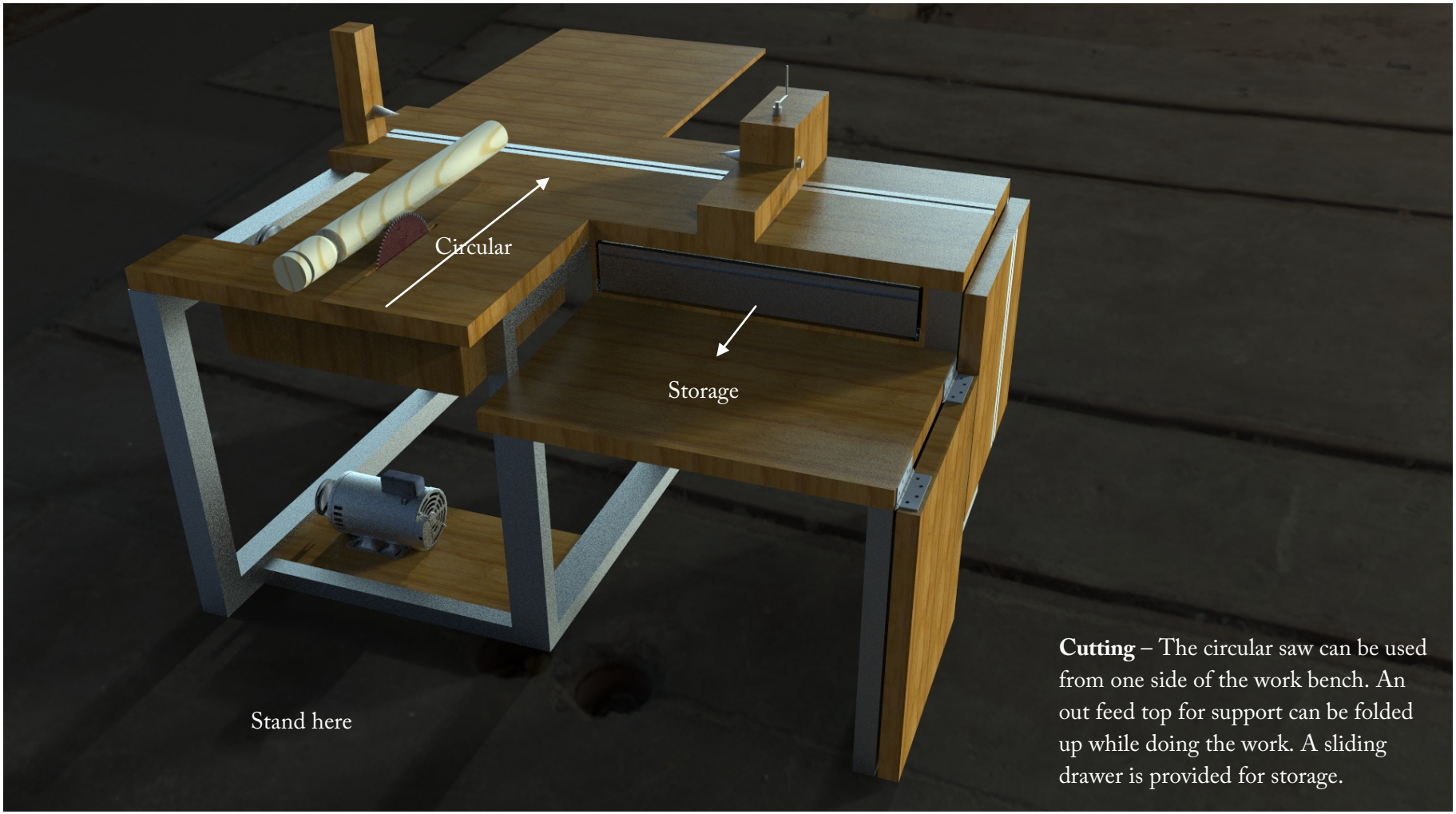
CONCEPT 1- COMBINING THE FUNCTIONS

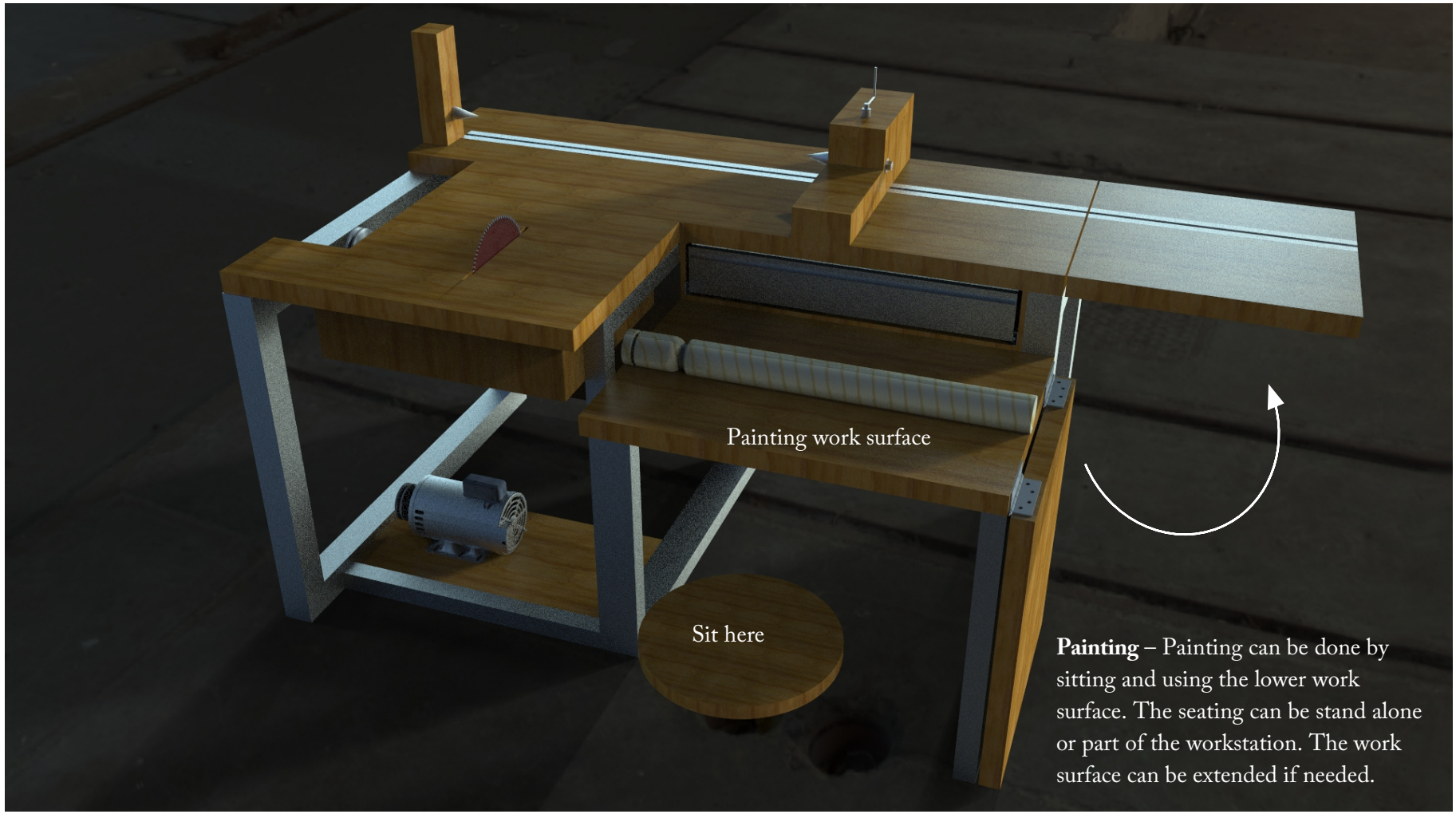
This concept has a multifunctional worktop which can be used for more than one purpose at the same time. This includes turning, cutting and drilling which can be performed by standing. Meanwhile, painting can be done by sitting on a height adjustable stool.

