

Water quality checking product

product design **project II**
report
by

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Approval Sheet

The product design project titled
"Design of water quality checking product"
by Yogesh S. Patankar is approved for the partial
fulfillment of the requirement for the Post graduate
degree in Industrial Design.

Project Guide

Co-guide

Chairperson

Internal examiner

External examiner

Date

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Mr.Anirudha Deshpande(Media Lab Asia)
Ms.Archana(Chemistry department of IIT)
All my classmates to keep me energetic all the time.

The chemical department of IIT Bombay has developed a biosensor which works on conducting polymers. These type of sensor can check the presence and quantity of various elements in a liquid. Media Lab Asia took this project for further development and appointed people from various department like Electrochemistry, Microelectronics, Biomedical, industrial design centre of IIT Mumbai and people from media lab Asia. I took this project under Guidance of Prof .Munshi of IDC ,IIT Bombay. The projects main aim was to do research in water quality checking. On every Friday a meeting is used to held in Chemistry department where all the people in group meet and discuss on various issues of design at various levels of sensor design. Group looks on to the progress of every person. Inputs are given from experts in different people which are used in design of the product.

The projects main aim to develop a water quality checking product which can be carried in fields, outside the laborotary. Each and every technical issue is discussed in meeting and solution for problems were finalized by consulting with the people.

The effort is to make such a product which is useful to people who are doing research in this field. Exploration for design ideas was done in many ways. At every level of design concepts were evaluated and then carried forward .

The chemistry department of IIT Bombay has recently developed a biosensor which can sense presence and quantity of elements in liquid. Media lab Asia ,sister concern of Media lab USA took the project to develop a product using this technology. The project is an interdisciplinary course where people from various departments of IIT work together. The people from chemistry department develop the sensor and look for its sensitivity and other related problems. The electronics department will develop the PCB and sensor cartridge .The IDC will design the product by combining the internal circuits and related usability , functionality issues . There was no product developed on this technology and also which liquid is to be tested was not clear. Then first we concentrated on water for checking its parameters. The biosensors are very compact and small in size .They work on the principle of change in electrical conductivity as compared to other ion exchange based products which are available in global market .All the sensors available in market are based on some other techniques of sensing elements not big work has been done in the area of biosensors 10 years ago.

Recently some researchers have done great work and they have come up to stage of using this technology effectively as product .Biosensors have not been used in large numbers to check the liquids like water,blood,urine,milk,chemical mixtures etc. The biosensors have very wide use in the field of food technology and beverages where they are used to taste the quality of the beverages and to check the food for any type of poisoning from microorganisms. Now the same biosensor can be used to check water quality, to check the blood constituents ,milk fat contents ,urine for glucose.

Amongst blood, water and milk we started our work with water quality checking .We focused our work with water so that it can form base knowledge to go for higher complexity. If we see the present water quality checking products ,they are based on the ion exchange methods. They mostly come from other countries like Japan as such India is not making any sensor which can sense more than one parameters .

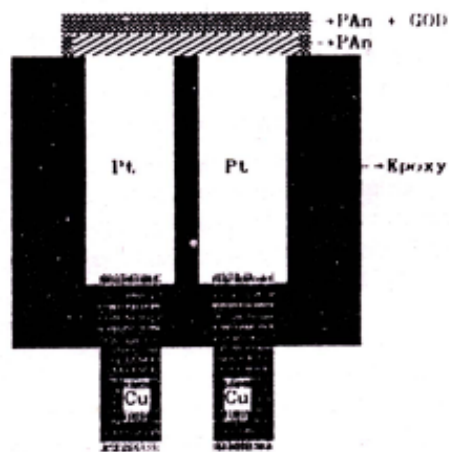
If we see the present water quality checking products, they are based on the ion exchange methods. They mostly come from other countries like Japan, as such India is not making any sensor which can sense more than one parameters. The water quality checking in India is done by government labs on District and taluka level. They use very old techniques like titration, calorimetric which are very time consuming. Recently in some government organization in urban area they started buying some instruments to check some parameters. The water quality checking in rural areas is done by primary health care department. The samples are taken from villages and are sent to district level for water quality checking. There are no sophisticated labs available at taluka level as the cost is very high. The reports take lot of time to come from district level. If we can make a product at low cost affordable to government. The total time can be brought down and decision making can take place immediately. The instruments are foreign make so they are very costly in the range of 1 to 1.5 lacks. Now the biosensor technology developed in India is used to make the product the cost of the product may come down to 20 to 30 thousands. The size of present sensors is also major consideration because the sensors are very big in size as they use ion exchange methods. So they are difficult to carry to the field. But the biosensors is very compact it's like small electronic PCB measuring the parameters. There is lot of scope in making the product compact, portable using the biosensors.

Advantages of biosensors

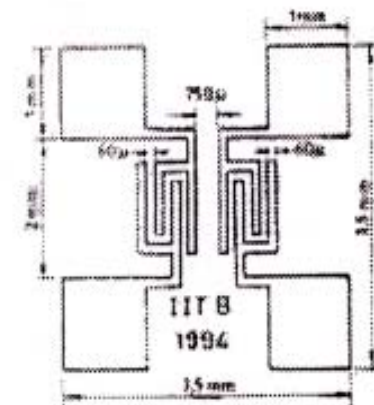
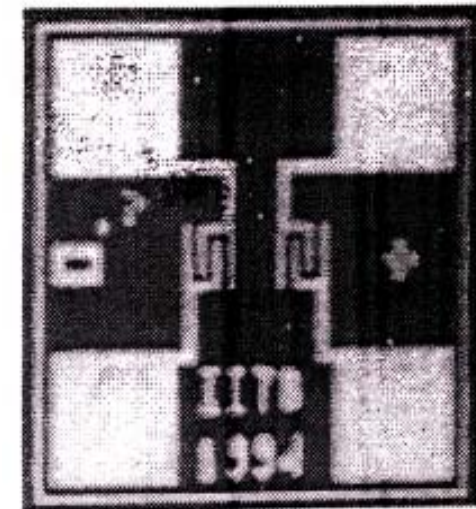
- 1 They are very compact
- 2 The cost range as compared to other technologies is cheap
- 3 The Reading given is instant

My main focus in this project is to come up with a product which can check water quality in the field.

What is biosensor??



The biosensor is analytical device incorporating a biological or biologically derived material either intimately associated or integrated within a physico chemical transducer. The aim to produce an electronic response that is proportional to the concentration of analyte. The change in electronic conductivity of conducting polymers in response to change in pH has been made use of in fabricating sensors from biomolecules. Specificity to desired molecule can be achieved by immobilizing the appropriate enzyme into the polymer matrix. The sensor is having bread/butter/jam configuration. It consists of two platinum disks shielded in epoxy and separated by a gap 8 micrometers. Polyanniline was deposited on platinum (bread) and grown to sufficient to bridge the gap between the electrodes. Now the element specific enzyme (jam) will be immobilized on the polyanniline. So for every element there will be specific enzyme to be immobilized on polymer.



In nature water is 100% pure when it comes from clouds that is condensation from vapour to water droplets .But there is no such thing as "pure" water on ground all of it contains gases or minerals .Water is polluted by both nature and the activities of human beings .In most cases the pollution is hardly severe and is not particularly detrimental to health .However a few substances that are health hazardous do occur in water and can cause illness or even death .

Impurities present in water

Dissolved impurities :

Dissolved impurities of water include dissolved inorganic salts,organic salts &gases.The examples of dissolved salts include sulphates,chlorides, carbonates & bicarbonates ,nitrates, nitrites of calcium,sodium,iron,potassium, magnesium etc .Dissolved gases include gases like oxygen,carbondioxide,nitrogen oxides and traces of ammonia & hydrogen sulphide .

Suspended impurities :

Suspended impurities of water include suspended inorganic matter and suspended organic matter.The examples of suspended inorganic matter include clay and sand .Suspended organic matter includes oil globules and vegetables and animal decay products .

collidal impurities :

Colloidal impurities of water include finely divided clay and silica ,ferric hydroxide ,aluminium hydroxide,humic acids,organic waste products,colouring matter and complex protein aminoacids .

Bacterial impurities:

Bacterial impurities of water include bacteria other micro-organisma and other forms of animla and vegetable life found in water .

Sources of water pollution

precipitation:

Moisture collect around minute particles in the atmosphere until a droplet forms and grows to such a size and weight that it falls. The nucleus of droplet may consist of particle of ice ,dust blown from fields, ash emitted during volcanic eruption or crystals of salt evaporated from sea spray. The air also contains many gases .Carbon dioxide in air combines with water to form carbonic acid ,hydrogen sulphide forms hydrosulphonic acid .

Ground water pollution :

water moves slowly through the ground , remaining in contact with soil and rocks for a long time . Therefore various elements are dissolved from the enclosing soil and rocks causing the water to increase in mineral content.

Human induced pollution

pollution of rain :

Present day atmosphere contains a diversity of extraneous and common place materials .It steadily absorbs a wide range of solids , liquids and gases resulting from human activities. These elements then go into rain to pollute the rain water .

Surface water pollution :

Disposal of industrial , municipal and domestic wastes directly into streams has been a major source of water pollution.

Pollution of ground water :

The quality problems of human influenced ground water are most commonly related to water soluble products that are placed on land surface and in streams substances that are deposited or stored in the ground above the water table Disposal, storage or extraction of material below the water table.

Accidental spills of hazardous materials:

Many kind of toxic and hazardous materials are transported throughout world by ship, truck, rail and aircraft. Accidental spills do occur in such situations which are unavoidable .

Industrial wastes :

Many industries like chemical, petrochemical, leather, power plants, fertilizers and many more release their hazardous waste directly into water, streams, rivers, lakes, sea to pollute them .

Significance of water quality constituents

An examination of water analyses clearly shows that the major dissolved substance in water comprise a small number of elements, usually in ionic form. These include the ions of calcium, magnesium, sodium, bicarbonate, sulphate, chloride. Although it rarely happens in water sample these substances can combine to form a total of nine dissolved chemical compounds. There may be several other compounds in water but they are generally in much smaller quantities. Mineral substances found in low concentrations include iron, magnesium, silica, nitrate and fluoride as well as trace elements. Even minor concentration of some of these substances can produce undesirable taste, colour, odour or staining or can even adversely affect health. Water contains lot of dissolved constituents which are small in number and usually in ionic form. They include the ions of calcium, magnesium, sodium, bicarbonates, sulphate & chloride. They may be several other compounds in water but they are generally in much smaller quantities. Even minor concentration of some of these substances can produce undesirable taste, odour, colour or staining or can even adversely affect health.

Dissolved solids:

Dissolved solids denote the concentration of mineral constituents dissolved in water. Dissolved solids do not include gases, colloids or sediments but consists chiefly of carbonates, bicarbonates, chlorides, sulphate, phosphate & nitrites of calcium, magnesium, sodium, potassium with traces of iron, manganese few others.

Sodium:

The major source of sodium in natural water is from weathering of feldspar, evaporates & clay. All natural waters contain some sodium concentrations of which range from less than 0.5 mg/l in brines. Sodium is not especially important in water for domestic use but it can affect the persons with an abnormal sodium metabolism. Sodium in excess of 500 mg/l when combined with chloride produces a salty taste.

Potassium:

Common salts potassium are very soluble & not easily from water. concentration normally less than 20 mg/l in natural water may be as much as 100 mg/l in hot springs & exceed 2500 mg/l in brines. Potassium is essential nutrient but large concentrations are laxative.

Calcium:

Calcium is derived from nearly all rocks the greatest concentration is derived from limestone, dolomite gypsum & gypsiferous shale. Concentration of calcium in natural water range between 10 & 100 mg/l. Calcium increases hardness of water so it is required to put limit on calcium. Calcium concentrated water also causes problem to boilers & other heat exchange equipment.

Significance of water quality constituents

Magnesium:

Sources of magnesium include Ferro magnesium minerals in igneous and metamorphic rocks and magnesium carbonate in limestone & dolomite. Human require about 350mg/l of magnesium daily. Magnesium is non-toxic but it gives bad taste to water.

Bicarbonates and carbonate:

Bicarbonate (HCO_3) & carbonate (CO_3) are commonly reported as causing alkalinity, the capacity to neutralize acids. The recommended range of alkalinity for public water supplies is 30 mg/l to 400 mg/l. Concentration less than 100 mg/l are desirable for domestic water.

Sulphate :

Sulphate produces a detectable taste at concentration of 300 to 400 mg/l and a medicinal or bitter taste if the concentrations exceed 500mg/l.

Chloride :

Chloride forms a major dissolved substance in some natural water. In sea water the average chloride concentration is 19300mg/l & inland concentrations generally decrease to less than 1mg/l. In water chloride concentrations in excess of 250 mg/l may impart salty taste excess may be physiologically unsafe.

Iron:

Iron concentration in natural water is generally less than 5 mg/l. Water with low pH usually contains more than alkaline water. Concentration in excess of 0.3mg/l will cause staining of laundry & utensils. It adversely affects the food processing, dying, and bleaching. Iron more than 0.3 mg/l in water can cause aesthetics qualities such as taste & odour.

Manganese:

Concentrations of manganese in natural waters are generally 0.02mg/l or less. Safe limit of manganese in drinking water is 0.05mg/l. More concentration affects the odour & taste.

Nitrate:

Nitrate in water supplies comes from atmosphere, legume plants, plant debris, animal excrement & sewage as well as nitrogenous fertilizers & some industrial wastes.

Fluoride:

Fluoride occurs in just few types of rocks. Higher concentrations do occur in aquifers in a few areas and certain insecticides, chemical wastes & airborne particles & gases from aluminum smelting plants. The element fluoride is utilized by animals including humans in the structure of bones and teeth. Large concentration of fluoride are toxic.

Significance of water quality constituents

pH:

The pH solution describes its hydrogen ion activity .The pH scale ranges between 0 and 14 .Water with pH 7 is neutral & less than 7 is acidic a pH greater than 7denotes a basic solution .The pH of drinking water in itself has no affect on health on the other hand corrosion is associated with pH less than 6.5.

Trace elements

They normally occur in concentration less than 1mg/ l .Many trace elements are essential to human beings but in some cases there is only a small safety range between requirement & toxicity.

Arsenic:

Toxicity of arsenic is well known, it accumulates in the body & causes arsenosis.Safe limit is only 0.05mg/l

Barium:

Barium has possible toxic effects on the heart, blood vessels & nerves. Safe limit is 1mg/l

Cadmium:

Cadmium collects in the liver, kidneys, pancreas& thyroid of humans & other animals .Safe limit is 0.01mg/l in water.

Chromium:

Chromium is neither beneficial nor essential to the body .Safe limit is 0.05mg/l.

Lead:

Lead is another poison which accumulates in body ,Safe limit is 0.05mg/l .

1 Data collection

- 1 Getting all information about the biosensor from chemical and electronics department.
- 2 Existing world wide options in this area checking out parallel technologies.
- 3 visiting the water quality checking labs to know about present methods and instruments of checking the parameters.
- 4 visiting other places like water treatment plants to know the importance of water quality checking .
- 5 Visiting village to know about the user profile

2 Data analysis

Data is processed , analyzed, assimilated for identifying the problems in the current process of water quality checking

1. Listing down various parameters required checking drinking water
2. making a matrix of applications and the respective parameters
3. Choosing the areas of application
4. Listing down the user profile

3 Developing product brief

Project justification based on above information and analysis

- 1 Formulate the problem in solution neutral terms and
- 2 Coming up with key requirement list

4 Concept development

1. Developing the concepts

- * identifying the problems of existing systems and trying to solve them in design
- * Finalizing the layouts of internal components and fixing the dimensions of them .
- * Finalising the connectors and PCB design by discussing with people from other departments
- * listing down the usability and functional issues and solving them independently.
- * considering various approaches for design like dipping sensor in water or putting drop on sensor and developing the concepts on it .
- * considering the user and minimizing the activities to be done by user.

5 Concept Evaluation

In light of different constraints , requirement list, Mockup models

6 Final design selection

Selected concept is refined through step by step , iterative evaluation and development. Detailed dimensioned drawings and specifications to quantify whatever abstract and ambiguous.

7 Execution

Final model making after doing dimensioned drawings for the model making and finishing to the last detail.

8 Documentation

Report and presentation

Worldwide options

pH meter



Sentron pH meter



Bio world laboratories
model-HI98114



Hach instruments USA

Portable instrument

The pH meter is widely used in various industries for checking the acidity or basicity of water and other various chemical solvents .

