Project-2

RE-DESIGN OF A SPECIMEN CUTTER FOR METALLURGICAL ANALYSIS

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Guide : **Professor G.G.Ray, Ph.D**

IDC,IIT-BOMBAY

November, 2003

APPROVAL SHEET

The industrial design project-II

RE-DESIGN OF THE SPECIMEN CUTTER FOR METALLURGICAL ANLYSIS

By

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02613009

is approved for the partial fulfillment of the requirements for the post-graduate degree of

Master of Design in **Industrial Design** at

Industrial Design Centre,
Indian Institute Of Technology,Bombay

Guide.....

Chairperson.....

External examiner.....

Internal examiner.....

Acknowledgement

I would like to express my gratitude towards my guide Professor G.G.Ray,Ph.D , for his esteemed guidance through out this project.

I specially express my thanks to Professor M .Bhandari for his constant support and timely inputs regarding this project.

I'm grateful to all the faculty and my friends of IDC who has given me their valuable suggestions and helped me.

ABSTRACT

New technical applications and the operating requirements pushed to higher levels have created a continued need for the development of new alloys. In metal working industries, work pieces of most different shapes and dimensions are of different materials are worked. The material properties of different metals are to be care fully studied before they are sent for the fabrication or take a shape of any component. For this purpose the metallurgical properties of the metals are to be observed and estimated. Based on this estimation the suitability of the material to the specific purpose will be known. A metallurgist separates a layer of metal from the parent metal and carries the study based on the requirement. For the separation of a layer from its parent component a specimen cutter is used in the metallurgical laboratories for mechanical preparation of solid specimens.

The project deals with a new design and development of the existing, fully manual equipment with enhanced functionality adopting contemporary technical developments , increased usability,substantial reduction of human intervention and aesthetics to create new identity and reduce monotony etc., which results in efficient and accurate out put.

Table of contents

Table of contents

1. INTRODUCTION

1.1 INTRODUCTION

Metallurgy as an art has been practiced since ancient times. Metallurgy is the science and technology of the metals. The worker of metals is mentioned in the bible and in the Greek and Norse mythology.Ancient man knew and used many native metals. Gold as used for ornaments ,plates and utensils as early as 3500 B.C. The art of smelting ,refining ,and shaping metals was highly developed by both the Egyptians and the Chinese.

Knowledge of dealing with the metals was generally passed directly from the master to apprentice in the middle ages,leading to an aura of superstition surrounding many of the processes. Very little was written on the metallurgical processes till 1556.In succeeding years, much knowledge was added to the field by the people trying to duplicate the work performed by their ancestors.The person dealing with the metals is called metallurgist.

Until the beginning of the last quarter of the 19^{th} century,most investigations of the metal structure had been macroscopic(by eye)and superficial.The science of the structure of the metals was almost non-existent

The situation was ripe for the detailed attention of the individuals whose back-ground was more scientific than practical.The rapid development in this field has been taken place during the period of 1864.

About 1922, more knowledge of the structure and the properties of the metals was added by the application of X-ray diffraction and the wave mechanics.

INTRODUCTION

Metallurgy is really not an independent science since many of its fundamental concepts are derived from physics, chemistry and crystallography.The metallurgist has become increasingly important in the modern technology. Years ago, the great majority of the steel parts were made of cheap low carbon steel that would machine and fabricate easily.Heat treatment was reserved exclusively for the tools.

Designers were unable to account for the structural inhomogenity,surface defects etc. and it was considered good practice the large factors of safety. Consequently,machines were much heavier than they should have been, and the weight was considered as the mark of quality. This attitude persisted to some extent, to the present time but has been seriously discouraged by the aircraft and the automotive industries.

They have emphasized on the development of the strength-weight ratio in good design,and this led to the development of new high strength ,light weight alloys.

New technical applications and the operating requirements pushed to higher levels have created a continued need for the development of new alloys. For example, an exciting wankel rotary engine – an internal combustion engine of unusual design that is more compact,lighter and mechanically far simpler than the ordinary reciprocating piston motor of equal horsepower. A bothersome problem has been the seals between the rotor and the metal wall. Originally the seals were made of carbon and seldom lasted for more than 20,000 miles. Research developed a new sintered titanium-carbide alloy which has given life times of up to 100,000 miles .

1.2 ROLE OF SPECIMEN CUTTER

To study the structural composition of the metal and its alloy's and for the development of the same,the metals are examined under the highly advanced micro scopes. For this kind of microscopic analysis, a thin film or slice of, 0.1mm to 5mm thickness of,the metal is required. This kind of precise cutting is possible with only certain type of cutters, with very special features, made exclusively for this purpose . Metallography is the most reliable way of identifying the structure of a given product through the processes such as cutting, mounting, grinding and polishing, etching and analyzing under electron microscope. The purpose for sample preparation is to obtain the material's true structure, without deformation of any kind. In order to achieve perfect results in the shortest amount of time, the necessary equipment and preparation methods must be utilized. Even the most advanced preparation equipment will produce poor results if the choice of cutter does not match the requirements. The cutter must be chosen carefully to ensure that the desired goal is attained at each preparation step.

1.3 SITUATION ANALYSIS

In metal working industries, work pieces of most different shapes and dimensions are of different materials are worked. The material properties of different metals are to be carefully studied before they are sent for the fabrication or take a shape of any component. For this purpose the metallurgical properties of the metals is to be observed and estimated.based on this estimation the suitability of the material to the specific purpose will be found . So the fabrication industries send their samples to the metallurgical laboratories for analysis. As the component itself cannot fit under a microscope, a layer of metal is separated from the parent metal, mounted and then the study is carried. For the separation of a layer from its parent component a specimen cutter is used in the metallurgical laboratories for mechanical working of the metals.

Apart from this, students pursuing engineering (all branches of mechanical),especially metallurgical engineering, study the entire analysis as their core subject. During this course of action they are taught and trained about the analysis through the practical. The specimen cutter is used to serve the purpose in the laboratories for the microstructure analysis.

1.4 RECOGNITION OF NEED

I had come across the specimen cutter which is in use at the structure analysis laboratory in the metallurgical department ,IIT-Bombay. It works on the technology of using the diamond granules, resin/metal bonded, in the wheel form to slice the metal pieces.

I noticed certain features of the equipment are causing pretty inconvenience to the users while using it, such as loading the work piece,alignment of the work piece,application of the load on the disc,collection of the work piece after slicing, preserving the diamond wheel cut-off noise ,safety.etc. This pre and post slicing operation consumes much of the time , they expressed dissatisfaction when asked for the feedback.

I strongly felt that the high-end technology that is used is not properly served. I realized that,keeping the technology constant, there is a potential scope for the re-designing the same product emphasizing on functionality usability and appearance.

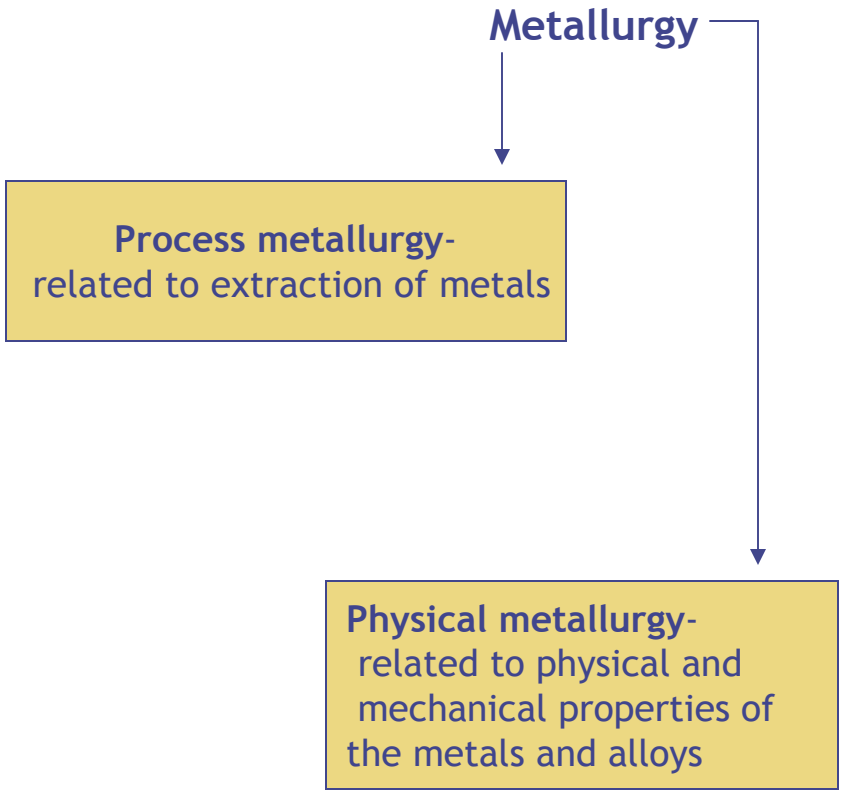
1.5 DESIGN METHODOLOGY

- Realization of the need
- Data collection and **analysis**(research,user survey,study of existing products)
- Design brief
- Understanding the design challenges.
- Product brief(considerations)
- Design specifications
- Conceptualization(possible solutions/synthesis/alternatives levels-1,2 3 4/mock up's)
- Concept evaluation with product brief.
- Development of selected concepts.
- Working drawings
- Prototype/mockup
- Feed back/evaluation
- Refinement
- Final model.

2. DATA COLLECTION AND ANALYSIS

2.1 LITERATURE SURVEY

What is metallurgy ?

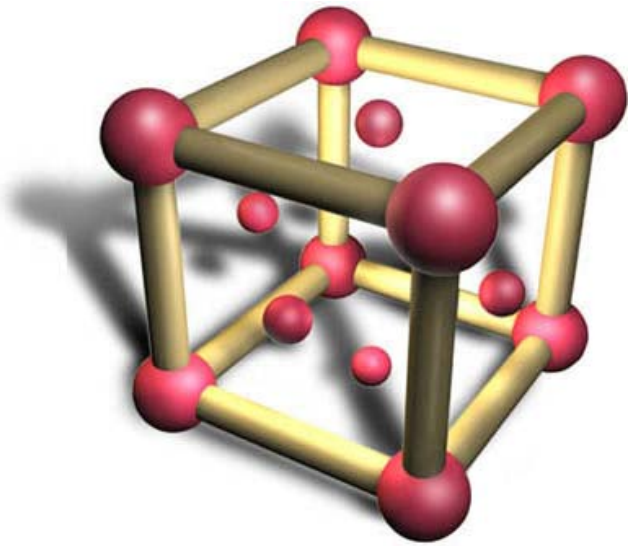


Metallurgy is the science and technology of metals

Physical Metallurgical analysis

The analysis, studies the properties of the metals and alloys as affected by three variables.

- **Chemical composition-**
  The chemical constituents of alloys.
  - Micro structure analysis -a thin layer of the metal (specimen)
- **Mechanical treatment-**
  Any operation that causes change in shape such as rolling,drawing,stamping,forming or machining
  -Micro structure analysis -bars,rods,plates,etc.
- **Thermal or heat treatment-**
  The effect of temperature and rate of heating and cooling.
  - Macro structure analysis -bars,rods,plates,etc.



Chemical composition of the metal plays the crucial role in the metallurgical study.

Chemical analysis

The study of the micro structure on the specimen , which determines various chemical compositions and their influence on mechanical and thermal properties of the metals.

- Strength
- Toughness
- Hardness
- Heat treatment,etc.

2.2 RESEARCH

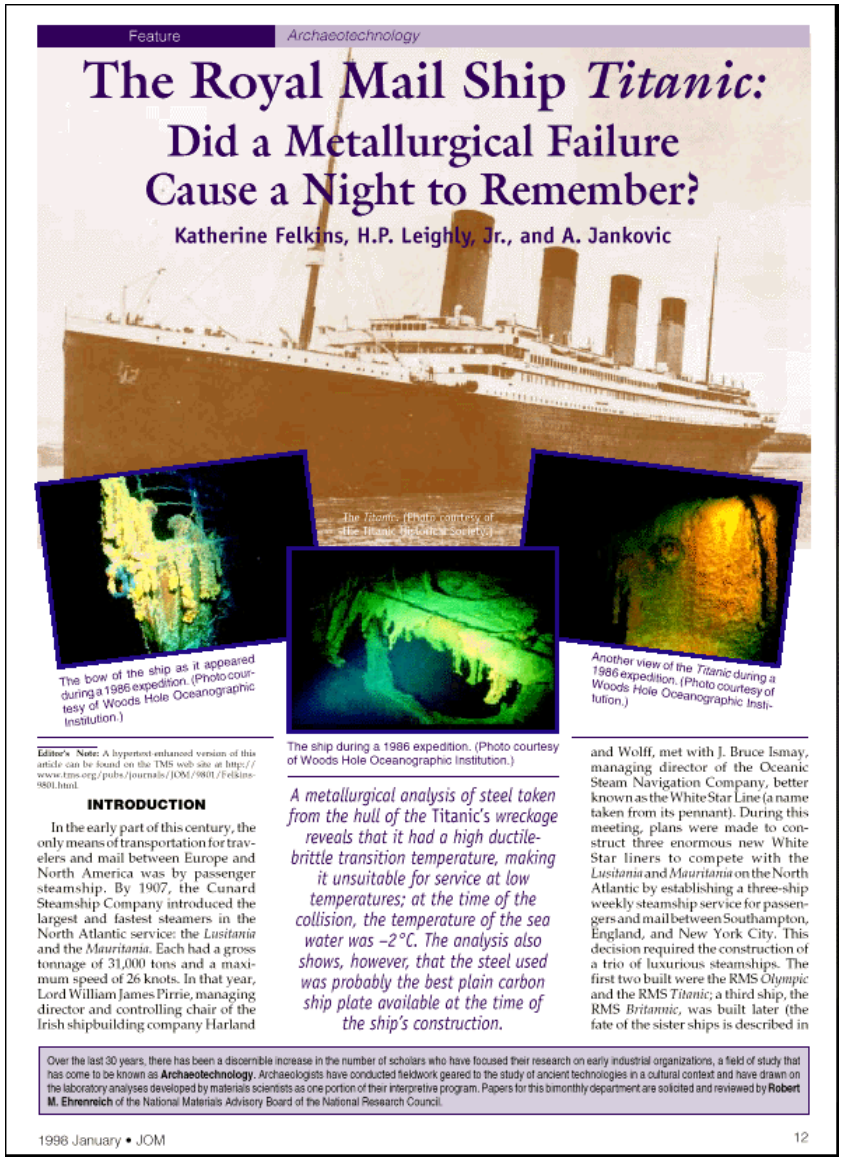
Why metallurgical analysis ?

Any metal, before getting fabricated or take any shape of a component or a product, is analyzed for its structural characteristics. Based on this the suitability criteria, whether or not the material suits for the particular product to perform particular function is known.

For example the metal that is yet to use for the boiler tube is tested whether….

- It will withstands the temperature or not.
- Retains the structural strength with out collapsing.
- Remains with out getting affected by the water .

RESEARCH



Feature | *Archaeotechnology*

The Royal Mail Ship *Titanic:* Did a Metallurgical Failure Cause a Night to Remember?

Katherine Felkins, H.P. Leighly, Jr., and A. Jankovic

The bow of the ship as it appeared during a 1986 expedition. (Photo courtesy of Woods Hole Oceanographic Institution.)

The ship during a 1986 expedition. (Photo courtesy of Woods Hole Oceanographic Institution.)

Another view of the *Titanic* during a 1986 expedition. (Photo courtesy of Woods Hole Oceanographic Institution.)

Editor's Note: A hypertext-enhanced version of this article can be found on the TMS web site at http://www.tms.org/pubs/journals/JOM/9801/Felkins-9801.html.

INTRODUCTION

In the early part of this century, the only means of transportation for travelers and mail between Europe and North America was by passenger steamship. By 1907, the Cunard Steamship Company introduced the largest and fastest steamers in the North Atlantic service: the *Lusitania* and the *Mauritania*. Each had a gross tonnage of 31,000 tons and a maximum speed of 26 knots. In that year, Lord William James Pirrie, managing director and controlling chair of the Irish shipbuilding company Harland and Wolff, met with J. Bruce Ismay, managing director of the Oceanic Steam Navigation Company, better known as the White Star Line (a name taken from its pennant). During this meeting, plans were made to construct three enormous new White Star liners to compete with the *Lusitania* and *Mauritania* on the North Atlantic by establishing a three-ship weekly steamship service for passengers and mail between Southampton, England, and New York City. This decision required the construction of a trio of luxurious steamships. The first two built were the RMS *Olympic* and the RMS *Titanic*; a third ship, the RMS *Britannic*, was built later (the fate of the sister ships is described in

A metallurgical analysis of steel taken from the hull of the Titanic's wreckage reveals that it had a high ductile-brittle transition temperature, making it unsuitable for service at low temperatures; at the time of the collision, the temperature of the sea water was –2°C. The analysis also shows, however, that the steel used was probably the best plain carbon ship plate available at the time of the ship's construction.

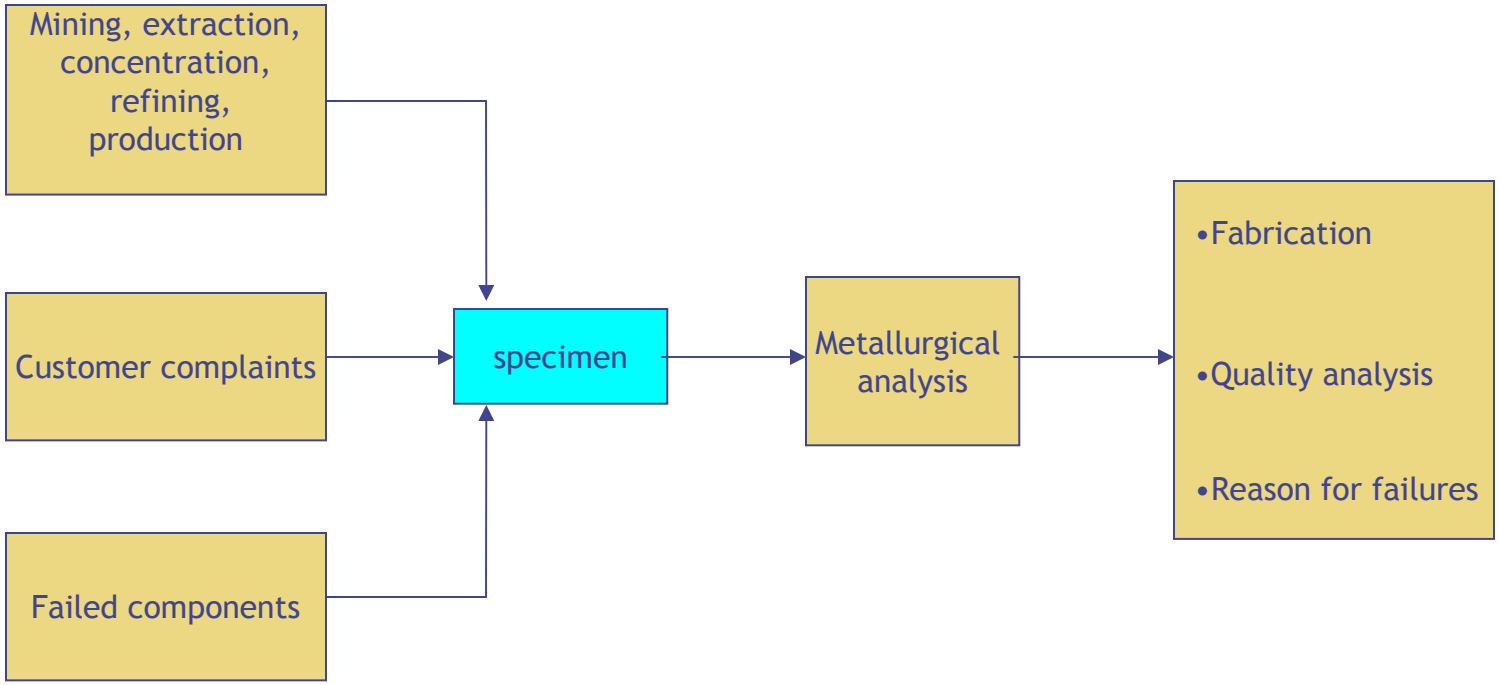
Over the last 30 years, there has been a discernible increase in the number of scholars who have focused their research on early industrial organizations, a field of study that has come to be known as **Archaeotechnology.** Archaeologists have conducted fieldwork geared to the study of ancient technologies in a cultural context and have drawn on the laboratory analyses developed by materials scientists as one portion of their interpretive program. Papers for this bimonthly department are solicited and reviewed by **Robert M. Ehrenreich** of the National Materials Advisory Board of the National Research Council.

JOM -Journal of metals materials and minerals
January 1998

"A metallurgical analysis of steel taken from the hull of the titanic's wreckage reveals that it had a high ductile-brittle transition temperature, making it unsuitable for service at low temperatures; at the time of the collision, the temperature of the sea water was -2°C. The analysis also shows, however, that the steel used was probably the best plain carbon ship plate available at the time of the ship's construction"

- Various failures ,their reasons and the quality of the material can be determined and reasons can be drawn out by analyzing the microstructures of the failed components.

RESEARCH

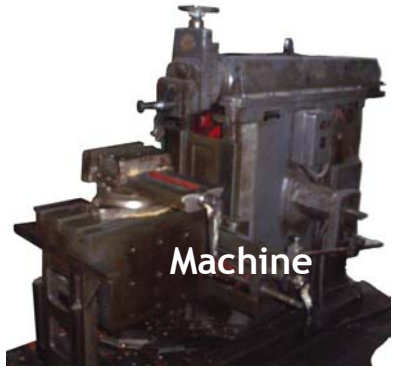


- Metals, that are to be fabricated,
- Materials of whose quality the user want to check,
- Failed Components of which the reasons are to be drawn and evaluated…..

…….are sent for microstructure analysis. For this purpose a thin layer of metal from the above category is to be taken.The thin layer which undergoes the metallurgical analysis is termed as **specimen.**The equipment that is used for the slicing a layer of the metal is called **specimen cutter.**

RESEARCH

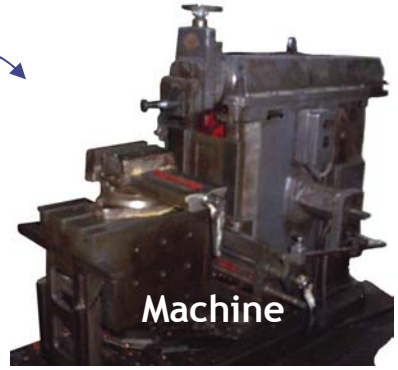
material



Between material and machine either material is brought to the machine or machine is brought to the material .

For metallurgical analysis...

material



A thin layer of material is separated and taken to the machine . The layer is separated by the specimen cutter.

Why we need cutter ?

The metal that has to be tested is taken in the form of a small component (bar,rod ,plate).this is done by using the manual hack-saw or abrasive cutters.

Then the metal bar/rod is heat-treated at various levels based on the various requirements and results,desired.

Then a thin layer of the metal is sliced from the component.This is not possible with the ordinary cutters as the slice required for the analysis ranges from .1mm-.5mm. This precision is not achieved by the ordinary cutters. A specimen cutter with a specially made precision cut-off wheel is used for this requirement.The slice thus obtained is called specimen.

Then the specimen is collected and mounted on bakelite or resin and polished to the mirror surface .

This specimen is then observed under high resolution microscope for the microstructure study. Depending on the microstructure various conclusions of the metal is drawn and the mechanical and the thermal properties are decided.

Then only that metal is allowed to go for the fabrication.

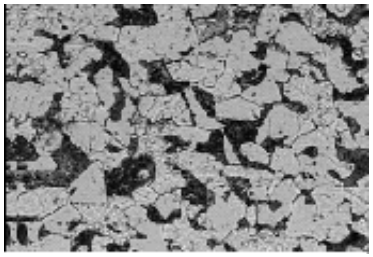
RESEARCH

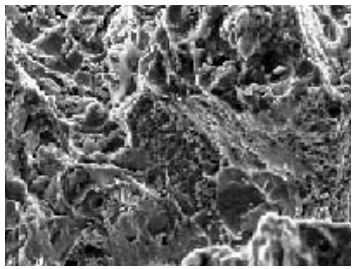
Characteristics of a good specimen

- **Retention of original properties**:
  The specimen that has been cut from the metal should possess the same original properties after cutting .
- **Plane and uniform surface:**
  The cut surface should have a perfectly plane and uniform surface with out any up's and down's.
- **Deformation or scratch free surface:**
  The surface should not have any scratches and distortion
- **Free from over heating**:
  The surface should be free from getting heated during cutting because heating results in the change in the properties.
- **Mirror finish :**
  The surface should have mirror finish absolutely scratch free

RESEARCH

Micro structures of metal





Criteria of choosing the cutter

- Based on the requirement (company, customer)
  - when the customer buys material and he want to re-check/check(when failed) the metal that is bought from the manufacturer.
- Based on the material availability and cost of the same
- Based on the on the test to be performed

- **X-ray Diffraction Test, Scanning Electron Microscopy, Energy Dispersive X-ray Analysis, Optical Emission Spectrography.**

  Specimen thickness: 1- 1.5mm

  (image magnification: 200-25,000 times)

- **Transmission Electron Microscopy.**

  Specimen thickness: 0.1- 0.5mm

  (image magnification: > 15 million times)

RESEARCH

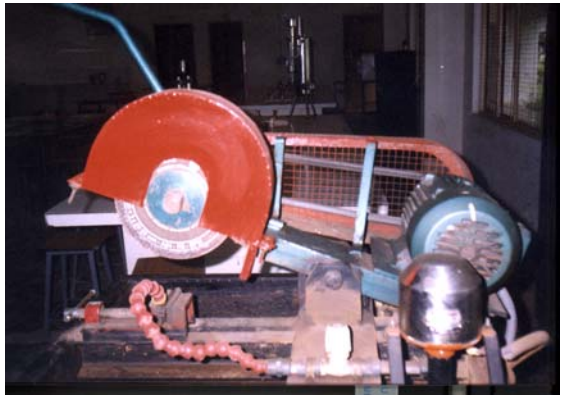
Various kinds of cutters available

Manual hacksaw

- manual cutting
- Provided with plastic handle
- Nickel coated frame
- Cuts in four positions

Power hacksaw

-hydraulic hacksaws
-designed to meet the demand for compact and efficient machines
-capable of cutting accurately, quickly and economically.
-The controls are simple and easy to operate



Rough abrasive cutter

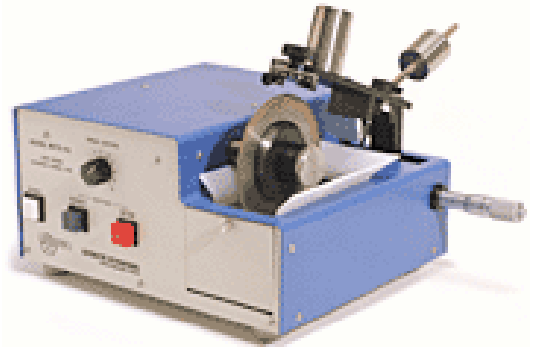
- manual abrasive cutter
- cuts at high R.P.m
- cuts very quickly
- fully manual operation

RESEARCH

Various kinds of cutters available

Precision abrasive cutter

- automatic and manual control
- pulse feed and automatic feed
- capable of cutting at very high speeds
- cuts up to diameters of 70mm



Precision diamond cutter

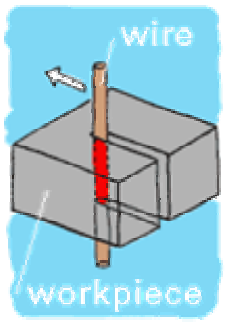
-low speed diamond wheel saw

-designed for wide range of materials

-min surface damage

-easy operation

--highly precise and accurate



Electrical discharge machining

- make a very straight cut
- no removal of material from already cut surfaces
- not put any stresses
- Uses an electrically charged wire
- A spark jumps from the wire to the work piece
- Material is locally vaporized
- The wire never contacts the work piece
- Puts in virtually no stress if cut in "skim cut" mode

The table shows the comparison between various cutters

RESEARCH

Basis	MANUAL HACKSAW CUTTING	ABRASIVE CUTTER (ROUGH)	ABRASIVE CUTTER (PRECISION)	DIAMOND CUTTER (PRECISION)	E.D.M
Scratches	Very high	High	Moderate	Almost no	No
Post polishing	Highly req.	required	required	very less	Not needed
Heat affected zone	very high	High	almost no	no	no
Coolant supply	Intermediate	yes	yes	yes	yes
R P M	To and fro	3000-4000	100-1000	0-300	Linear cut
Precision	No	No (5mm)	yes(0.8mm)	yes(0.1mm)	Yes(.1mm)
Specimen size can cut	250mm,25	75mm,40	40mm,25	50mm,25	100mm
Shape	Regular	Moderate	Regular	Regular	Any shape
Vibration while cutting	yes	yes	no	no	no
Cutting time (manganese steel)	23mmdia - 20min	3440RPM - 23mm dia - 3min	120RPM - 23mm dia- 40min	120RPM- 23mm dia- 90min	Depends
Specimen collector	no	no	no	no	yes

RESEARCH

The table shows the comparison between various cutters

Basis	MANUAL HACKSAW CUTTING	ABRASIVE CUTTER (ROUGH)	ABRASIVE CUTTER (PRECISION)	DIAMOND CUTTER (PRECISION)	E.D.M
Scratches	**Very high**	**High**	**Moderate**	**Almost no**	**No**
Post polishing	**Highly req.**	**required**	**required**	**very less**	**Not needed**
Heat affected zone	**very high**	**High**	**almost no**	**no**	**no**
Coolant supply	Intermediate	yes	yes	yes	yes
R P M	To and fro	3000-4000	100-1000	0-300	Linear cut
Precision	**No**	**No (5mm)**	**yes(0.8mm)**	**yes(0.1mm)**	**Yes(.1mm)**
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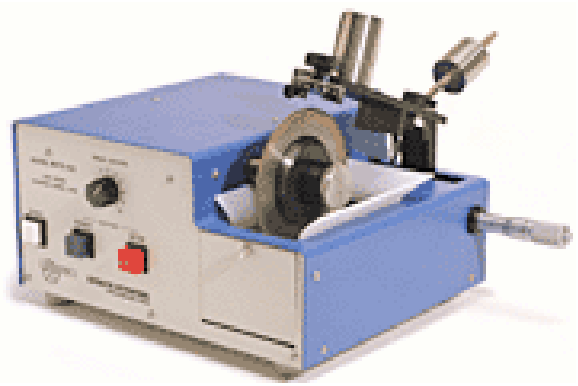
Specimen collector	no	no	no	no	yes

The table shows the variations and facets in operational and selection process of different cutters that consolidate the final criteria of selecting the diamond cutter.