This works as a central workstation for a workshop with craftsmen working around it.


Turning - One side of the workstation functions as the lathe with the help of a foldable work surface.
Lathe
Stand here

Drilling – The drill bench can be used by lifting the foldable worktop. The height of the drill bench can be adjusted to suit the work surface.


Circular
Storage
Stand here
Cutting – The circular saw can be used from one side of the work bench. An out feed top for support can be folded up while doing the work. A sliding drawer is provided for storage.


Painting work surface
Sit here
Painting – Painting can be done by sitting and using the lower work surface. The seating can be stand alone or part of the workstation. The work surface can be extended if needed.

CONCEPT 2 – ISOLATING THE FUNCTIONS

This particular concept makes use of modularity to achieve the possibility of creating multiple layouts for craftsmen. A modular frame with interchangeable worktop as well as parts helps to do multiple works simultaneously.

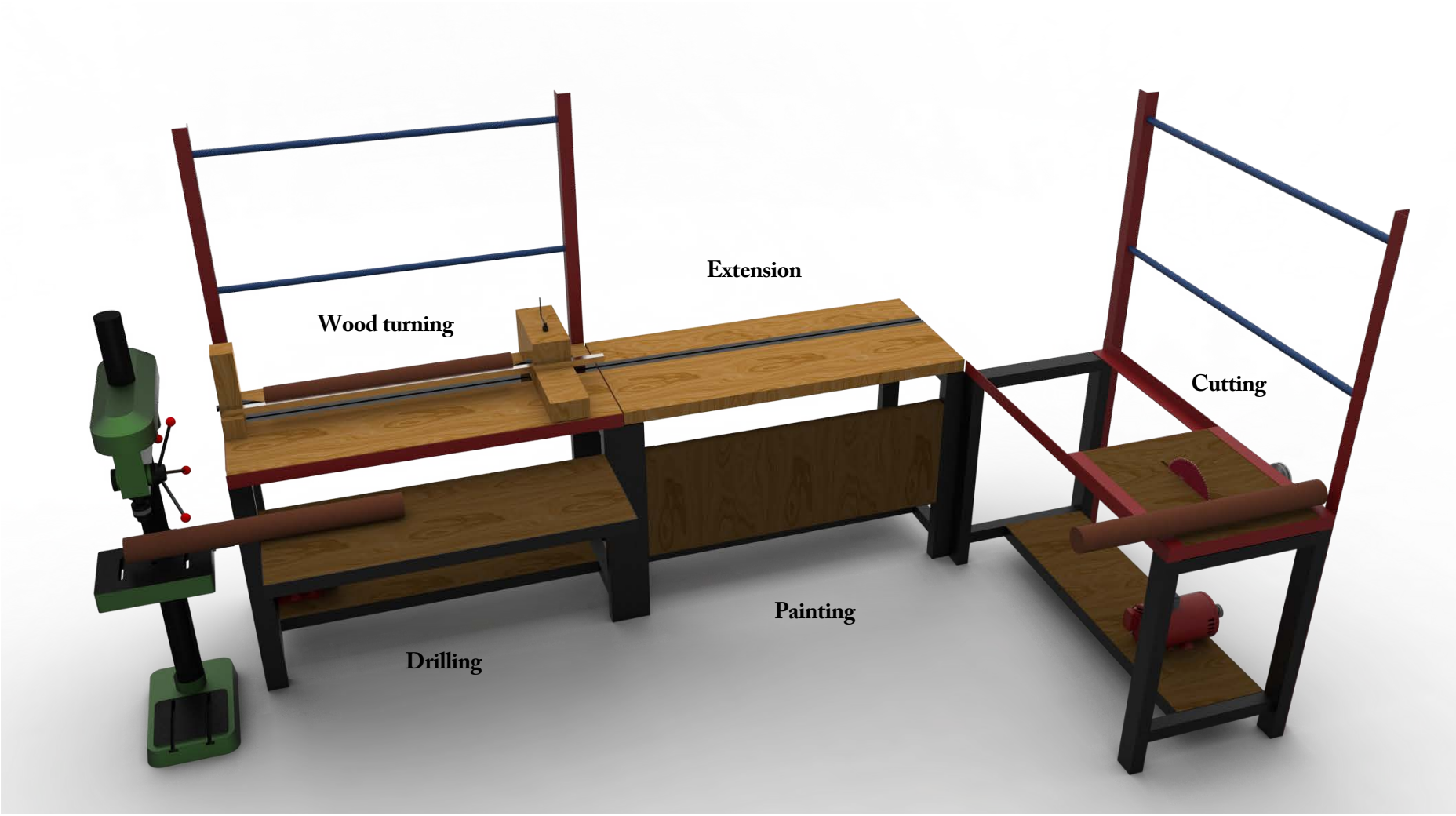
This also helps the craftsman in choosing the type of workstation he requires based on the type of craft he does.

Modularity is achieved by isolating the functions into different work surfaces which can be fixed on the same frame size. There are also folding worktops which can be kept hidden when not in use. Storing can be done using frames mounted on the workstation.

ACHIEVING MODULARITY

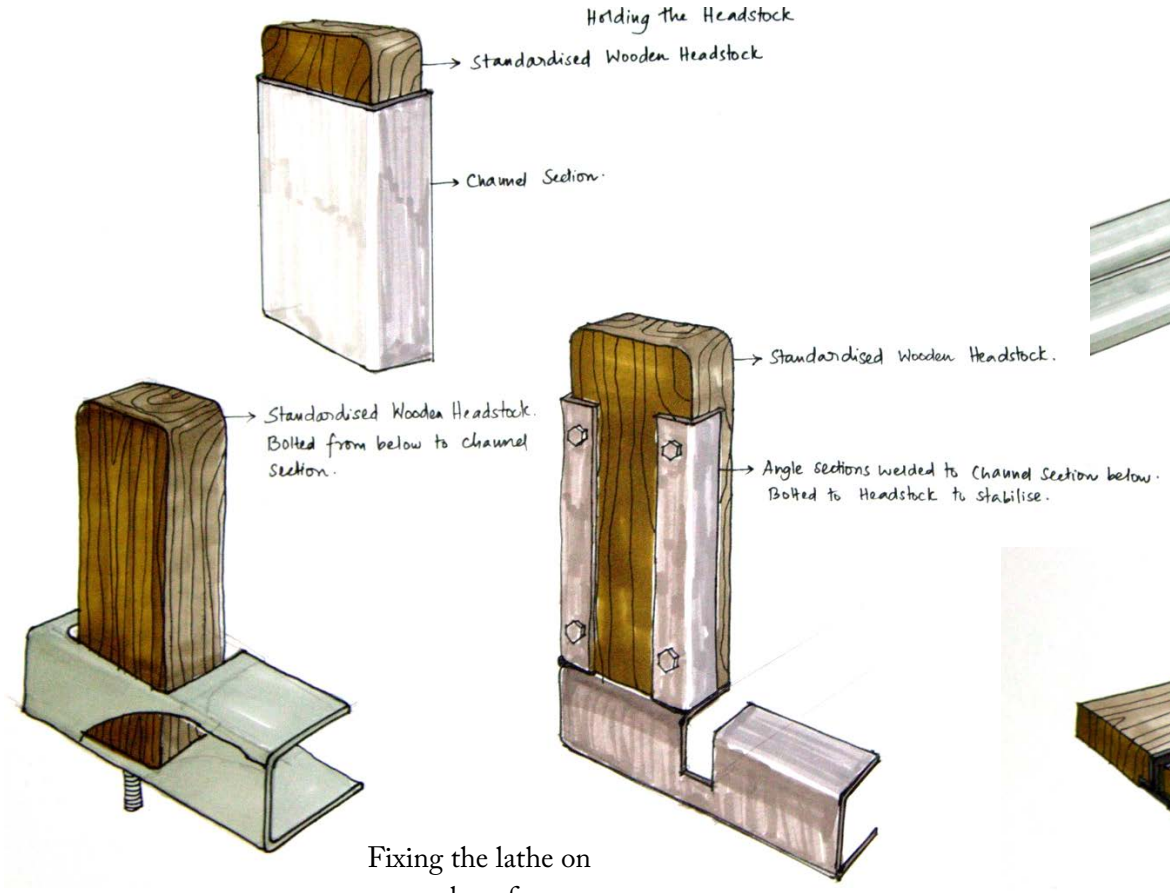
Here modularity is tried to achieve by using similar frame size for performing multiple tasks. Wood turning, Wood cutting, Painting and assembling worktops make use of similar modules which can be fixed on to the frame.