They are very compact can be carried in your pocket some of them have electrode inbuilt and others have electrode separate from the instrument.

The forms are also very straight to ease the storage and its portability. The switches are feather touch in many cases to achieve the water proofness.



Sedico limited



Analyticon information systems USA



Bio solids products



Milwaukee meters australia
pH 40 model



Pike agri lab supplies

Worldwide options

pH meter



Tri-essences products

Portable instrument

The new forms are coming in pH meter .They are becoming more and more ergonomic.The colours used are also attractive .The forms are no longer straight but they are different.



Camlab uk



Korean product



North central labs

the main problem with all these instruments is the elctrodes and wire. The electrodes are big in size for just one parameter that makes the instrument big not so compact.



Pike agri lab supplies



Spectra pure water quality instruments



Sentron pH meter



General scientific Instrument services model 2000

Worldwide options

pH meter



Environmental laboratory
model 320

Table top laboratory instrument



Thermo orion model 261 S



Thermo Russell products
Model RL-150



Thermo Russell products
Model RL-100

some of the pH meters are table top instruments .They have one instrument,stand,electrode.The electrodes need the calibration so one standard solution is always provided. The electrodes are dipped in electrolyte to maintain its sensitivity when not in use .



orion pH meter model 330



John morris scientific
instruments



Knick industries model 765



Tamar industries-Israel



Analyticon information systems USA



Worldwide options

Turbidity meter



Hach instruments

Turbidity is measured using the principle of scattering of light .The light is passed through sample and then from other side the amount of light received is measured which gives the amount of particles present in water. So these instruments are not portable they all are used in laboratories or some of them are in the form of kit .



technika instruments



ICM meters



Hach instruments

The instrument is from Hach instruments .It is provided alongwith six bottles of standard solution used for calibration .



ICM meters



Hach instruments

The kit is portable and it contains all the accessories required for measurement and calibration.



sigrist photometer

Worldwide options

Multi parameter instruments



The Hanna instruments can check pH –TDS–temp at a time .Very compact instrument.

The multiparameter instruments can check more than one parameters at a time .They range from two to six parameters at the most eight in some cases.The instruments are very costly .They are very sophisticated .

The horiba instrument is very useful in drinking water quality checking as it checks six parameters at a time such as temp,pH,conductivity,TDS, dissolved oxygen,chloride.The instrument is portable. Special casing is provided along with it .



Horiba instruments

Worldwide options

Multi parameter kits

Hach instruments



The multiparameter kits provided with all the accessories to check the parameters. Everything is packed in bag. So they may contain the instrument or different instruments to check the parameters. The standard liquids are also provided in different bottles.



The kit contains various instruments and liquids. so the whole setup becomes portable. But the difficulty is arranging the instrument and bottles inside. The leakage problems are also there.

1 District health laboratory–Thane

The district health lab in thane comes under the thane municipal corporation .The area covered by this lab is thane district.They mainly check the quality of drinking water .In that they have two aspects

- 1 biological safety of water .
- 2 chemical safety of water.

Chemical safety of water

In this the samples are brought from village in thane district .The primary health workers from all taluka s in district collect sample in five liters cans and send them to district labs .

The present instruments and methods used are very old .they use titration ,calorimetry to calculate various parameters which normally take very long time .

The lab checks total 13 parameters

pH
Chloride
free ammonia
nitrate
fluoride
hardness total
alkalinity
nitrite
Oxygen absorption
Total solids
albuminoid ammonia .



The instruments used

They have newly purchased a instrument from thermo orion company .As seen from picture side it is table top instrument .It can check two parameters *fluoride and nitride* .The two parameters have two different electrodes .The instrument needs calibration every day.



1 District health laboratory–Thane

Biological safety of water

The water contains pathogens which are harmful to human health .so as long as you check water biological quality alongwith chemical quality the water will not be called as potable water.

The samples are brought from the villages in small containers with all the details like name of place , time , date to the district labs . Then the samples are tested with MPN test .Normal MPN test takes two days .

This instrument shown in the side is called as incubator.



This instrument is called as water bath in which the samples are heated .

Problem identified

- 1 Old methods
- 2 instruments require manual calculations
- 3 Problems in Thermo Orion
 - costly instrument for just two parameters
 - for each ion there is separate electrode.
 - setup is time consuming.

2 Pollution control Laboratory–Thane

The pollution control laboratory in Thane is checking water from Nalas , gutter running in industrial zone . Also they check the well,bore well,lake,river,creek water for any type of pollution .It comes under the Thane municipal corporation so it also checks the water from the Thane city for contamination .

The following is the parameter table for different applications



Well/Bore well/lake	Creek	Nala	sludge	industrial effluents
PH,Turbidity,TOS Conductivity,DO Total hardness Chloride Alkalinity,nitrate Sulphate,nitrite, Phosphate, COD BOD Ca,Na,K,F,Ar,Cd,Fe	pH C BOD SS DO Salinity	pH TSS COD BOD S DO N	COD BOD NO2 Phosphate N Ph Hg,Cr,Pb Cd	pH SS DO COD BOD oil & grease

2 Pollution control Laboratory–Thane

Various instruments used in laboratory



Atomic adsorption spectrophotometer



Flame photometer(Ca,K,Na,Li)



Spectrophotometer



UV-spectrophotometer

Problem identified

- For metal ions Costly machinery is used
- Tedious calibration procedure
- The test requires qualified personnel.

Problems in Horiba U-10

- Costly instrument.
- Not water proof
- Difficult for one person to handle.

3 Water treatment plant –Bhiwandi

The treatment plant in Bhiwandi–Thane is having capacity of 250MLD.It is the main treatment plant which supplies water to thane city .They have their own water quality checking lab .Where they check pH,turbidity,chloride on hourly basis.For pH they use universal indicator method which is a visual test .They have table top Ph meter but it is out of order.The turbidity is measured by instrument from Hach which is good ,sophisticated machine. The chloride is checked by



Universal pH indicator



Hach turbidimeter

Problem identified

Visual tests used.
Non portable instrument.
Report from district lab takes very long time .
Instruments are not user friendly – require specialized personnel.

4 Taluka place shahapur–Thane District

The main aim to visit shahapur village was to understand the water quality checking procedure in villages ,the flow of water samples from villages to district place and also to know the awareness of people about water quality and its importance.

I visited total five places in Shahapur village

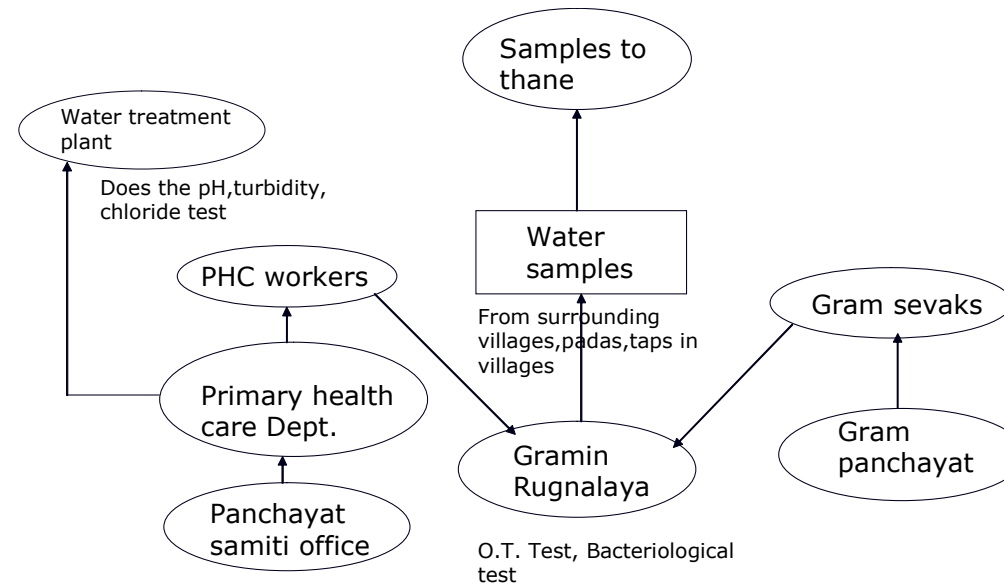
- 1 Grampanchayat office
- 2 Gramin Rugnalaya
- 3 Panchayat samiti
- 4 Gothehar water treatment plant
- 5 Tahsildar office

All the places were visited and the flow of samples was analysed throughly. Then people were interviewed to identify the loop holes and flaws in procedure of sending the samples to district.

Problems identified

- 1 The tap water and water from elevated reservoirs is to be on weekly basis ,but the reports take long time .
- 2 PHC workers carry samples from villages to labs which is time consuming.
- 3 Important parameters like hardness,flouride,arsenic are not checked on field .
- 4 The decision making is not possible on site .
- 5 In the case of epidemic it becomes more difficult to find out the source

Flow diagram to show the procedure of flow of samples .



Need for new product

- 1 Results from district take very long time to come to the taluka level which makes the whole process of water quality checking very lengthy.
- 2 Heavy metal ion checking like lead, cadmium is done by very costly machines in labs so again it makes inconvenient to check them at taluka level.
- 3 Heavy metal ion checking is very costly and cannot be done on site itself which is absolutely necessary in some cases.
- 4 The instruments used in labs are not portable and mostly they are very specialized for parameters means for one or two parameters there are separate instruments.
- 5 Old methods like titration, calorimetry require graphs to be drawn after taking reading and then you get your results from graph.
- 6 Mostly the instruments work on ionic methods so they have big electrodes to check the parameters that makes them again non portable. The maintenance is cumbersome.
- 7 The electrodes need to be dipped in standard solution all the time to maintain the sensitivity and protection from outside environment .
- 8 The samples are taken from all villages and sent to district level which involves complex procedure of maintaining them .
- 9 Present portable products can check at the most parameters mostly combination of two parameters is observed.
- 10 The products are very costly for Indian market . They cost between 1.5 lacs to 2 lacs .
- 11 The procedures in laboratory are very old and they require manual calculations so they take time .

Areas of application

Functions of various organisations

Grampanchayat and panchayat samiti

Weekly river data
Weekly chlorination of well and lake.
Checking for heavy metals if suspect is there.
Monitoring small water treatment plant.
River water suitable for fishes.

Municipal corporation

To maintain the water data
Water testing on request
Check industrial pollution in nala, sewage water.
Regular check of tap water and E.S.R.
Monitoring specific ions.

Other areas of application

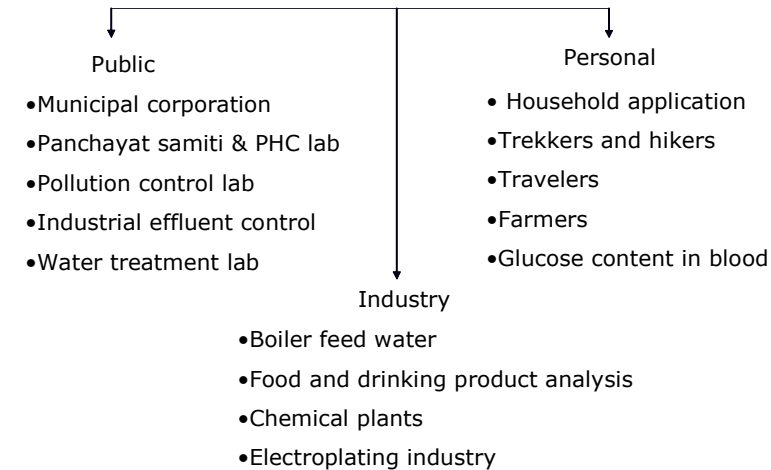
Industrial application

Boiler feed water checking
Textile industry
Electroplating industry
Soft drink industry

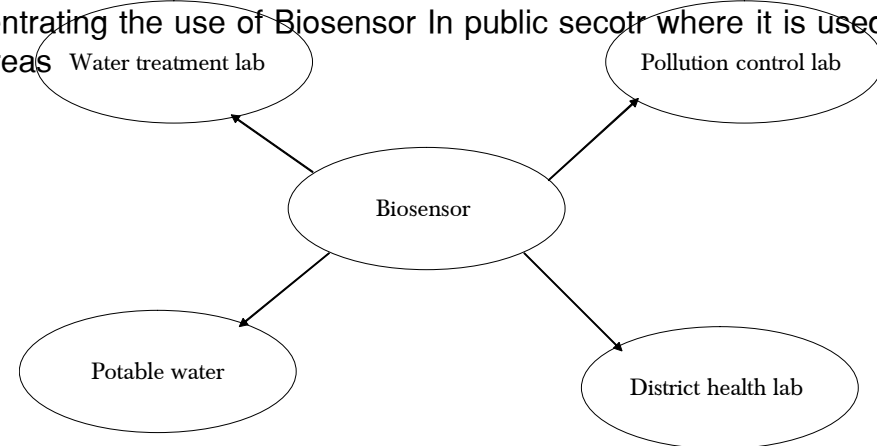
Personal product

Household application to check the quality of water
Trekking and hikers spring water
Travelers—water in road side hotels
Farmer—differentiate water as irrigation, cattle etc.

Chart showing the areas of application



I am concentrating the use of Biosensor In public sector where it is used following areas



Deciding the parameters

Identifying the various applications and then noting down the parameters required for checking. Then a matrix is made with the applications on in the rows and the parameters in the columns. Then the parameters checked by the biosensor presently is cross checked with the matrix and six parameters were decided to be checked by the instrument. Following parameters were identified

- 1 pH
- 2 Conductivity
- 3 Flouride
- 4 Potassium
- 5 Urea(ammonia)
- 6 Chloride

	Cl-	pH	Co3-HCO3-	DO,O2	No2-,No3-,NH3	Sulphide	BOD, COD	Alkalinity	salinity	F	Hg,Pb,Ar,Cd	K+,Na+	Biolo
Potable water													
Sewage water													
PHC worker													
Water treat plant													
aquarium			✓	✓	✓	✓	✓		✓	✓		✓	
Irrigation			✓	✓		✓			✓				✓

✓ ✓
✓

✓ ✓

✓ ✓ ✓ ✓ ✓

✓ ✓ ✓

✓ ✓

✓ ✓ ✓

The knowledge about the users was gathered from the field visits .I have visited the village shahapur to understand the user .Using that data user profile was determined .The present user is Primary health care department worker who goes around the villages and collect samples and give it to the gramina runalaya or send them to district level laboratory checking.According to survey in shahapur village there are 350 villages and around 250 workers moving around to collect the samples.while collecting they are also supposed to do chlorination of the well weekly .These workers are 12th passed out so they are familiar with new products such as television, radio etc.

The pollution control lab attendant or incharge move to the field in industrial area to collect the sample .So the user here is either 12 th passout or Bsc qualified.They have one portable product so they know the sophisticated technology .

We have to consider the PHC worker who moves around the villages and collects the samples .The user can do the testing of river water, spring, tap water, well water, lake water so he has to move in all types of terrains and environments.

To design □ Portable water quality checking product□

Technology

Biosensor technology in which conducting polymer polyanniline will be immobilized in between two electrodes. The presence and quantity of elements present in water will be noted by change in conductivity.

Sensor

The array of sensors for parameters is arranged on epoxy PCB cartridge .The cartridge will be used for predefined number of use and then it will be changed by new one. The size of sensor is 4cm*5cm.The sensor should to be scratched.

Sensor cleaning

The water on the sensor should be cleaned to avoid contamination.

Connector for sensor

PCB mounted edge connector with 18 points is used.It should be protected well from the water.

Electronics

The electronics used has the average area of 120 square cm.For compact arrangements the PCB is divided into two parts.

Batteries

Batteries are used to make the instrument portable .Four batteries of 1.5 V are required.

Display

Five line LCD display is preferable.

Buttons

Total six buttons are necessary. Power on/off, calibration1, calibration2, regeneration, rinse, test.

Standard liquids

To maintain the sensor sensitivity calibration is required so along with the instrument two calibration liquids are to be carried. In between two test regeneration of sensor is necessary so regeneration liquid is to be carried. The calibration liquid deposits salt layer on sensor so to remove that rinse liquid is also required. Total four liquids will be carried along with product.

Measurement

The water sample can be taken in separate container or dropper which ever is suitable .The contamination should be avoided.

Parameters to be checked

Total six parameters to be checked pH, conductivity, chloride, potassium, fluoride, conductivity.