RESEARCH



Criteria of choosing the diamond wheel cutter

- Scratch free surface.
- Requires minimum post polishing.
- High precision up to 0.1mm.
- Slow sectioning cutting - exclusively for TEM analysis.
- No damaging due to the deformation.
- Cheaper than E.D.M
- Constant coolant supply for avoiding heat effected zone
- With min polishing after sectioning the good surface finish,as that of E.D.M ,with out polishing,is achieved

BAL-TEC

BAL-TEC AG EM-T11ECHNOLOGY AND APPLICATION DWS 010 GRE

DWS 010 Diamond Wheel Saw

For mechanical preparation of solid specimens

Technical data

Dimensions

Width	330 mm
Depth	330 mm
Height	230 mm
Weight, approx.	7.7 kg
Wheel rotation	0 - 300 rpm
Max. blade diameter	100 mm
Max. sample diameter	33 mm
Max. sample load	500 g
Spindle diameter	12.7 mm
Micrometer setting range	25 mm
Coolant reservoir	350 ml
Max. load capacity	300 g

Connection

Voltage	230/115 V
Frequency	50 -60 Hz
Power input	< 100 W

Applications

- To saw and separate various materials such as: metals, semi-conductors, ceramics, glass etc.
- Thanks to low rotational speed (0 - 300 RPM), also recommended for fragile materials.
- The greatest variety of sample shapes can easily be mounted.

Features

- Compact table model.
- Minimal sample subsurface damage.
- Universal sample holder.
- Variable adjustment with powerful motor drive.
- Automatic cut-off on completion of the cutting process.
- Coolant is easy to change.
- Simple coarse and fine sample position adjustment by micrometer screw.
- Variable counterbalancing weight adjustment to match applied load requirements.

Specification

- Metal housing
- O-ring drive belt
- Coolant reservoir made of PE
- Automatic cut-off on completion
- Precision bearings for sample arm

Accessory kit consisting of:

- 1 Sample holder goniometer with 1 axis rotates 360°.
- 1 Sample holder with double clamps, specially designed for rod-shaped samples.
- 1 Sample holder with mounting device rotates 360° and secures flat, round and irregularly shaped samples, even suitable for metallographic cuts of up to 32 mm DN.
- 1 Pair of centering discs DN 61 mm.
- 1 Kit of graphite and aluminum sample carriers.
- 1 Coolant concentrate (0.95 l)
- 1 Sharpening stone
- 1 Diamond sawblade DN 100 mm; thickness 0.3 mm, 220 mesh.

Ordering Information

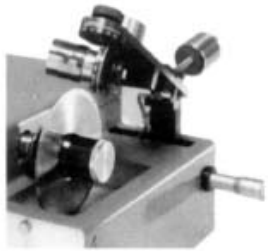
DWS 010 basic unit according to specifications
Order No.

230 V, 50 Hz	B 8010 090 62
115 V, 60 Hz	B 8010 090 63

Accessories

Vacuum Sample Holder
For glass sample plates of size 25 x 50 mm (e.g. for petrographic applications).

Order No.	B 8010 091 33



RESEARCH

Technical details of existing cutter in the market.

3. USER SURVEY

OBSERVING USER AT THE WORK PLACE

- Understanding the product (how it works, study of the existing products)
- User survey
- Analysis of the user (activity analysis,problem analysis,factor analysis,questionnaire,inferences from the user study)
- Understanding the user and product (activity analysis, user preferences, technology, peripheral products, latest products, interaction with the product).

USER SURVEY

3.1 Field study

Different areas where the product is used

- Metal production industries .
- Fabrication industries.
- Metallurgical labs, research centers.
- Educational institutes.

Field study has been conducted in the following places

- Technical Service Department – Mukand industries ltd
- Research and Development - Mukand industries ltd
- Metallurgical Department - IIT,Bombay
- Structure Analysis Laboratory - IIT,Bombay
- Metallurgical Analysis laboratory - VEC,Andhra Pradesh

USER SURVEY

MUKAND INDUSTRIES.LTD

Company profile:

Produces steel wires (5.5-28)mm and bars ranging from (5.5-100)mm

Clients for **MUKAND INDUSTRIES.LTD**

- MICO
- BAJAJ AUTO
- HERO HONDA
- PRESTIGE
- VENUS WIRES
- SONA STEERINGS

T.S.D – Technical Service Department (Shop Floor)

Purpose: High speed online cutting and evaluation.

To check

- Property maintenance
- Properties of the doubtful material
- To separate the mixed material

Cutter used- Rough abrasive

S.A.L – Structure Analysis Laboratory (R n D)

Purpose : When material needs to be evaluated for very fine details

To check properties :

- when the material or the component found to have fine cracks.
- when there is entrapment of inclusion.
- when there is complaints from the customer.
- when customer demands.
- when T.S.D forwards the sample.

Cutter used – Precision (abrasive)

USER SURVEY

Abrasive cutter in R n D

Insights :

- Needs a hectic installation for whole setup
- Transportation is heavy
- Pneumatic operation which gives auto feed needs nitrogen cylinder. This makes the whole setup too bulky

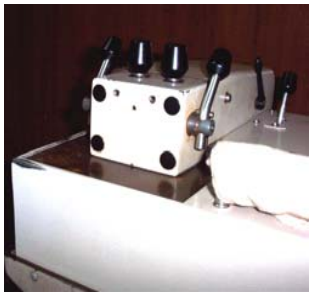
Manual feed of metal results in

- In-consistency in feeding
- Jaggered surface
- Surface burns
- Extra polish
- Strain

USER SURVEY

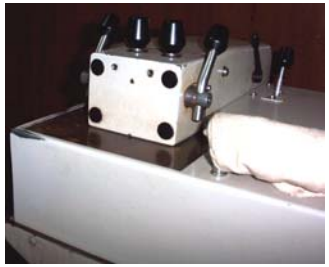
Insight-1

- The vice is flat Round pieces doesn't get gripped properly and intricate shapes as well

Insight-2

- Ambiguous vice operation - individually operated

Insight-3

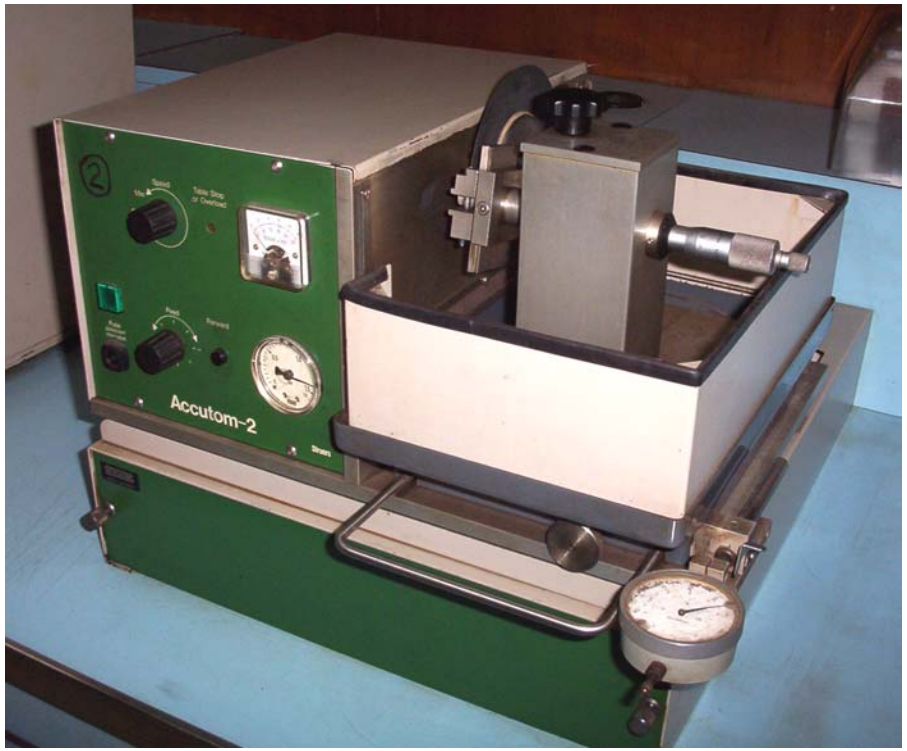
- No visibility while cutting is in process
- Judged by the auditory and touch sense



Insight-4

- Cutter moves towards the work piece
- Motor + cutter has to move
- Handle falls back when left

USER SURVEY



Precision cutter in R n D

Insights:

- No specimen collector after cutting.
- can not accommodate intricate shapes.
- confined to specific size.
- Less surface finish.

USER SURVEY

Insight-1

Fixing work piece in the vice



Insight –2

inconvenience






Insight-3

Working procedure with lot of human intervention

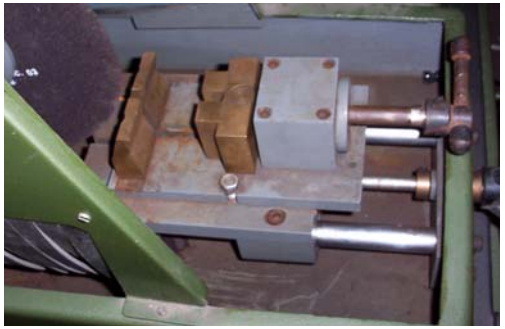
USER SURVEY

Diamond cutter in metallurgical dept, IIT

Abrasive cutter in metallurgical lab, IIT

USER SURVEY



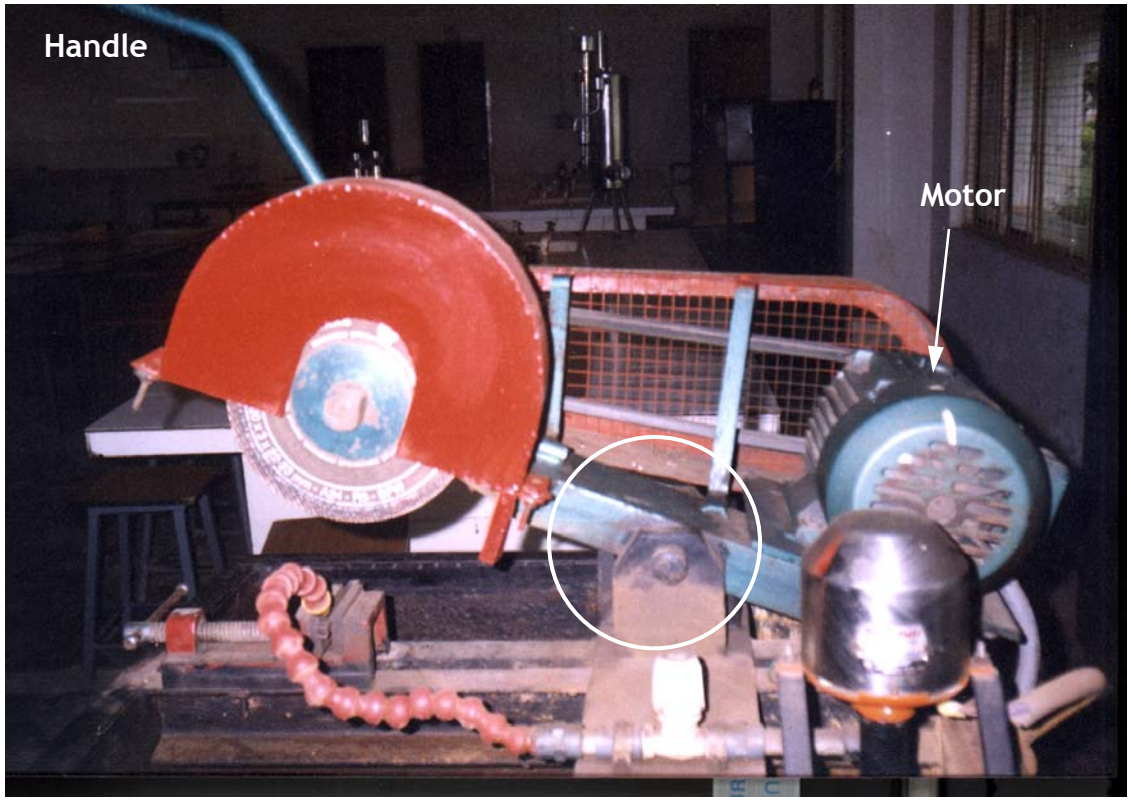


Separate control panel, coolant tank and motor makes it look bulky. The interiors will become dry and struck due to the no availability of the lubricant.



Feeding is done manually and demands lot of human intervention all the time.

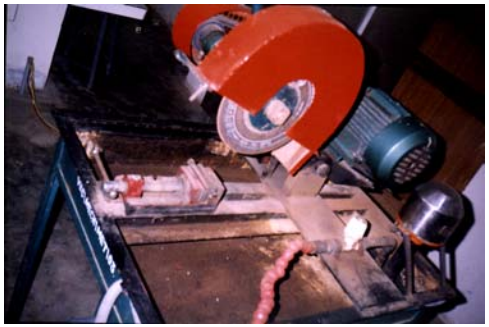
USER SURVEY



Abrasive cutter in metallurgical lab ,Andhra Pradesh

- Whole assembly is balanced on a pivot.

USER SURVEY


- Coolant bath is open and possibility for the contamination.
- Cutting posture imparts 5-8kg of load on the arm.
- Cutting is associated with vibration.

3.2 UNDERSTANDING THE PRODUCT

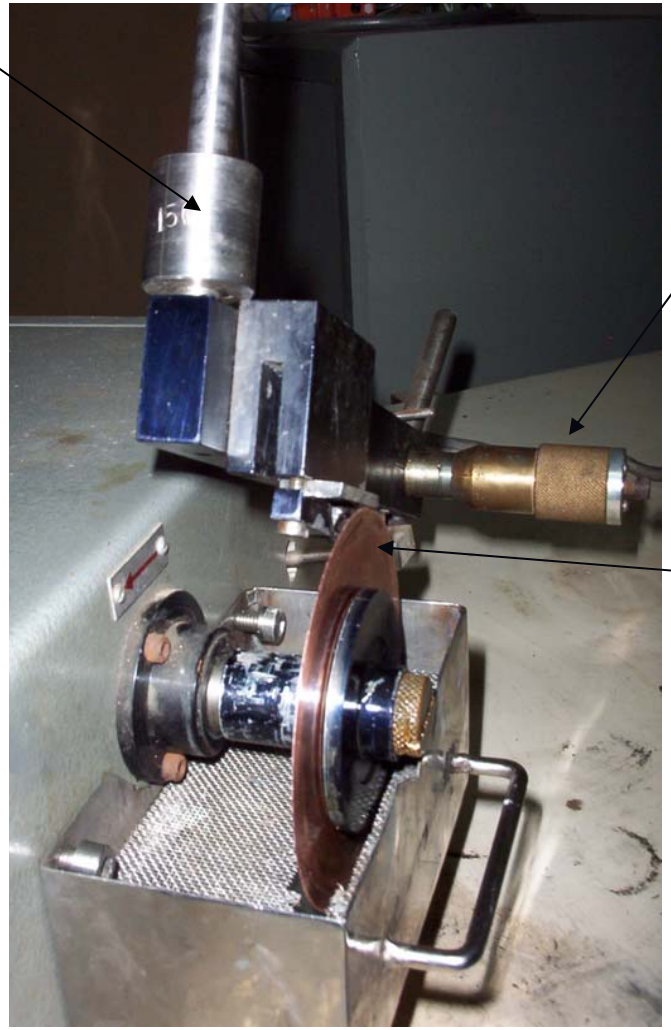
Design features

Diamond wheel cut-of in metallurgical dept, IIT

Load

Vice

Coolant bath



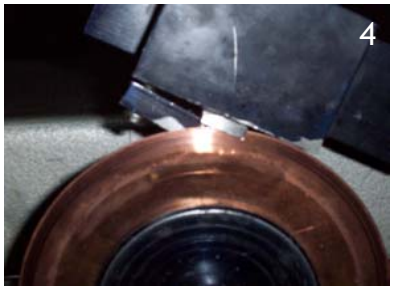
Micrometer screw

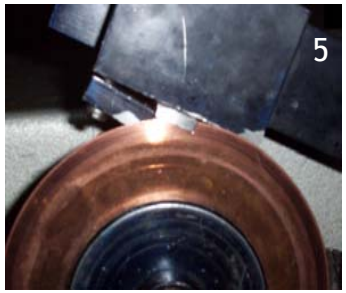
Cutting disc

UNDERSTANDING THE PRODUCT

How it Works ?

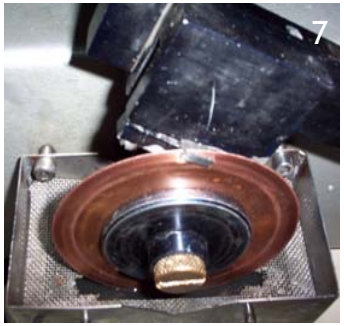
1, 2.The work piece is fixed in the vice and the lever arm is adjusted in such a way that the metal piece in the lever arm, positions on the diamond disc. Then the RPM is adjusted depending on the metal and thickness of the cut is adjusted using micrometer.

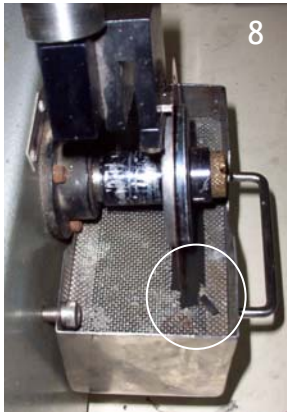




3-7. The lever arm thus placed stays like that. Now the power is switched on and the cutting starts as the disc rotates against the metal piece.

8,9. After cutting the slice will fall in the tray that is provided and the lever arm falls back.





3.3 UNDERSTANDING THE USER

Activity Analysis

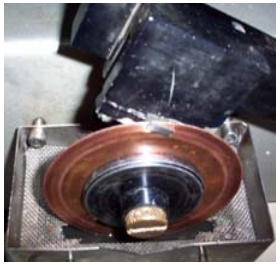
1.Fixing the work piece in the vice

2.Getting the work piece in contact with the cut-of wheel

3.Adding load

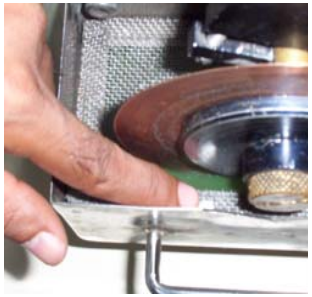
4.Setting the thickness of the slice

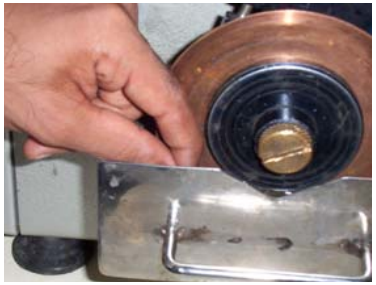
5.Setting the R.P.M



6.Slicing the work piece

7.Collecting the slice





8.Removing load

9. Removing the counter part of the piece

10. Fixing the vice back

11. Keeping it away from the miscellaneous handling

UNDERSTANDING THE USER
Problem Analysis

After conducting the activity analysis ,analysis of the problem is to be done based on the observations of the activity analysis .

Below listed are the sequential actions in this regard.

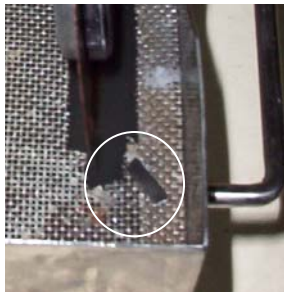
- Listing key problems
- Observed insights by interpreting the activity analysis.
- Preparing questionnaire-and rating based on the user emphasis
- Understanding the design challenges

UNDERSTANDING THE USER

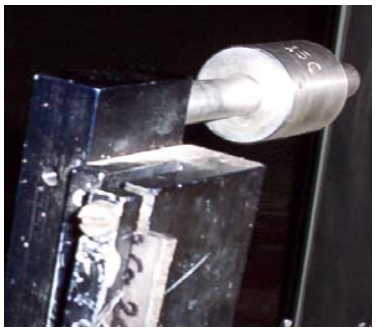
Problem Analysis-Listing key problems


1 .Fixing specimen in the vice


2. Adjusting and positioning for the accuracy

3. Collecting the specimen slice




4. Load application

Key problems are listed down and prioritized based on the first observation.

UNDESTANDING THE USER

Problem Analysis-observed insights

- Fixing specimen sample in the vice
- Can not hold the non-geometric shapes
- Can not orient in different planes
- Can not hold lengthier jobs
- Adjusting/positioning for accuracy
- Visibility
- Not accurate positioning
- Slice with over/under the desired measurement
- Load application
- Feeding of the work piece to the blade
- Vibration of the lever-arm
- Damage of the blade
- Abrupt shift in loading
- Sliding of the weights
- Lever-arm falls behind after slicing
- Collecting the specimen slice
- Frequent removal of the coolant tub
- Noise during cutting
- Separate control panel
- Transportation problem
- Congested workspace configuration

Other insights that are observed

Problem Analysis

UNDESTANDING THE USER

Preparing questionnaire-Rating the problem

KEY PROBLEMS	USER 1	USER 2	USER 3	USER 4	SCORE	WEIGHTAGE 10-POINT SCALE
FIXING WORK PIECE IN THE VICE - OPERATING PROCEDURE	8	8	7	9	32	32/4 = 8
POSITIONING THE SAMPLE FOR THE DESIRED CUT – ACCURACY	7	7	8	8	30	30/4 = 7.5
LOAD APPLICATION –ADDING AND REMOVING LOADS MANUALLY	9	7	6	9	31	31/4 = 7.7
FEEDING MECHANISM – LEVER ARM	10	5	9	9	38	38/4 = 9.5
COLLECTING SPECIMEN – FROM THE COOLENT BATH	10	10	10	10	40	40/4 = 10
HOLDING OF INTRICATE SHAPES - ORIENTATION IN VARIOUS PLANES	9	10	10	9	38	38/4 = 9.5
PLACEMENT OF COOLENT TUB - MAINTAINANCE	10	10	10	10	40	40/4 = 10
LEVERARM FALLS DOWN AFTER CUTTING	4	7	6	6	23	23/4 = 5.7
NOISE DURING CUTTING	5	7	4	4	20	20/4 = 5
VIBRATION OF THE LEVERARM WHILE CUTTING –WHEEL DAMAGE	9	10	10	10	39	39/4 = 9.7
SEPARATE CONTROL PANEL	5	8	5	6	24	24/4 = 6
ELEMNTS PROJECTING OUT - VISUAL CLUTTER,AMBIGUITY	8	10	8	9	35	35/4 = 8.7
CONGESTED WORK SPACE	8	7	7	9	31	31/4 = 7.7

Preparing the questionnaire based on the problems and listed them in sequence. Then the user is asked to give the weightage on the scale of 10. The issues that are stressed by the user are emphasized.

UNDESTANDING THE USER

Understanding the design challenges

After identifying the insights and emphasizing on the key problems,certain design challenges are observed in the following categories.

Taking these issues in to the considerations the design brief has been written .

security

TECHNICAL

Human intervention

Visibility

Design

Communication

Transportation

Safety

3. DESIGN BRIEF

4.1 DESIGN BRIEF

"To design a specimen cutter with a new functional identity and user friendly to operate and enhances performance, while reducing the substantial human intervention."

4.2 DESIGN SPECIFICATIONS

Based on the problem evaluation the inferences are taken from the user study and respective design specifications are drawn out

- The design should have a simple way of holding work piece
- It should hold intricate shapes
- It should able to orient in various co-ordinate planes easily
- It should invite less effort to position for accuracy
- Distance between the user and the micrometer screw should be reduced. visibility
- It should have a vibration free feeding
- It should invite no human intervention for the load application
- It should have consistent feeding
- Collecting the specimen should be easy
- It should allow for easy maintenance
- It should be noise free
- It should have Inbuilt control panel
- It should allow easy shifting
- It should allow the ingress and egress for the arms
- It should have an enclosure

DESIGN SPECIFICATIONS

Being studied the product and the user intervention with the same the aim is clearly understood and the following considerations are targeted.

- **Functional**

  Observing the equipment's functions and the scope for the enhancement.

- **Usability**

  Providing the user with the maximum possible convenience and the comfort while interacting with the equipment.

- **Ergonomical**

  For allowing user to interact most effectively and safely.

- **Aesthetic**

  To create a new identity that follows function and the characteristic features of the equipment.

4.3 PRODUCT BRIEF

Functional considerations

- To provide for different co-ordinate plane orientation for the work piece.
- To provide a easy and simple procedure for fixing work piece.
- To provide effective holding for the intricate shapes.
- To provide accurate positioning for perfect and precise slicing.
- To provide a consistent and vibration-free feeding method, which avoids the addition of external weights for load application.
- To provide a safe and soft platform for collecting the specimen slice.
- To provide with an effective way of coolant supply.

Usability considerations

- To provide an enclosure which cuts the noise
- To provide with “it’s done” kind of feed back for the completion of the job.
- To provide with auto cut-off power when the cutting is completed.
- To provide quick “return-to cut”, facility.
- To provide with the visual display for tracking cutting status.
- To provide easy transportation facility.
- To provide safety for diamond wheel cut-off.
- To provide a well articulated control panel.

PRODUCT BRIEF

Ergonomics considerations

- To provide enough space around the vice for ingress of hands and mounting work piece.
- To provide a very clear visibility for the micrometer screw graduations

Aesthetic considerations

- To cerate a new identity for a typical specimen cut-off.

Safety considerations

- To provide safety for diamond wheel cut-off.
- To provide safety from the flying particles of the work piece or the wheel (when broken).

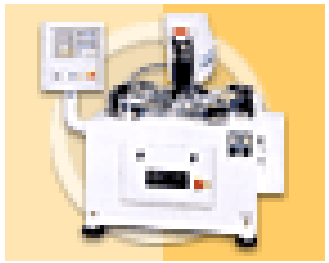
Keeping these considerations in the mind, concepts are generated.

5. CONCEPTUALIZATION

5.1 FIRST LEVEL ALTERNATIVES

5.1 **First** level alternatives

CONCEPTUALIZATION
FORM EXPLORATION

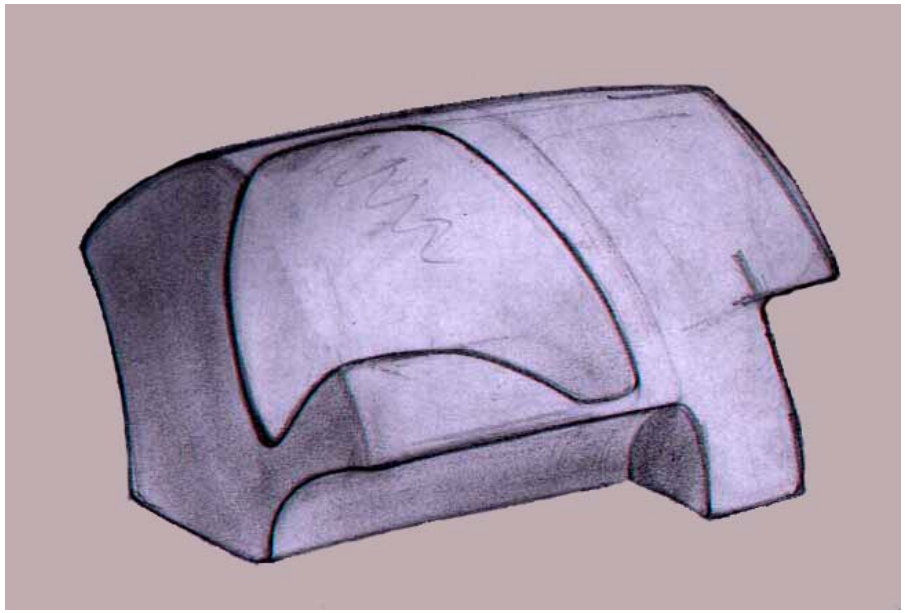


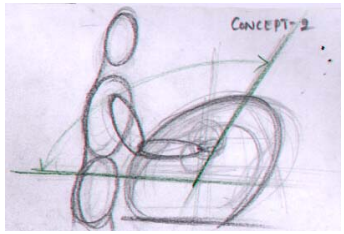
Ideation based on the contemporary metallographic products

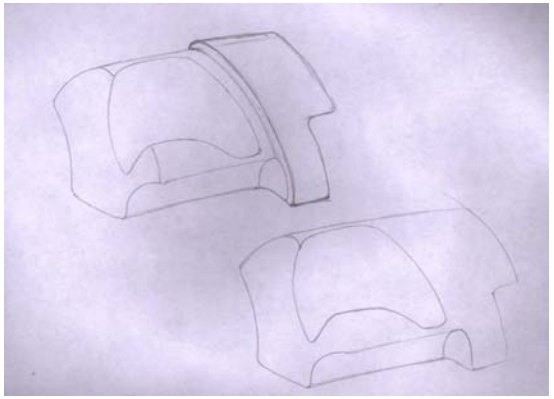
Control panel and the other detailing are not taken in to the consideration at the first level of ideation because of the reason to see only the overall form, how it looks. As the transparent part is the strong visual element its shape and relative size with the form is tried.