Different types of tool storage methods were ideated to achieve a similar design concept. These include similar modules of storages which can be fixed on the frame as well as used as sliding and folding drawers. The drawer can also be used as a quick access tool storage when pulled out.

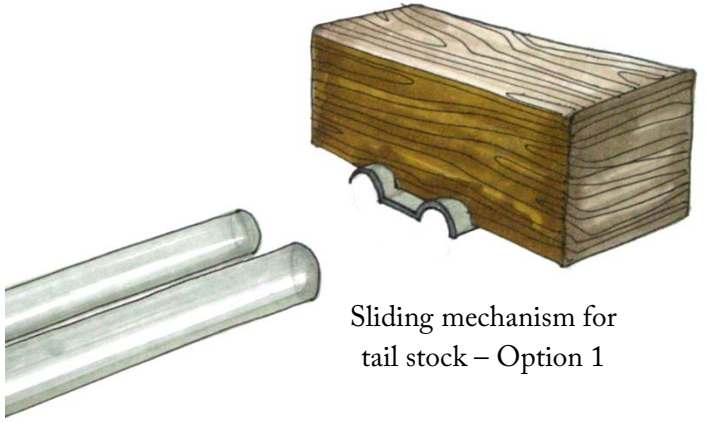

Extension
Wood turning
Cutting
Painting
Drilling

Sankheda: Design optimisation and Production

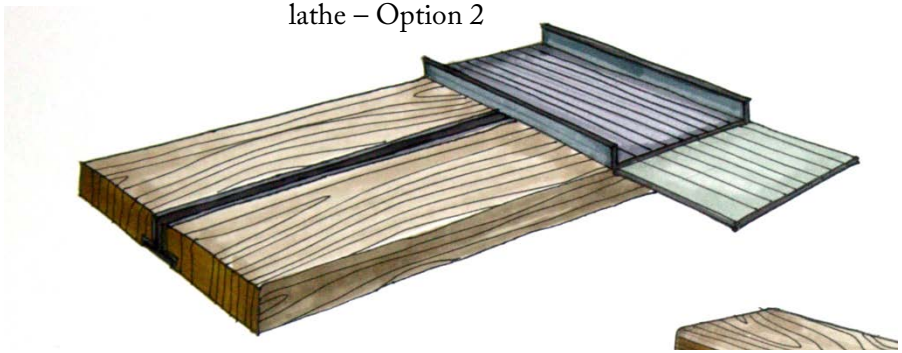
IDEATIONS – SUPPORTING THE LATHE



Fixing the lathe on work surface

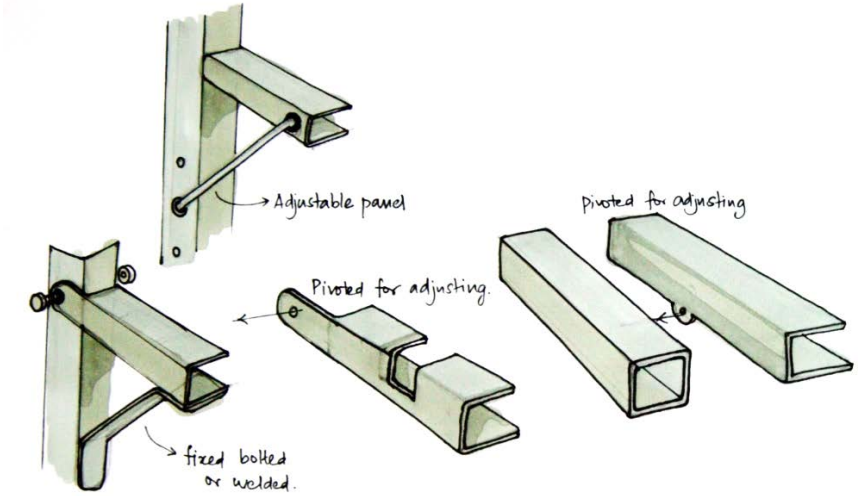


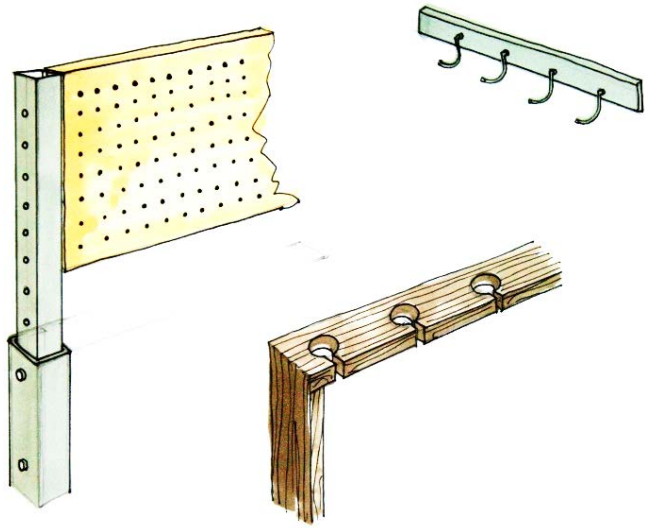
Sliding mechanism for tail stock – Option 1



Guide and sliding support for lathe – Option 2

IDEATIONS – FOLDING WORK SURFACE AND STORAGE





TAKE AWAY

Concepts

- The type of steel section to be used depends on the function as well as strength and cost of the section.
- Casting of metal cost many times compared to the use of sections and should be avoided.
- The stability also depends upon the type of joints.
- A systematic evaluation of the concepts is possible only after detailing of concepts

Advantages and drawbacks of the concepts are listed down for proceeding for concept detailing.

a) Advantages and Drawbacks of Concept 1

- Can be used in the centre of a workshop giving room for circulation.
- Can be used by multiple craftsmen.
- Multifunction workstation for all types of products
- Highly stable
- Same motor can be used for multiple functions.
- Primary functions can't be used simultaneously
- Limited flexibility to work surface
- Lack of provision for height adjustment
- No interchange of layout possible
- Limited facility for storage of tools and accessories
- Assistance to primary functions is possible
- Accessibility issues for machinery
- Difficulty in maintenance

b) Advantages and Drawbacks of Concept 2

- Can be used anywhere inside the workshop
- Can be used by multiple craftsmen
- Modular workstation
- Capable of multi-functionality
- Flexibility in work surface
- Flexibility in height of work surface
- Multiple layout possible
- Different ways of storing tools possible
- Easy maintenance
- All work surfaces are not stable
- Separate parts required for each function
- High number of parts required

FURTHER REFINEMENTS

- Based on the primary evaluation the modular concept was taken for developing further concepts.
- A comparison of material is required to decide which material should be used where.
- Understanding the load acting on the surface need to be checked.
- Study of steel sections and costing is required to develop further iterations.

a) Load on the workstation

The dead load which will act on the workstation was calculated to have a crude idea on the load acting on the workstation.