Usage

The product is going to be used in fields so it may be near to river, well, tap water in villages so product should be rugged and compact .The user educational qualification is 10 th pass out so the product should simple in use .The activities done by user to carry out the test should be minimal. The training time should be very less. The product is to be carried to long distances .The user may travel by bus, cycle, motorbike or by walk so product should fit in all these scenarios

User profile

The user in most cases is primary Health care worker who moves around the villages and padas to collect the water sample. The user's educational qualification is 10 th pass out and the lab attendant in cities or taluka level is Bsc pass out.

Form characteristics

□Form follows function□

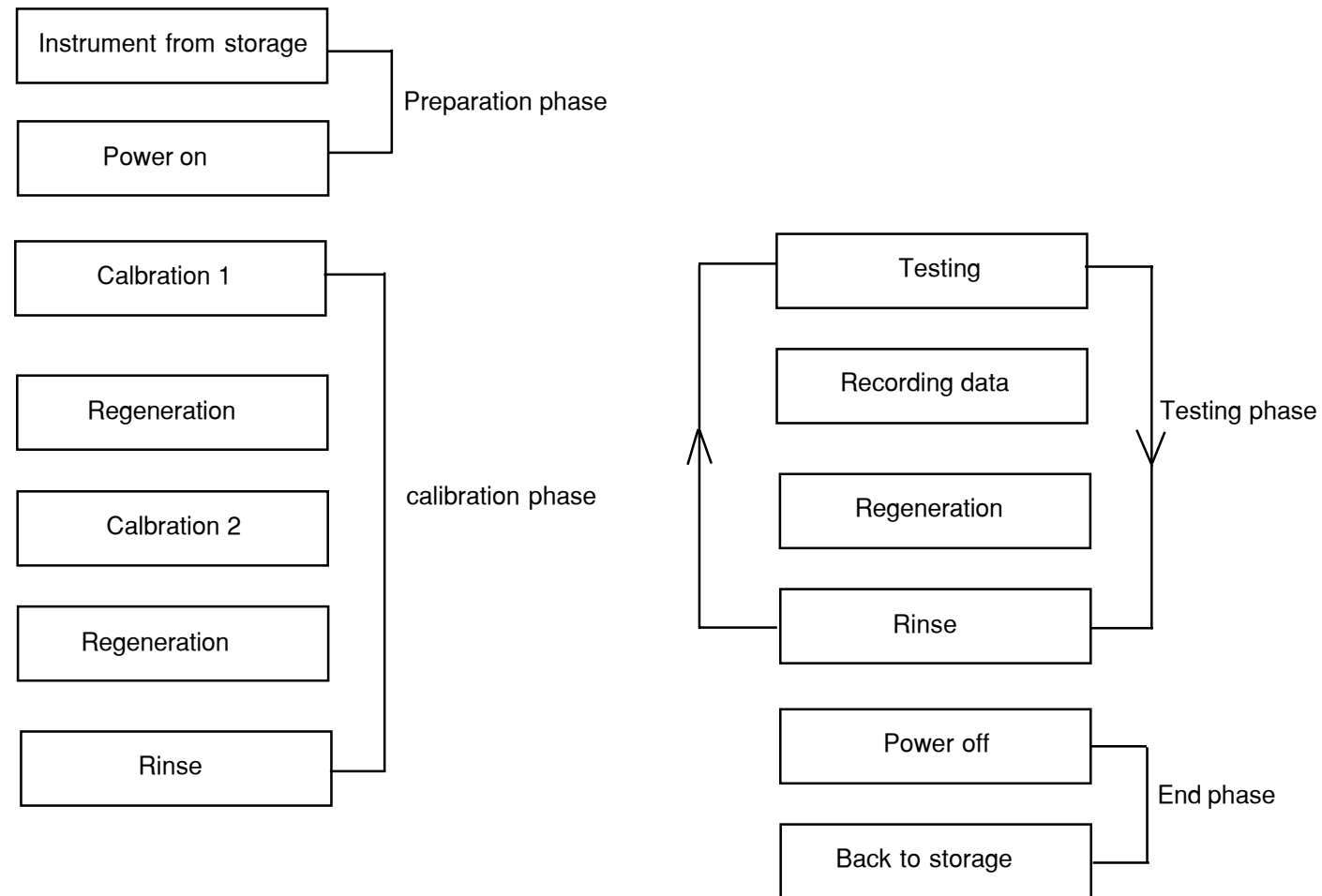
The form should not be just a box enclosing the internal things .It should evolve from the basic arrangements of elements like electronics, batteries, sensor, connector etc. The form should consider the grip arrangements .Ultimately it should not be obvious form some visual interest should be brought up.

Look

The technology is very sophisticated .The product should show some characteristics of high tech product.

Activity analysis

Flow chart



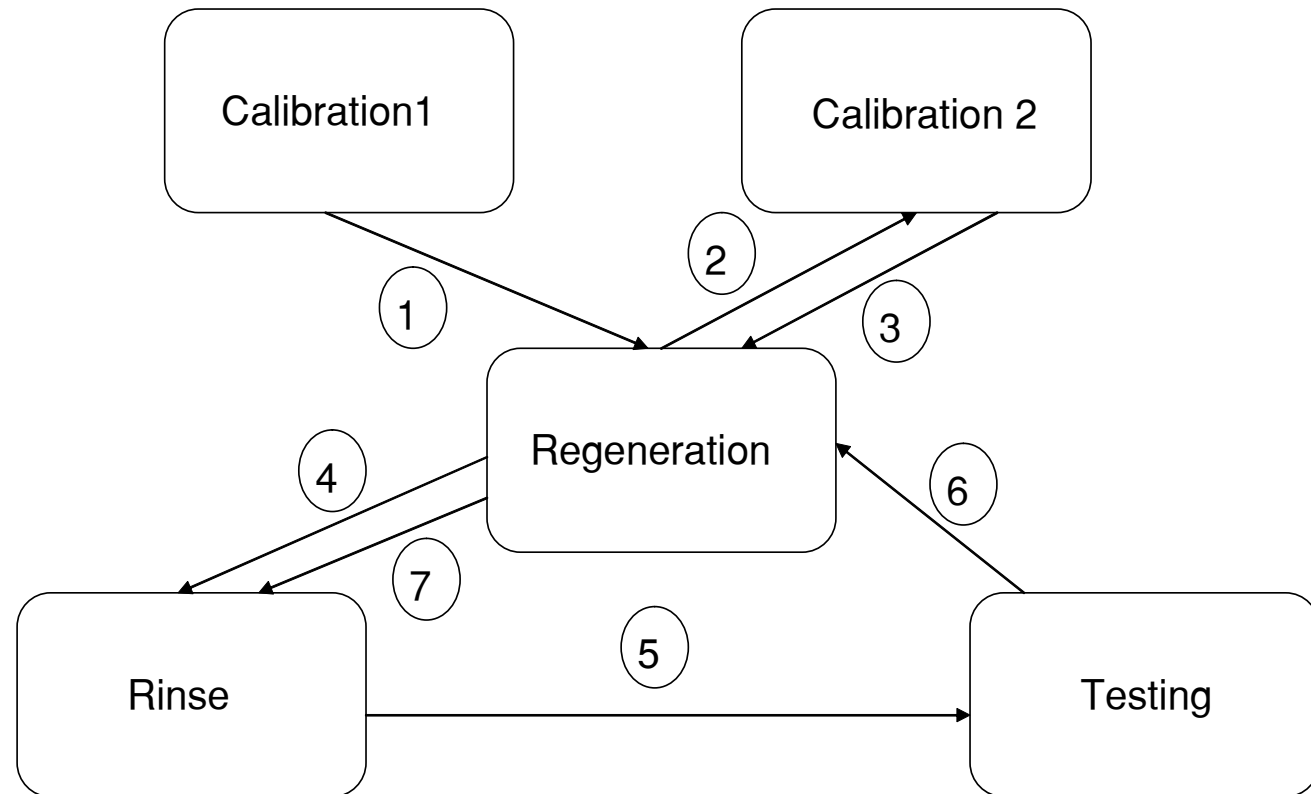
Activity analysis

Digrammatic representation

- 1 Calibration1–Regeneration
- 2 Regeneration–Calibration 2
- 3 Calibration2–Regeneration
- 4 Regeneration–Rinse
- 5 Rinse–testing
- 6 Testing–Regeneration
- 7 Regeneration–Rinse

Calibration loop
1-2-3-1

Testing loop
4-5-6-7



The data collected in user study and data collection was used in generating the concepts. Keeping in mind the product brief all the time concept were generated.

- * Noting down all the functionality and usability issues. Generating alternatives for each problem separately. Analysing them for list of attributes and filtering best alternatives.

- * Analyzing different situations and scenarios different ways of carrying the product were also studied & concepts developed for the same.

- * Two alternative approaches were considered
 - Dipping sensor in water.
 - Putting drops of water onto the sensor.

- * In both approaches there are again three different direction were considered.

- 1 Integrating all the liquids, instrument and probe containing sensor in one product
- 2 Completely separating all the parts
- 3 Integrating the sensor probe and liquids together forming cluster and keeping the instruments separate.

- * Different layouts were considered for the arrangements of elements like electronics and batteries. Then the layouts were compared with list of parameters and one layout was chosen for further development.

What my product is ???

Its a family of total eight elements

Instrument :

containing the electronics, batteries, display, buttons

Probe :

containing the sensor.

Note pad :

to note down the readings.

Calibration liquid1:

Mixture of High concentration of all parameters to be checked.

Calibration liquid 2:

Mixture of low concentration of all parameters to be checked.

Regeneration liquid:

To gain the configuration of sensor back after coming in contact with calibration or test liquids.

Rinse liquid:

To wash the salts deposited on sensor after coming in contact with regeneration liquid.

Sample collector

Sample is either taken in separate in beaker or it is taken by dropper in case of drop type.

The product contains various elements. The elements have to be placed in a much defined arrangement. Their dimensions and usage are fixed. The sensor is a thin PCB on which different electrodes with polymer and proper enzymes are deposited. The sensor is very sensitive to changes in environment. They are also sensitive to touch and scratch. A small scratch can change its configuration or altogether damage the sensor. So there are various functional issues associated with the sensor and listed down. Then each problem was taken separately and for that solutions were developed independently. After that a table was created in which the respective concepts were evaluated against defined attributes. Each idea was evaluated on a scale of zero to nine. The idea having maximum marks was chosen.

Functional issues

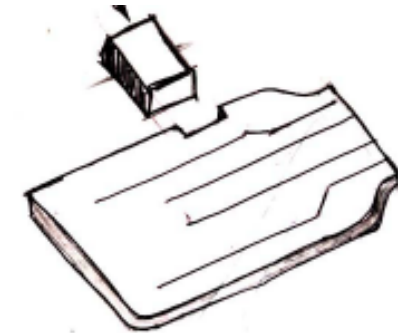
- 1 How to connect the sensor to electronics
- 2 How to replace sensor.
- 3 How to protect sensor
- 4 How to note down the data shown on display.
- 5 How to prevent the leakage of liquids to be carried.

Functional issues

1 How to connect the sensor to electronics

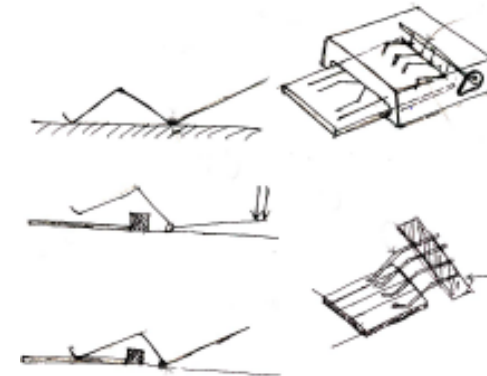
1 using slot and projection

The sensor will have a slot in the side and the body where the sensor is to be connected will have respective spring loaded projection. So when you want to slide the sensor just push the projection and leave when the sensor is in.



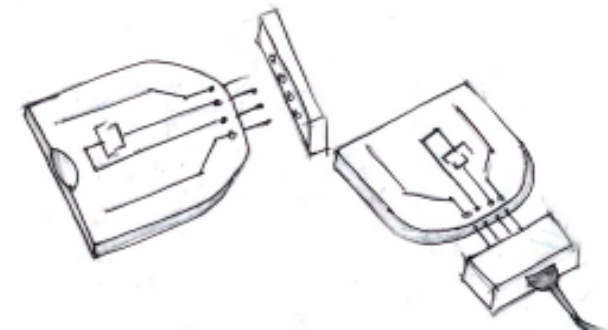
2 Using spring type connections which also holds sensor by friction

The joint is like male female joint where the sensor cartridge and connector have respective projections and holes.



3 Using male and female joint

The connector contains spring arrangement which actually gives pressure when the sensor is in the connector. The lever on the side of connector just lifts up all the points and allows the sensor to be changed. The sensor is hold tightly by the spring pressure.



Functional issues

1 How to connect the sensor to electronics

4 Tight fit friction joint.

The tight fit mechanical friction joint can be used to hold the sensor tight .The connector available in the market work on the same parallel principle. Where they have contact points in the form springs and the sensor is sided in to the points to make connection .All the computer PCB connector are of same type.



5 Giving snaps on sensor

The sensor is embedded in the plastic cover at the bottom .The plastic part has got small snaps which just fits in the connector .



independent evaluation

The concepts for first functionality issue were analysed against attributes. The rating was done as per the scale shown and then total was done. Concept having maximum marks has been used in further product development.

Concepts	1	2	3	4	5
Grip on sensor	6	7	5	7	6
Manufacturability	5	6	6	7	7
Ease in operation	6	8	7	6	5
Rugged	6	5	6	7	6
Total	23	26	24	27	24

Scale used



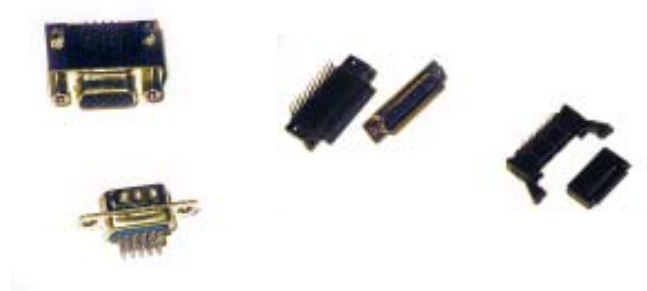
Functional issues

1 How to connect the sensor to electronics

Connectors are the main connections between the sensor and the electronics. The sensor can be pushed in and pulled out of the connectors. The instrument checks totally six parameters for that it requires 16 points to connect with the electronics. There is one more connector required to connect wire coming out from probe to the electronics. Connectors in the electronic market are of various types. Each one has specific advantages and disadvantages.

market survey for connectors

2 D-type connectors



They come with nice cover for the wire coming out and also very rugged as the female part is direct PCB mounted. The available points are 15 and 25.

4 Edge connectors



These are most compact of all connectors. They come up to 9 points.

1 Modem connectors



very compact in size but available up to 9 points

3 PCB Edge connectors



Mostly these connectors are used in computers to connect the different cards to the mother board. They are available in multiples of 2. They are most rugged of all options.

Functional issues

2 How to replace sensor

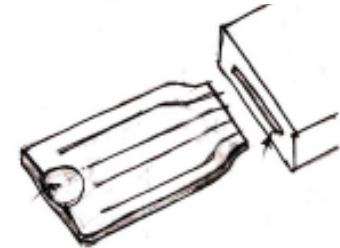
1 Arms on side of connector

The connector can have two arms coming out from sides so when the sensor is pressed inside the connector, the arms come inside locking the sensor in connector. When you want to replace just pull out the arms that actually pushes the sensor out. The normal port connectors in computers have the same kind of connectors.



2 Giving dimple on the front end

The sensor cartridge is fixed in connector by a mechanical friction joint and the sensor has got small dimple in front end which actually can be used to pull out the sensor.

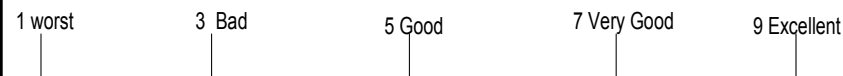


Concepts	1	2
Ease in operation	7	7
Grip	5	7
Simplicity in design	7	8
Availability of parts	5	7
Total	24	29

independent evaluation

The concepts for second functionality issue were analysed against attributes. The rating was done as per the scale shown and then total was done. Concept having maximum marks has been used in further product development.