First level alternatives

CONCEPTUALIZATION
FORM EXPLORATION





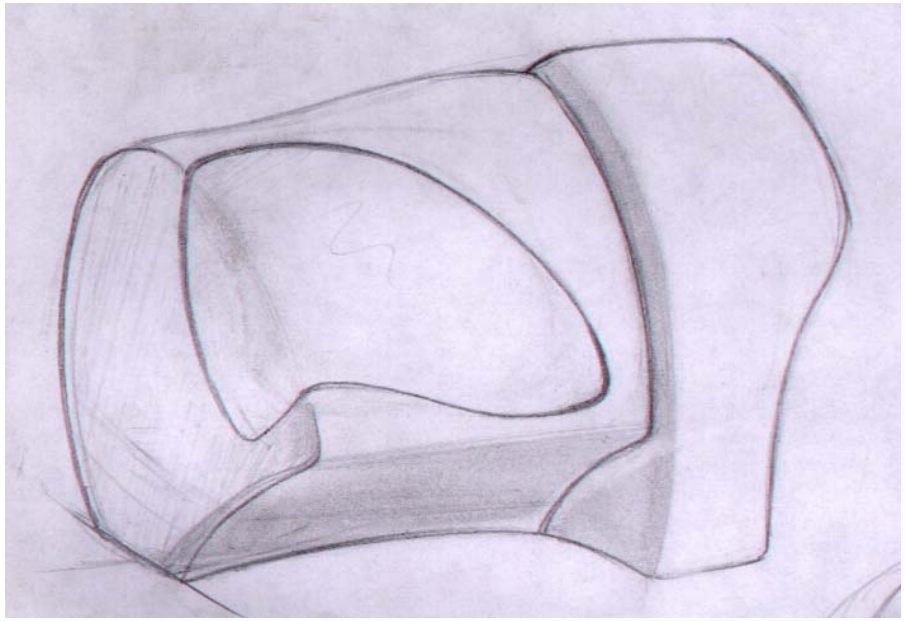


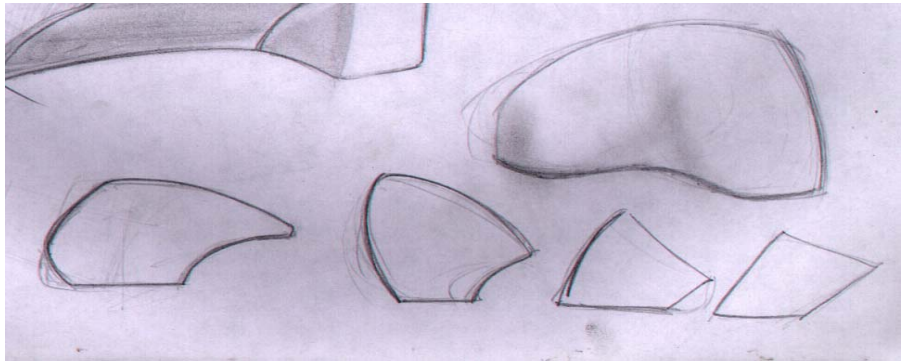
Concept-1

The idea behind this form is to make the product looking at the user while using it and the shape of the transparent part is more stylized to feel futuristic. Tilting of the vertical axis to wards the back to certain angle makes it quite comfortable for the user for ingress and egress .

First level alternatives

CONCEPTUALIZATION
FORM EXPLORATION

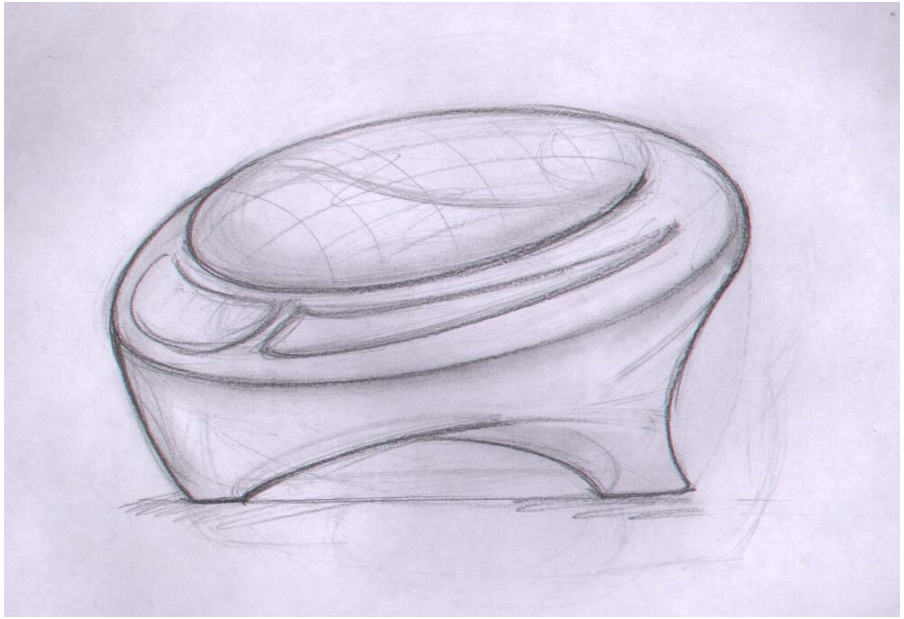




Concept-2

A little variation of the earlier with the attempt to break the continuity of the form flow. The control panel comes on the right side and making the strong statement . And the similar kind of attempt is made to tilt the vertical axis back,by variation.

First level alternatives

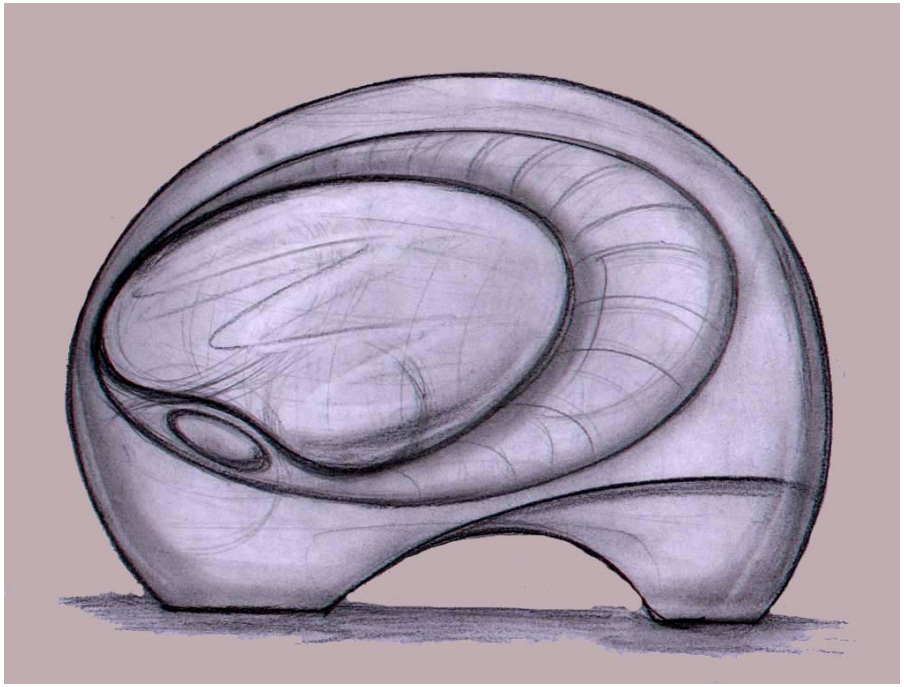


Concept-3

The idea behind this form is inspired from some of the contemporary products in the market , relevance of the scenario is not seriously considered. This is an attempt made to come out with a new contemporary visual idea.

First level alternatives

CONCEPTUALIZATION
FORM EXPLORATION

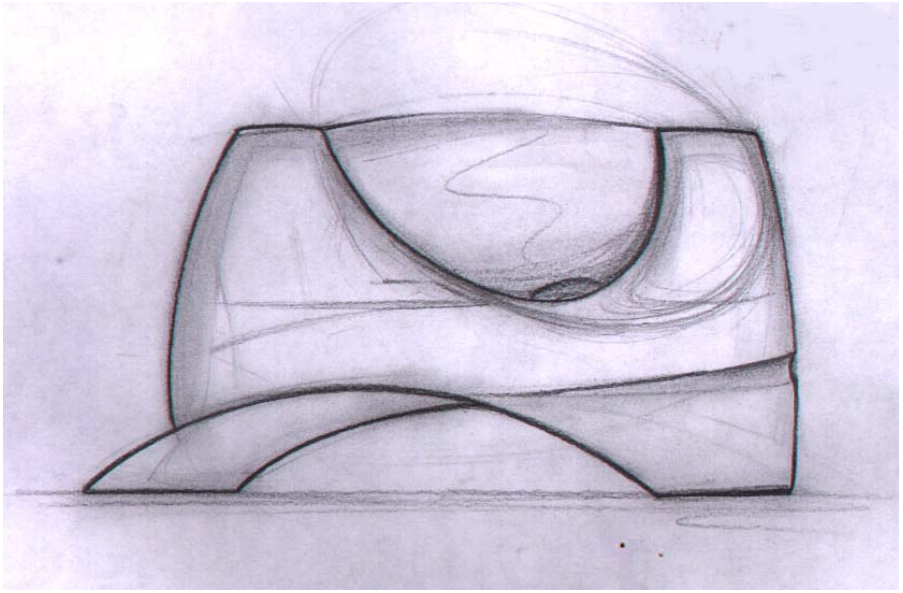


Concept-4

The form is inspired form the side profile of the latest and trendy small cars . The curves that are used are no way uniform or parallel with any other. This attempt made is reduce the monotony of the vision and give the contemporary look to the product.

First level alternatives

CONCEPTUALIZATION
FORM EXPLORATION

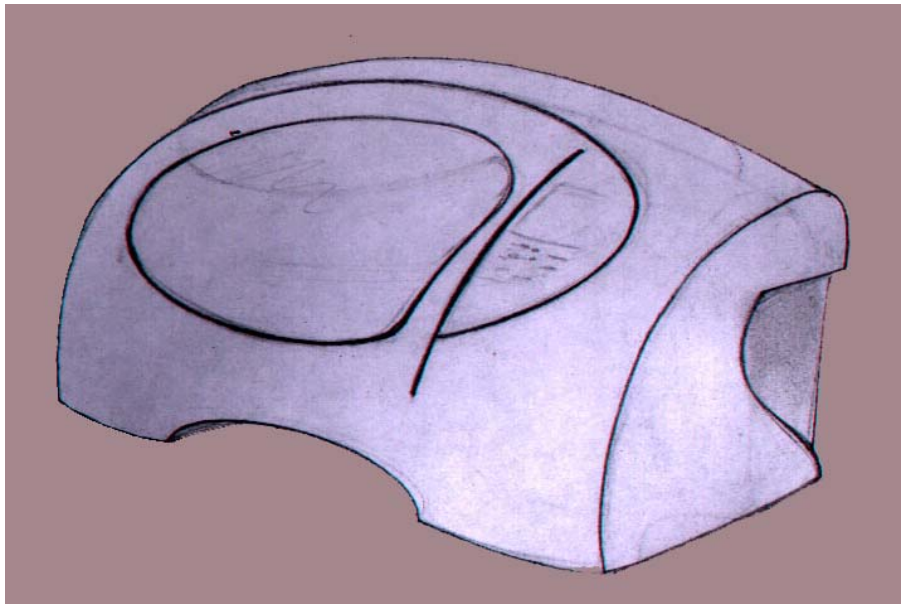


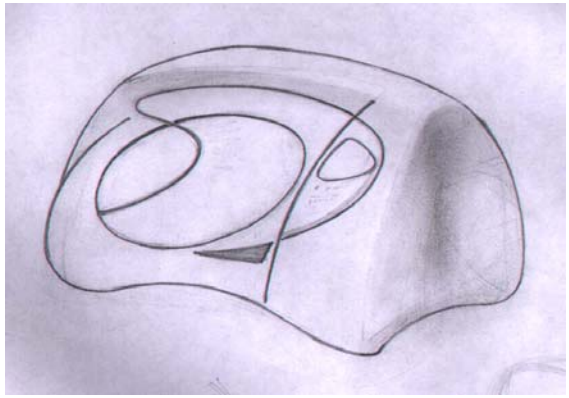
Concept-5

The attempt made is to generate the seriousness in the product by having the cut and crisp lines . Apart from the earlier one, which has free flowing curves that gives no seriousness, this may be closer to the the idea.

First level alternatives

CONCEPTUALIZATION
FORM EXPLORATION



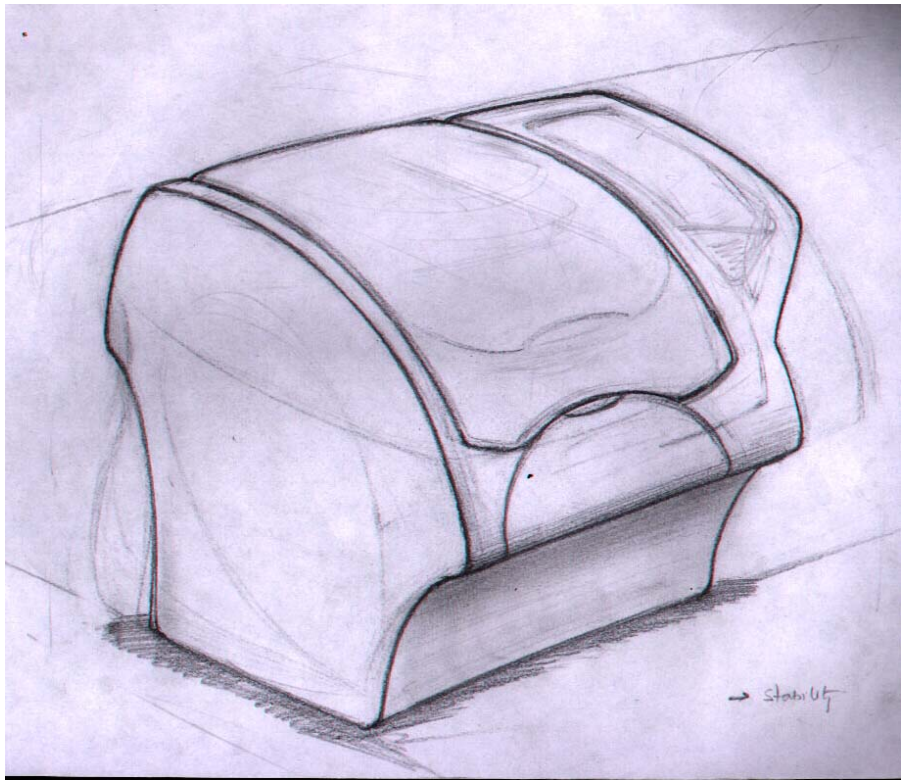


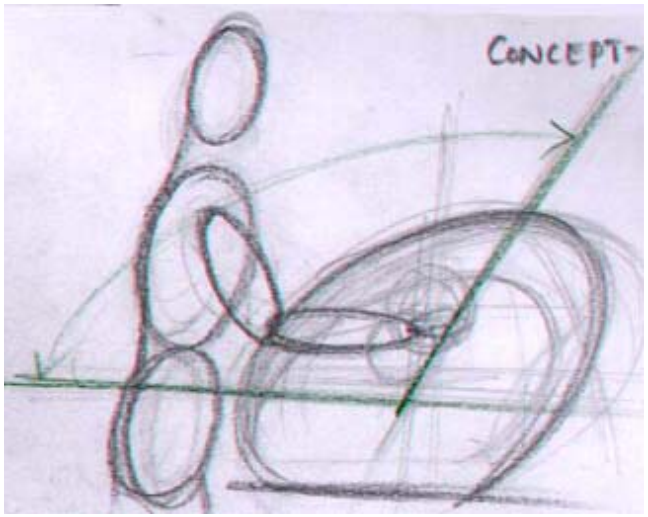
Concept-6

Worked with the interface and alternatives are tried out to have a different look.

First level alternatives

CONCEPTUALIZATION
FORM EXPLORATION



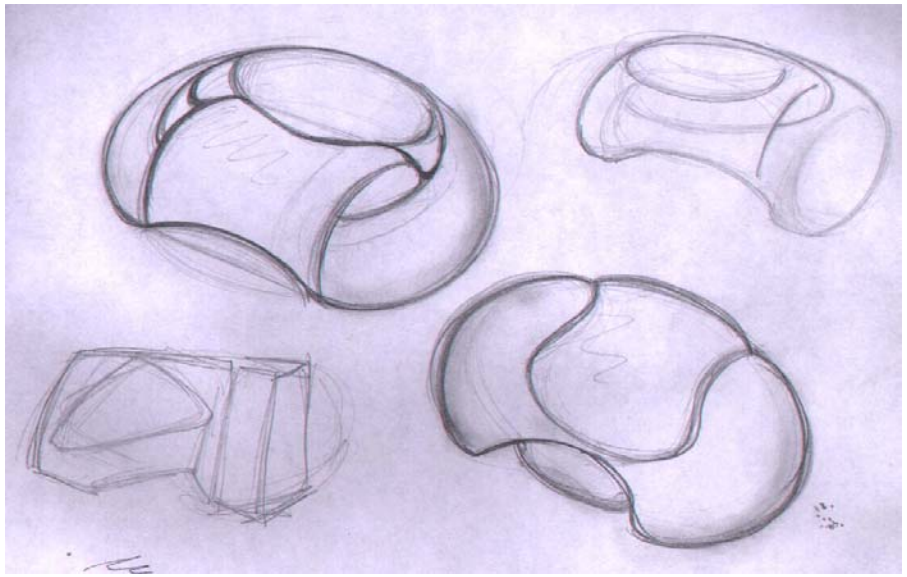


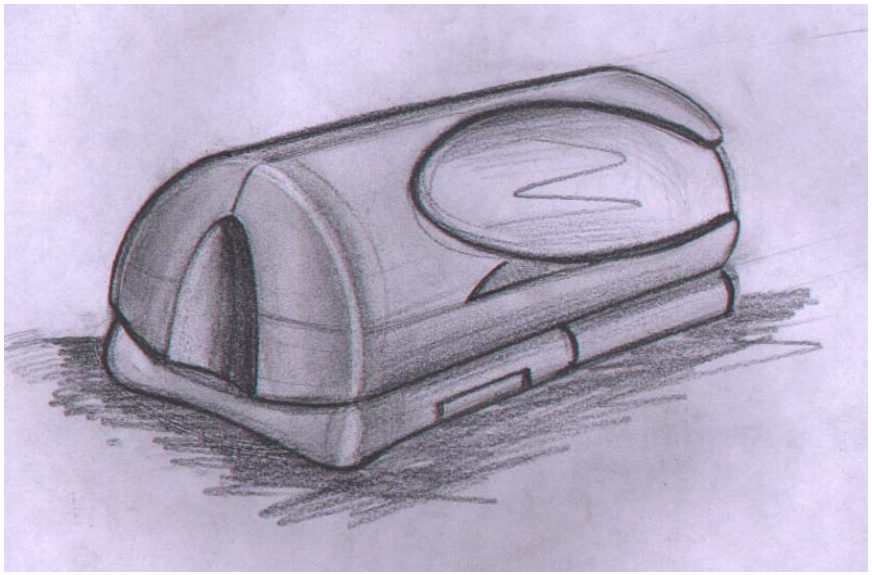
Concept-7

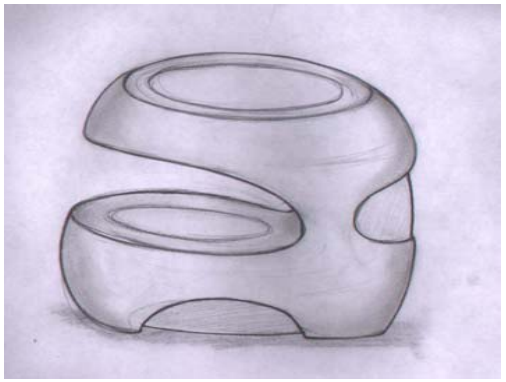
This is the form which is developed with the intention that the control panel should make a strong statement simultaneously providing the comfort of using the right hand.

First level alternatives

CONCEPTUALIZATION
FORM EXPLORATION







Forms that are tried out with free hand with out taking the product scenario in to consideration.

CONCEPTULIZATION

5.2 SECOND LEVEL ALTERNATIVES

Second level alternatives

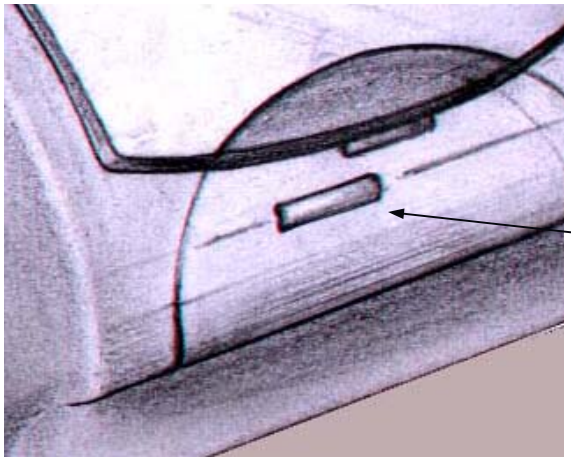
Conclusions drawn out from the first level conceptualization.

Though the forms are visually contemporary they are much complex when taken product scenario in to the consideration. Reduction of certain unwanted elements has to be done. Seriousness of the product is to be taken care of with the removal of the casual and leisure look from it.

Characteristic features incorporated for the second level concepts.

- Details which are not considered earlier are taken care of .
- Seriousness of the product is maintained.
- Emphasizing on certain expressions such as precision, accuracy, care , safety, expensive etc.

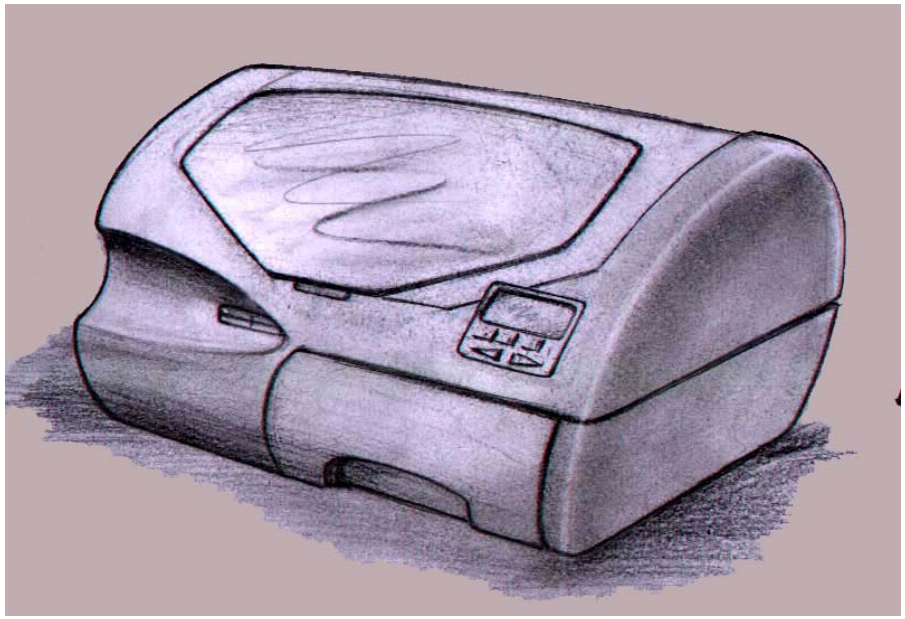
Second level alternatives

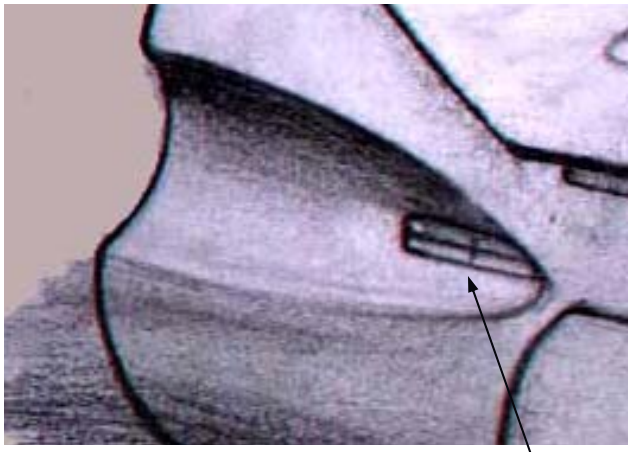


Concept-1

The form is worked and detailed out from the initial concepts. The equipment is a fully automated with the statement of the contemporary look. Control panel is made prominently visible.

Second level alternatives





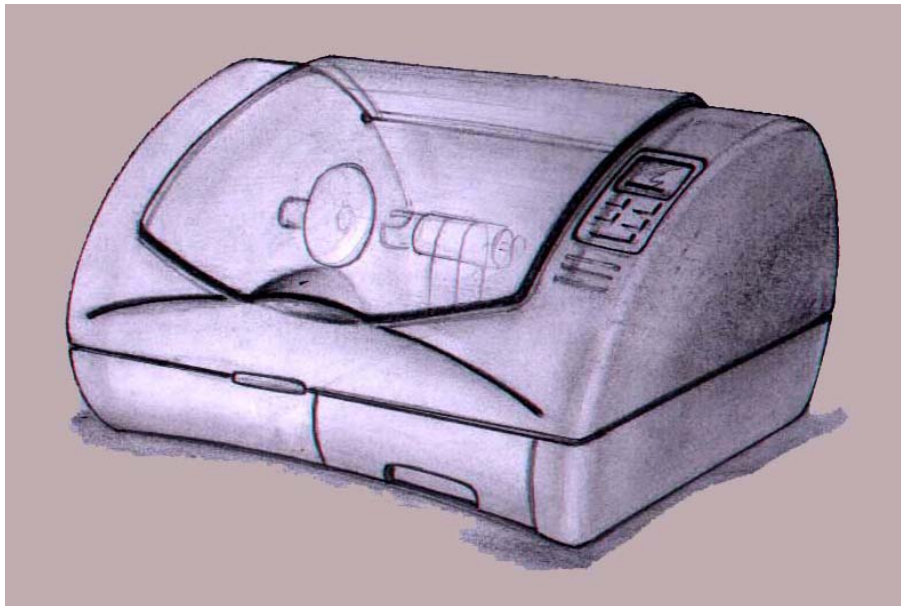
Negative volume treatment

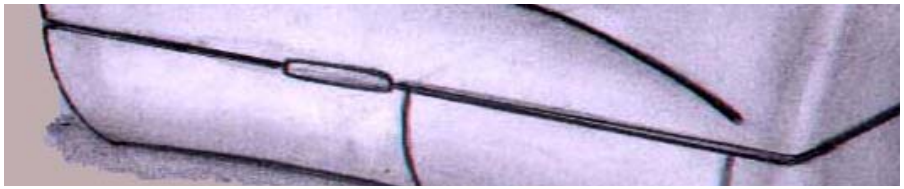
Ejecting specimen collecting tray

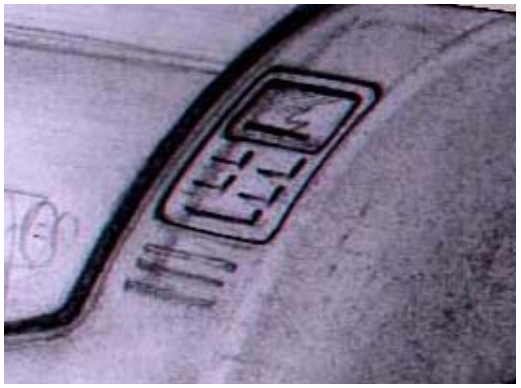
Concept-2

Negative volume is worked out to achieve a surprising element . The ejecting out specimen collector is provided in that space .