- Density of Indian teak – 0.65 to 0.9 x 10^3 kg/ m^3
- Weight of Typical Lathe – 16kg + 4kg Parts
- Weight of the motor = 20 Kg
- Weight of the Circular Saw = 10Kg
- Weight of Smallest Workpiece – 0.3 kg
- Weight of Largest Workpiece – 19kg
- Weight of Tools – 2 Kg
- Safety factor – 1.5
- 60kg X 1.5 = 90Kg

IDEATIONS – PAINTING WORKSTATION

- This workstation can be used by sitting on a comfortable chair or work stool.
- The design consists of a flat worktop which can be used for supporting the accessories and tools including paint cans
- The foldable worktop is used for performing the painting or finishing task
- Painting and finishing worktops can be based on the same module which can be adjusted according to the convenience of the craftsman sitting consists of sliding channels on which, flat metals members run. The work piece can be supported on these members and can be to which

TAKEAWAY

- The clamping method for the painting work is ideal as it can be easily tighten and released.
- A more standard clamping mechanism has to be achieved
- The work top does not address the basic requirements of user like keeping paint and brushes.
- Extension of length according o the product is not possible.

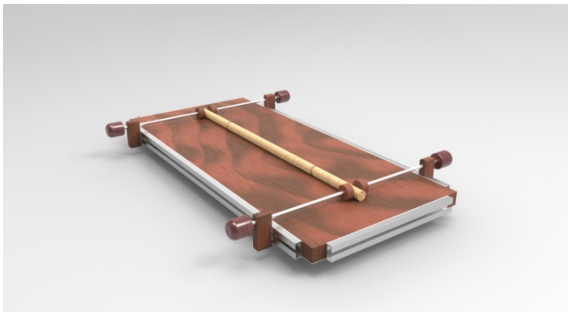


Figure 91

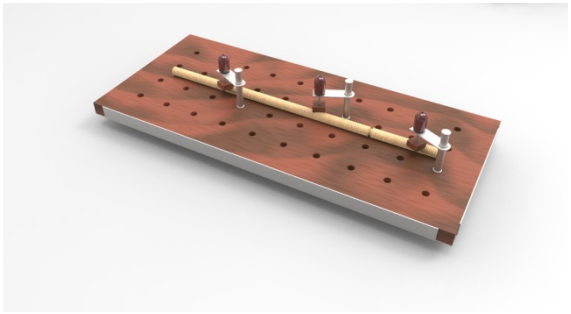


Figure 92

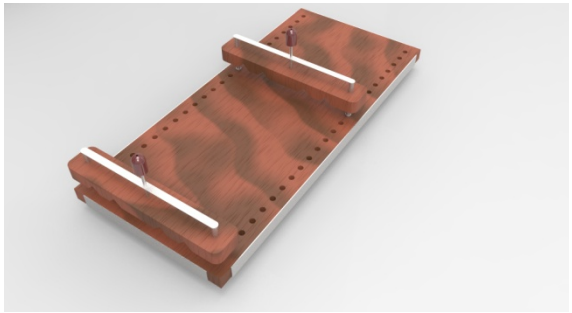


Figure 93

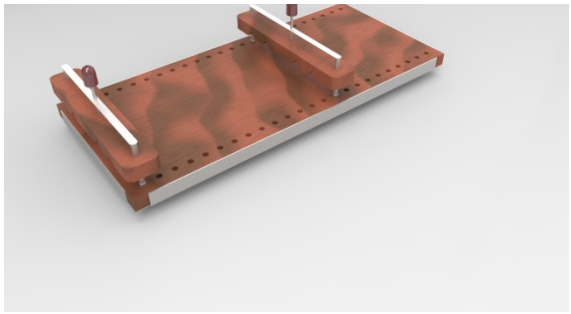


Figure 94

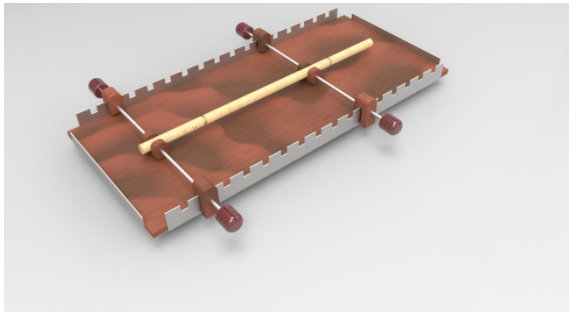


Figure 95

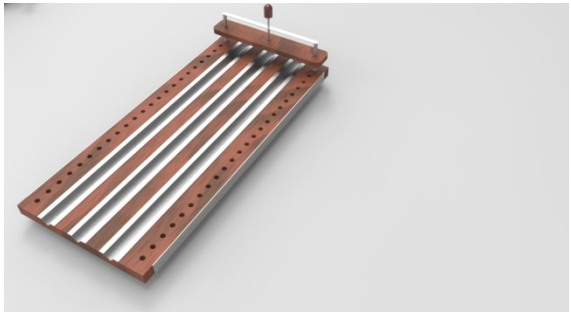


Figure 96

IDEATIONS – CLAMPING MECHANISM

Different clamping mechanism was ideated to work with different functions associated with the workstations.

Figure 91 – 96 shows these different ideations.

Various methods like parallel bar clamps, clamps based on dog holes, Wrenches and V channels are among these options.

TAKEAWAY

- The clamps are not meant for easy release and hence these do not assist in drilling or other quickly removable applications.
- Particular clamps have to be selected based on the clamping requirements.
- Quick release clamps like cam clamps and speciality clamps have to be studied.

Final Concept

Final Concept is based on how modular parts can be used in functions to optimise production and assembly. In this concept the workstations are divided into three types namely Turning, Painting and Assembly work stations.

These work stations are process oriented which incorporates existing machines.

a) Worktop
b) Frame

The worktop varies according to the process it is meant for. Worktop in all these types has mainly two parts. One is the 60X35 worktop to which machinery is fixed or accessories are attached. The second one is the workable surface on which guides or clamps are fixed to assist working.

All the frames of turning, painting and assembling workstations are different. There are two types of frames for each function. A Primary frame and an extension frame which can be chosen by the craftsman based on his type of work.