Scale used

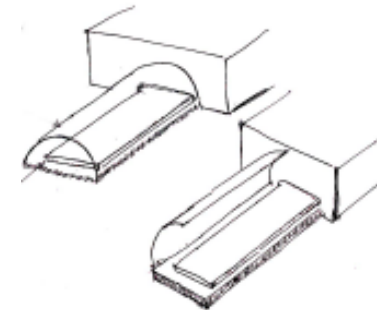


Functional issues

3 How to protect sensor

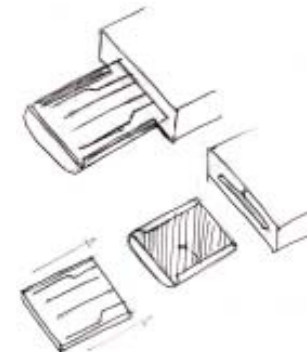
1 Giving a folding cap

The sensor should not be touched or scratched .The cap over it prevents it from any touch and dust while in use.The cap is folding so when you want to use the sensor for testing open the cap take reading and then close cap to protect it.



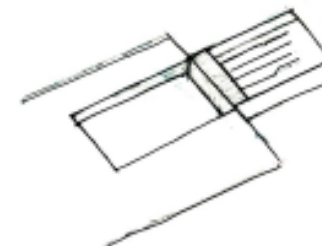
2 Giving a base cap for sensor

A plastic cap is attached to the base of sensor .The sensor is slid into the base plastic cap.The base cap protects the sensor from shocks and coming in direct contact of other materials also holds it tight.



3 Giving a hinged base cap

In this idea the base cap holding the sensor can be hinged to the main instrument .To use sensor open the cap and close the cap after use .The closing cap serves two purposes one is holding the sensor and second is protecting it from dust and other shocks.



Functional issues

3 How to protect sensor

independent evaluation

The concepts for third functionality issue were analysed against attributes. The rating was done as per the scale shown and then total was done. Concept having maximum marks has been used in further product development.

Concepts	1	2	3
Simplicity in design	7	7	6
Ease in operation	7	6	7
Contact with sensor	8	6	6
Total	22	19	19

Scale used



Functional issues

4 Recording o data shown on screen

1 providing a diary and pen

The data shown after taking reading is projected on display screen .This data is to be stored somewhere.Alongwith the data we have to store date,time and place name to keep track on to the waterbody.This can be achieved by giving a dairy alongwith the product.User uses his dairy to note down date,place ,time and reading.Diary can be easily integrated with the interface.Pages are loose pages having clip to hold them.



2 Giving webcam

Electronics can be modified to store the data .Each reading can be separately stored if we add microcontroller to the circuit.Data can be stored in chip but the place details cannot be stored for that product has to have text input.To avoid that a small webcam can be given with the product.Webcam takes the image of place where user has done the checking .Afterwards the images can be correlated with data stored.



3 Giving sound recording.

Instead of giving webcam which is an expensive instrument sound recording can be given .After taking each reading user speaks out the place details in the mike provided on the instrument.The data can be retrieved in the office by connecting to the computer.



Functional issues

4 Recording o data shown on screen

4 Stylus and digital screen

Text input becomes easy when we use stylus and digital screen. The user can enter data about the place in his own words using stylus. The screen also can have graphics to support the text entry. It is just like simputer screen.



5 GPS system

The problem of text entry can altogether be solved by GPS system. When the user presses the save option on interface, Chip inside saves the parameters and respective to that GPS system saves the latitude and longitude of the place. End of the day with the help of computer data can be retrieved.

Concepts	1	2	3	4	5
Ease in noting	7	6	5	6	8
Steps followed by user	7	6	6	6	8
Cost	8	6	6	6	5
Access to info after use	8	7	7	7	6
User control	7	7	6	7	6
Total	37	32	30	32	33

independent evaluation

The concepts for fourth functionality issue were analysed against attributes. The rating was done as per the scale shown and then total was done. Concept having maximum marks has been used in further product development.

Scale used



Functional issues

5 Preventing the leakage of bottles

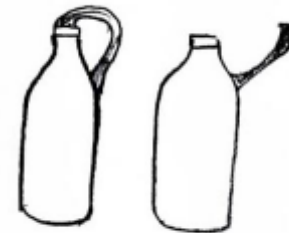
1 Dropper bottles

Dropper bottles are standard and easily available in market .Bottles have sprout through which drops can be put on sensor.Bottles are very flexible and can be easily squeezed.Cap on the top prevents it from leakage.



2 Dropper bottles with flexible cap

The same above bottles can have flexible caps which snap fits in the holes at the top.Caps are very easy to pull out and then drops can be put on the sensor.Also cap is integrated with bottle so there is no problem of misplacing cap.



3 Rubber bush

In medical field the saline bottles used to have same detail as shown in the exaggerated view.The rubber flaps are like springs and placed against each other.When user pushes the sensor inside the cap rubber flaps depart away and spring back when sensor is removed.Reverse is not possible



Functional issues

5 Preventing the leakage of bottles

4 Capsules

Medicine is available in the form of capsules. Same technique can be used, all liquids are enclosed in capsules. At the time of use cut the capsule water comes out and falls on sensor. The capsules altogether solves the problem of leakage and to some extent saves the space for storage, problem of orientation change problem. Capsule can have thin membrane at the opening so when user squeezes capsule the membrane breaks off and water comes out.



5 Non return valve principle

Bottles have a non return valve at the opening. That eliminates the cap. Spring allows water to go out when bottle is squeezed but does not allow water to come out when in storage.



6 Bottles with screw caps

Standard bottles with screw caps can be used. Technique is very simple which cost very less. The leakage proof can be achieved almost 100%.



Functional issues

5 Preventing the leakage of bottles

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Functional issues

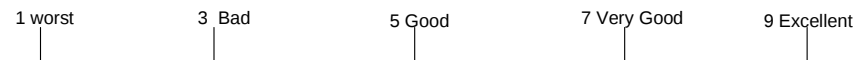
5 Preventing the leakage of bottles

independent evaluation

The concepts for fifth functionality issue were analysed against some attributes. The marking was done as per the scale shown and then total was done. Concept having maximum marks has been used in further product development.

Concepts	1	2	3	4	5	6
Operation	7	6	6	6	7	6
Cap	6	7	7	8	7	5
Reliability	6	6	6	7	6	7
Orientation change	5	6	5	8	6	7
Manufacturing	7	6	5	6	5	7
Total	31	31	29	35	31	32

Scale used



The sensor needs calibration to maintain its configuration. The calibration is a step by step procedure in which the first the sensor is made contact with low concentration solution and then higher concentration solution. The life of sensor is also short which can be say for 10 uses and then you have to through the sensor. When you change the sensor calibration is needed. After contact with each liquid the sensor characteristic changes so it needs regeneration. Regeneration is nothing but mixture of electrolytes. During regeneration specific current is passed through sensor to regain the properties. After regeneration the sensor is deposited with layer of salts so to remove it needs rinse solution. The liquids containing the high and low concentrations, regeneration, rinse are to be carried all the time. Now as the product is to be carried in field there are various issues related to use of sensor and liquids. They are listed down and same methodology was used as in the functional issues.

Usability issues

- 1 How to use sensor and liquids together
- 2 Number of swithes and activities to be performed
- 3 Storage and carrying of liquid.

Usability issues

1 *sensor and liquids together*

- 1 Rotating and swiveling sensor integrated with bottles.

There are total 4 liquids to be carried along with sensor .The sensor is contained in an probe which is mounted on central rod .The horizontal arm is hinged to the central rod so that sensor can swiveled or it can rotated .The aim is to integrate the liquids and the sensor .While changing the liquid lift the sensor from liquid by rotating and then swiveled to the second liquid for second measurement.The system is complex and involves lot of manufacturing details.

- 2 Sensor with vertical slide and rotating arm.

The sensor is mounted on horizontal arm and the arm is mounted on vertical slide .The sensor has two motions one is vertical up and down .Second one is rotating motion .So when one reading is over lift the sensor up rotate it and keep it in second bottle .The

Usability issues

1 *sensor and liquids together*

3 probe slide and sensor vertical spring adjustment

In the view of minimizing the steps carried out by user new idea of probe sliding in a channel is developed. The sensor has vertical spring loaded adjustment. Bottles are kept below slide and probe can be slided horizontally to change the bottles. The sensor is vertically adjusted with one knob to facilitate the horizontal slide. The mechanism is easy to use for user but it increases the complexity of probe.

4 Selective arrangement

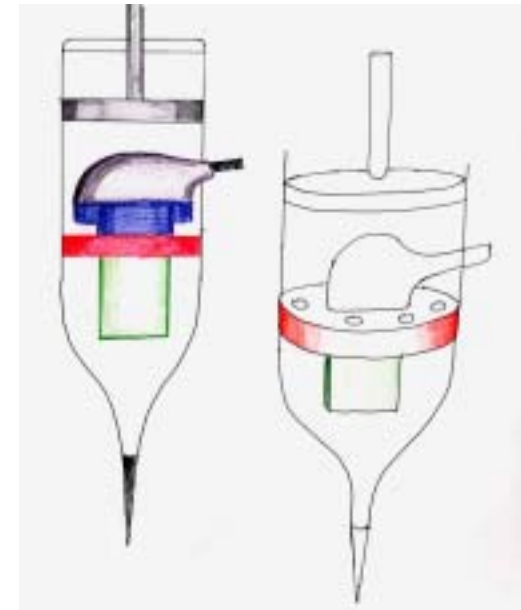
To eliminate the step of lifting up the sensor from one bottle and then putting in other bottle, idea of selective measurement is tried. Here the bottles are arranged in cylinder. Cylinder can be divided in four compartments diametrically. Each compartment has one hole. Just below the sensor is ring containing only one hole. The ring can be rotated in whatever position you want. The cylinder is joined with the compartment containing sensor on which water from top compartment falls. After taking up the reading the whole assembly is turned upside down so that liquid falls back to original compartment. The system is very useful in eliminating the steps done by user. But it has serious problems of contamination and quantity of liquid required.

Usability issues

1 *sensor and liquids together*

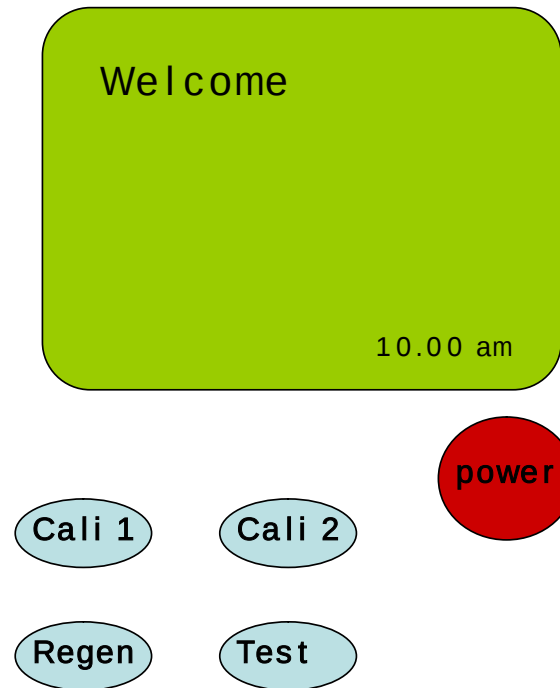
5 Injection syringe

This idea is generated by taking inspiration from injection syringe. The sensor is inside a syringe. The bottles are kept in the form of clusters. The reading is taken by sucking in the water from respective bottle after use either liquid can be thrown or put back in bottle. Here same contamination problem is unavoidable.



Usability issues

2 Number of switches and activities to be performed

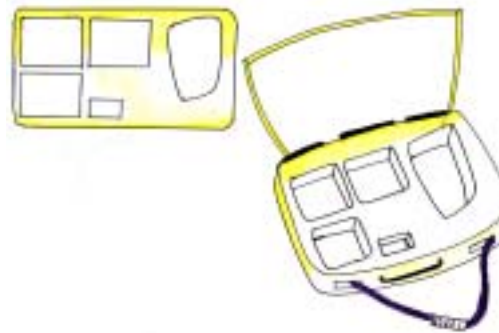


According to the activity analysis the interface design was done. There are total 5 main activities: calibration 1, calibration 2, rinse, regeneration, testing. The activities are shown on the display screen as a list. The buttons are in the form of scroll buttons and an enter button for choice. The function of the user's choice is selected by scrolling up and down. The values appear on the screen which can again be accessed by a scroll button. The interface requires a less number of buttons but requires training and involves more chances of confusion and mistakes done by the user.

The second option is developed to give simple steps followed by the user. Instead of giving the option list on screen, separate buttons are given for each option. The user is not doing any scrolling but is using separate buttons. This would be easier for the user considering his educational levels. The interface needs more number of buttons but the system is simple, requires less training.

Usability issues

3 storage and carrying of liquid



As said earlier my product is family of several elements. To carry all these elements together there has to be some kind of enclosure. The enclosure is not only a box but it is systematic arrangement and grouping of elements.

Totally three different arrangement were considered. In the first one all the elements are arranged horizontally. The form of bag is also so designed that it follows one language all over.

The second option was developed from taking inspiration from match box to make it compact. Also it allows some kind of grouping to be done in elements. The instrument is kept in one compartment and the elements are kept in second compartment on other side. The elements are accessed by sliding out the compartments.

The third concept is to keep all the elements vertically so that the orientation and leakage problem of liquid is minimized.



Concepts–Dipping sensor in water

1 *All elements separate*

Following are the separate elements

- 1 Instrument containing electronics
 - 2 Probe containing connector for sensor
 - 3 Bottles
 - 4 Storage and usage of all these elements
- First

Instrument design

The instrument is element which comes in contact with the user for most of the time

First the instrument was taken for design as it is the major part of whole system .It contains PCB and batteries.The electronics circuits takes care of all calculations and calibrations to be done.After discussing with people from microelectronics department of iit mumbai the dimensions of PCB required was finalised.The area required was 120 square cm approximately.

After that various layouts of PCB and batteries were generated.Each layout has some specific advantage for compactness or size or form.According to grip and shape each layout adds some properties. Layouts were then analysed for attributes,two of them were selected for further development.

The tow layouts were used for further exploration in form and .The main aim is to facilitate the ergonomic grip and easy accessibility to switches.For each layout three different forms were generated keeping in mind all the basic configuration .The user should get some idea about what the product is used.Then proper arrangement of displays and switches was necessary to avoid confusion in use.The visual elements were developed by taking inspiration from other hightech products like mobile,cdplayer,tv remote.The curves outlining the form was developed to give the same image of modern product.All the time though the form are very organic some basic rules of manufacturing were followed.

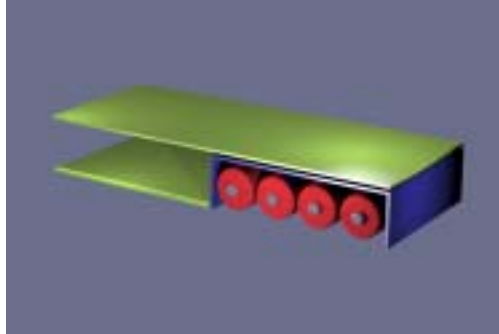
The next step was to evaluate the concepts and come up with one concept to further work on.For the chosen concept was again three more alternatives were generated.The three alternatives were following the visual language of the parent form but they were different in the curves.

Concepts–Dipping sensor in water

1 All elements separate

Layouts

Layout 1



The whole electronics is divided into two PCBs ,one on top of other.the four batteries are kept horizontal and parallel to width
The dimensions are
PCB1=7.5cmX6 cm=45 cm squ.
PCB 2=13 cmX6 cm=78cm squ.
Total=123 cm squ.
The product becomes lengthwise smaller and becomes compact in that direction.

Layout 2



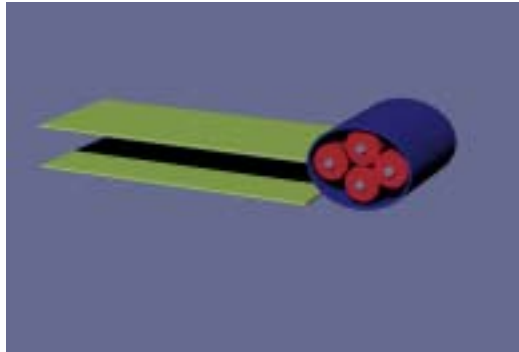
The batteries are space consuming so this concept was developed to conserve the space lengthwise and the height was increased by one battery dimension. One of the PCB was made inclined to neutralize the effect of height increasing.
The dimensions are
PCB1=11cmX6cm=66cm squ.
PCB2=8cmX6cm=48cm squ.
total=114 cm squ.
This layout allows to get some new form and slim arrangement in front.