Second level alternatives



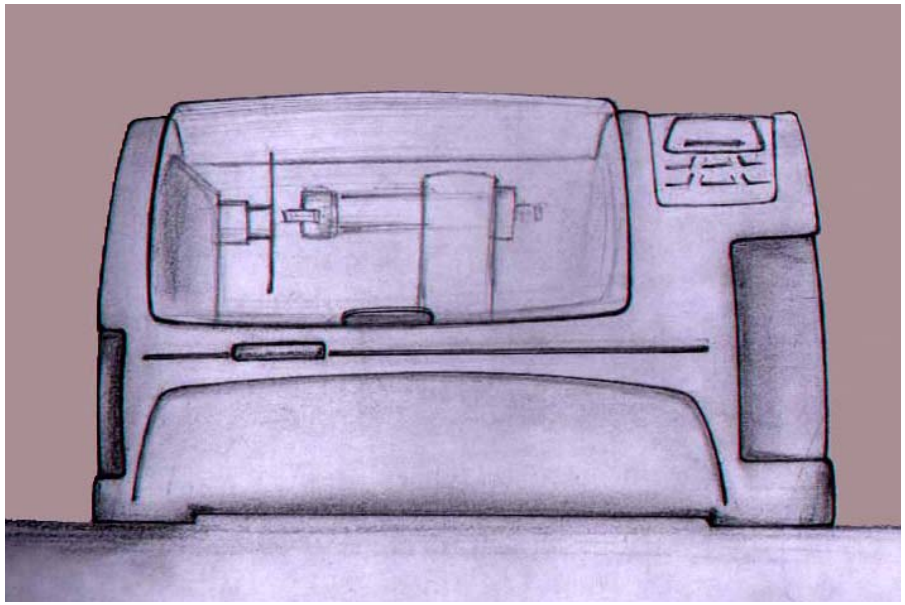


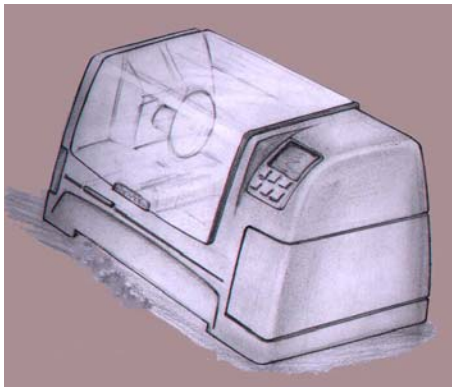


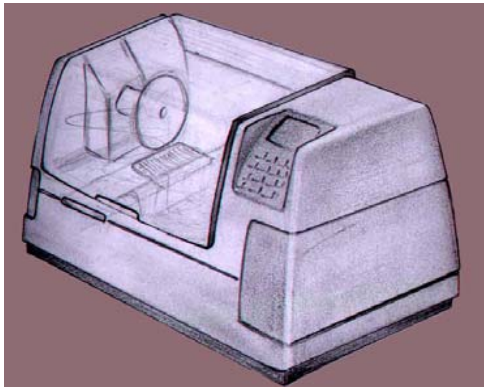
Concept-3

The form has a compact look with the element of symmetry and the control panel is merged in the surface . The ejecting out specimen collector is provided and kept in continuity with the volume separation.

Second level alternatives



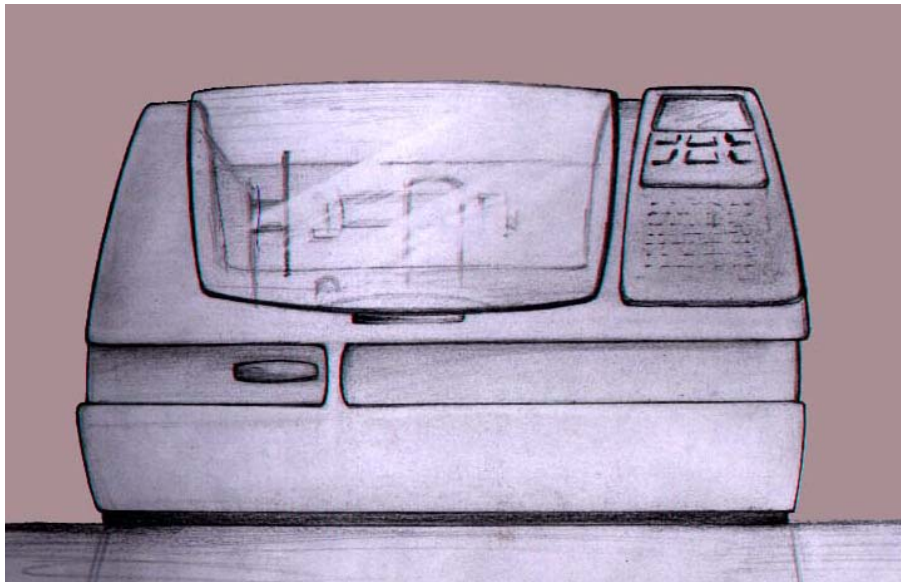


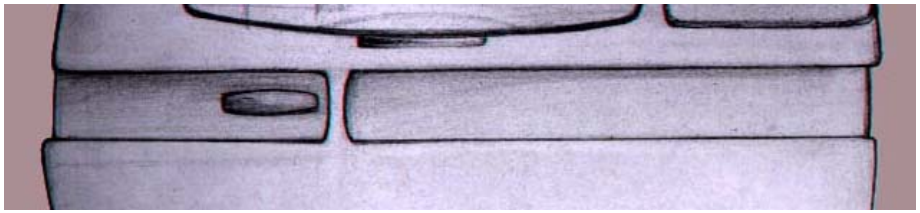


Concept-4

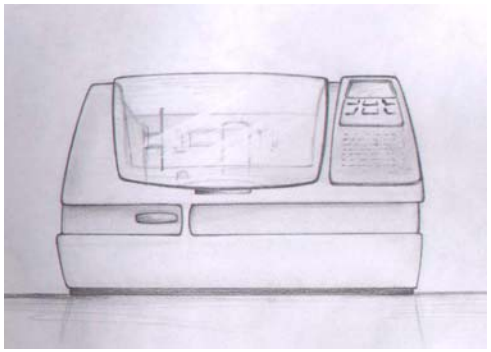
Stand-up-straight form, treated with more formal approach. Grooves and other elements are provided to break the continuity of the form . The openings on the sides are separated fro the regular surface continuity.

Second level alternatives





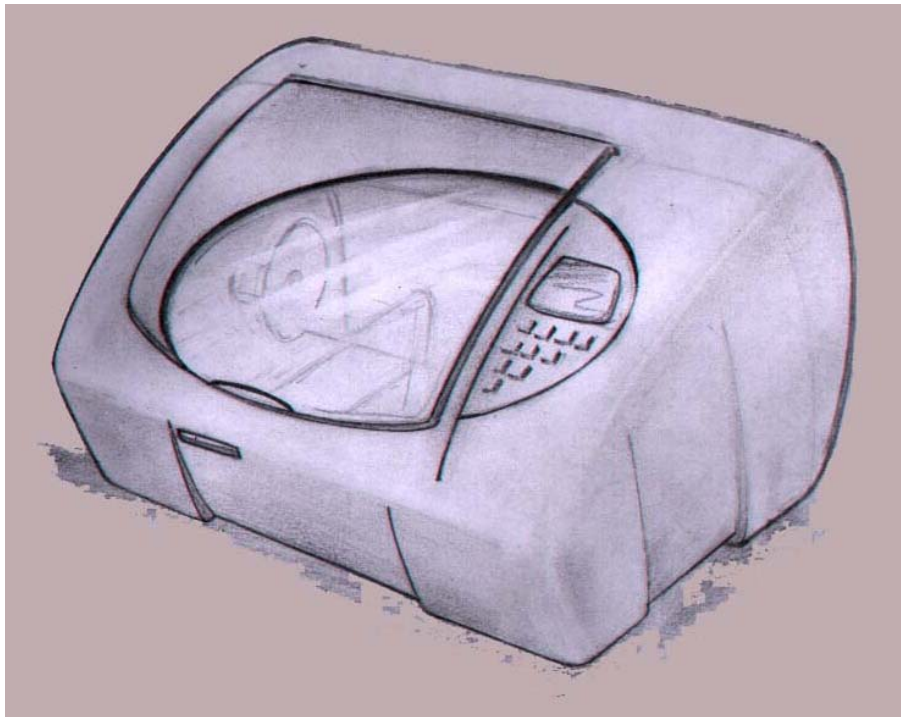
Volumetric separation by incorporating the groove .

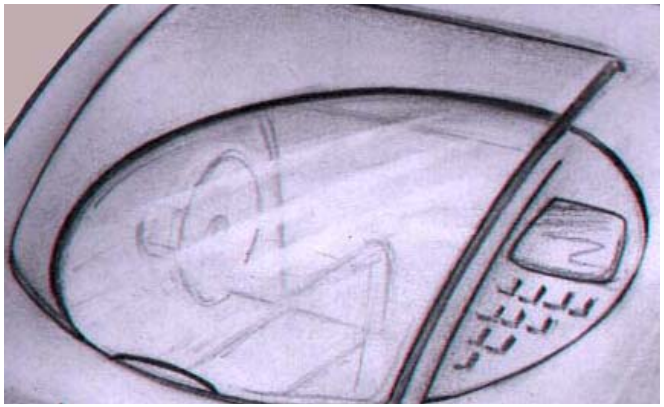


Concept-5

Stand-up-straight form treated with more formal approach. Prominent groove is provided to break the volume in to two halves separating the upper half from the lower . This gives brings in more industrial approach with a element of seriousness and precision.

Second level alternatives

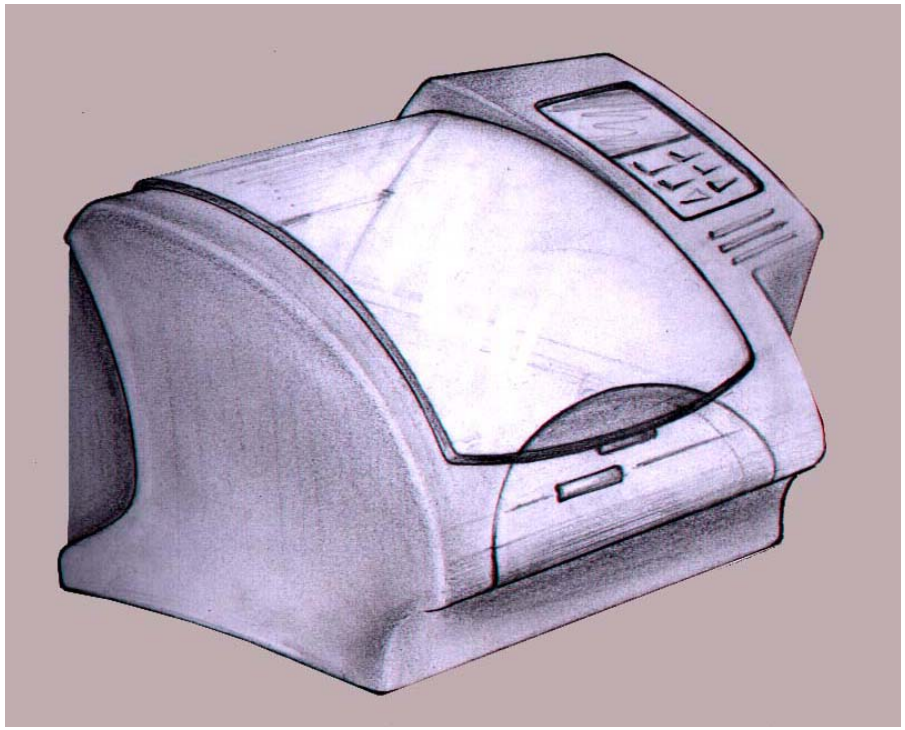


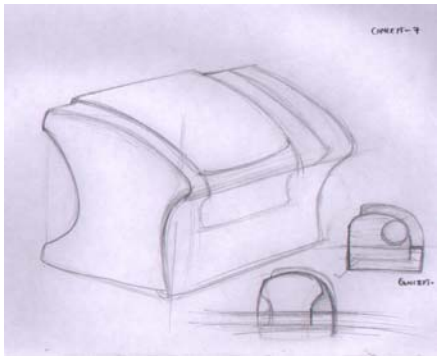


Concept-6

Partial transparency and a element that runs that encircles the control panel brings in a element of interest .

Second level alternatives

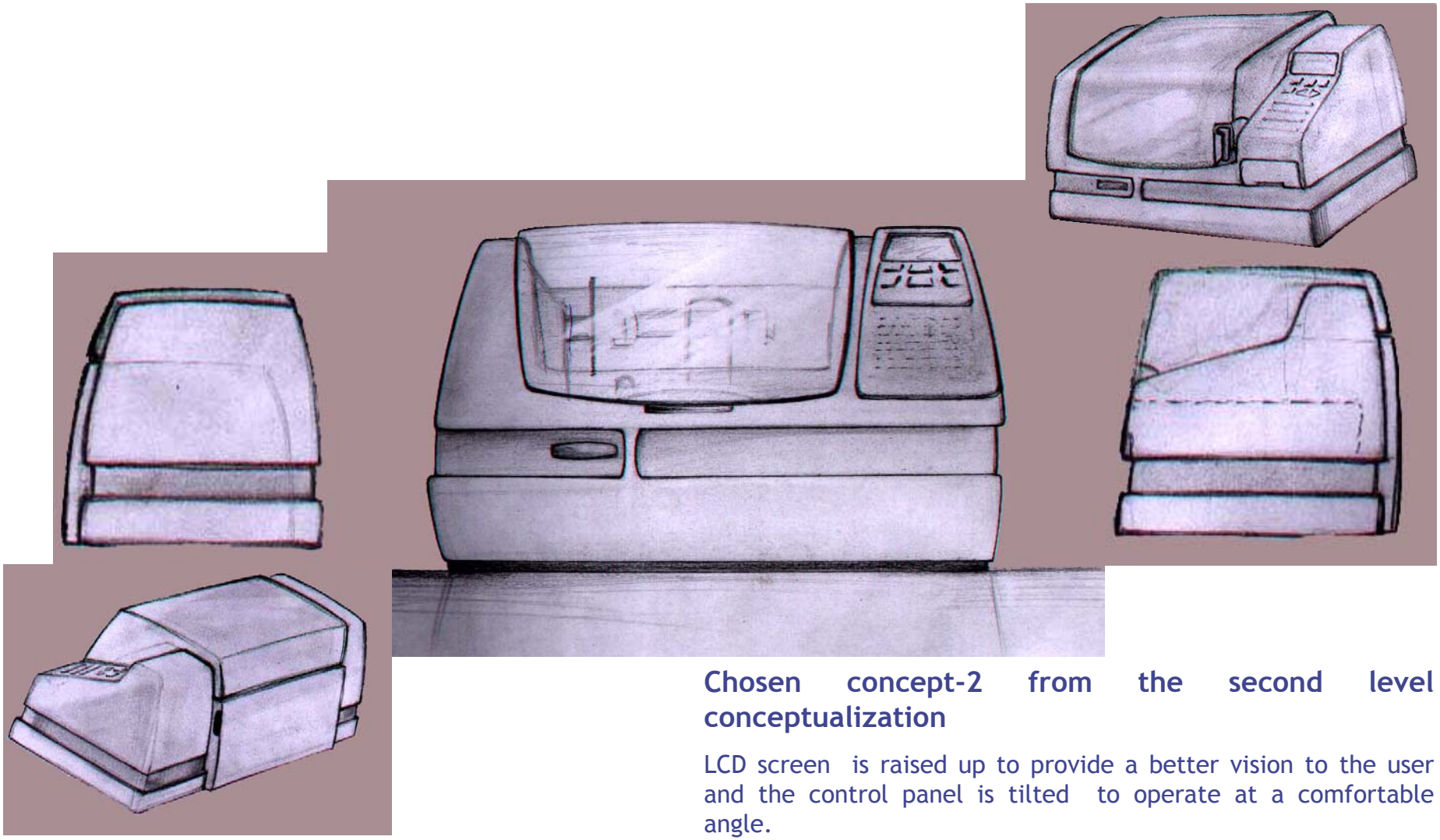




Chosen concept-1 from the second level conceptualization

LCD screen is raised up to provide a better vision to the user and the control panel is tilted to operate at a comfortable angle.

Second level alternatives



Chosen concept-2 from the second level conceptualization

LCD screen is raised up to provide a better vision to the user and the control panel is tilted to operate at a comfortable angle.

Second level alternatives
Mock up model

Chosen concepts from the second level conceptualization

Concept is chosen taking the relevance and the targets that could be achieved by it . Its functionality and the usability are most suitable to the product scenario.

CONCEPTULIZATION
5.3 THIRD LEVEL ALTERNATIVES

Third level alternatives

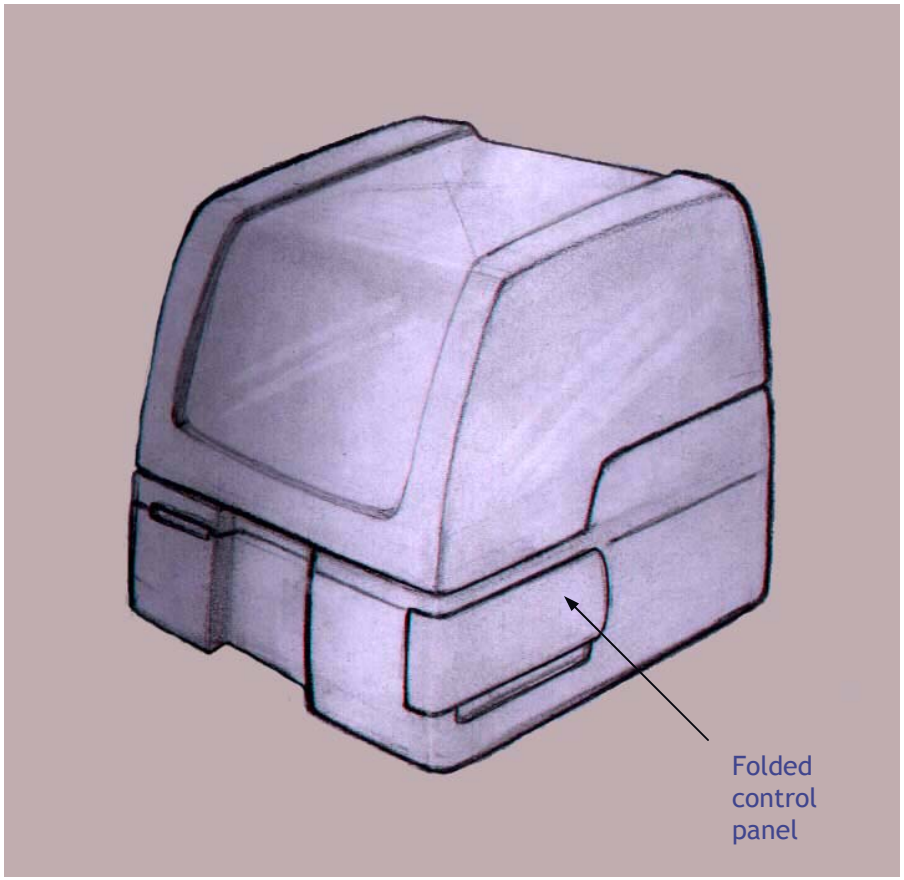
Conclusions drawn out from the second level conceptualization.

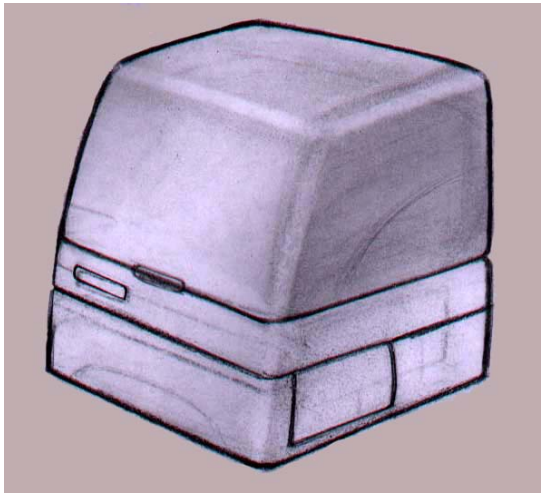
Forms have some default identity of a regular table top products such as printer, copier which will invite a element of appreciation and discussion.

Characteristic features incorporated for the third level concepts.

- Increasing the operational part to one –quarter below.
- Trying the alternative like entire upper half transparent.
- Trying out the alternatives like making it partially transparent . Hiding the controls to stress on the single handed use .
- Emphasizing on certain expressions such as precision, accuracy, care , safety, expensive etc. with added ruggedness strong and elegance

Third level alternatives



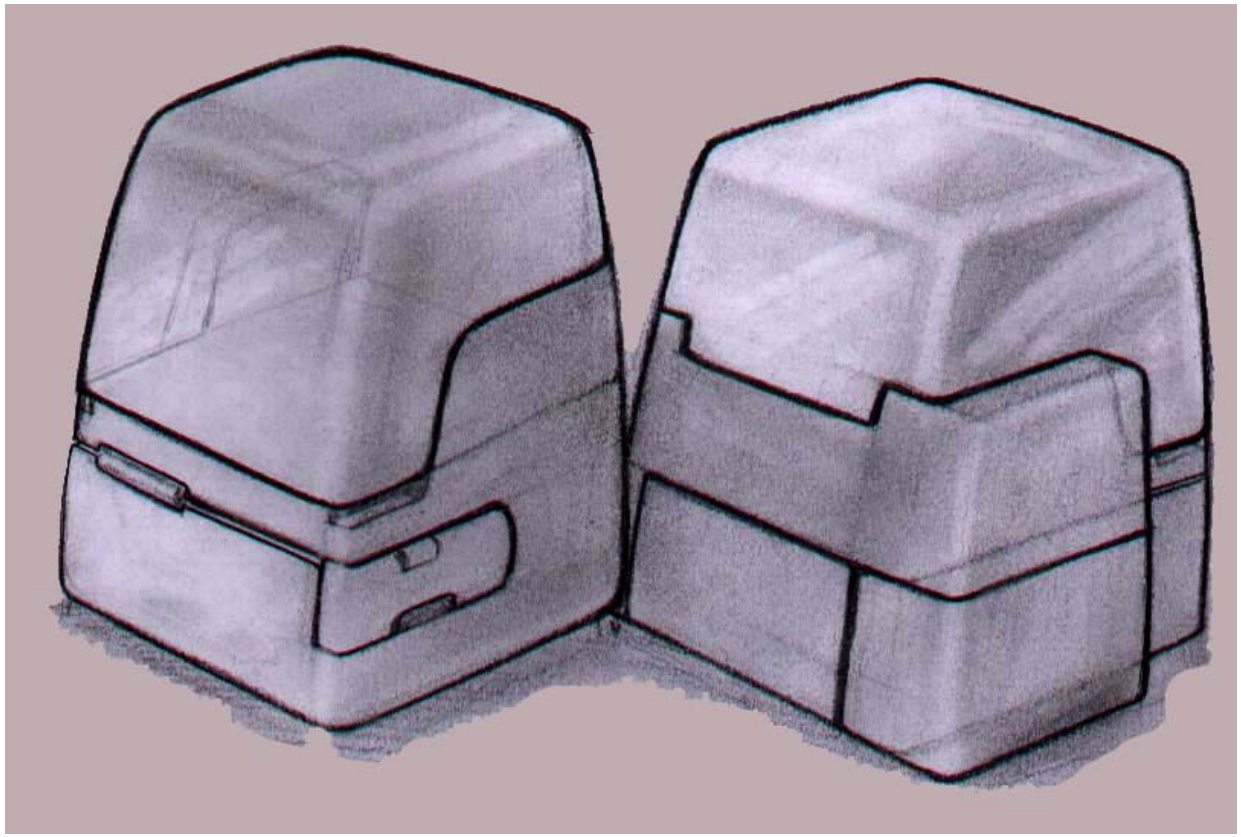


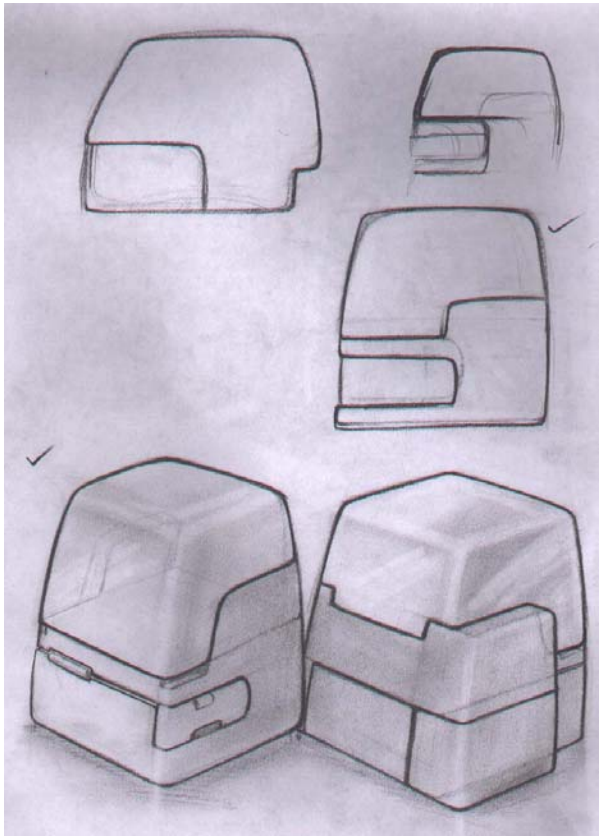
Basic form of idea with
out any treatment

Concept-1

Muscular expression is added to emphasize on the strong industrial product . The form doesn't have control panel visible from any of the side . It is a foldable kind of control panel. This keeps the novice user away and ends him up with a aborted tampering . This issue will take care of the safety part.

Third level alternatives

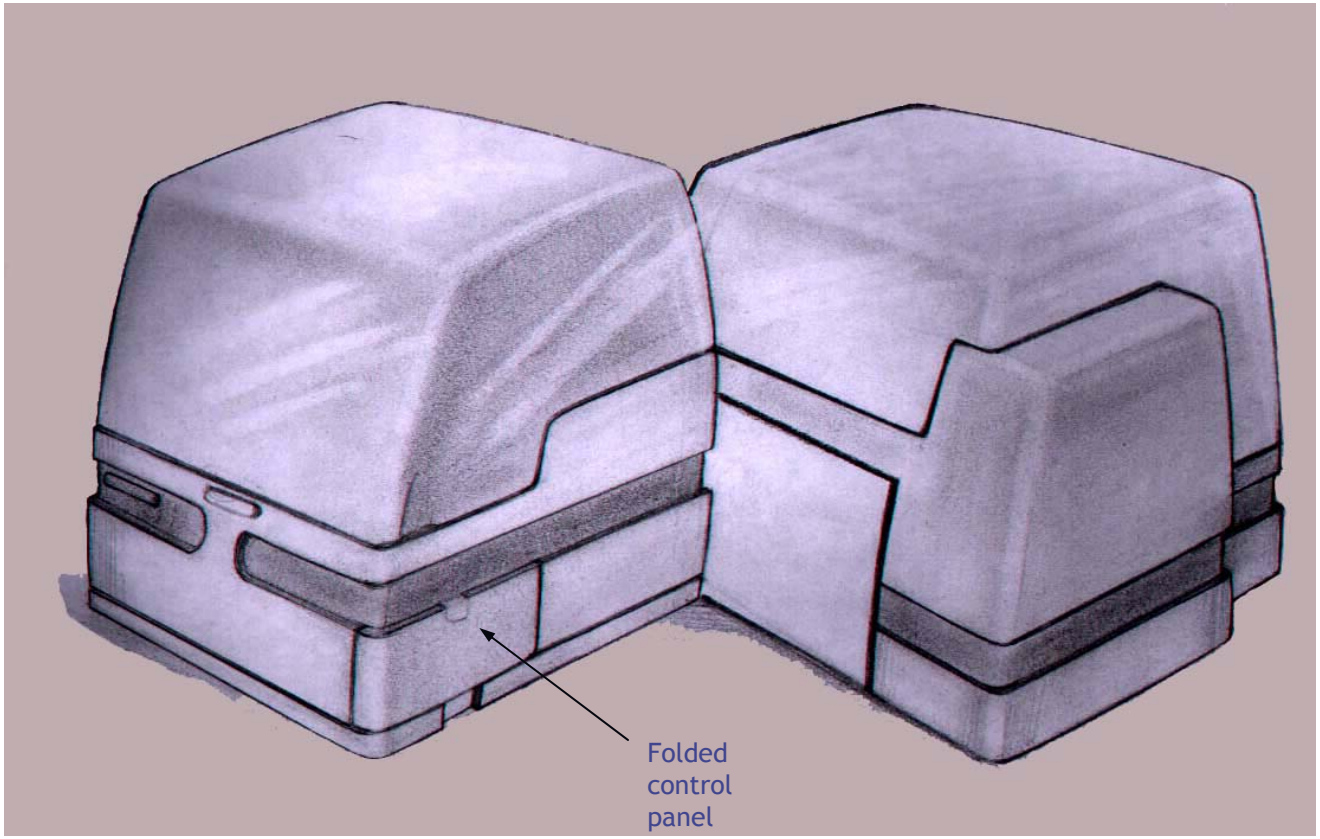




Concept-2

Similar kind of treatment in the same series with out the treatment on the transparent cover.