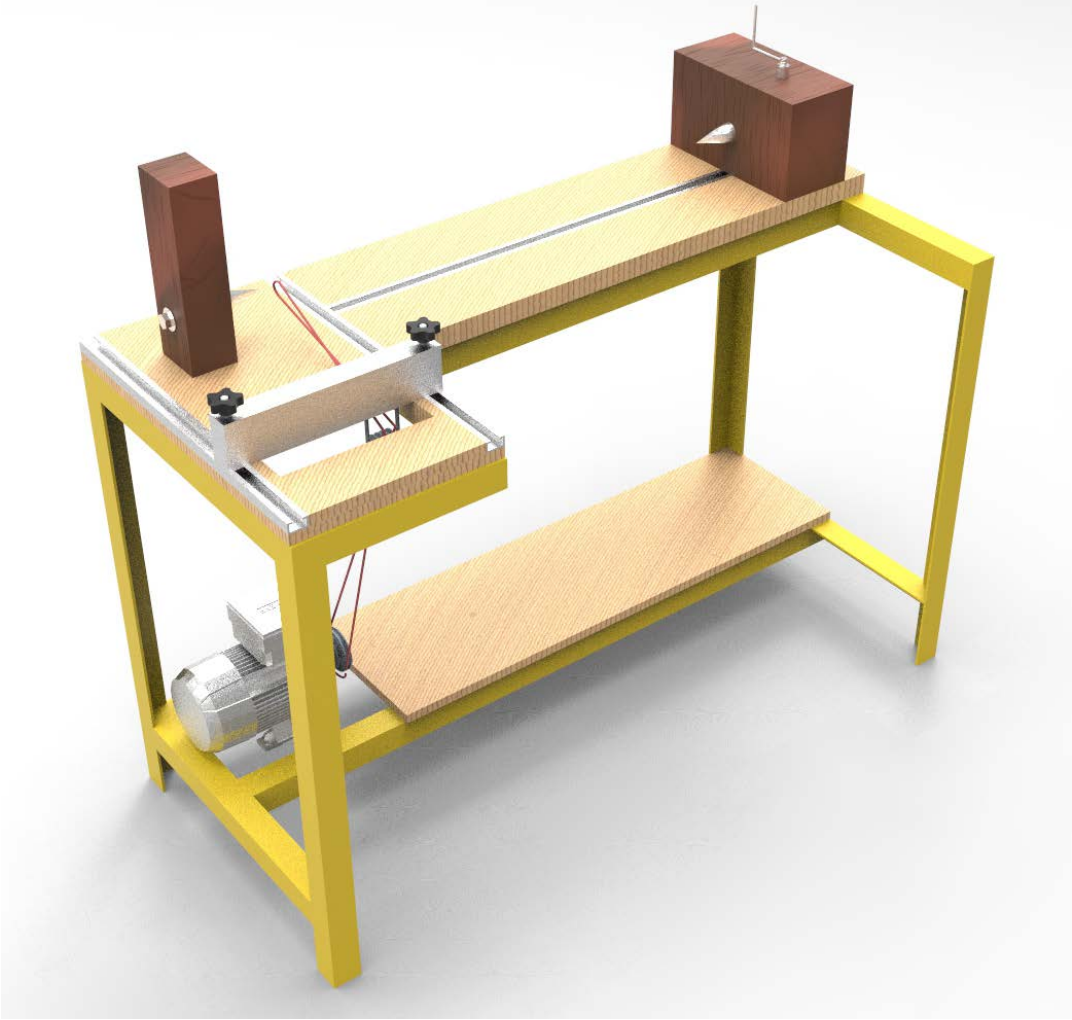


Figure 97

WOOD TURNING WORKSTATION

The wood turning work station consists of the lathe which is standardised.

The worktop consists of two modules in plywood. One is a 35x60 cm module to which the headstock of the lathe is attached. The second module is again a plywood top on which the tail stock can run.

The motor is mixed below the top adjacent o the footrest. The pulley (Rope) runs through the plywood module to tie around the wood piece.

The frame is of two types. A basic frame as shown in Fig.97 and an extension frame which is optional as shown in Fig.99.

Fig. 98 shows the exploded view of the workstation.

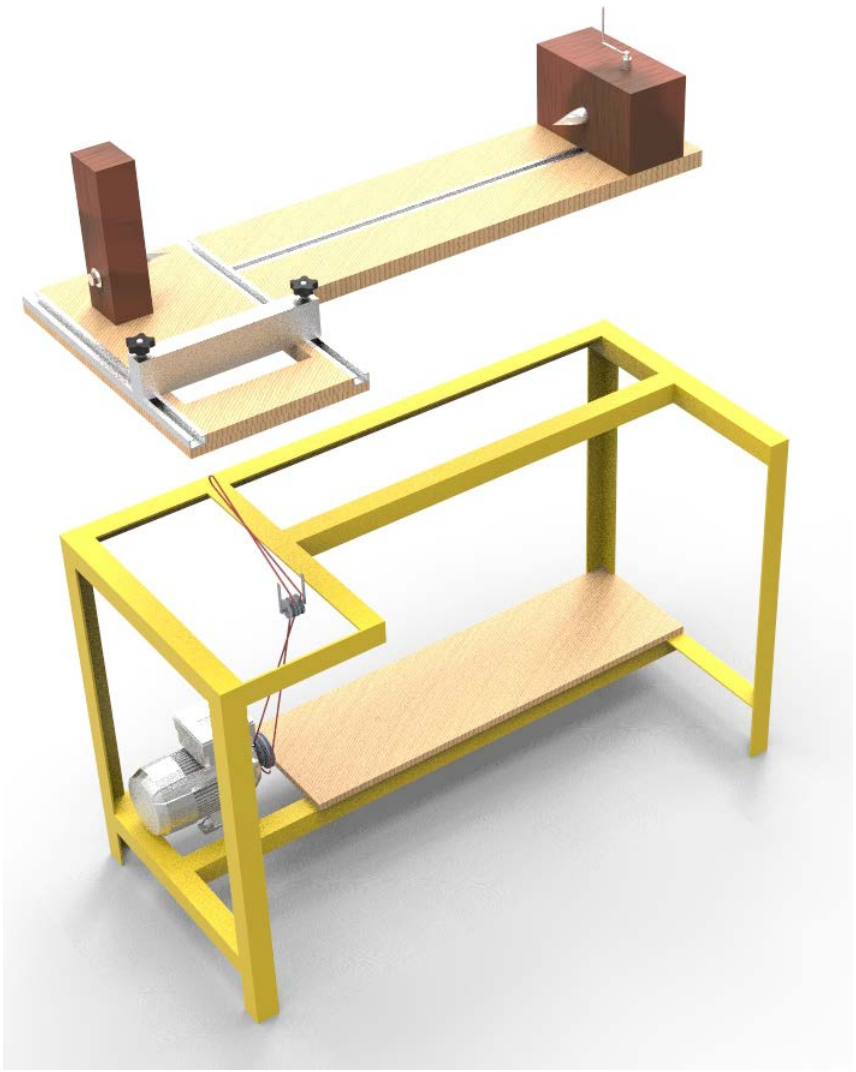


Figure 98

Figure 99

Figure 100

PAINTING WORKSTATION

The painting work station consists of the lathe which is standardised which can be used in painting. This can be motorised or manual as required by the craftsman.

The worktop consists of two modules in plywood. One is a 35x60 cm module to which the headstock of the lathe can be attached. This module can include containers to accommodate tools as well as paint while working. A second module is again a plywood top which can be adjusted according to the user requirement. This worktop is hinged on top and can be moved for comfortable working for long hours.

The motor is mixed below the top adjacent o the footrest. The pulley (Rope) runs through the plywood module to tie around the wood piece. This adjustment can be altered when not in use.

The frame is of two types: A basic frame as and an extension frame similar to the lathe.

Fig.101 shows the exploded view of the workstation.