Concepts–Dipping sensor in water

1 All elements separate

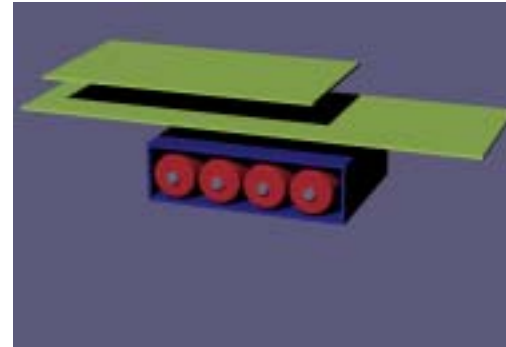
Layouts

Layout 3



The batteries are clustered at the back .This arrangement becomes more compact. The weight is concentrated downwards so it stands well with support. The PCBs are arranged parallel one above the other.
PCB1=12cmX5cm=60 sq cm
PCB2=12cmX5cm =60 sq cm
Total=120 sq cm
The width becomes an advantage for very good grip ,very good ergonomic forms can be generated out of this layout.

Layout 4



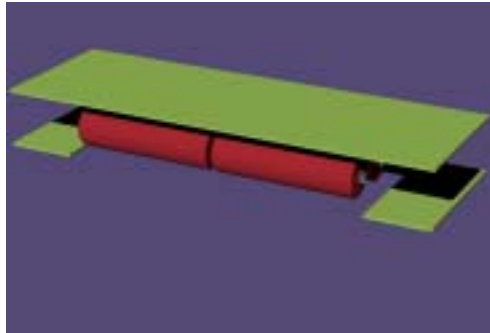
Here the attempt was to follow the curve of hand .That adds to the ergonomic grip .The instrument just fits in users hand. The battery cluster is kept at the bottom and the two PCBs are kept at the top. The height increases but the form becomes more curvaceous and follows the curve of hand very well.

Concepts–Dipping sensor in water

1 All elements separate

Layouts

Layout 5



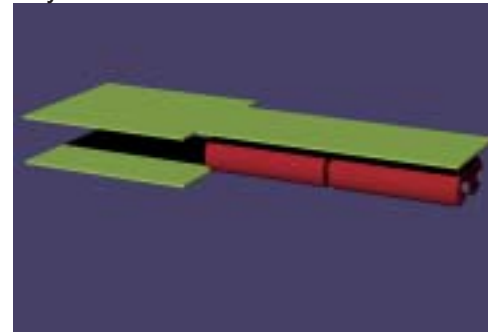
The batteries are placed parallel to the length. the lower PCB is arranged as per the batteries. the top PCB gives connection for display and switches.

$PCB1 = 15\text{cm} \times 5\text{cm} = 75 \text{ sq cm}$

$PCB2 = 5\text{cm} \times 5\text{cm} + 10\text{cm} \times 2\text{cm} = 45 \text{ sq cm.}$

Total = 120 sq cm.

Layout 6



The arrangement is such it gives just enough space for grip and the display area is like part projecting out. The grip is easily identifiable.

$PCB1 = 6\text{cm} \times 7\text{cm} = 42 \text{ sq cm}$

$PCB2 = 6\text{cm} \times 7\text{cm} + 10\text{cm} \times 4\text{cm} = 82 \text{ sq cm}$

Total = 124 sq cm.

Concepts–Dipping sensor in water

1 All elements separate

Layout	1	2	3	4	5	6
Ease in manufacturing	8	6	6	7	6	7
Fixing details	8	6	7	8	7	6
Accessibility to inside	8	7	8	8	7	6
Display and switch fixing	7	5	8	8	6	8
Weight distribution	8	6	7	7	7	8
Grip,form,copactness	8	6	8	8	8	5
Total	47	36	44	46	41	40

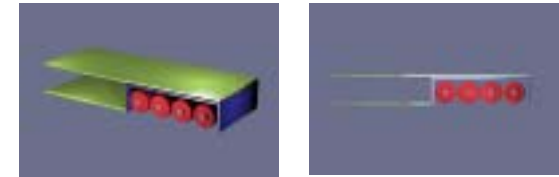
Scale used

1 worst 5 neutral 9 Best

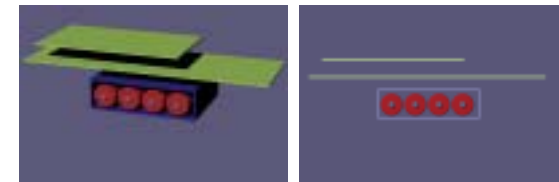
Evaluation of Layouts

Chosen layouts

1



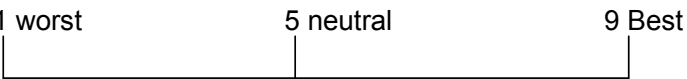
4



Concepts-Dipping sensor in water

1 All elements separate

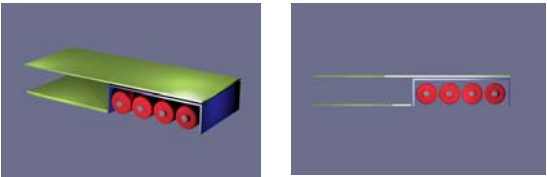
Scale used



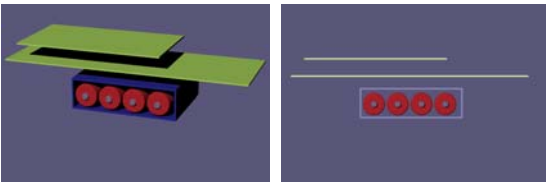
Evaluation of Layouts

Chosen layouts

1



4



Concepts-Dipping sensor in water

1 All elements separate

Initial exploration

To get the feel of volume initial exploration was done in thermocole. The visual elements and the curves look very different in 3-d as compared to sketch that clarity was obtained from thermocole models. All models were studied and initial base was made to generate forms in next stage.



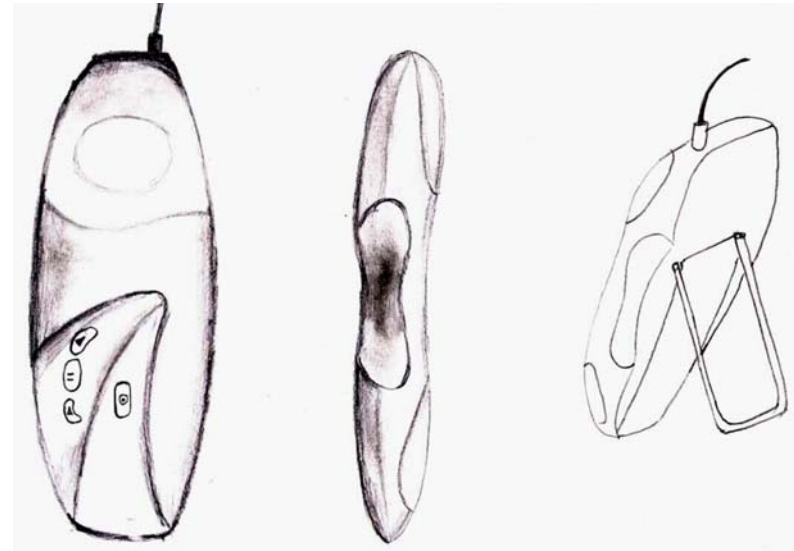
All the thermocole models were made to the scale. On some models visual elements were also tried.

Concepts-Dipping sensor in water

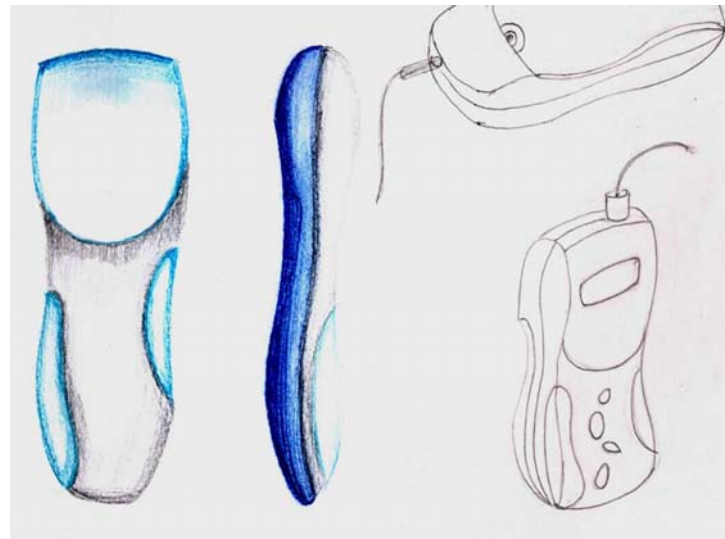
1 *All elements separate*

- 1 Form is such that it follows some kind of rhythm, the elements are grouped and then arranged. The side curves that it nicely fits in hand. Also on the back side it has stand which is foldable. That allows instrument to stand on table. So instrument becomes handheld as well as tabletop.

concepts for layout1



- 2 In the second option the inspiration was taken from a tv remote. Here also the bulging elements on the side have some kind of repetition but they are not exactly same. They follow some language but they have asymmetry in them which makes the interest. The wire connection for the probe is from the top to avoid the hinderance with hand while in use.

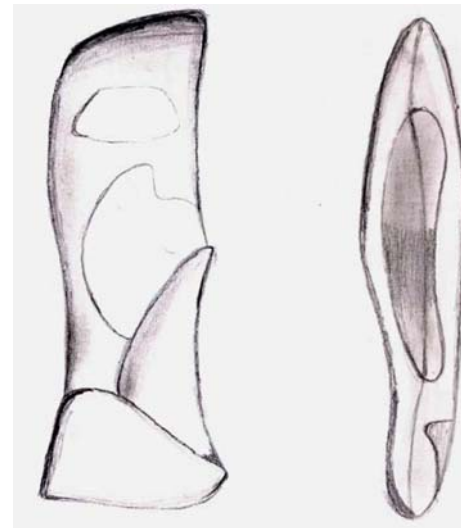


Concepts-Dipping sensor in water

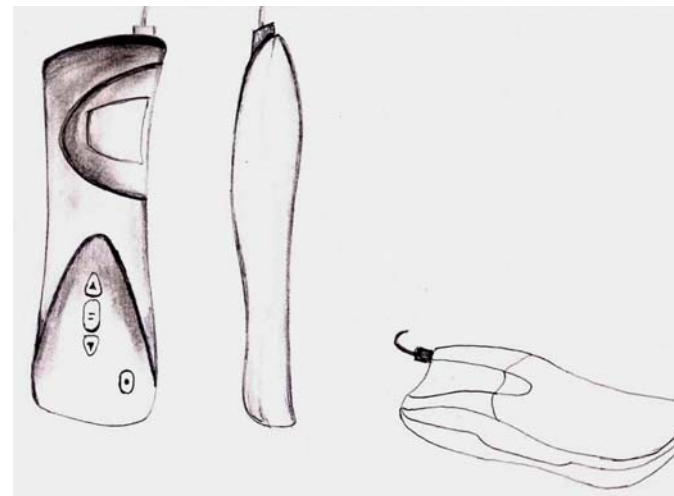
1 *All elements separate*

- 3 Inspiration was taken from kite. Kite has got tail and wing like structure same type of form was developed on basic grid of Layout decided earlier. Interface is also surrounded by a patch going with the form. The form is slim so easy to hold. Negative scoop on the side also creates some interest.

concepts for layout1



- 4 Attempt here is to create interest in form by creating play of negative and positive surfaces. The switches is on to the convex surface that is on the bulge. negative curve on the back is given to create interest in the curve.

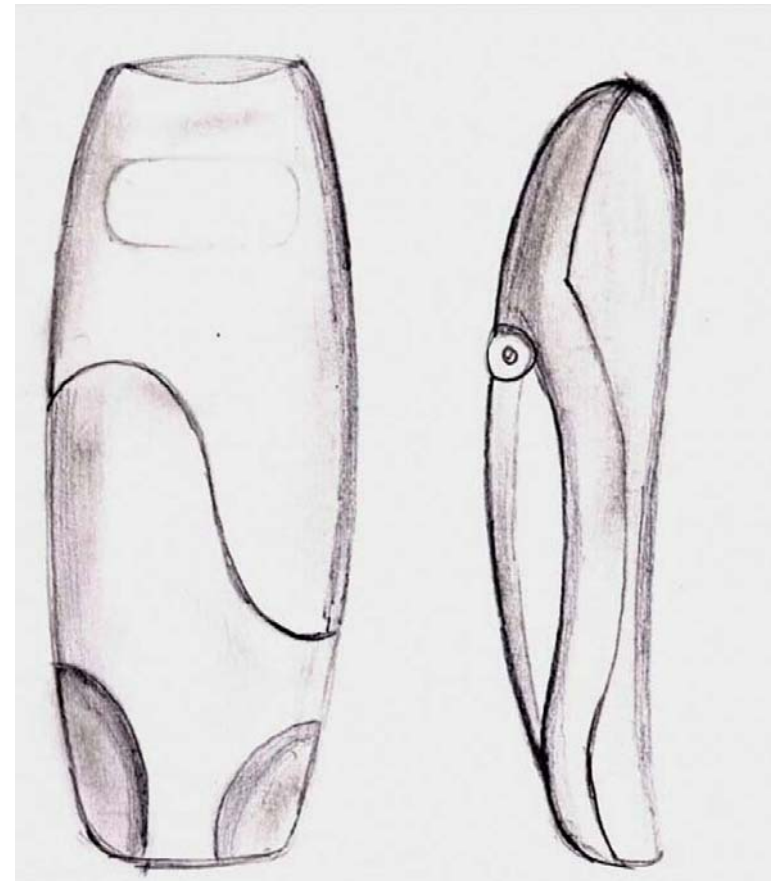


Concepts-Dipping sensor in water

1 *All elements separate*

- 5 Here i tried to merge the back handle with the form. the Back handle is used when the product is used as table top instrument. It also gives some interest by creating the space between the handle and body. Parting line is also going smoothly along the curves.

concepts for layout1

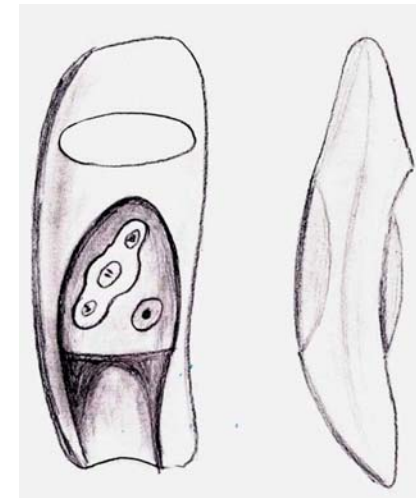


Concepts-Dipping sensor in water

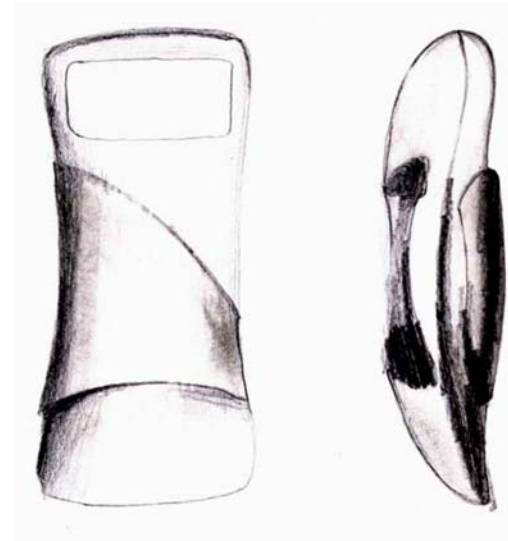
1 *All elements separate*

- 1 The second layout is developed for the ergonomic grip. The form developed follows curve of hand very well so it gives very good grip while measuring. Elements added on the interface plays a very important role in creating interest. Switches are placed on the raised surface giving easy access. Parting line is also following the curve at the bottom.

concepts for layout 2



- 2 Form is straight forward. Negative curves on sides plus on the sides helps in good grip. Interface is enclosed on raised surface, boundary of which follows some rhythm in curves.