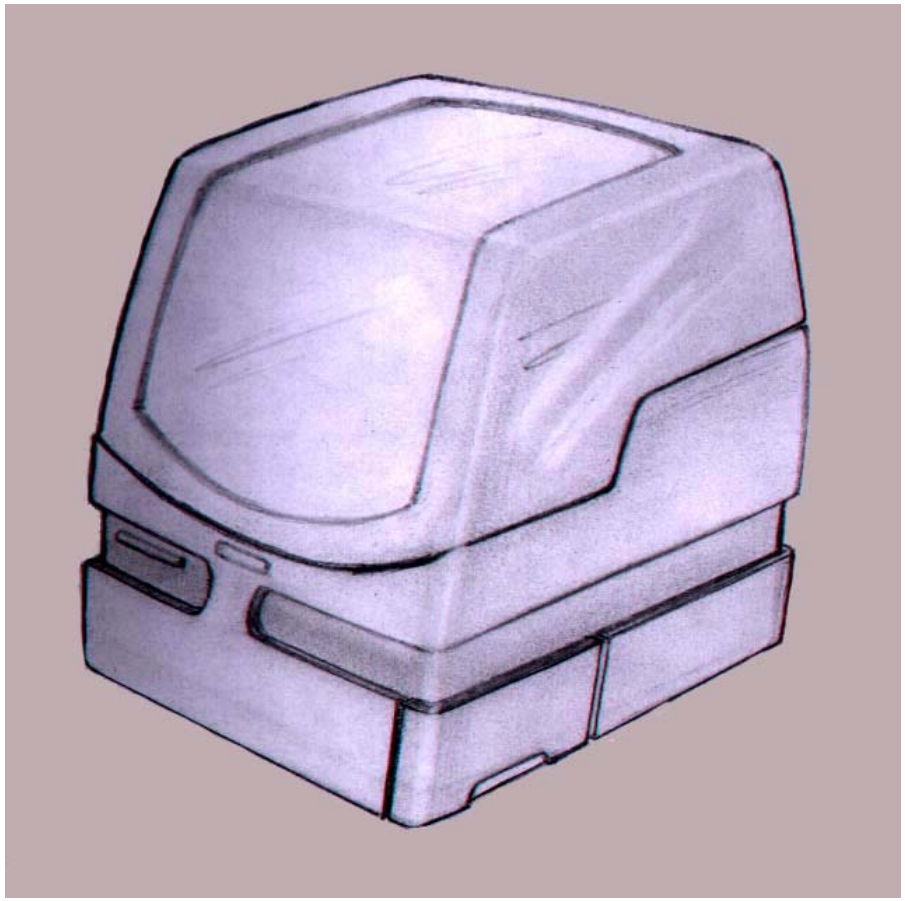
Third level alternatives

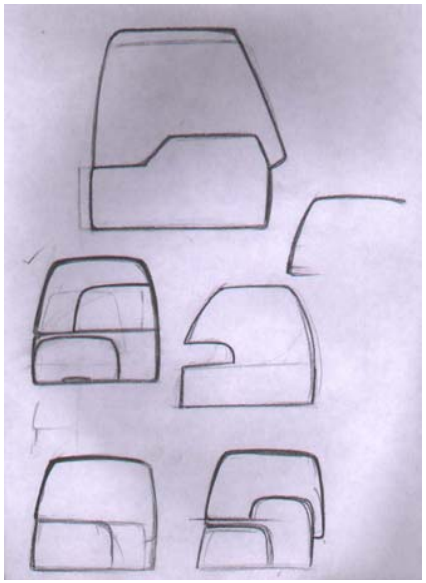


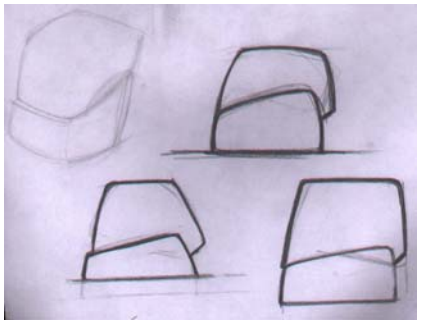
Concept-3

Bringing in certain interesting elements from the concept chosen at the 2nd level of ideation and giving the similar treatment.

Third level alternatives





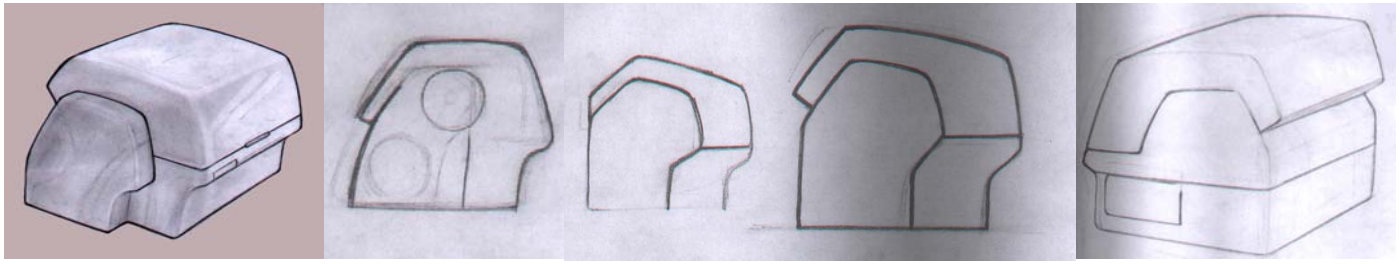


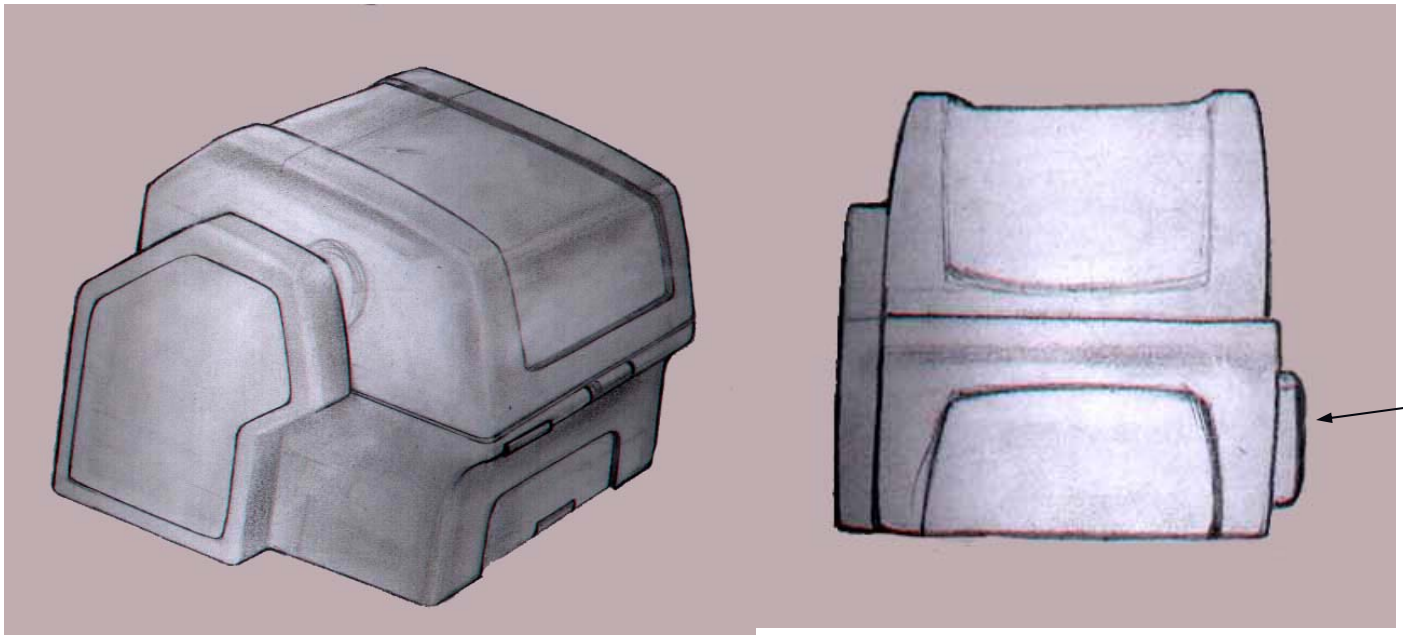
Working drawings

Concept-4

Muscular expression is added to emphasize on the idea of strong industrial product . The form doesn't have control panel visible from any of the side . A little bit of variation results in a entirely in the new concept .

Third level alternatives





Concept-5

Treating with the shift of volumes.

Third level alternatives
Mock up model

Chosen concept from the **third** level conceptualization

CONCEPTULIZATION

5.4 FOURTH LEVEL ALTERNATIVES

Fourth level alternatives

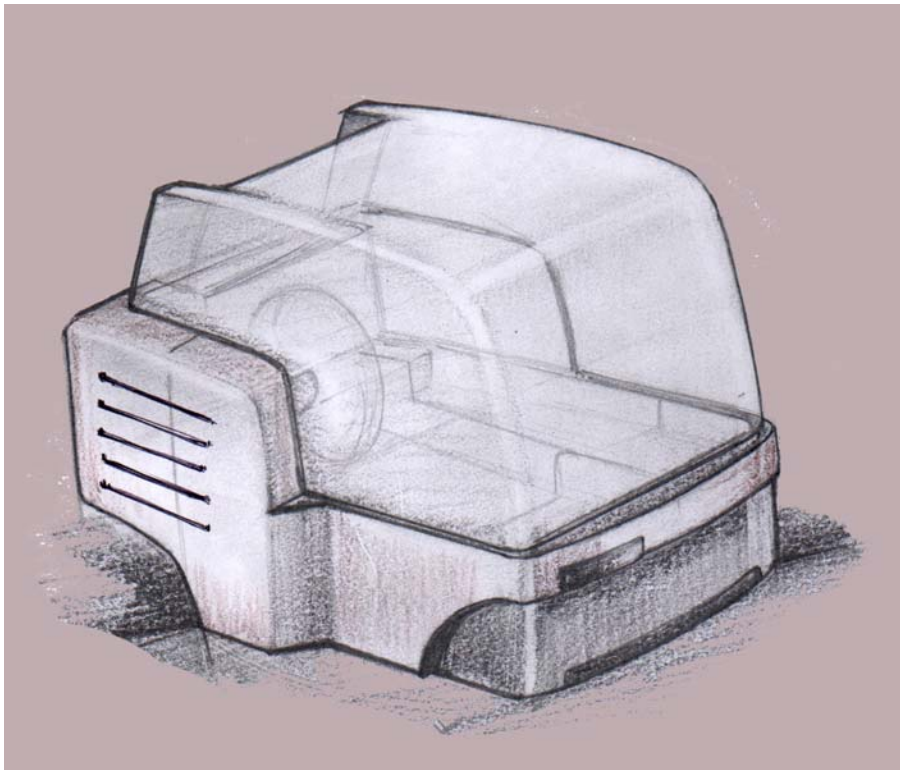
Conclusions drawn out from the third level conceptualization

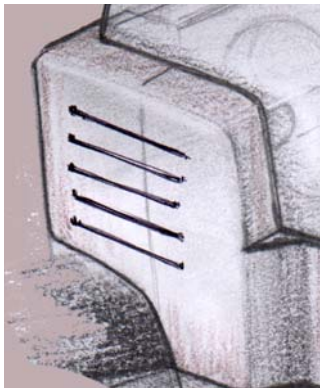
Curvatures on the industrial/laboratory forms give them a delicate and gentle feeling . Bumps on the surface may mislead the identity. Should not make a convenient note to the users in finding out where the control panel is,unlike, all the user-friendly products.

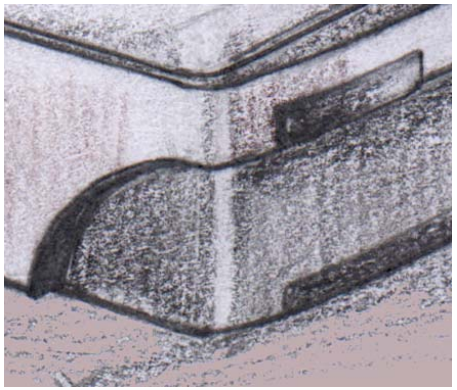
Characteristic features incorporated for the fourth level concepts.

- Cut-and-dry kind of the formal treatment .
- Sleek gaps should be taken care of .
- Sharpness in proportions .

Fourth level alternatives



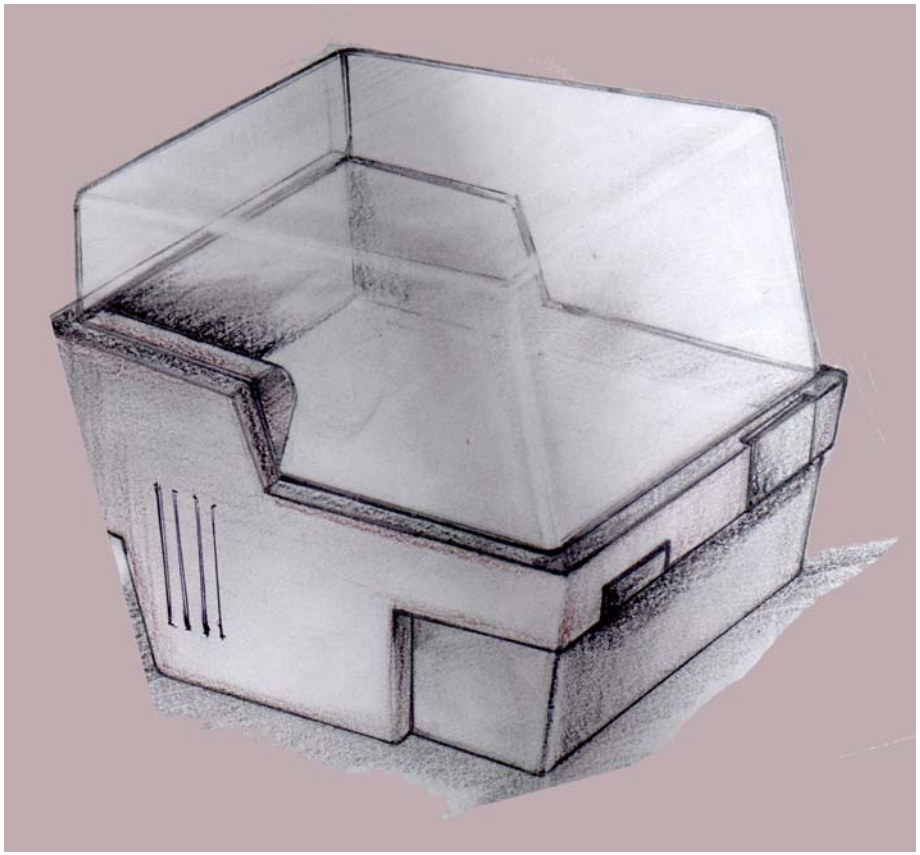




Concept-1 Alternative-1

Proportion and the detailing is taken care of and the volumetric treatment is emphasized to give a strong look.

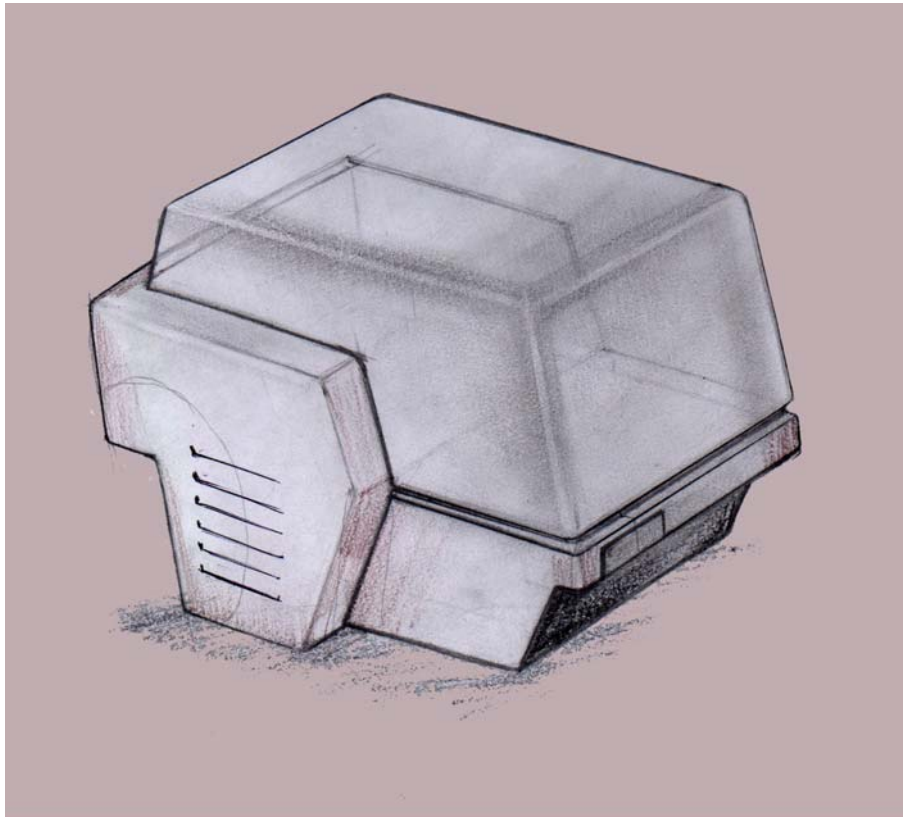
Fourth level alternatives



Concept-1 Alternative-2

Similar kind of elements with straight edges avoiding the curved surfaces.

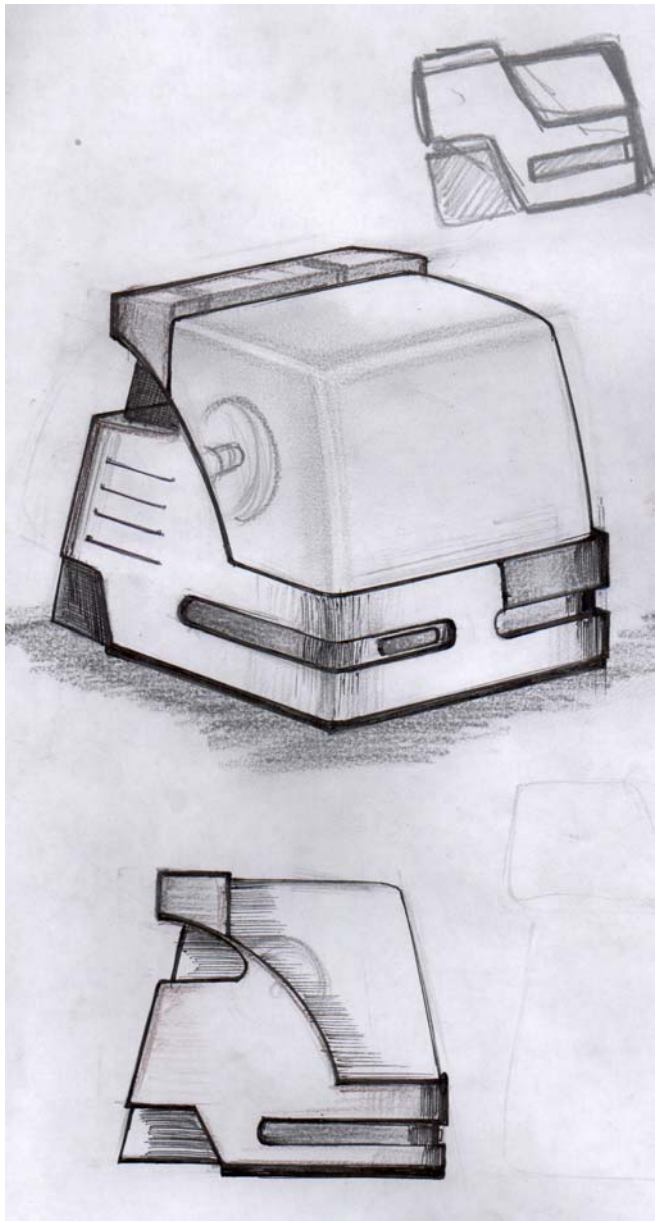
Fourth level alternatives



Concept-1 Alternative-3

Proportion and the detailing is taken care of and the volumetric treatment is emphasized to give a strong look.

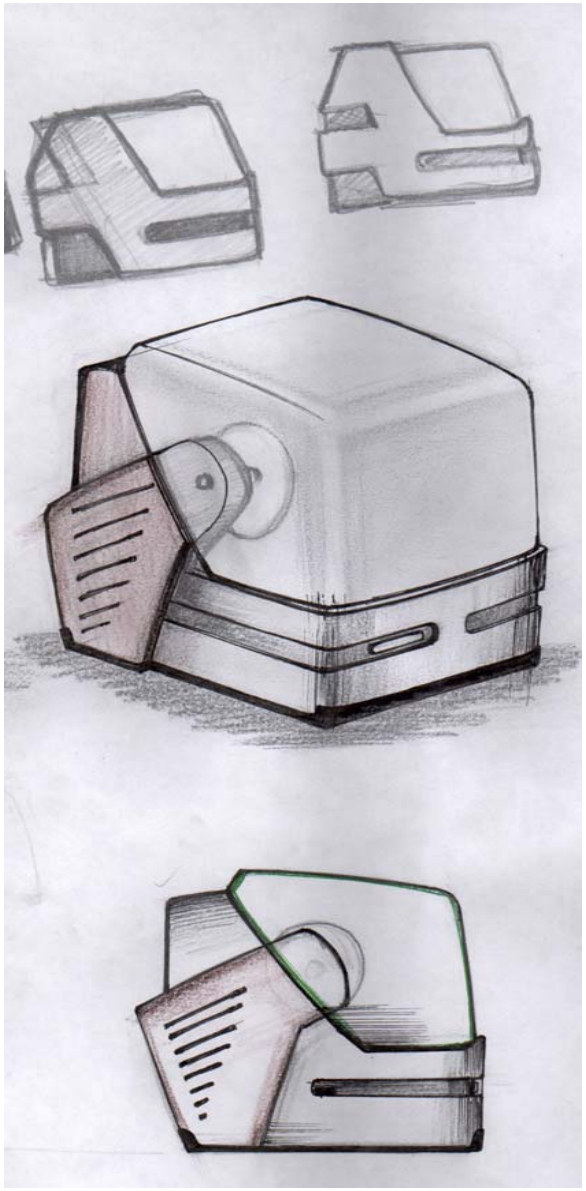
Fourth level alternatives

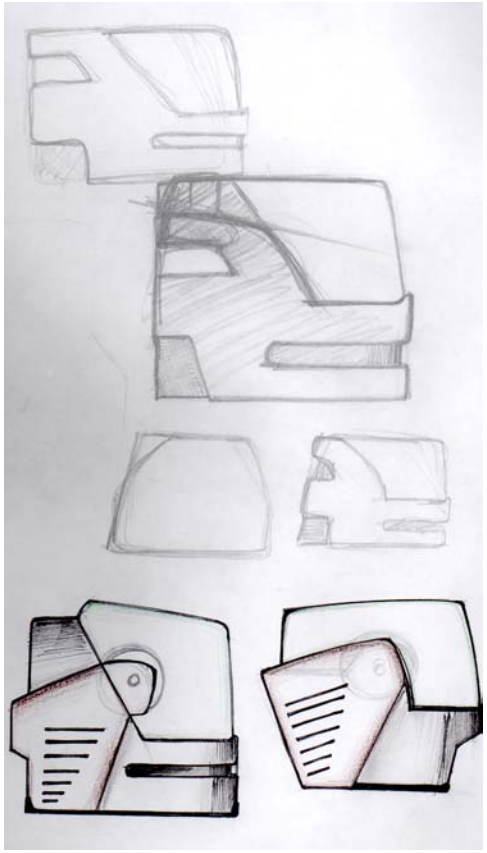


Concept-2 Alternative-1

Elements which are striking and out of the surface treatment is given

Fourth level alternatives

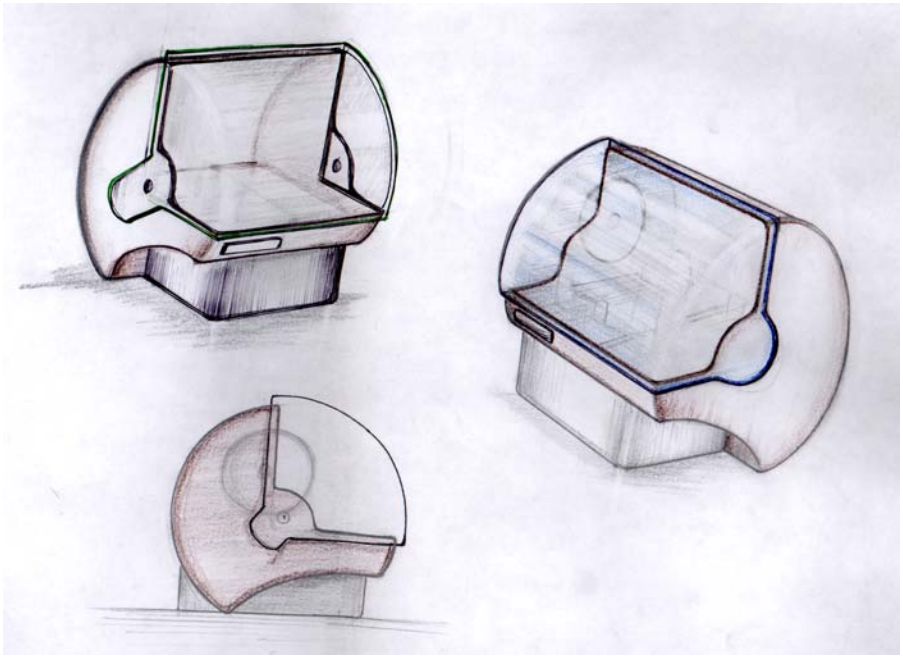


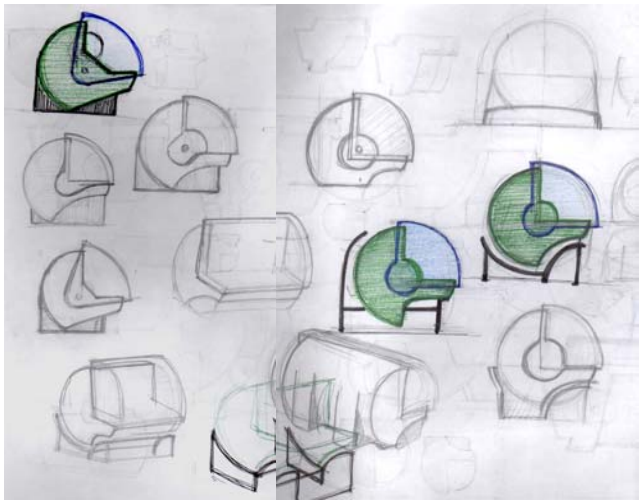


Concept-2 Alternative-2

Elements which are out of the volume with absolutely no symmetry

Fourth level alternatives

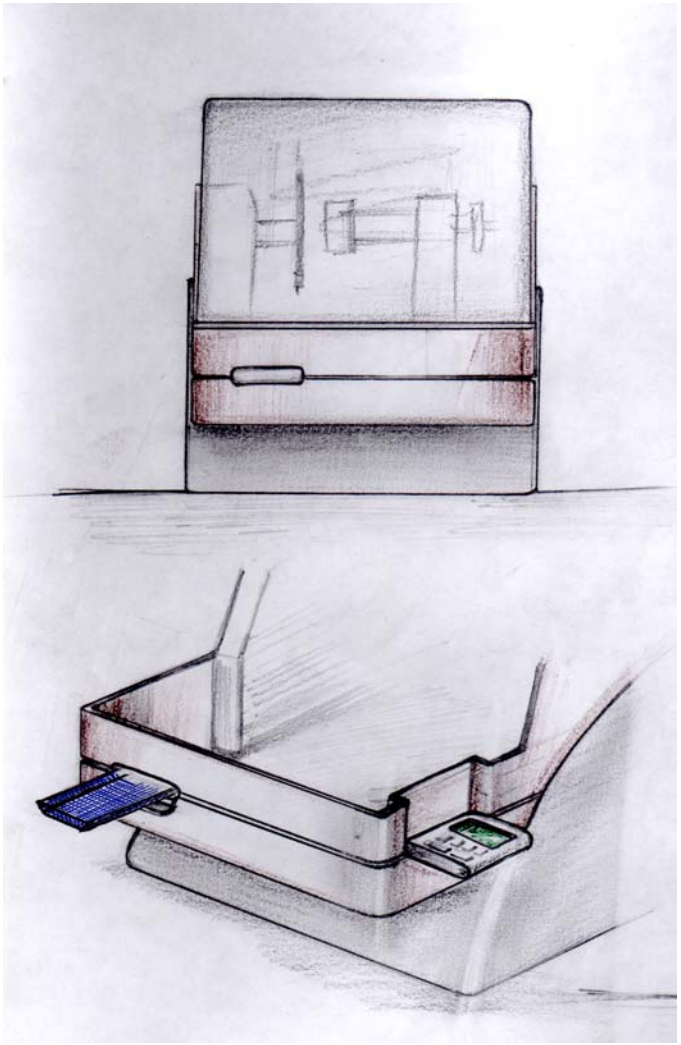


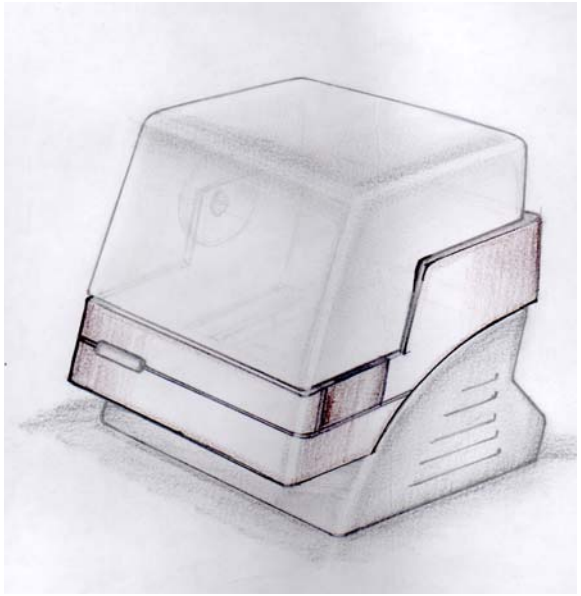


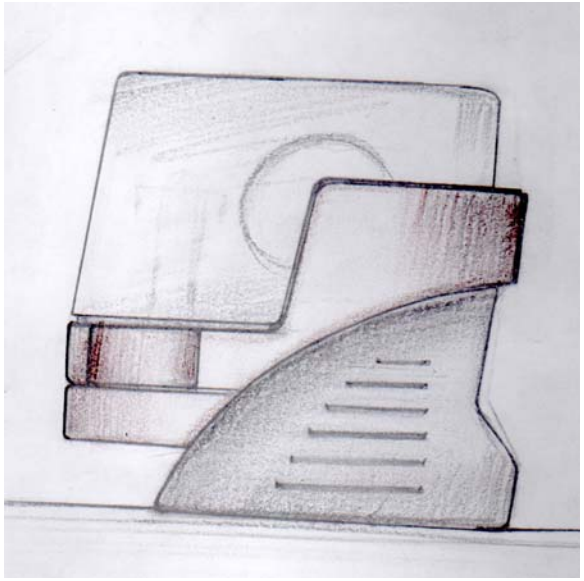
Concept-3

A completely different kind of form .which expresses that the is a rotating disc in side the enclosure.