Figure 101

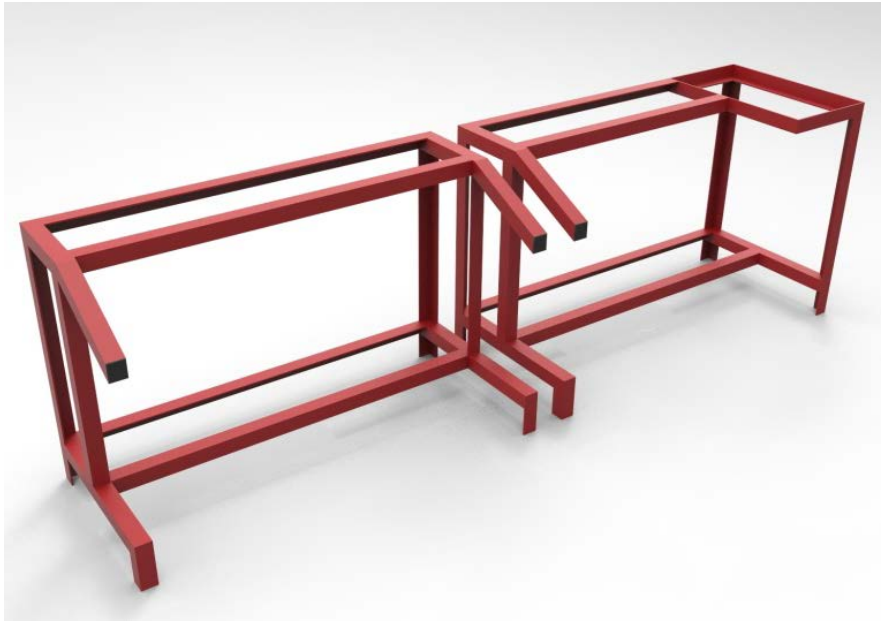


Figure 102

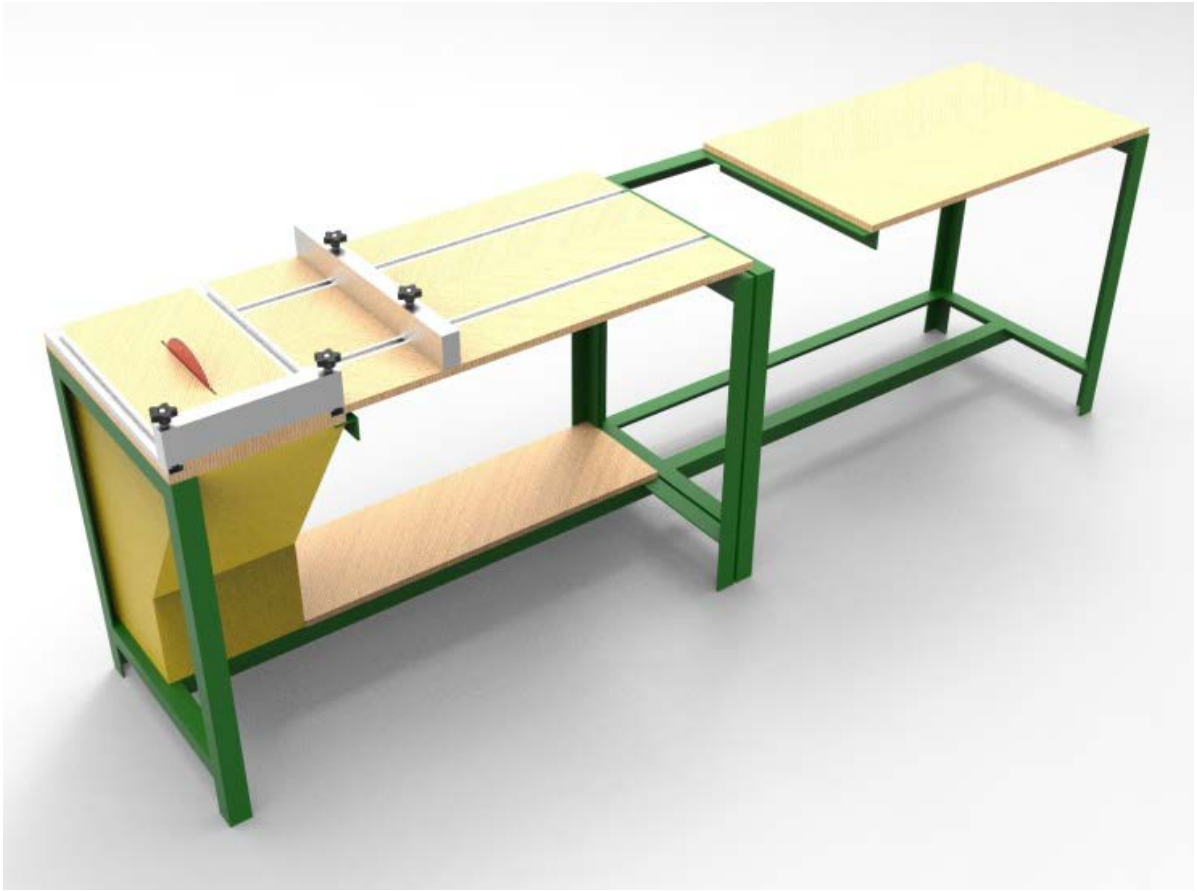


Figure 103

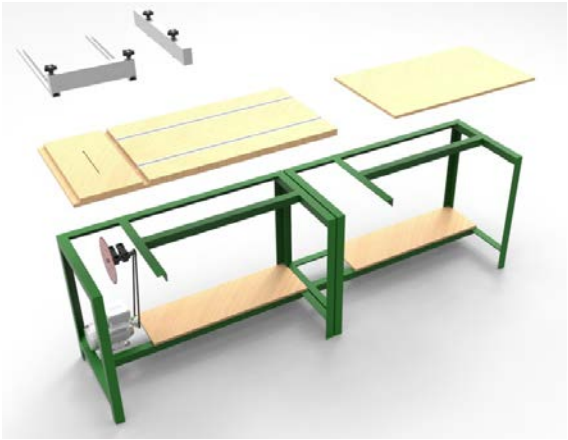


Figure 104

ASSEMBLING WORKSTATION

The assembling work station consists of the cutting saw attached to a basic module similar to the lathe.

The motor is mixed below the top adjacent o the footrest. The belt runs through the plywood module.

The frame shown in Fig.103 consists of the table saw station placed along with a similar frame which can accommodate the work top of a drill bench.

MOCKUP MODELS

Figure 105

Figure 106

Mock-up models of all three workstations in scale 1:4 were made using wooden frames, styrene sheets and aluminium channels. These are to be used to do concept validation at Sankheda.

FIELD VISIT

The physical models were made such that it could be assembled at site easily. This method was also helpful in showing how the product could also be easily assembled at site if bolting is also used along with welding. The modular aspect of design could also be presented using this method by means of worktops which could be dismantled or interchanged.

Figure 107

The mechanism involved in the workstation was explained through digital representation of the same. After assembling and explaining the concept, a team of craftsmen who are involved in respective activities in the manufacturing process were asked to provide feedback.

Figure 108

Figure 109

Figure 110

Figure 111

The above images shows the concept validation done at Sankheda.

CONCEPT VALIDATION

a) Wood Turning

- Direction of turning is important – The direction of turning process in lathe used in Sankheda was from right to left since the headstock was always on the right side. This was not given importance in the design.
- Lathe on higher position – Craftsmen agreed to the position of the lathe on higher position as few of them have previously worked on imported lathe machines and shared the experience using them.
- Adjustable for different heights – Height of the table is a crucial factor in the design of the lathe bed. According to the craftsmen they need good visibility of the wood piece they are working on.
- Lathe chuck not required – This comment was put forward since the design of lathe was following minor changes and required clarification on its feasibility. The existing wood turning process requires adjustment of the wood piece while turning. Using a chuck will hinder this.
- The extension using modularity – This method was accepted as the craftsmen agree on the enhanced usability of the new design by converting the large lathe into smaller modules.
- Indigenous lathe – The craftsmen all stood by the idea of indigenous lathe and modification to the existing machine in terms of simplifying the mechanism was accepted

b) Painting

- Time variation – The time of painting using brush varies widely according to the skill of the craftsman
- Tilting surface not required – The tilt feature of the painting worktop design was not tolerable as the paint will spill and flow during painting.
- Clamping not required – Clamping of work piece while painting is not required as it increases the time taken for painting. The method of holding the work piece without fixing the end so that it can be rotated is entertained.
- Orientation of working keeps changing – Craftsmen who work on painting position the work piece in different ways. The new design addresses only one such way of holding the work piece.
- Tools should be nearby – The tools used for painting should be nearby the worktop and designed in a way to avoid spillage during work.

c) Assembling

- Clamping during drilling - Clamping method if any increases time taken for drilling when. The craftsmen do not mind holding the work piece as it reduces the time taken drastically.

REFINING

The comments from the craftsmen were used to design a more appropriate workstation for them. Refining the three workstation led to the development of a uni-frame design which can be used for all the three processes. Proof of concept of the mechanism of lever for lathe, mechanism of sliding on lathe bed was made to assist in the process.

a) Revised workstation frame

Figure 112

The frame is designed in such a way that it accommodates all the machinery required for turning, painting and assembly processes.