Concepts-Dipping sensor in water

1 *All elements separate*

Evaluation for concepts

Out of the total seven concepts for the layouts two were shortlisted. Then computer rendering was tried in that the concept no 1 of layout one is finalized for further details



concept1 -layout1



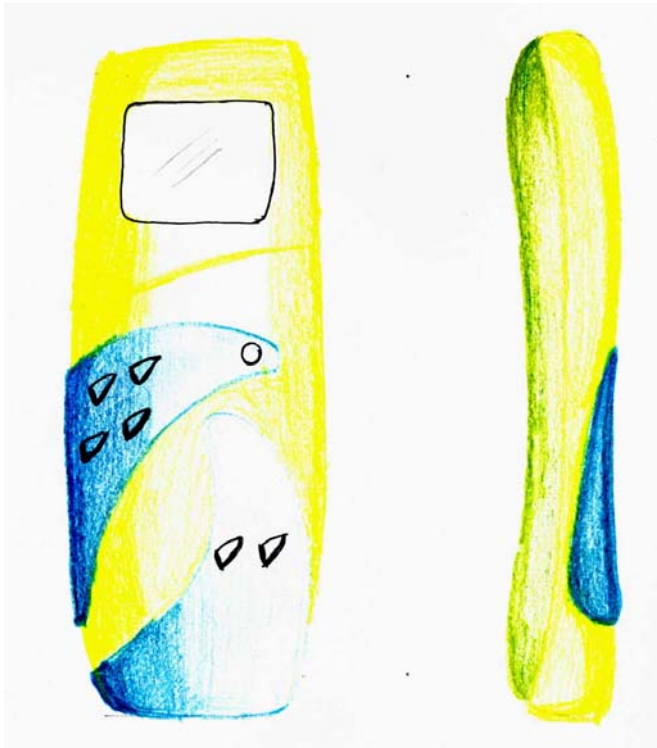
concept2-layout2

Concepts-Dipping sensor in water

1 All elements separate

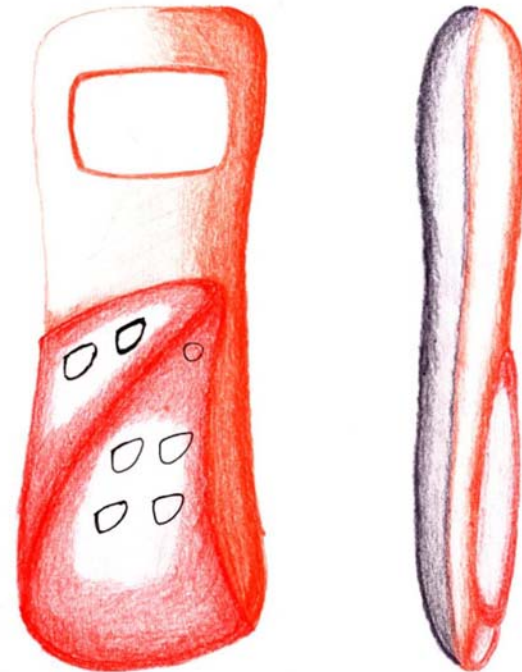
The chosen concept has some repetition in the curves. The visual elements also repeat in themselves. The variation shown aside follows the basic language of repetitions in elements. All of them are different in curves and visual elements.

1



Variation of chosen concept

2

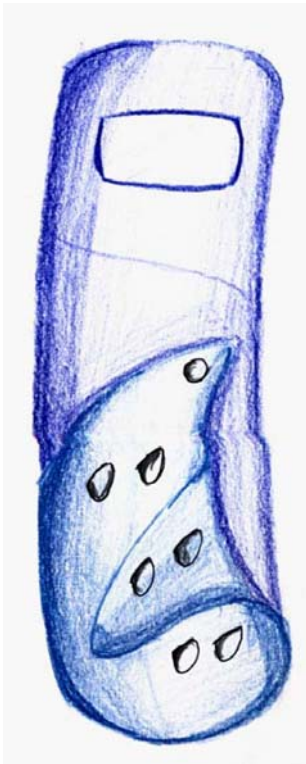


Concepts-Dipping sensor in water

1 All elements separate

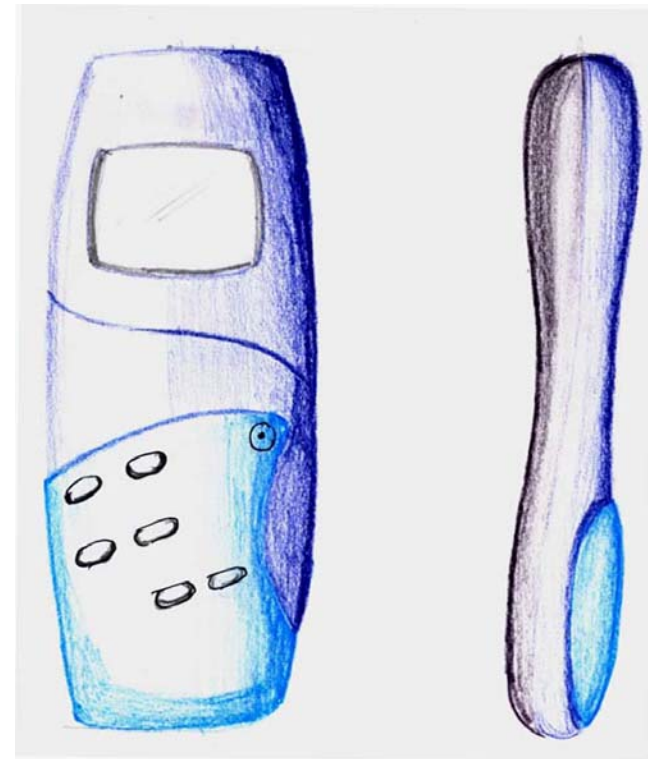
Variation of chosen concept

3



Curves are repeating but the complexity was increased by creating negative in-between the positive bulge. This adds lines on the surface creating interest.

4

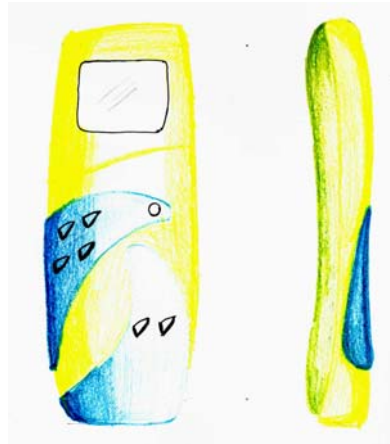


The outer form also shows some repetitiveness and the interface element boundary also plays very important role in maintaining the originality of concept. Some of switches are on the bulge at the centre which makes the concept different from others.

Concepts-Dipping sensor in water

1 *All elements separate*

All the three variations were compared for some set of parameters like grip, newness in form, visual elements, Repetativeness in curves variation 1 was finalized as final for instrument.



Final concept for instrument



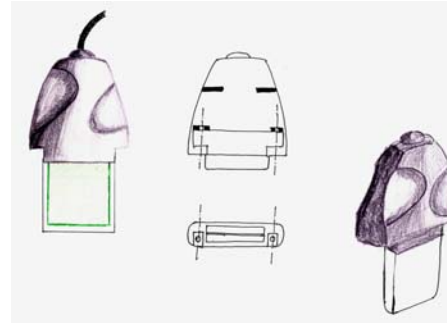
Concepts-Dipping sensor in water

1 All elements separate

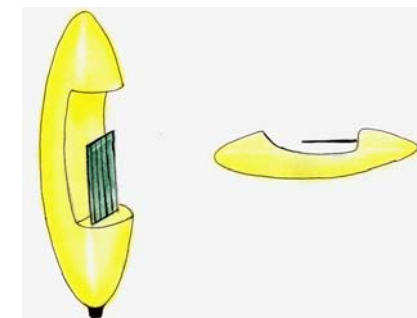
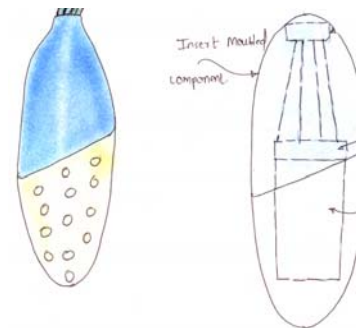
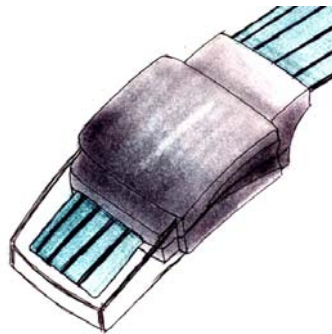
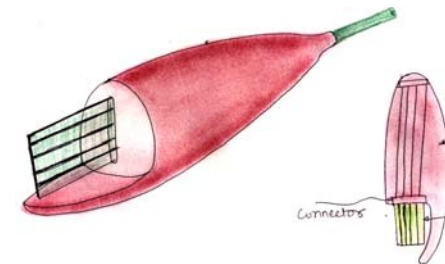
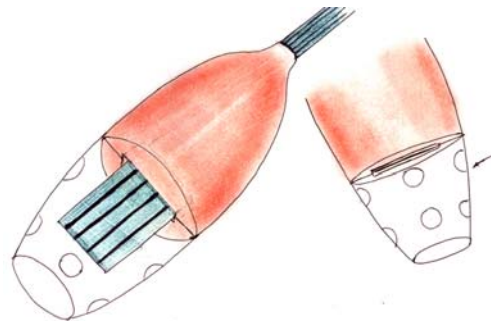
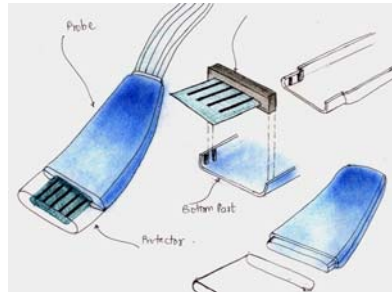
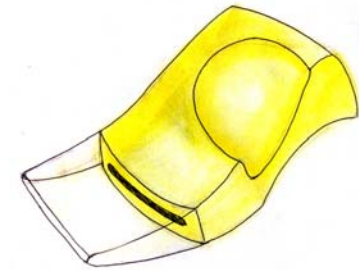
Sensor is thin PCB of size 4cmX5cm, it fits in the connector. The probe is enclosure for these elements. To design the probe following parameters were considered

- 1 Grip
- 2 Compactness
- 3 Wire outlet
- 4 Manufacturing

Initial sketches



Probe for sensor



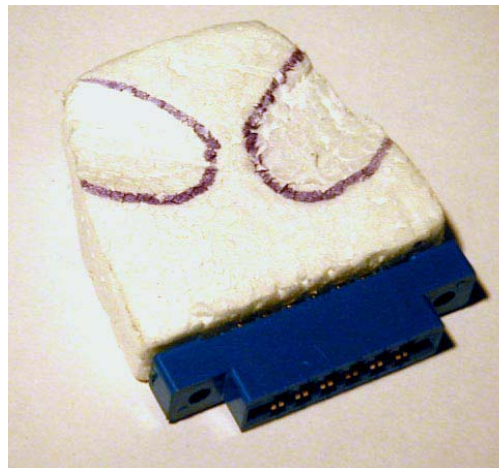
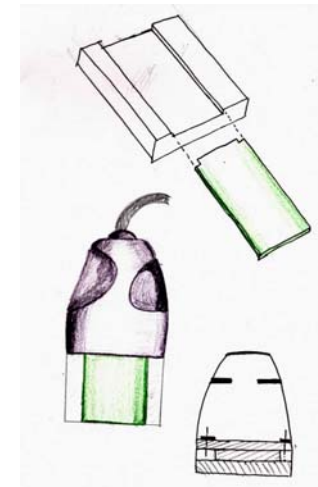
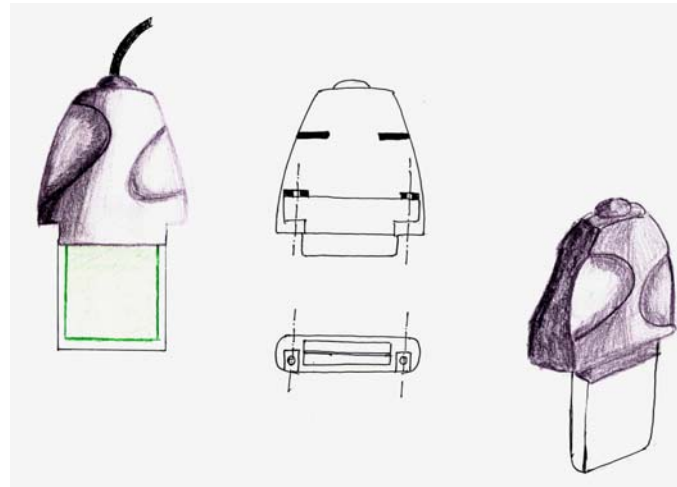
Concepts-Dipping sensor in water

1 All elements separate

Probe for sensor

Final design for probe.

Initial sketches were based on the grip and ease in use. Out of that one concept was taken for further development. Probe is also one of the important parts of the product, it should follow the same language as the instrument. Chosen concept was further developed to get the same language. According to the basic dimensions of the connector, the sensor probe was designed. Then a series of thermocole models were generated and tested to get the final shape as shown in the figure. The sensor is slid into one plastic base and the plastic base is connected to the probe. The sensor is protected from outside by having a transparent cover which just fits outside the connector.



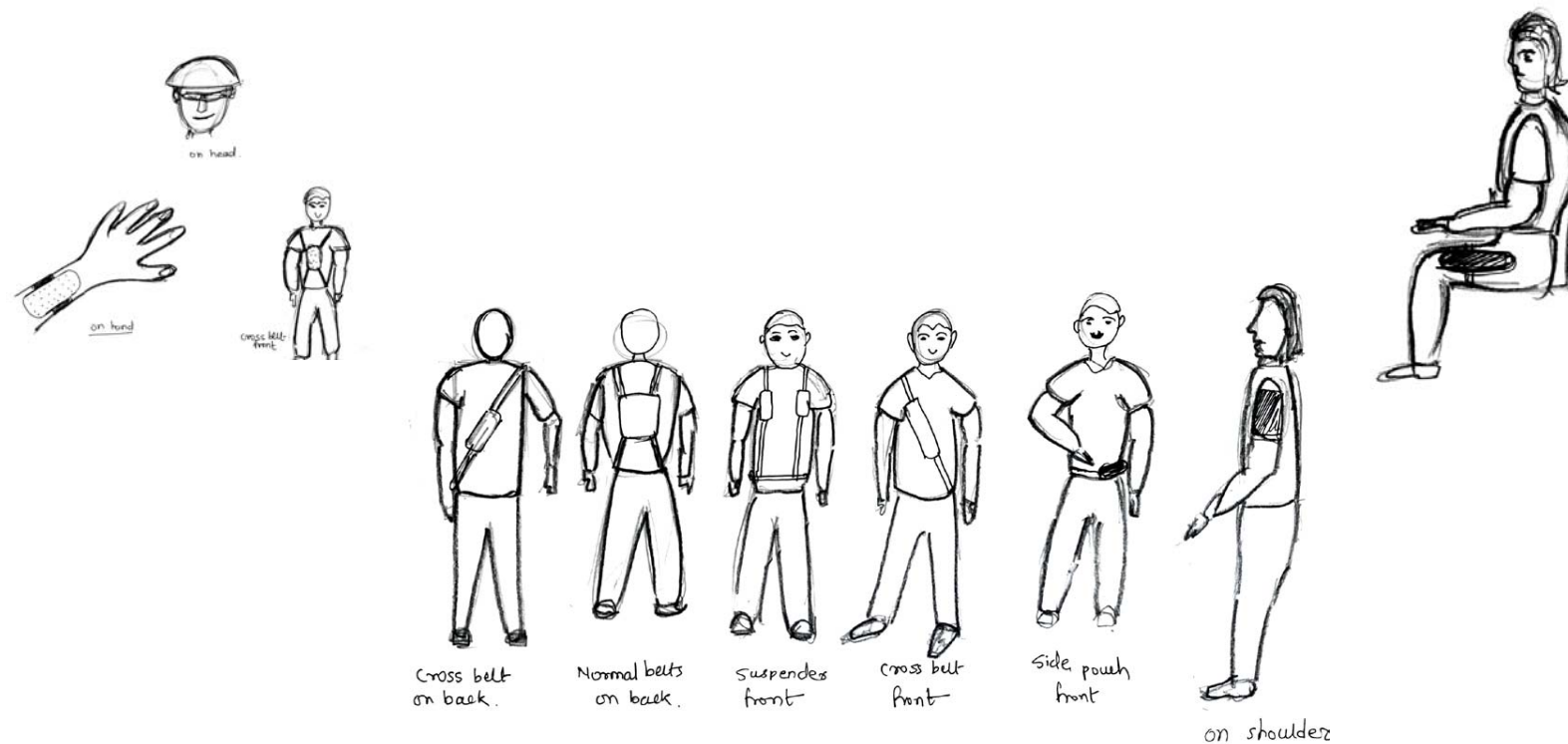
Concepts-Dipping sensor in water

1 All elements separate

Storage for all elements

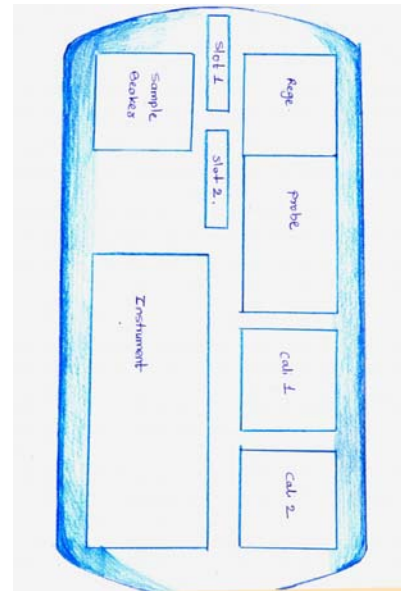
Instrument, probe, liquids, wire to connect the probe to instrument has to be carried by the user to the field. User may go by any means of transport so the casing must be such that it encloses all such things carefully in minimal space. First step was to analyse in how many ways person can carry instrument on his body. Every position was analyzed. Each position has got some advantages and disadvantages while carrying.