Fourth level alternatives



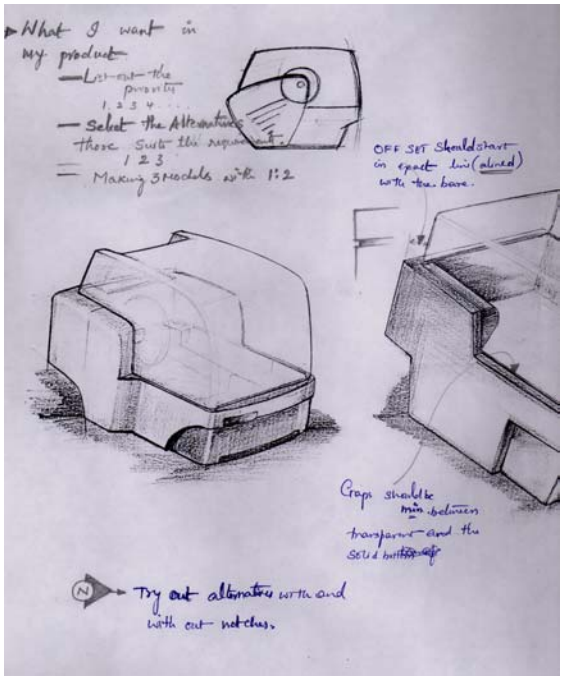


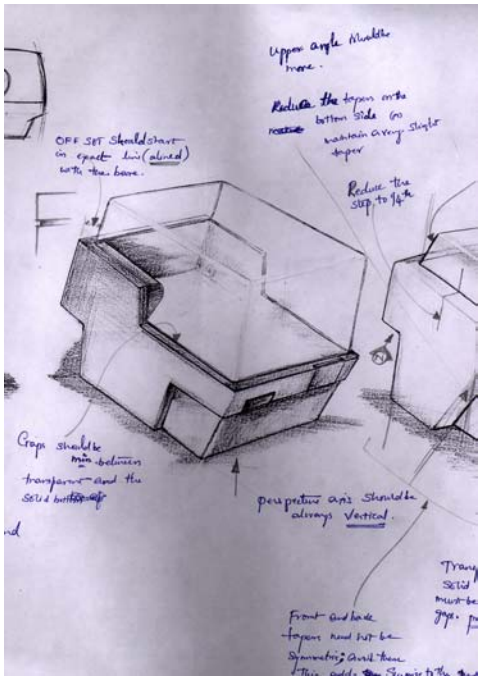


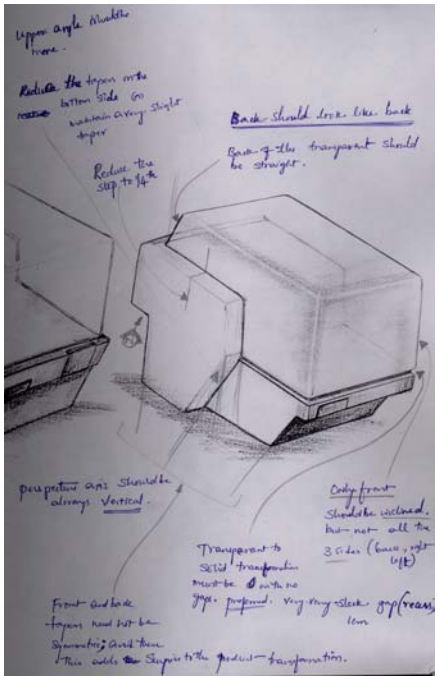
Concept-4

A completely different kind of form .which expresses that the is a rotating disc in side the enclosure.

Fourth level alternatives





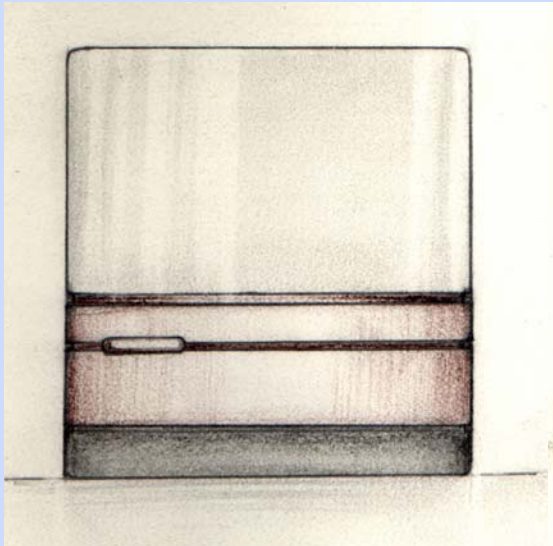


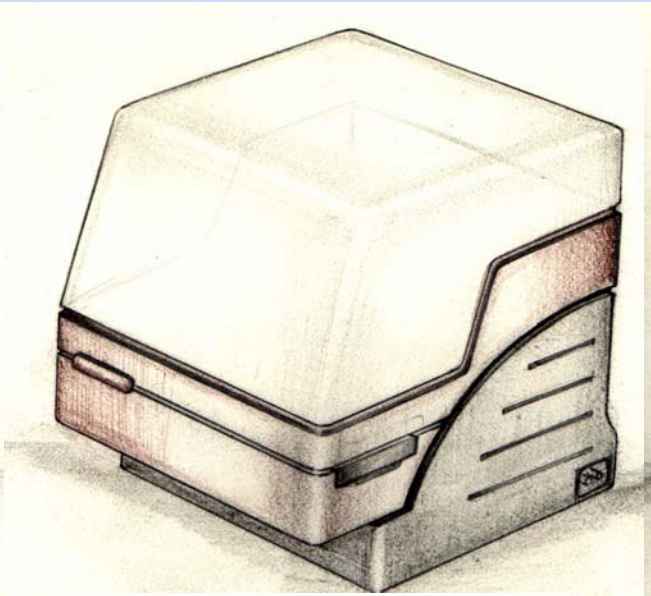
Concepts-Refinement

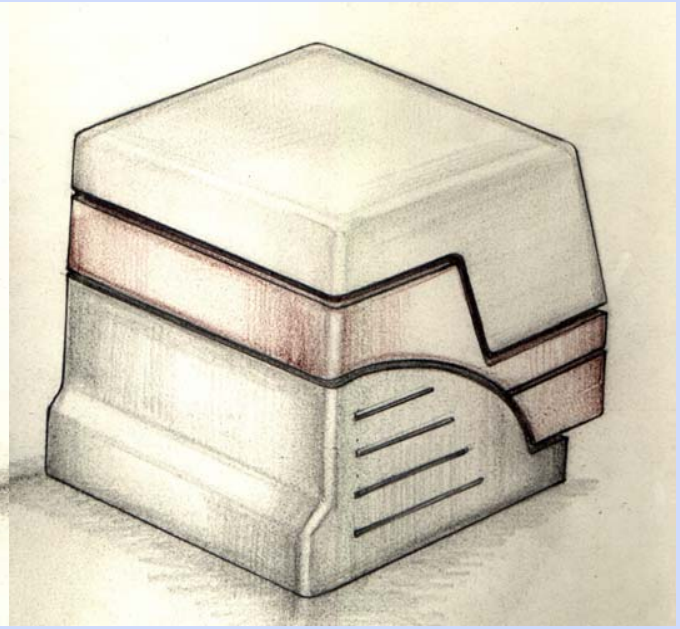
Places where the refinements has to be made are plotted and worked out .

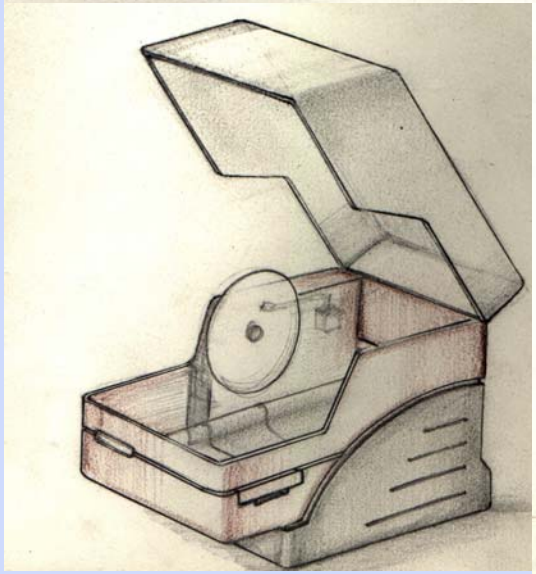
6. FINAL CONCEPTS

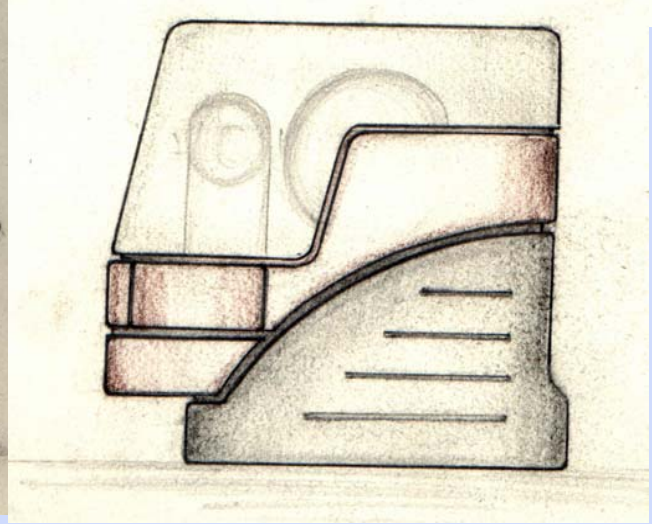
Final concept-1





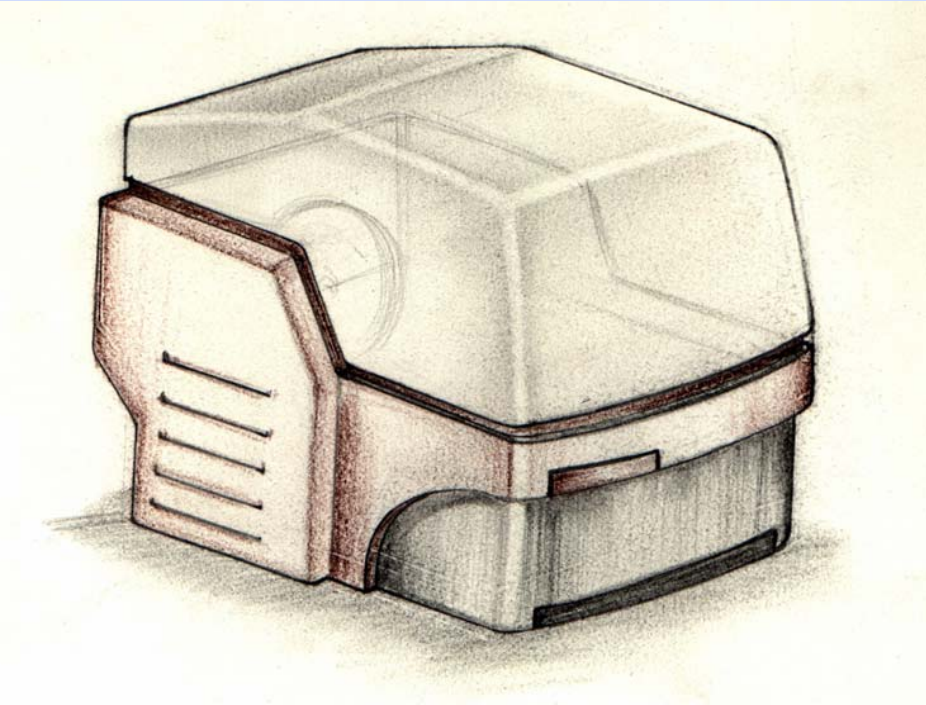


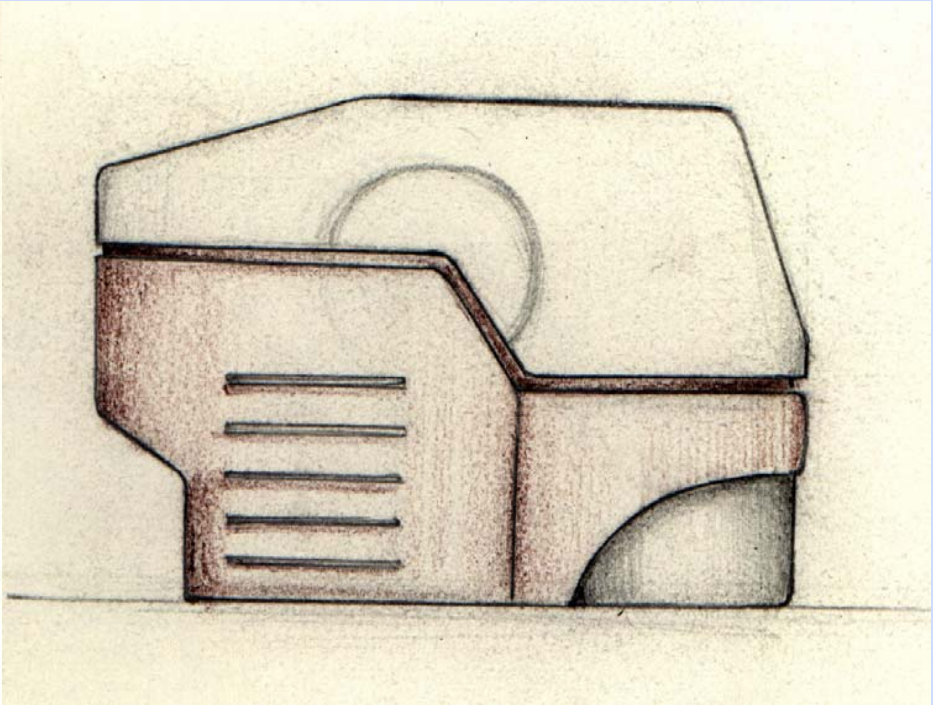




Treated with different flow of elements that adds up a sense of surprise to the over all form.

Final concept-2





Treated with different flow of elements that adds up a sense of surprise to the over all form. By having the variation in the visual flow from front to back .it give the strong and sturdy look which is the one of the characteristic feature that a industrial form should have

6.1 FINAL CONCEPTS- MOCK UP MODELS

Mock up models for the final three concepts after refinements

CONCEPT-1

Mock up models for the final three concepts after refinements

CONCEPT-2

Mock up models for the final three concepts after refinements

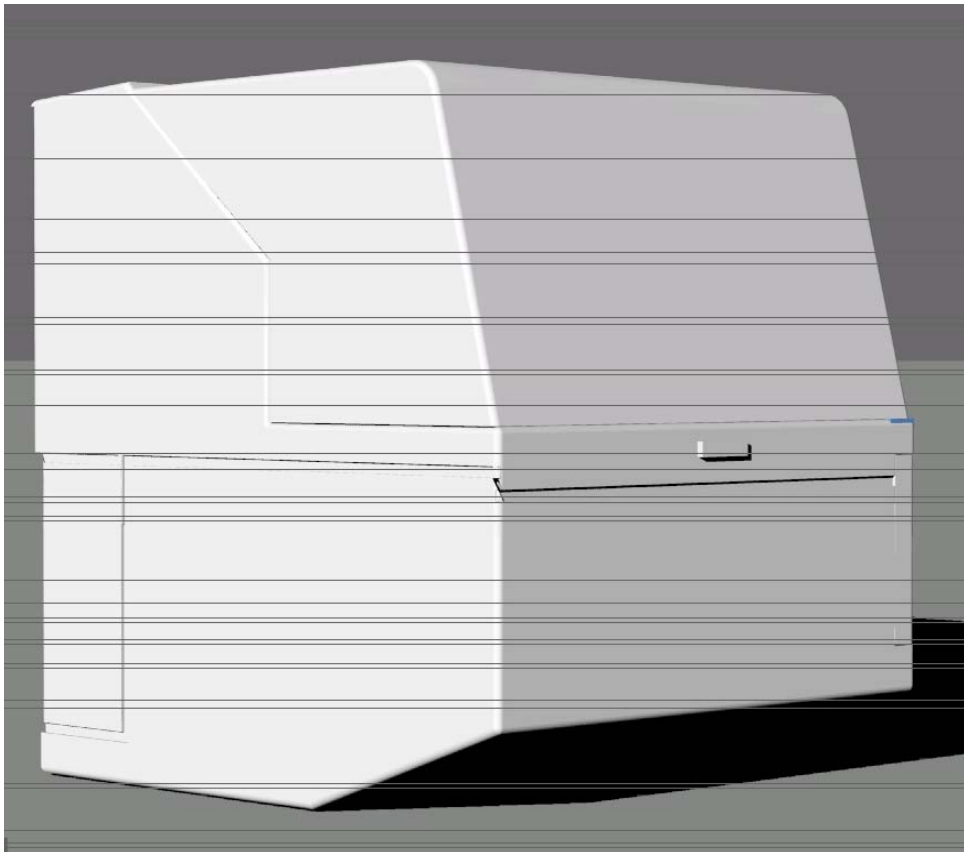
CONCEPT-3

EVALUATION CHART

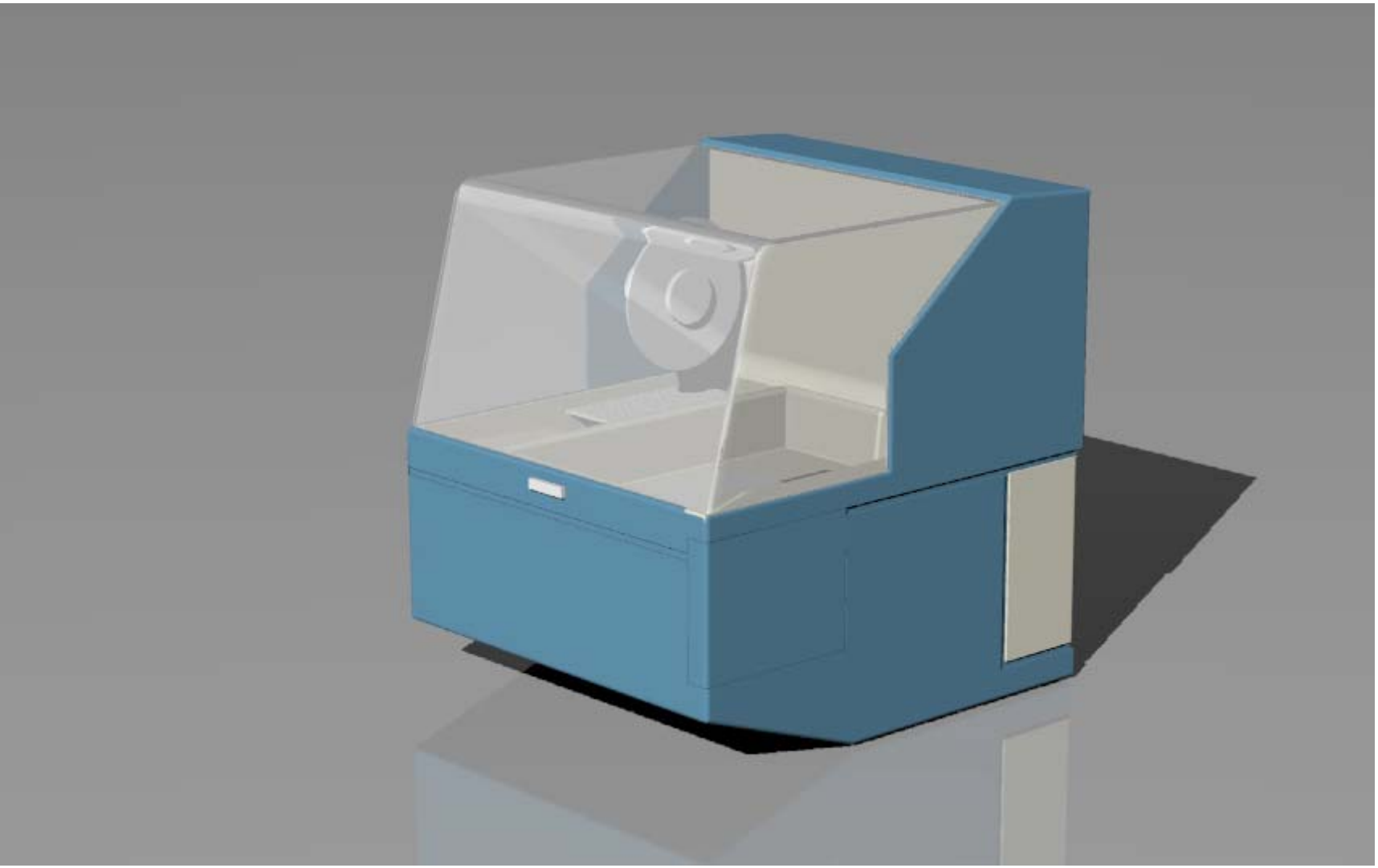
KEY FEATURES	CONCEPT-1	CONCEPT-2	CONCEPT-3
FIXING WORK PIECE IN THE VICE - OPERATING PROCEDURE	8	8	7
POSITIONING THE SAMPLE FOR THE DESIRED CUT – ACCURACY	7	7	8
LOAD APPLICATION –ADDING AND REMOVING LOADS MANUALLY	9	7	6
FEEDING MECHANISM – LEAD SCREW	10	10	9
COLLECTING SPECIMEN – FROM THE TRAY	10	10	10
HOLDING OF INTRICATE SHAPES - ORIENTATION IN VARIOUS PLANES	9	10	10
PLACEMENT OF COOLENT TUB -MAINTAINANCE	10	10	10
CONTROL PANEL ORGANISATION	4	8	6
VISUAL DISPLAY	5	8	4
ENCLOSURE	9	10	10
INBUILT CONTROL PANEL	5	10	5
OVERALL FORM VISIBILITY	8	10	8
COMPACT AND CONVENIENT WORK SPACE	8	10	7
SCORE	102	118	100
WEIGHTAGE	102/13 = 7.8	118/13 = 9.07	100/13 = 7.6