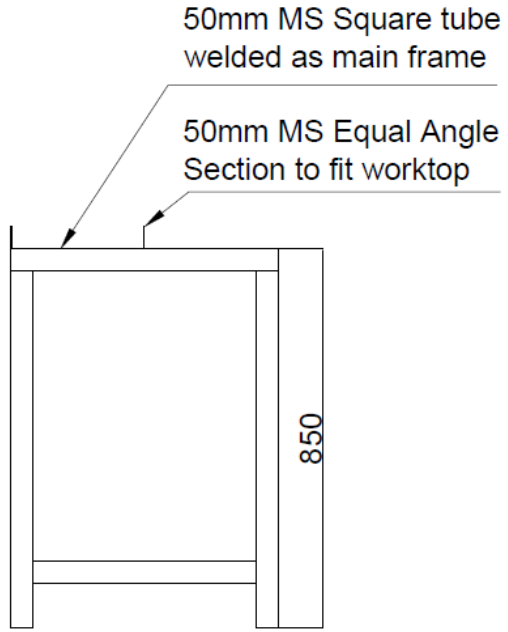


Figure 113

b) Wood Turning Workstation

Figure 114

The wood turning process

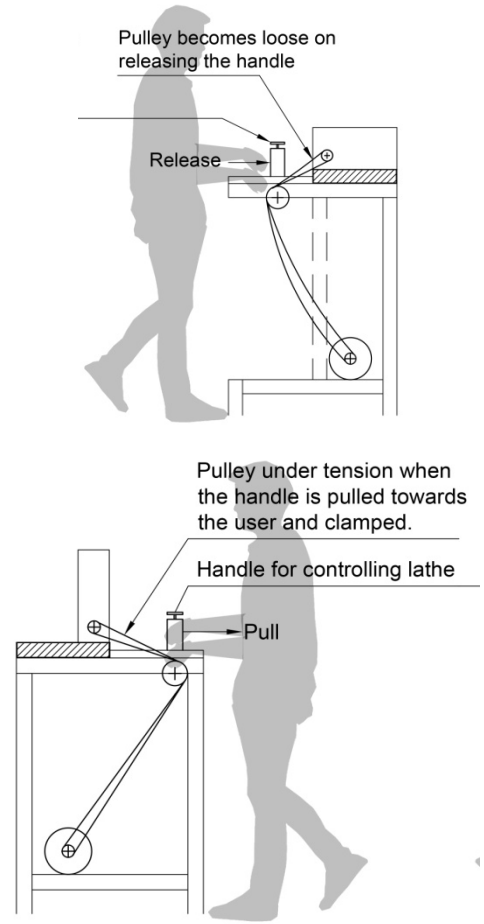


Figure 115

c) Workstation for Painitng

Figure 116

The paining process

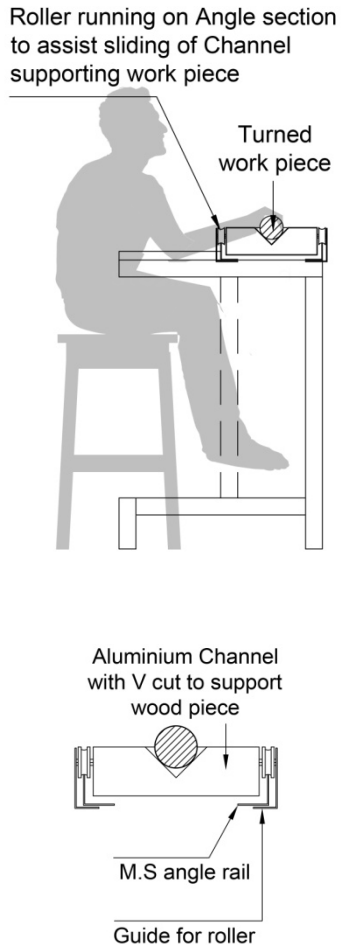


Figure 117

d) Workstation for Cuting during assembly

Figure 118

The cutting process

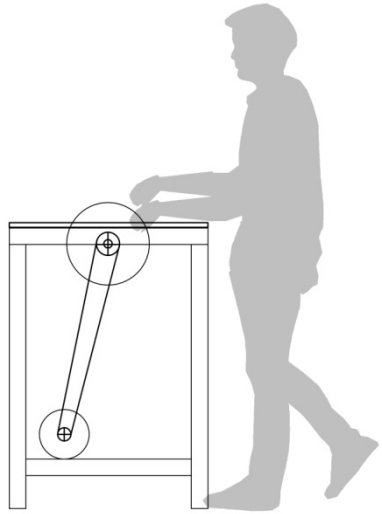


Figure 119

e) Workstation for Drilling during assembly

Figure 120

The drilling process

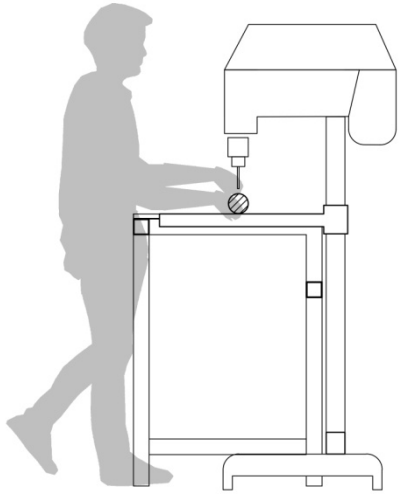


Figure 121

MANUFACTURING

Section of the frame is to be chosen based on the load on the workstation, Motor power and Vibration. A manufacturer was consulted to obtain an idea on the gauge of steel as well as the sections to be used in the frame.

According to the load calculated and the type of motor used an appropriate section was suggested by the manufacturer.