How many ways person can carry instrument on his body

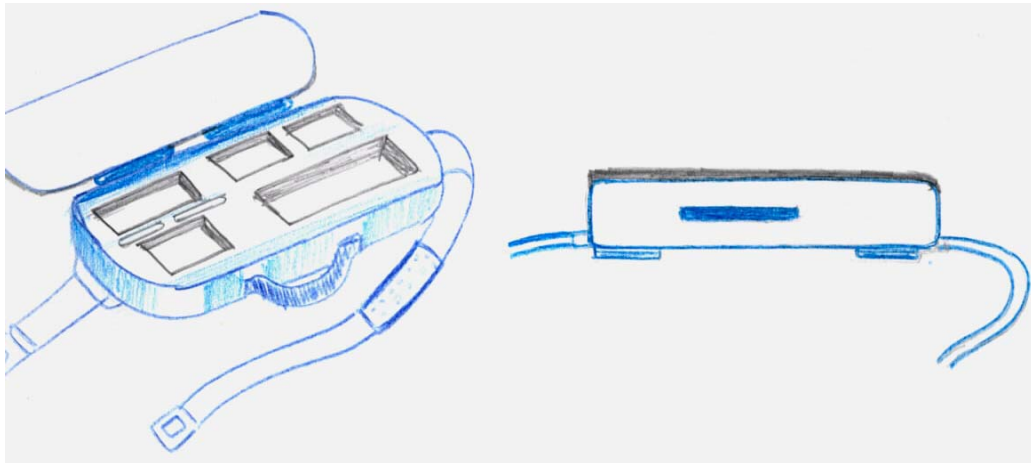


1 All elements separate

Calibration procedure is required after 8 hours or when the sensor cartridge is replaced. The user has to do mainly test, rinse, regeneration in a day. The layout of bag was determined with proper grouping of elements. Bag is carried on back while not in use. User goes to the field and then keeps it on the ground for further use. To protect the bag from soil and to give approximate parallel surface small bushes can be attached at the bottom. The different elements are kept in foam body which negative spaces to hold the elements tight. The bag option here is compact in thickness but little longer in length.



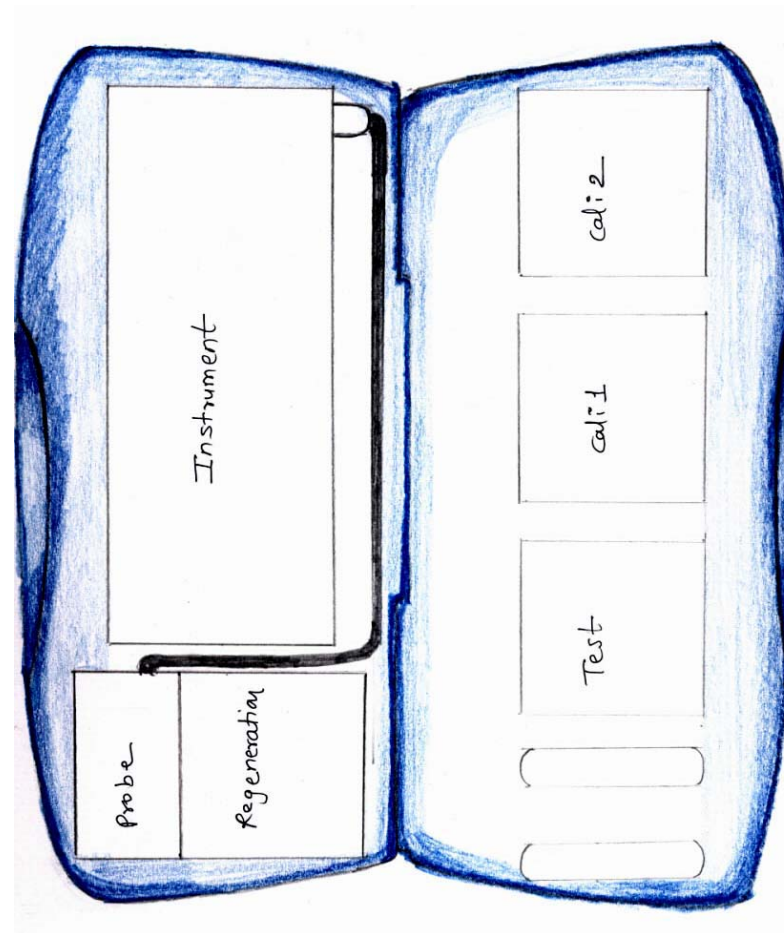
Storage for all elements



1 All elements separate

Storage for all elements

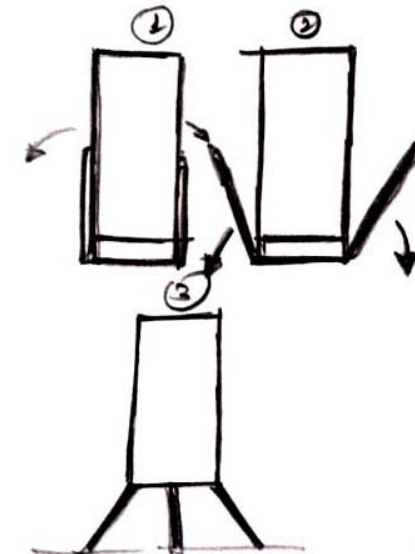
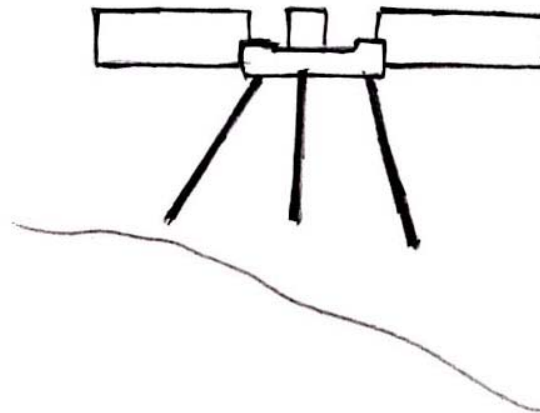
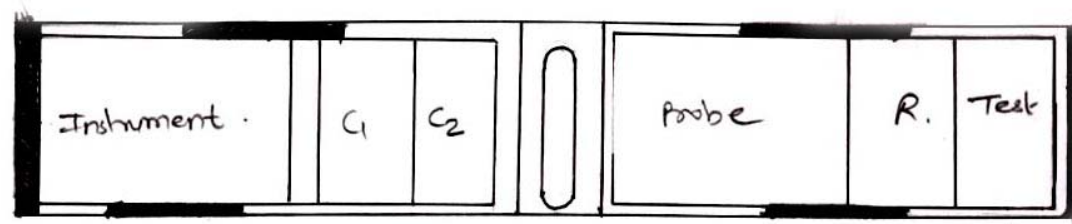
Second option was developed to make the bag very compact. Both the flaps of bags are used. In one flap the bottles are kept horizontally. Second flap is used for keeping the instrument and probe. Bag is very compact in length and can be easily carried on back. Liquid bottles here need tight sealing as their orientation is going to be changed often. Nylon can be used for bag as it is available in various colour shades, textures. Inside elements can be again put in foam fixing to get hold on elements. The slot given on the side of liquid bottles are used for testing. One slot is used to keep the probe and other slot is used to keep the sample beaker. Test water is taken sample beaker and sensor is dipped in it to take reading. Reading is noted down on note book provided along with the product.



1 All elements separate

Storage for all elements

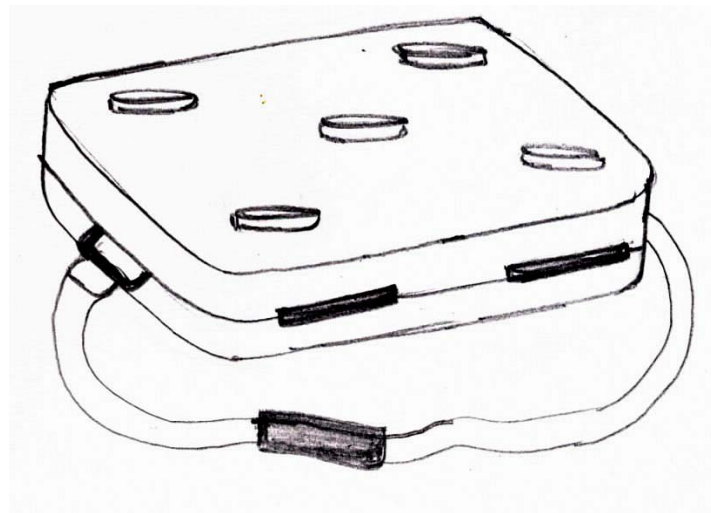
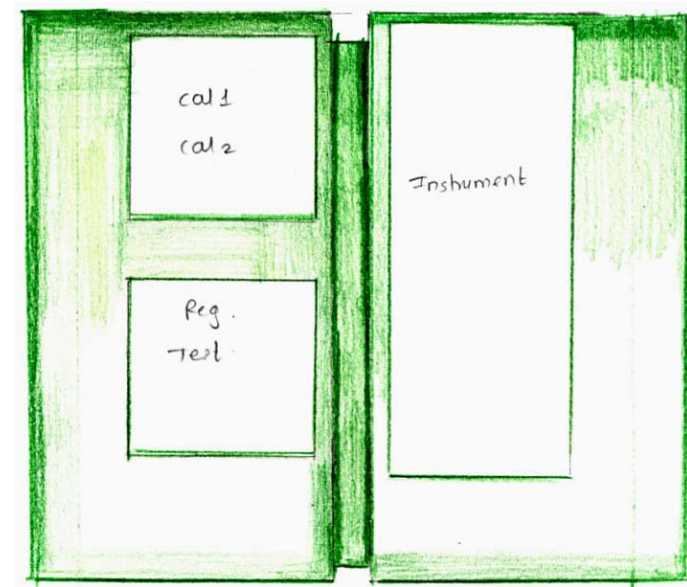
Third concept was developed to facilitate the use of product in any terrain. The product is like compact cylinder. Cylinder has three legs like a *tripod*. The legs can be adjusted in height plus they can be swivelled so if there are rocks near to water to be checked, user can keep product on ground easily. One spirit level can be given on the product to level it parallel. The cylinder cut opens in two portions. Each half has got the respective elements. The centre of cylinder can be used to keep the bottle and probe for checking. After use legs can be nicely fold and merge with the cylinder to make the product even compact than last two concepts.



1 All elements separate

Another way of carrying product on body is near to waist. If everything is compacted in small box then it can go near to waist. Bottles can be grouped and arranged in vertical fashion in one flap of box. Instrument is fixed in another flap with the probe. The whole box goes near to waist held by a belt. When user opens box flap containing instrument is seen. Reading is taken by holding the probe in hand. The whole procedure can be done while user is standing so that eliminates the complex tripod mechanisms and also makes product useful in any terrain.

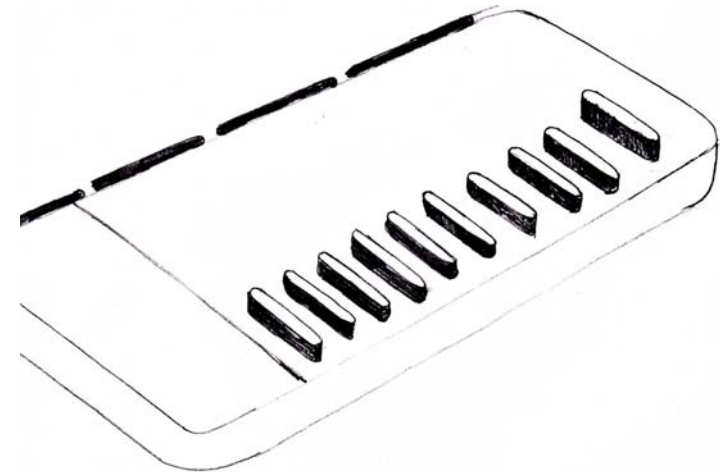
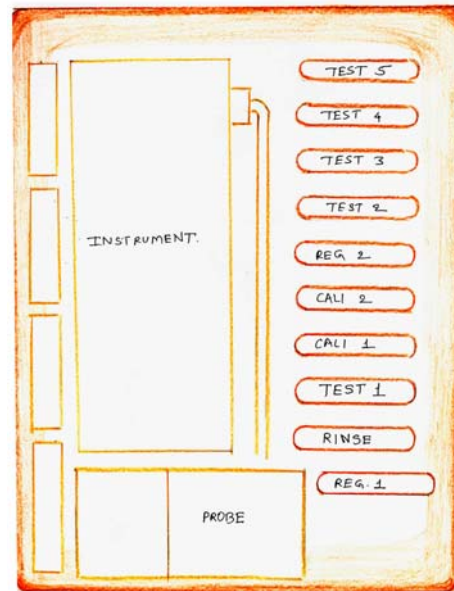
Storage for all elements



1 All elements separate

The readings shown on the screen are to be note somewhere. One option was to give save option on the instrument where all the readings were stored in the chip in electronics. The place details will be taken in small dairy to be carried along with product. But while discussing with Other members in the project the idea of storing data in digital memory was dropped. So to reduce the problem of carrying dairy fifth concept was developed. According to statistics available with me the approximate calculation is that user will de at the most five readings in a day .So provide extra 4 empty containers along with the product. Now there is no need to throw sample after every use. The place details and readings can be written on the container itself. This can save some space. The probe is kept horizontal which is then inserted in particular container. The whole container can be kept on ground for measurement.