CHOSEN CONCEPT

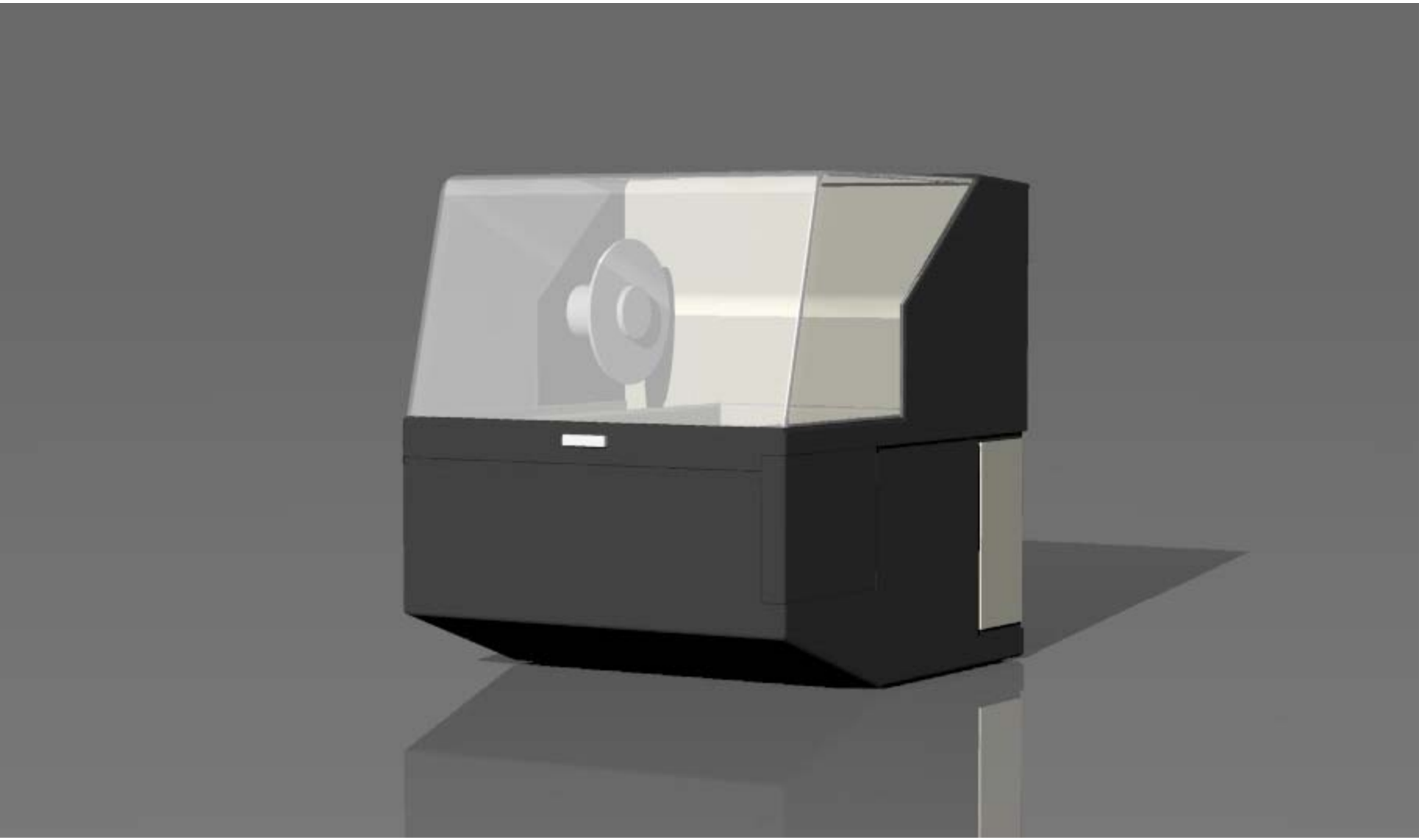
Thermocol model of the final concept



Digital model of the final concept



Digital model of the final concept- its variations

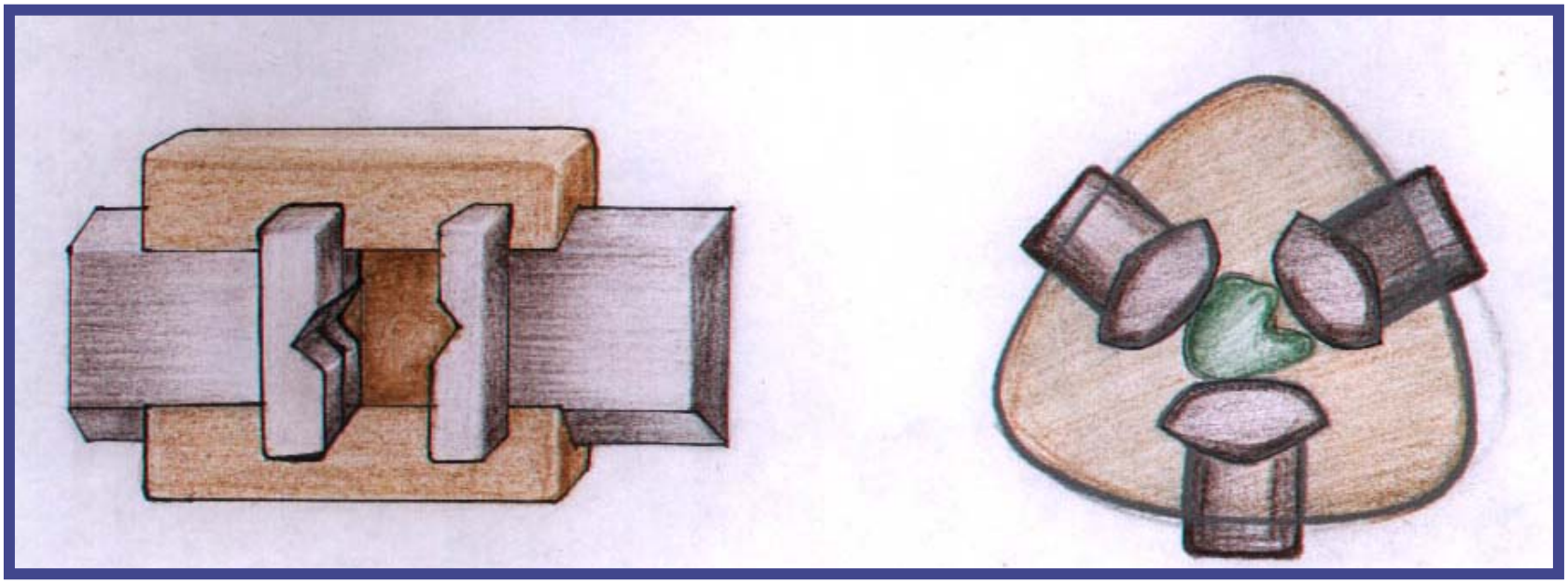


Digital model of the final concept- its variations

7. SOLUTIONS FOR THE FUNTIONAL PROBLEMS

FUNCTIONAL PROBLEMS - SOLUTIONS

Holding work piece in vice

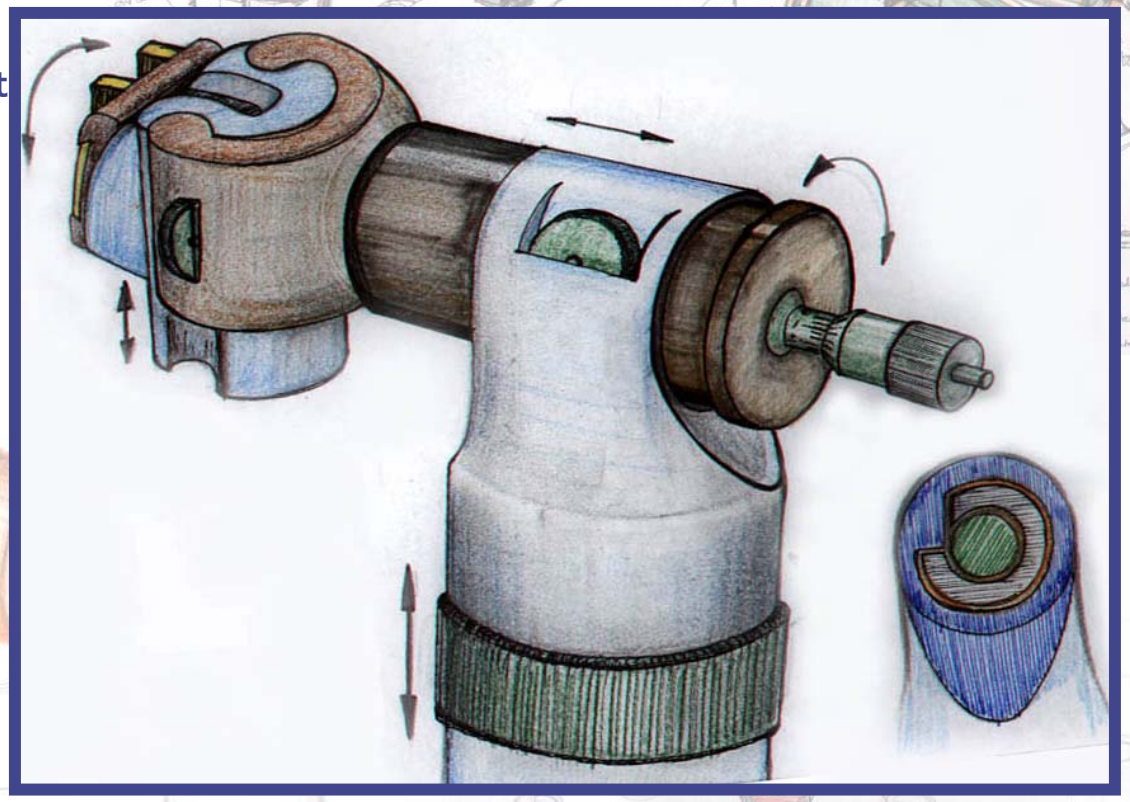


For geometric shapes

For intricate shapes

FUNCTIONAL PROBLEMS - SOLUTIONS

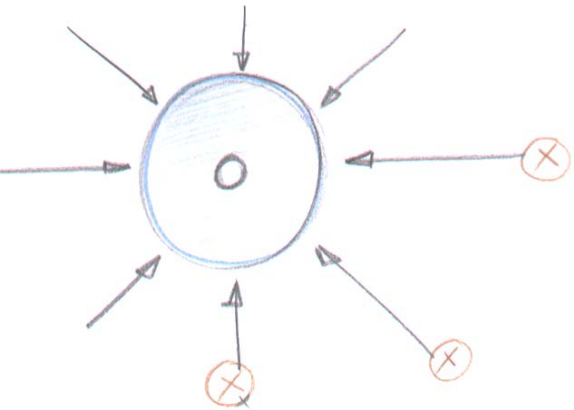
Orientation of work piece in different planes



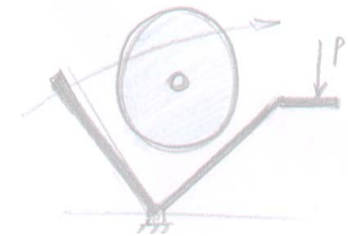
Concept adopted from the robotic hand and its features. Thus generated a design which can able to orient the work piece in all co-ordinate planes. Controls are provided taking the requirements and the ergonomics in to the consideration.

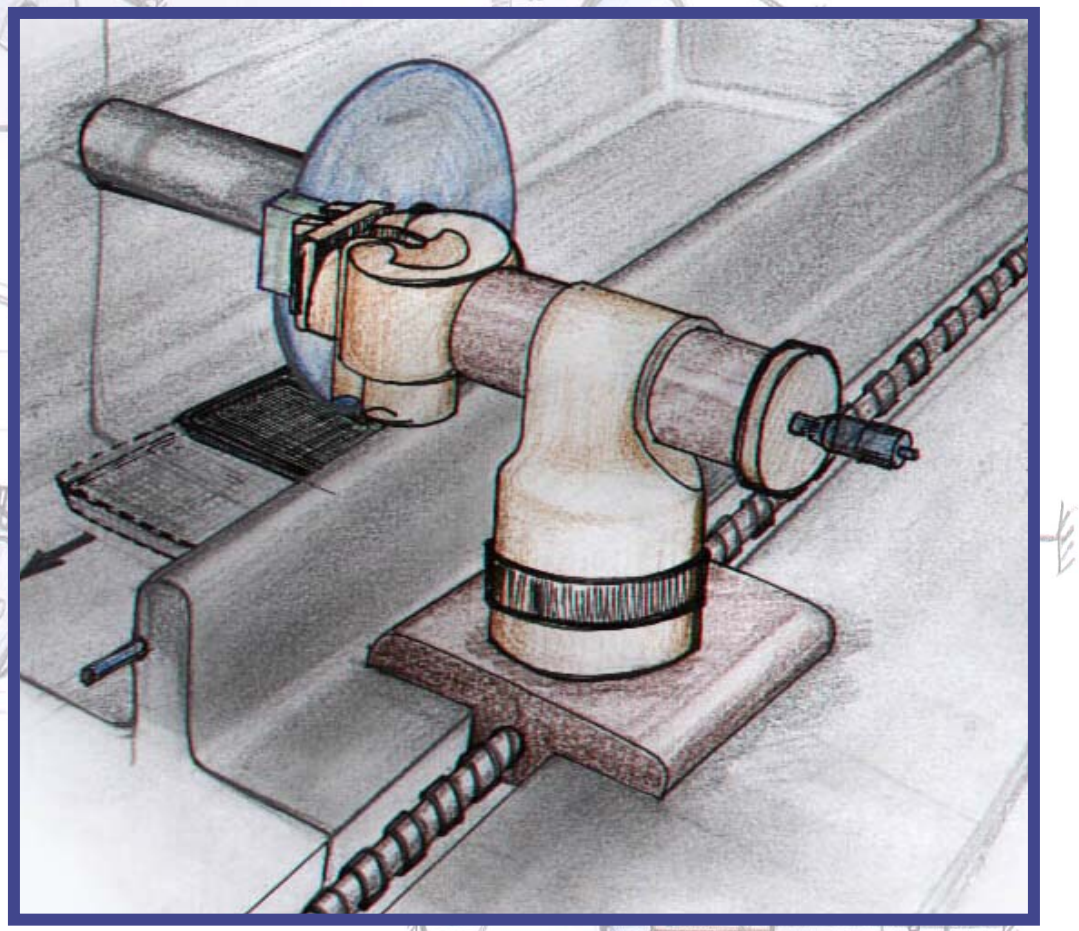
FUNCTIONAL PROBLEMS - SOLUTIONS

Application of load



Possible ways for feeding

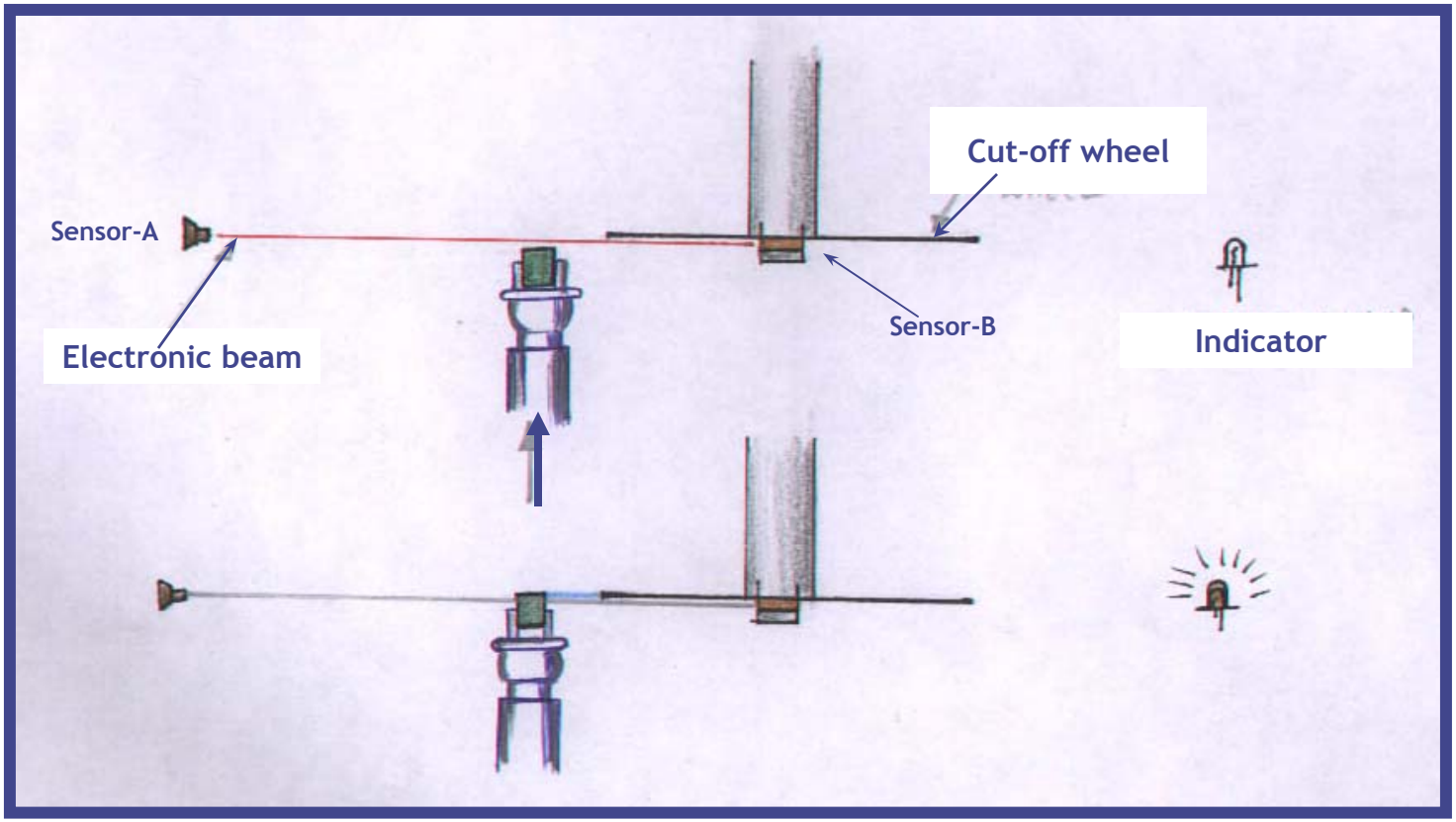




The whole vice is mounted on the flat platform that is driven by the lead screw. The principle is chosen for consistent and vibration free feed. Constant feeding is carried in only horizontal direction as the other directional movement is arrested.

FUNCTIONAL PROBLEMS - SOLUTIONS

Positioning for accuracy

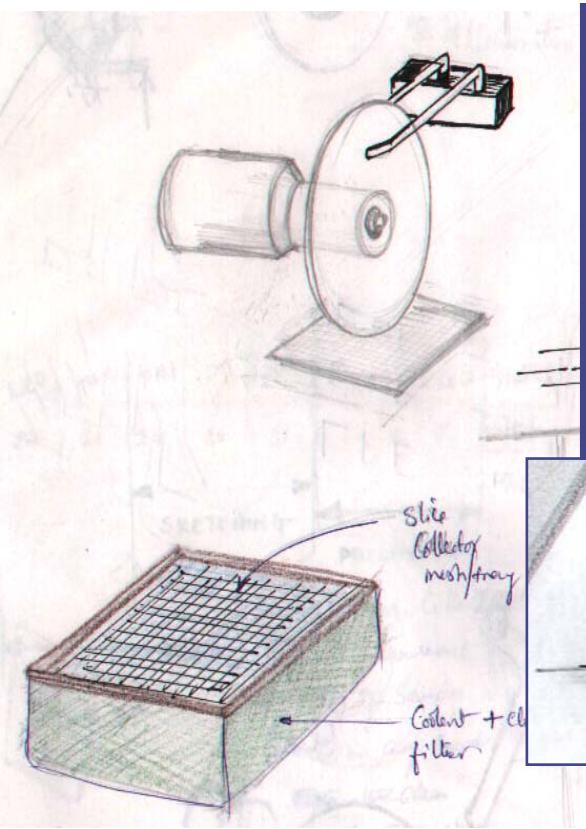


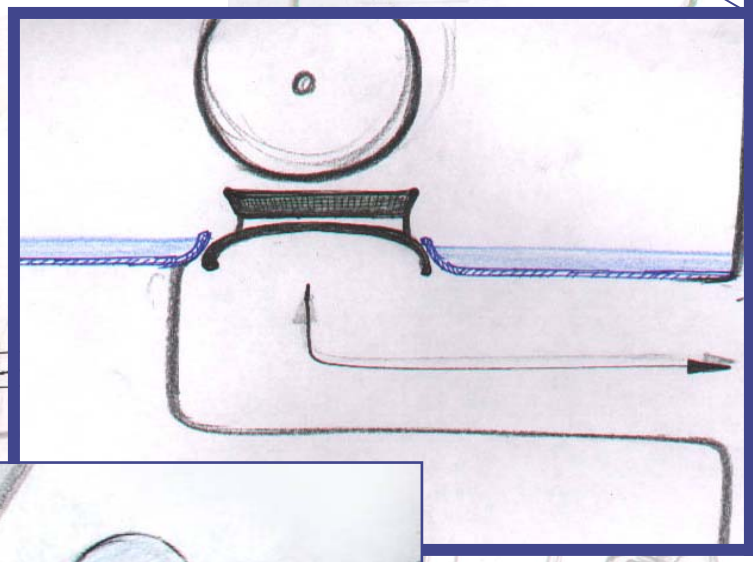
Accuracy for the thickness is achieved by using the electronic sensing technique. The disc arbor contains a sensor-A which is in direct beam contact with the sensor-B . When ever the work piece interrupts the beam the indicator glows. Firstly ,the work piece surface should be exactly in line with the cutting disc. This is achieved by initial surfacing by slicing the edge which is any way not useful. At this position the work piece surface is exactly in the plane of the cutting disc surface. Now the micrometer is adjusted to the desired cut very easily.

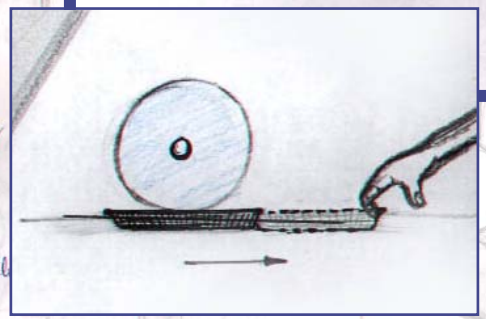
FUNCTIONAL PROBLEMS - SOLUTIONS

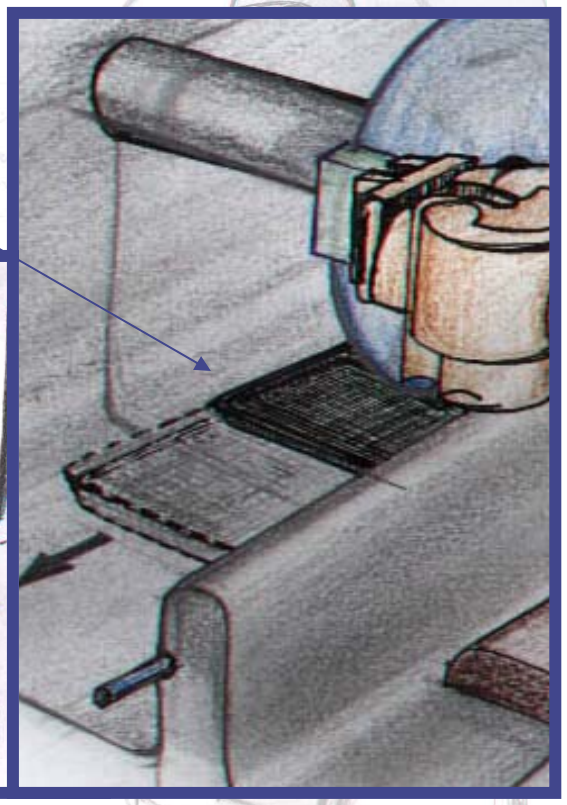
Collection of specimen slice

Collecting tray





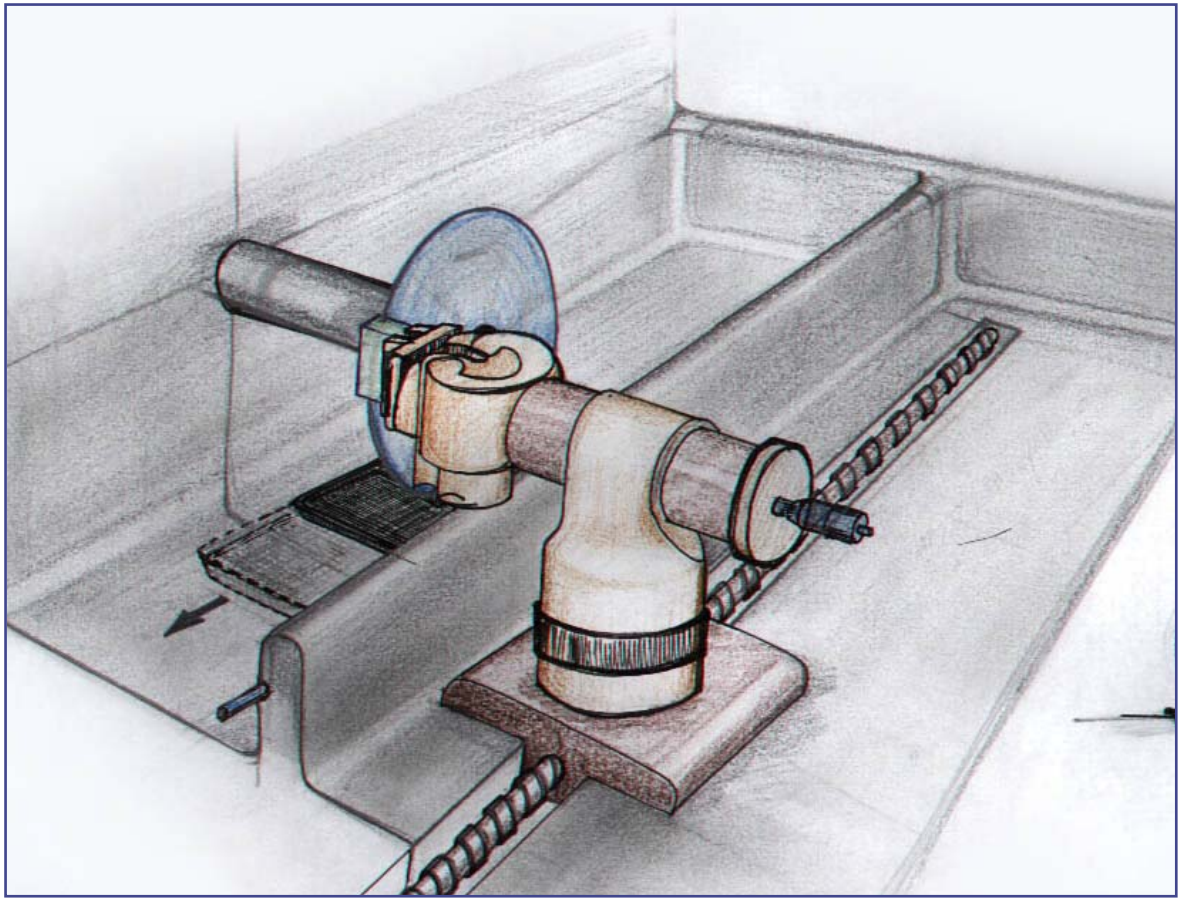




The specimen is collected in a tray that is provided below the cut-off wheel. After collecting the specimen, the tray will be ejected out for convenient pick up.

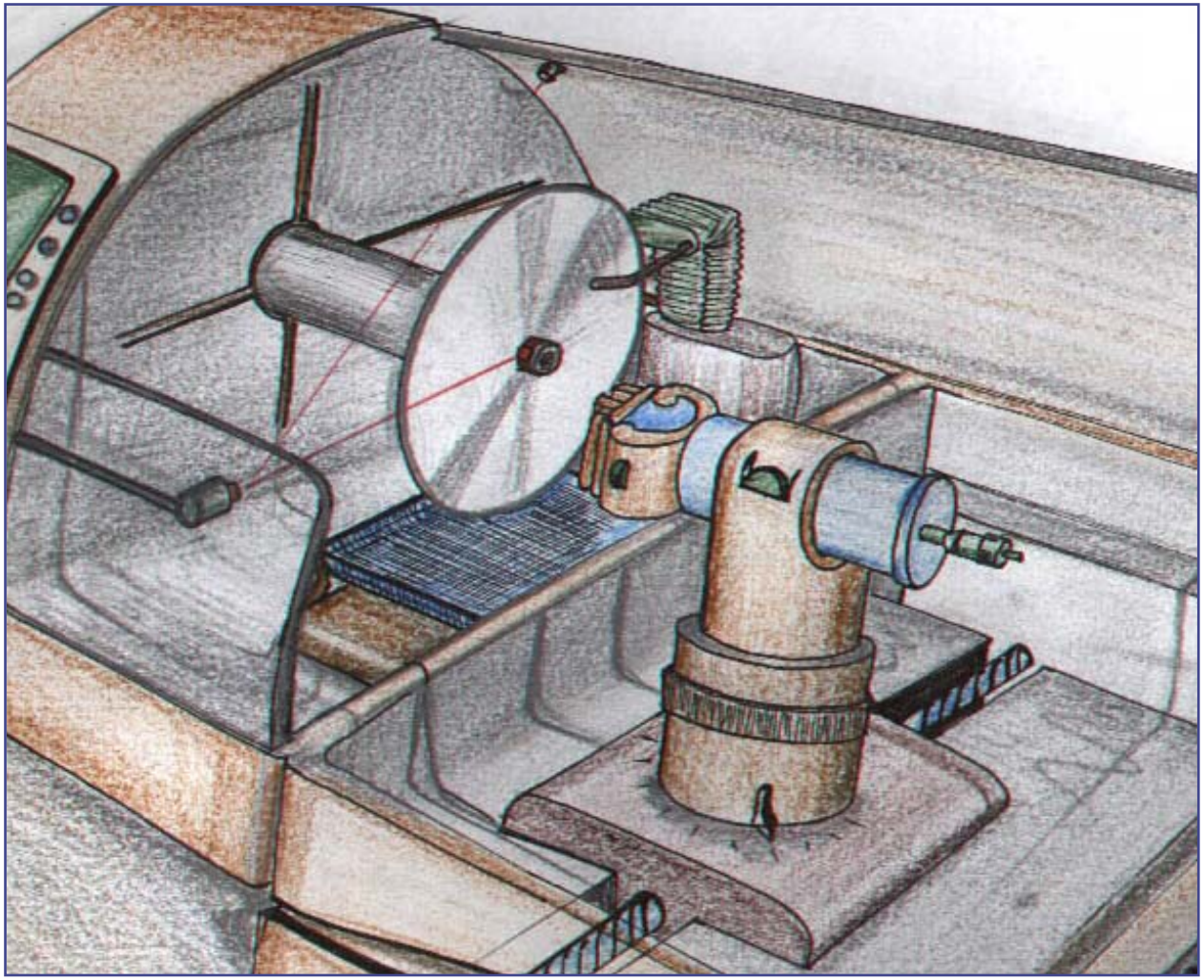
FUNCTIONAL PROBLEMS - SOLUTIONS

Separate chamber for coolant circulation

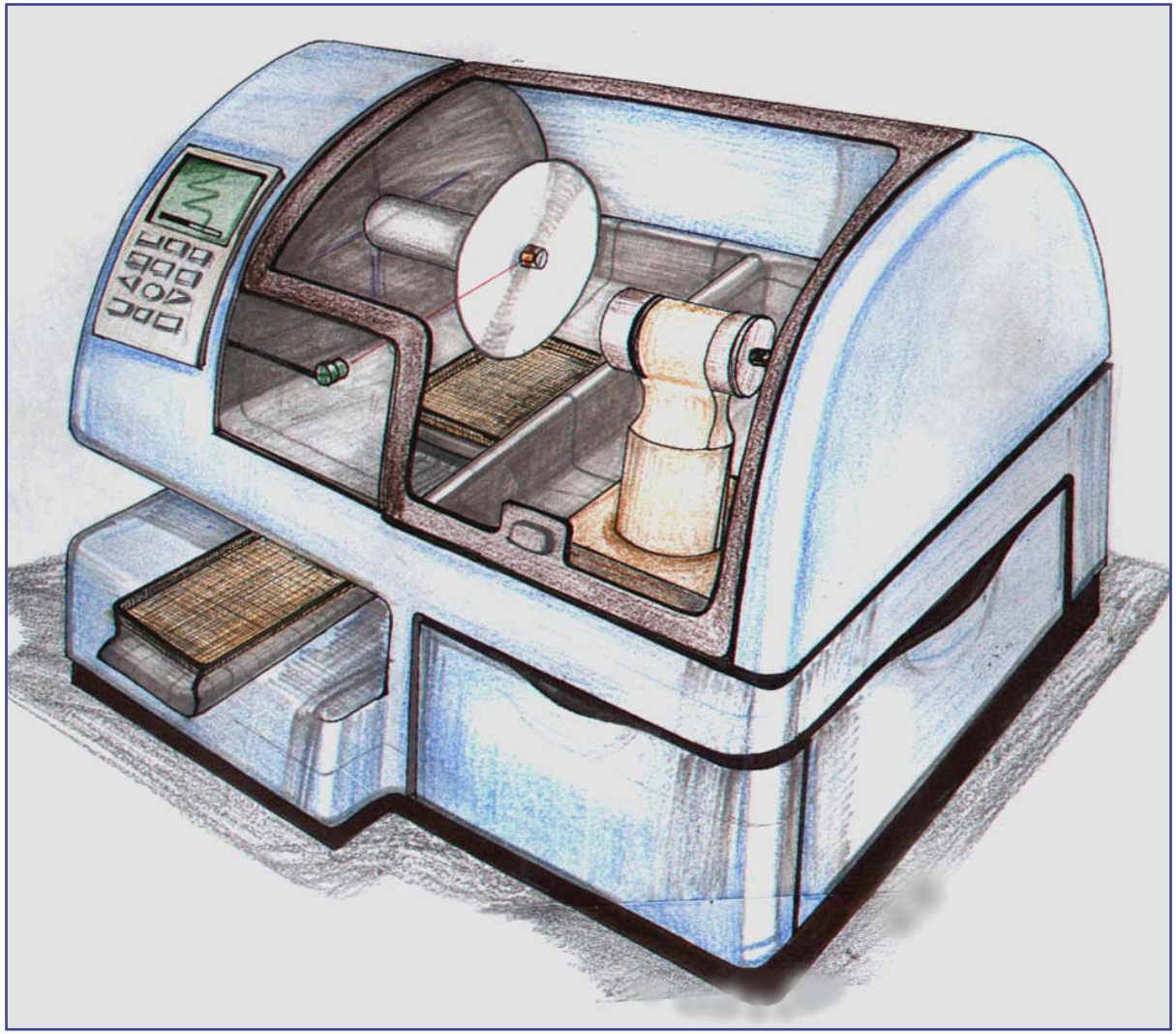


Cutting chamber is separated in to two partitions. With this the possible soiling of the feeding set-up will be avoided,which is not there in the present cutters.