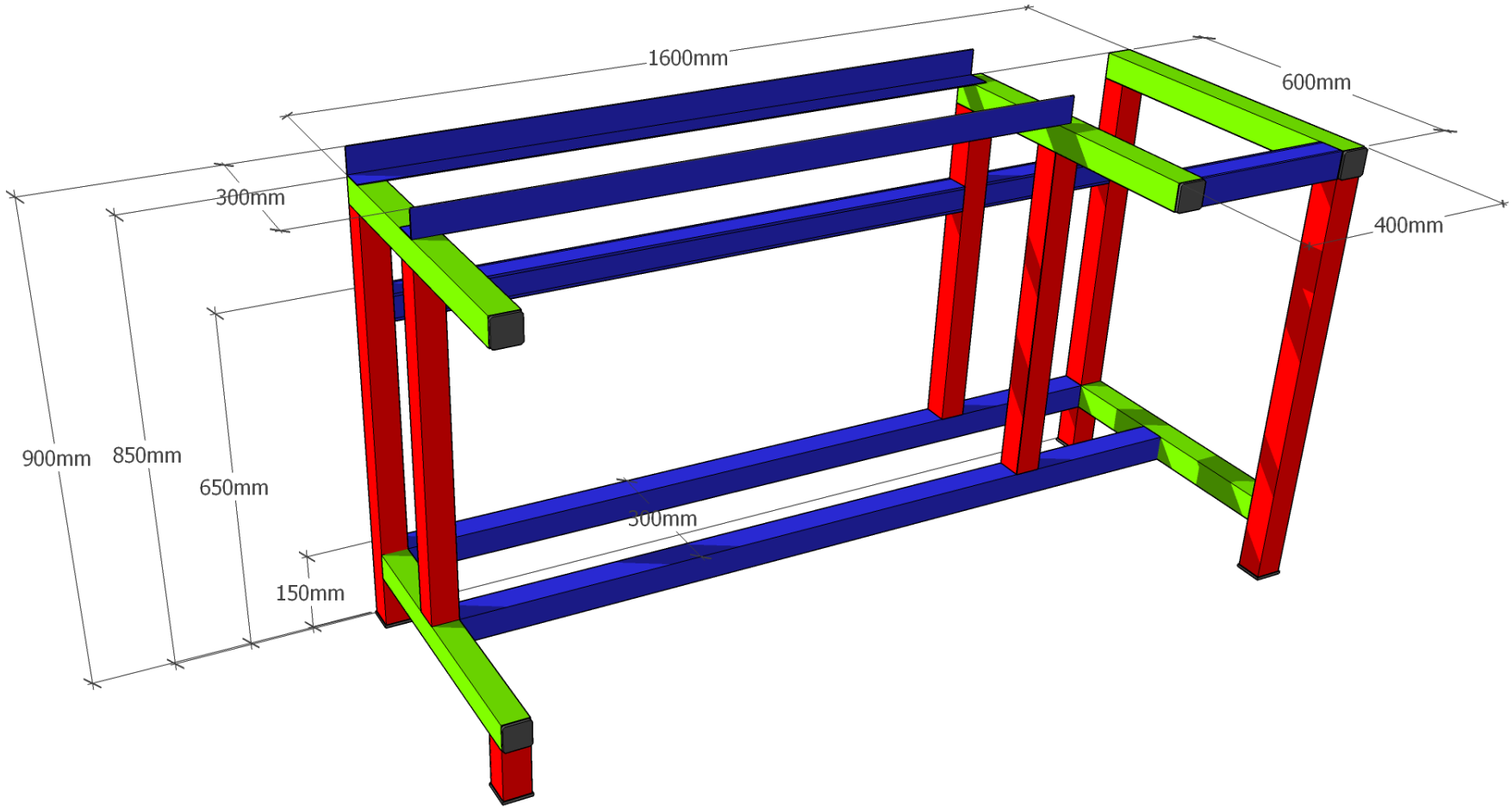
Sections suggested by Manufacturer

- 40X40 MS Square Tube Section – 14 Gauge for main frame
- 50x50 MS Square Tube Sections – 16 Gauge for main frame
- 16 gauge 50mm Equal Angle Sections for top rail.

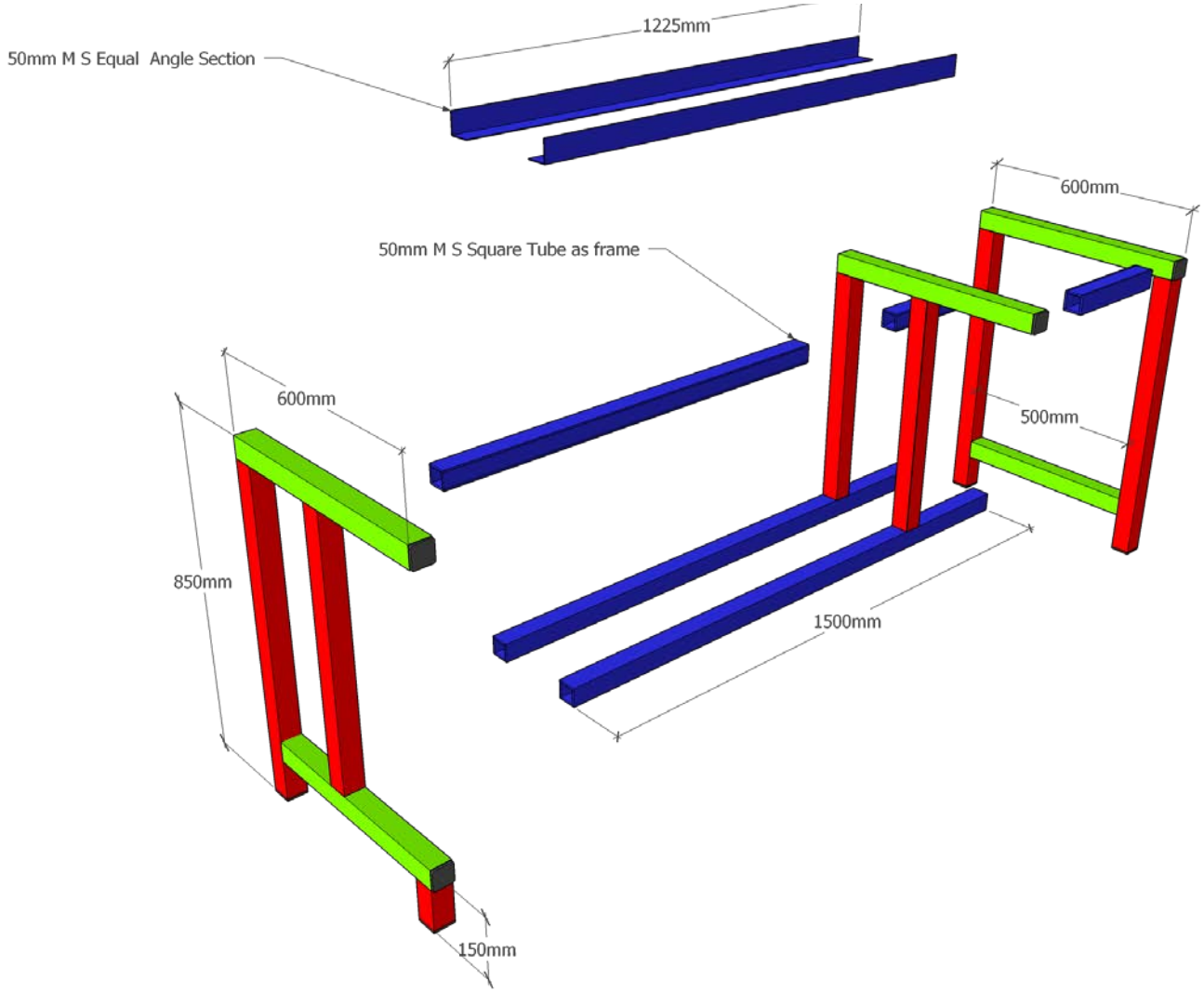
Material for Worktop

- 35mm thick wood plank/ two 18mm thick plywood stuck together for work top.
- 18mm plywood as worktop for mounting circular saw to the module.

Frame dimension

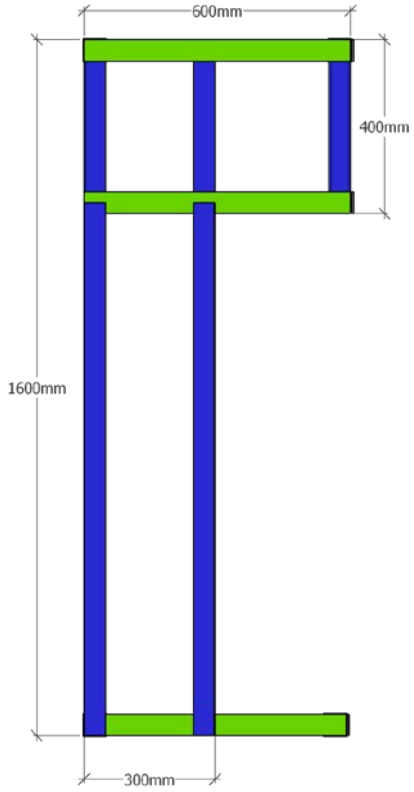


welding the Frame



Elevation

Plan



References

Chakrabarti, D. (n.d.). *Indian Anthropometric Dimensions (For Ergonomic Design Practice).*

http://gaatha.com/sankheda-furniture/. (n.d.).

(n.d.). *http://www.tribuneindia.com/2002/20020302/windows/main4.htm.*

https://en.wikipedia.org/wiki/Sankheda. (n.d.).

ILO, IEA. (n.d.). *Ergonomic Checkpoints.*

LIST OF FIGURES