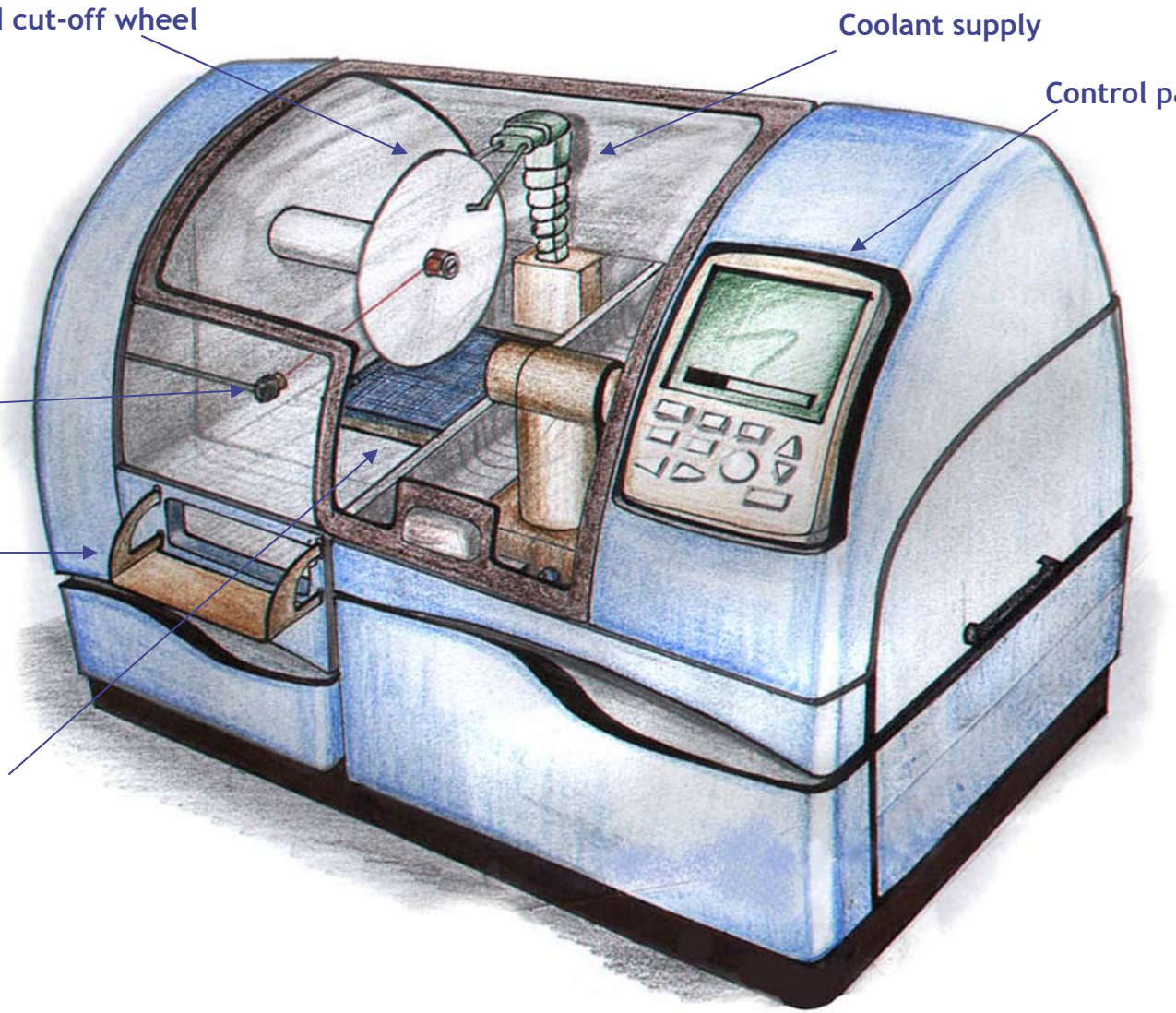
Configuring the alternatives



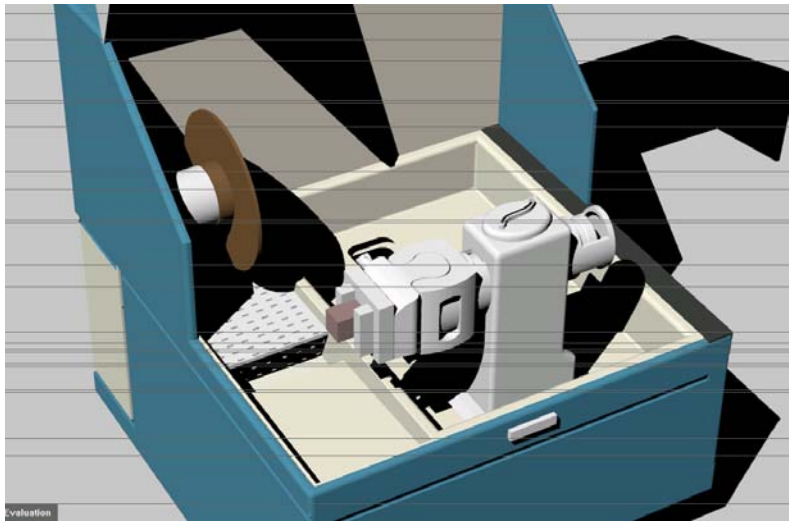
Configuring the alternatives

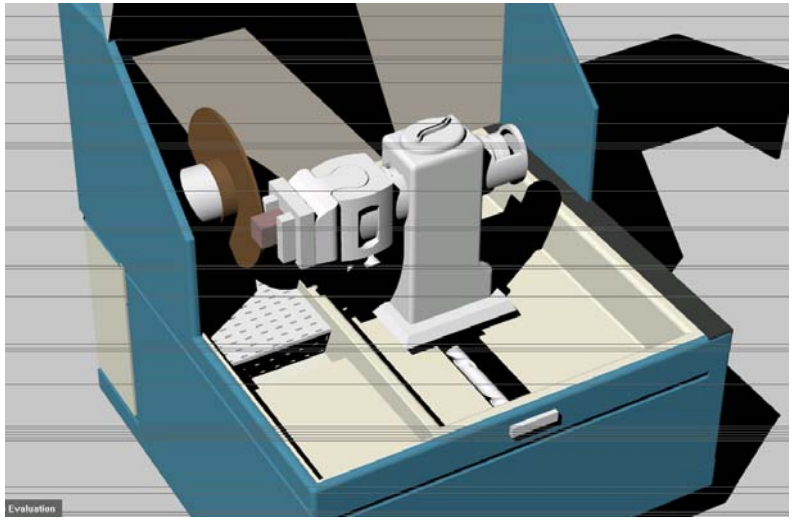


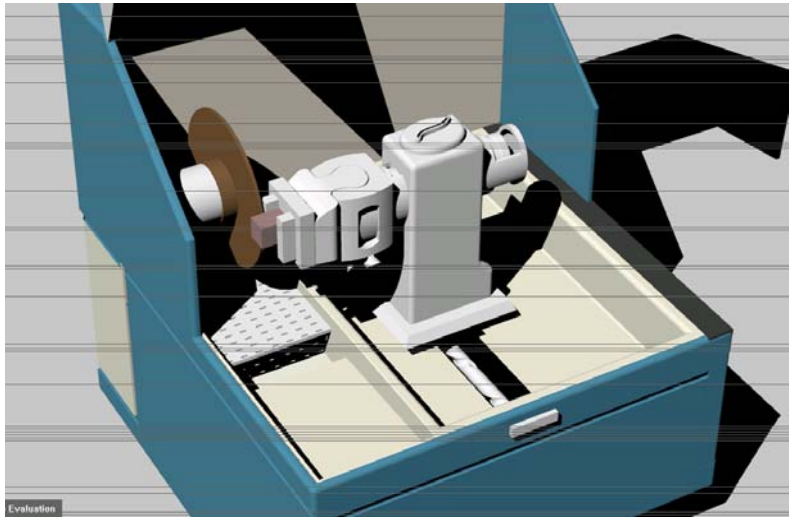
Configuring the alternatives



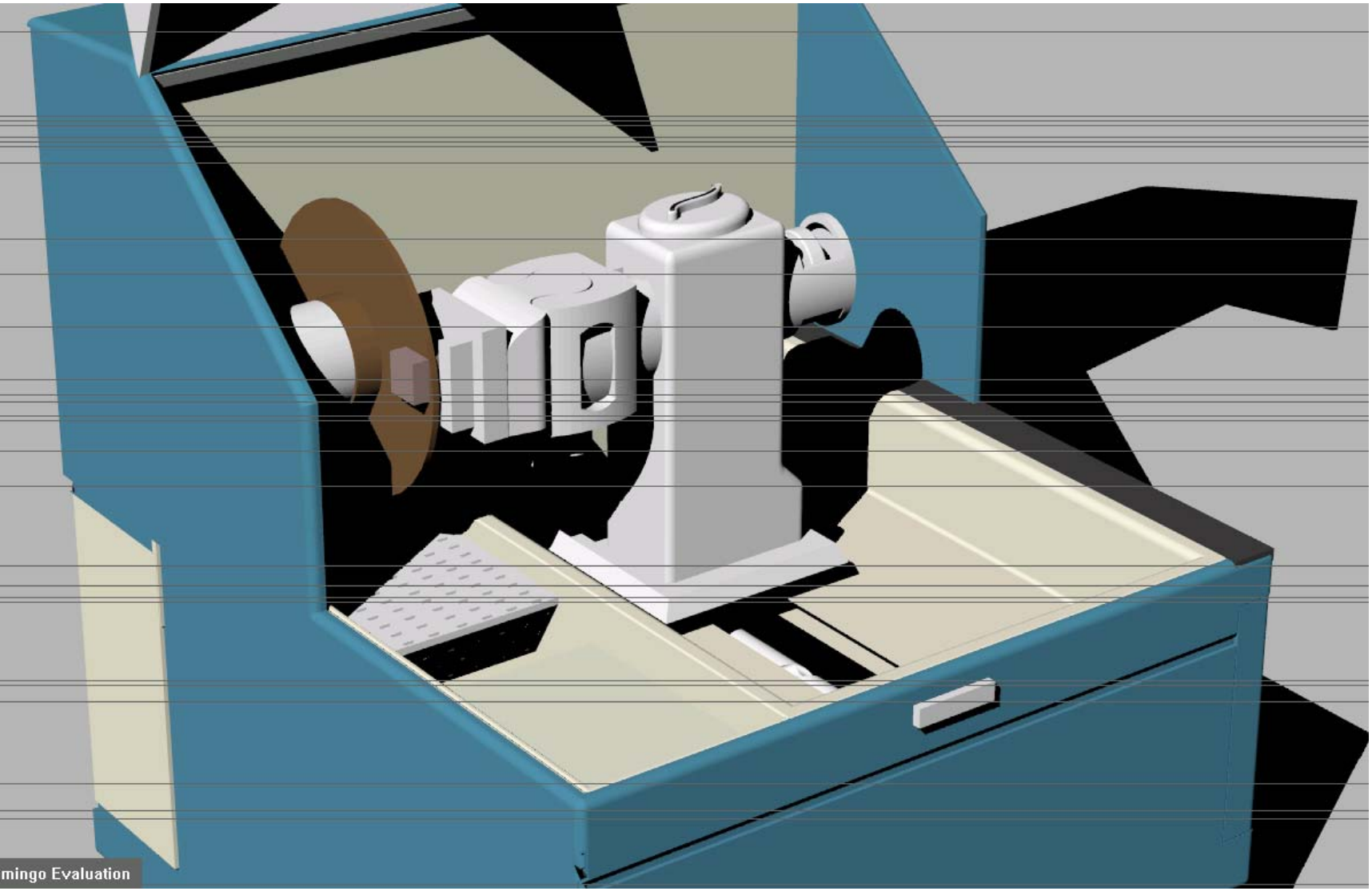
8. FINAL MODEL





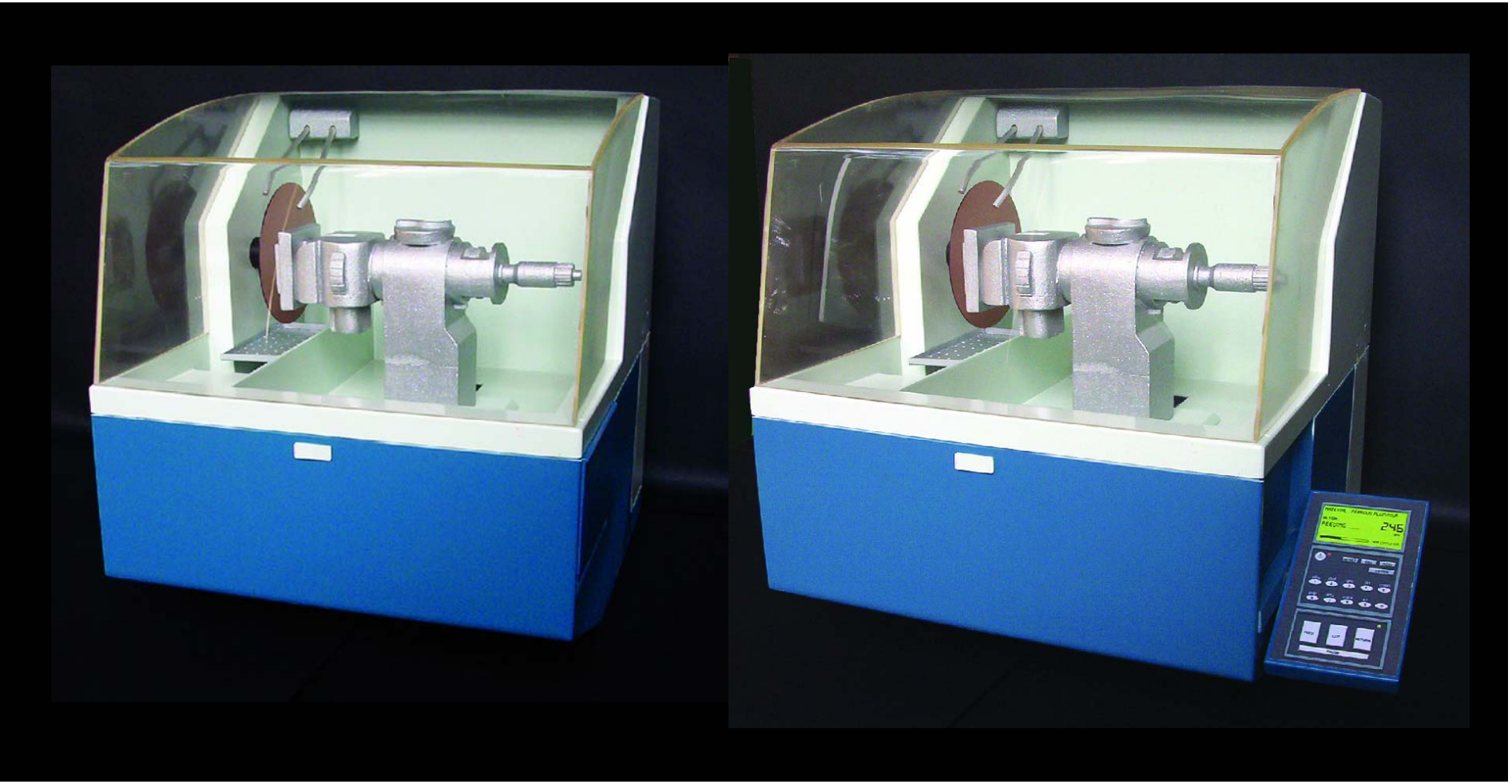


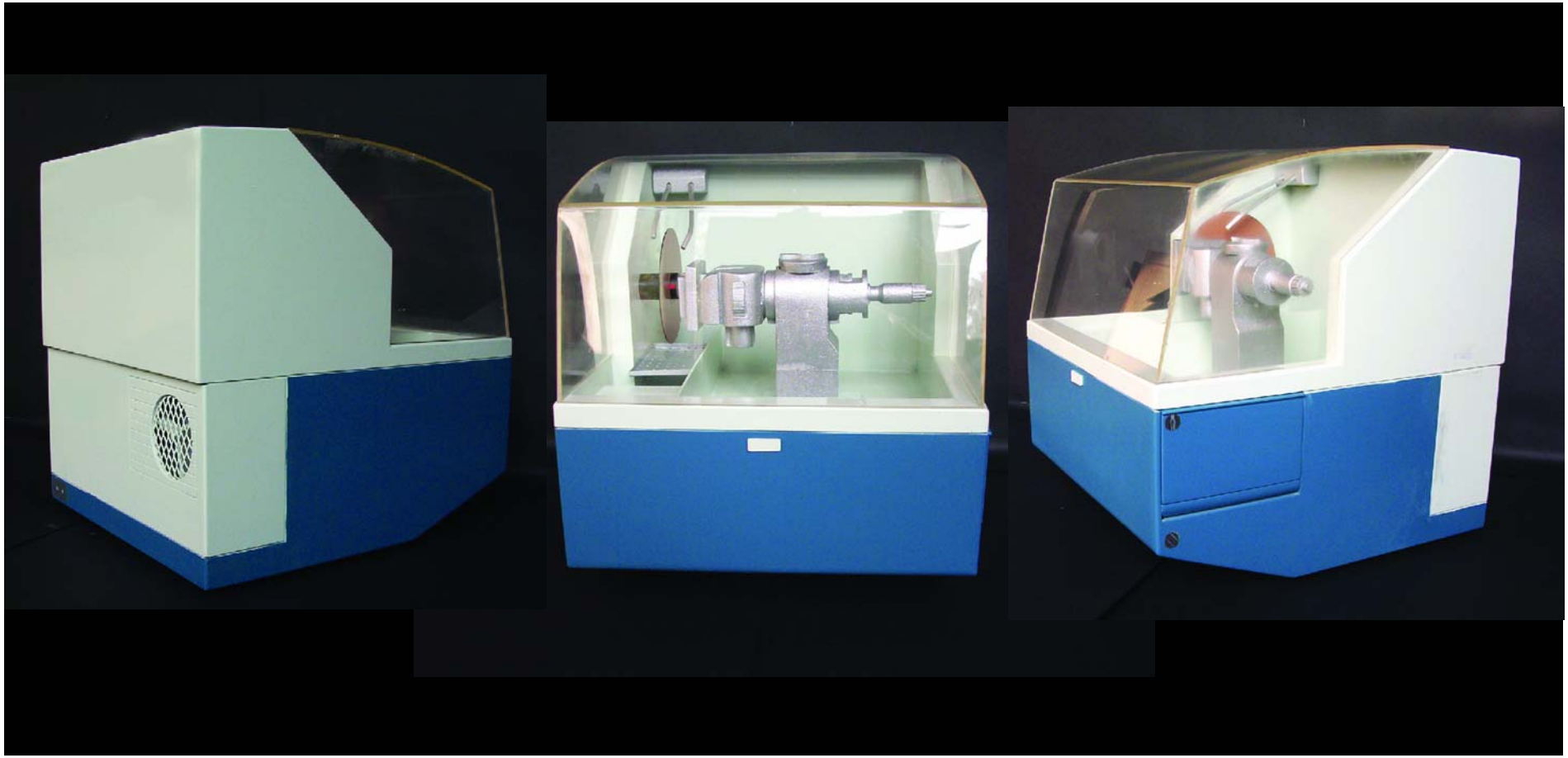
Cutting in action



Cutting in action

PHYSICAL MODEL



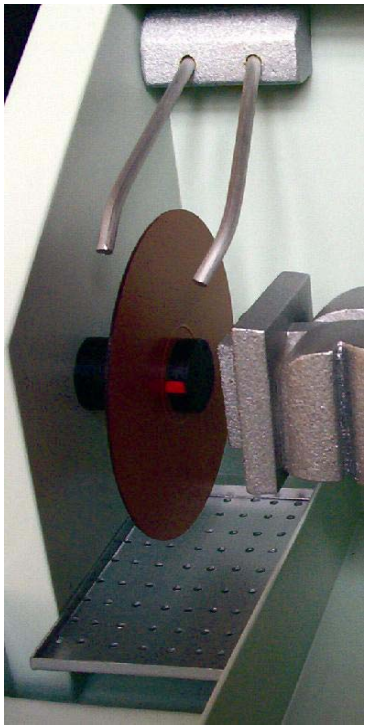


Control panel with digital LCD screen

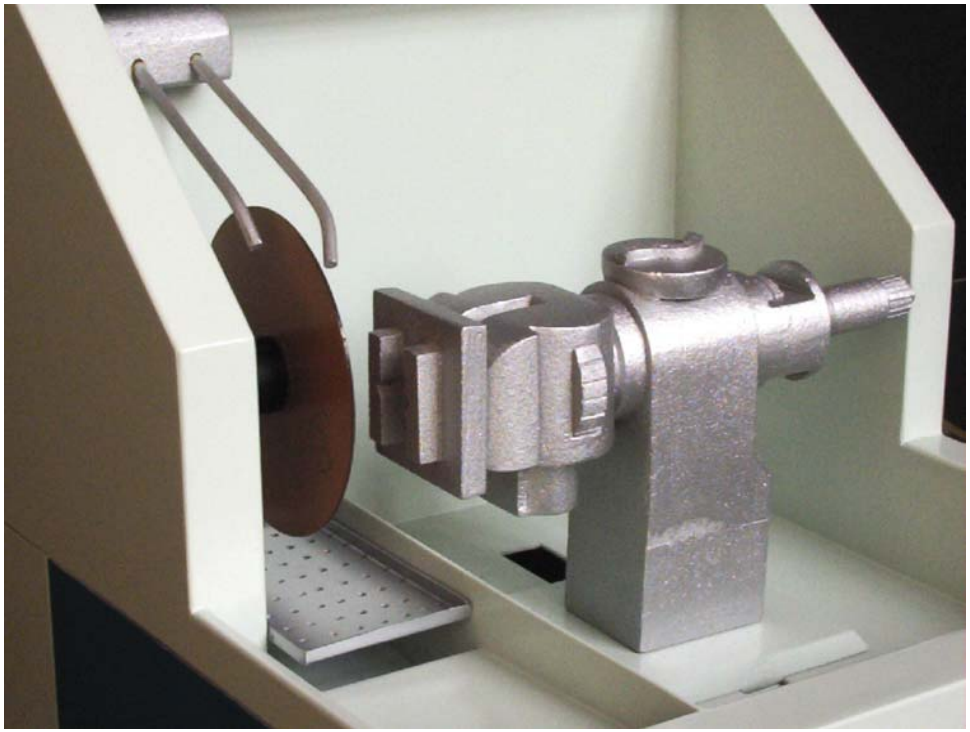
-Foldable

-Integrated

-Displays RPM, cutting status bar, material type, operation type



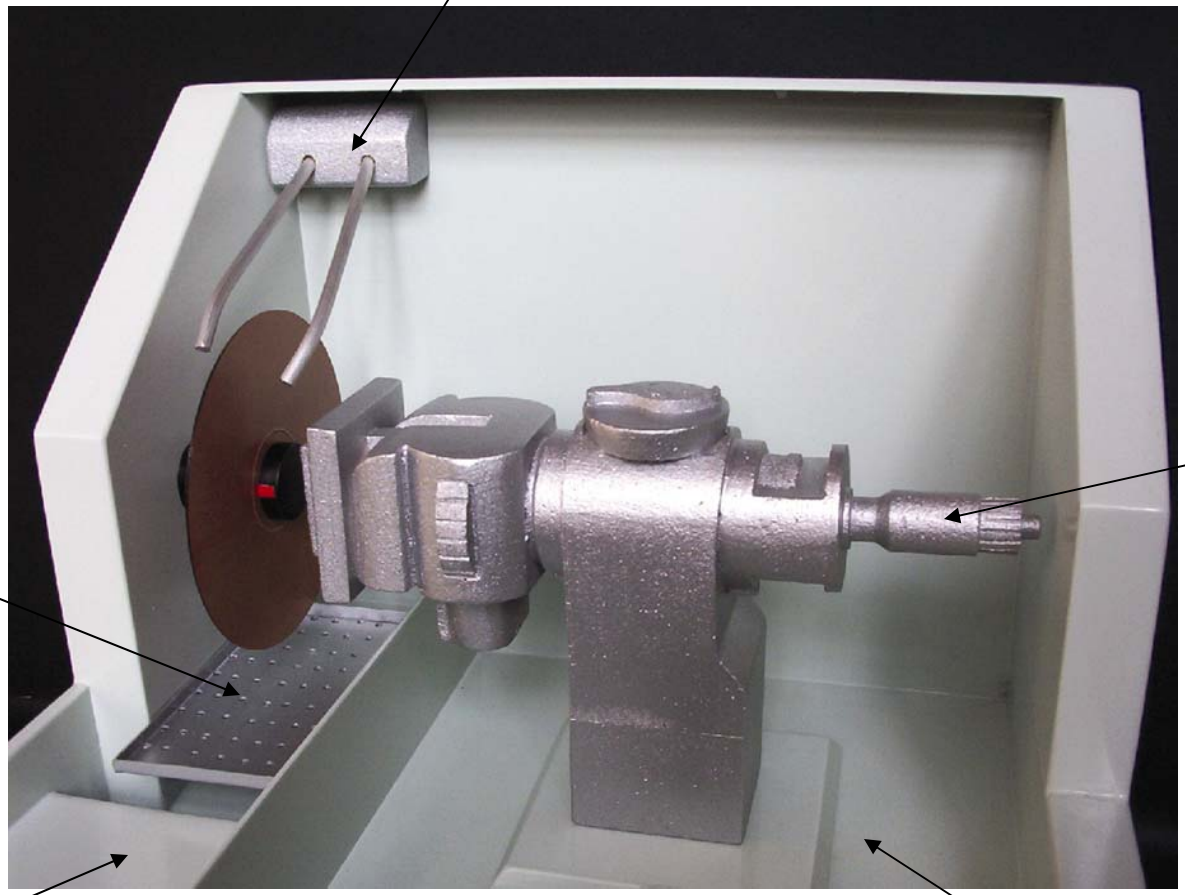
Cutting disc – Optical positioning sensor –Sliding specimen collecting tray



Specimen holding vice with multiple co-ordinate plane positioning.

- Provided with digital micrometer

- Accurate positioning


Coolant supply
Digital micrometer
Sliding collecting tray
Cutting chamber/coolant chamber
Vice chamber

PRODUCT INFORMATION

Technical data:

Height	- 392mm
Width	- 342mm
Depth	- 395mm
Weight	- 7 kgs
Wheel rotation	- 0- 1000 rpm
Max blade dia	- 120mm
Max sample dia	– 45mm
Max sample load	- 500g
Micrometer setting range	- .1 – 25 mm
Coolant reservoir	- 1000 ml
Synchronous motor(TMC servos)-180mm	
Connection voltage	- 230/115v
Power input	- < 100 kw

Features:

- Fully automatic with **L C D – display.**
- Strong and functional form .
- Substantial reduction of human intervention.
- Multiple co-ordinate plane, specimen holding vice .
- Variable RPM adjustment with automatic and powerful synchronous drive .
- Automatic cut-off with completion of cutting process
- Compact coolant chamber.
- Provided with sliding specimen collecting tray.
- Extreme precision adjustment with digital micrometer.
- Accuracy positioning with optical sensor.
- Compact and convenient control panel .
- Automatic feed and load adjustments depending on the type of material.
- Memory recall.
- Visual status recognition from control panel.
- Transparent enclosure.
- Exhaust fan to drive heat of motor.

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