Storage for all elements



1 All elements separate

Thermocole model



Storage for all elements



2 *Integration of bottles and probe keeping instrument separate.*

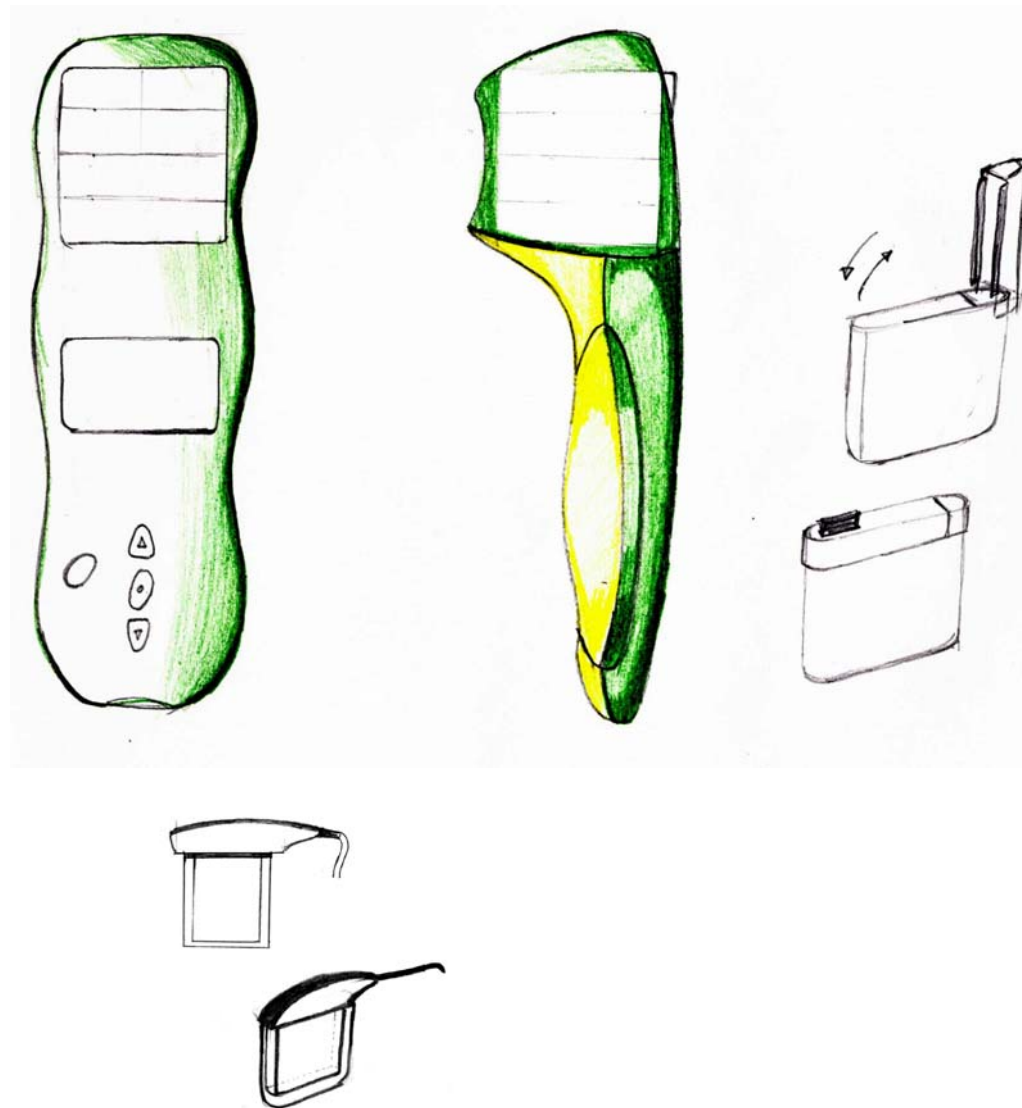
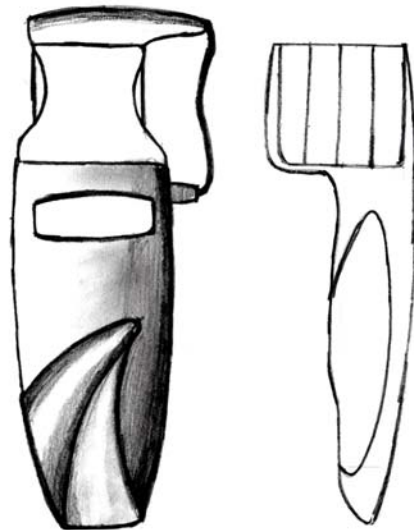
Instead of keeping the elements separate they were integrated with each other the integration may be 100 % or may be intermediate. The partial integration is possible. The bottles and probe are used frequently with each other so they can be integrated. Concepts were developed considering the user and his comfort.

Bottles are arranged in cluster along with the probe. Using the analysis done earlier the product is carried on a cross belt running over chest. The product has got a hinge near to its base so when user wants to use the product he just opens it and instrument comes in front of him. The bottles are tied near to waist on the same belt. One bottle at a time can be taken out for reading and put back in the side pocket on waist. In this whole activity the user donot have to hold instrument in hand so his one hand is free to do activities such as holding probe and taking out, placing in bottles.



3 All integrated into one.

The best way to eliminate the storage for product is integrate all elements into one. The probe is attached to the product by a wire like in previous examples. All the liquid bottles are kept in front, integrated with the product. Caps can open from one side. User holds product on the sides of the interface and the bottles come in front. There is opening for the bottles from sides so they can slide in and out for refilling. The test bottle can be taken out in same way and like other bottles. As the product is big and heavy grip is enhanced by giving slight bulge on the side.



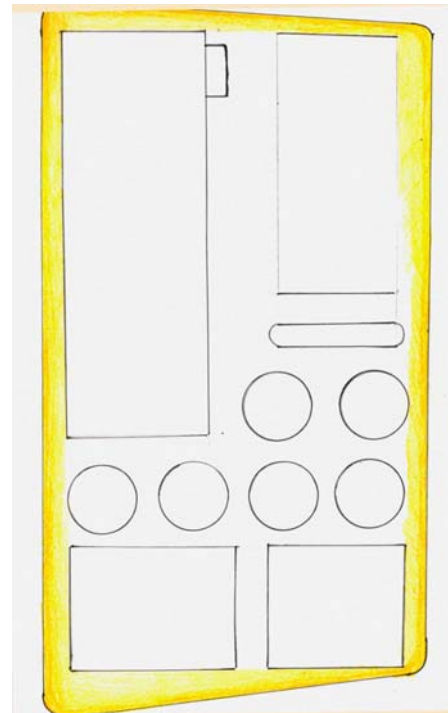
Concepts-Dipping sensor in water

why do drop the idea of sensor dipping in water??

- 1 The liquid bottles become cumbersome while carrying. There are leakage problems.
- 2 While taking readings the sensor is to be pushed into liquid bottles and taken out and put into other bottle. So there is problem of spillage of water.
- 3 Water always sticks to the sensor .The sensor area is also large 20sq cm so there is water loss all the time. The standard liquid is mixture of ions so it is not advisable to loose so much liquid at one use that may increase the quantity of liquid to be carried. In turn it increases the space required.
- 4 While transferring sensor from one bottle to other water drops may fall on the instrument or container
- 5 All the time the caps from the bottle are to be removed so this is added activity and if the user is doing the activity standing then it becomes more troublesome for them .
- 6 The most **important problem** is the **contamination** of liquids .Sensor is transferred from one bottle to other bottle so liquid gets transferred from one bottle to other, that contaminates liquid. The concentrations are changed which adversely affects the readings.
- 7 Liquid bottles have some constraint on orientation ,it cannot be changed frequently. This limits its arrangement in container bag.
- 8 Connector should be kept apart from water , water shorts all the connections finally affecting the readings. So when user dips probe in water there may be chance that water comes in contact with connector .it requires proper sealing which increase the complexity.

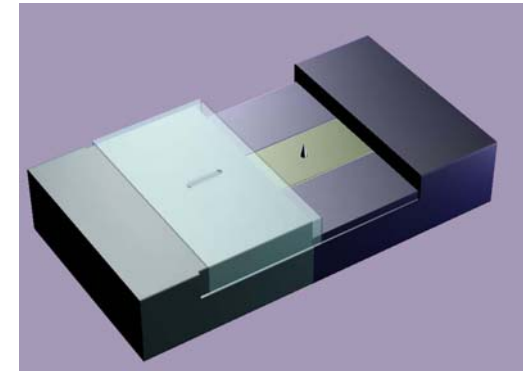
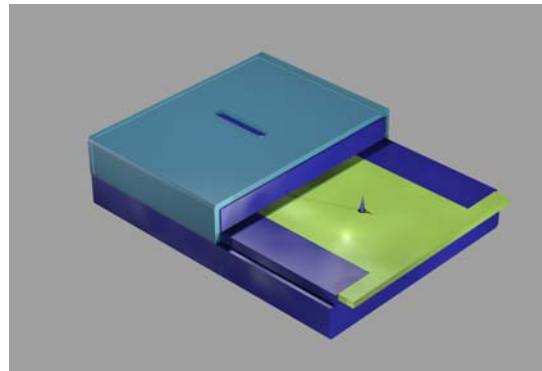
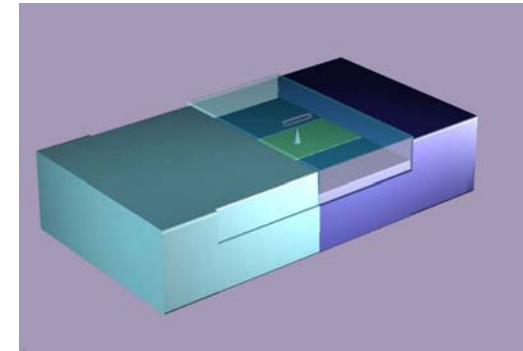
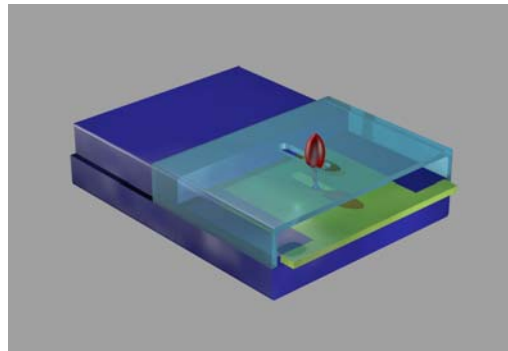
All elements separate

Putting drop on sensor altogether solves the problem of contamination of liquids. Liquid is contained in the small dropper bottles. As the sensor is not dipped size of bottles becomes very small. The container also becomes very compact. The user carries the bag on back when in use he keeps it on ground .One small platform is provided alongwith the probe which is taken out and kept on ground .The probe is kept on that platform .Few drops are properly kept over sensor to take readings .for removing water from sensor surface user cannot use sponge or blotting paper as it may damages the sensor. So only way is giving jerk to sensor or blowing air over it. Jerk may not be the good idea for connector and wires connecting to it. Pushing air on sensor is better idea to remove water .



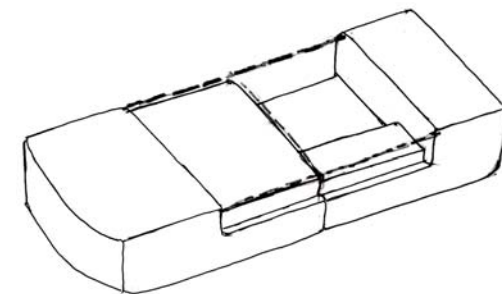
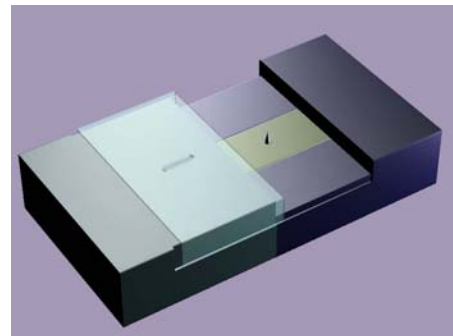
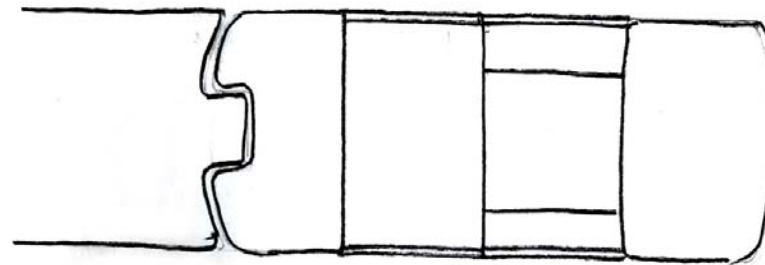
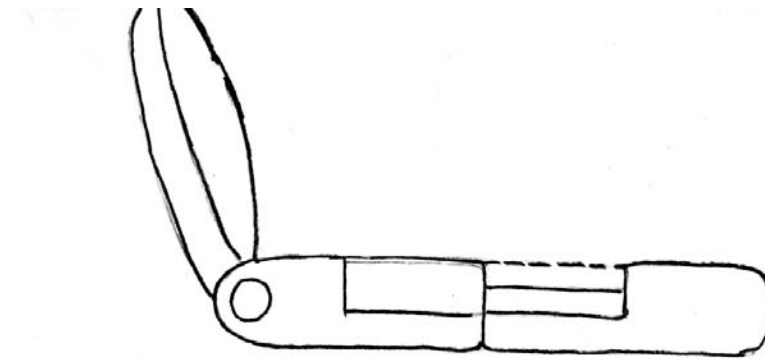
All elements integrated

In the previous example the idea of the putting drops from containers have the same problems as in the dip type sensor. This problem can be solved to large extent by using capsules. The capsules contain the required amount of liquid, the capsule can be ruptured by cutting it or puncturing it. In cutting operation blade has to be supplied which is dangerous. The needle point can be given at the centre of PCB as shown in figure. Capsule is just kept over needle point which punctures it. The PCB is designed such a way that it has small well around the active around. This helps in keeping water only in active area. The sliding cover is used to protect the sensor from dust also it protects it when not in use. Another option is to use using hinged cap to protect sensor. The slide cap obtains lot of space and it is complicated structure.



All elements integrated

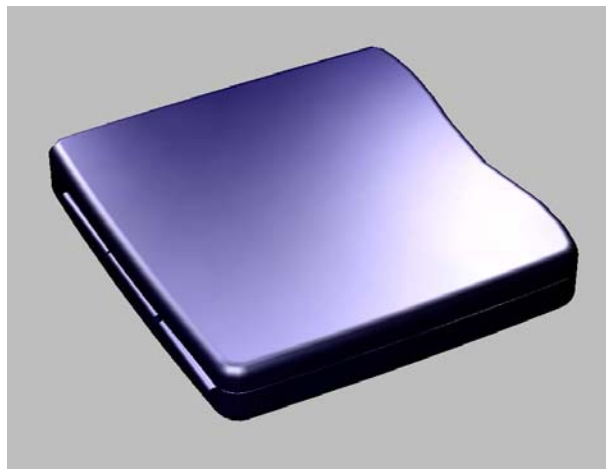
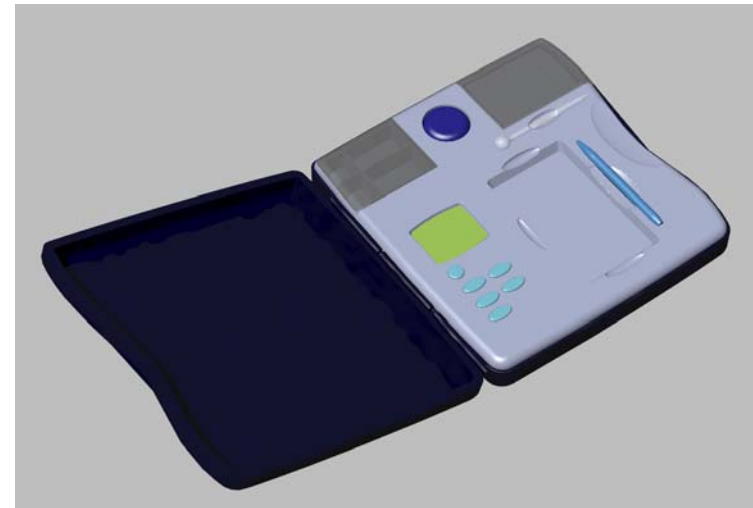
The concept of closing the sensor by a sliding cap and using capsules to carry liquids can be converted into very compact product as shown in sketch. The display and PCB, batteries can be accommodate in the upper flap. The Bottom part contains all the connector and sensor portion. The sensor part can be detached from the main body which allows sensor to be replaced after its life is over. The blower for the sensor water can be placed in the back portion of sensor compartment.



All the elements are combined into one product. First step was to finalize all the dimension blocks required for all elements. The blocks identified are

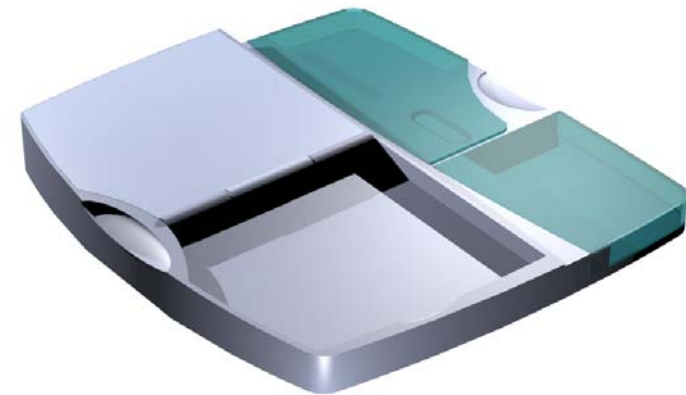
- 1 Display and switches
- 2 Diary & pen
- 3 Capsules
- 4 Sensor & Dropper
- 5 Air blower.

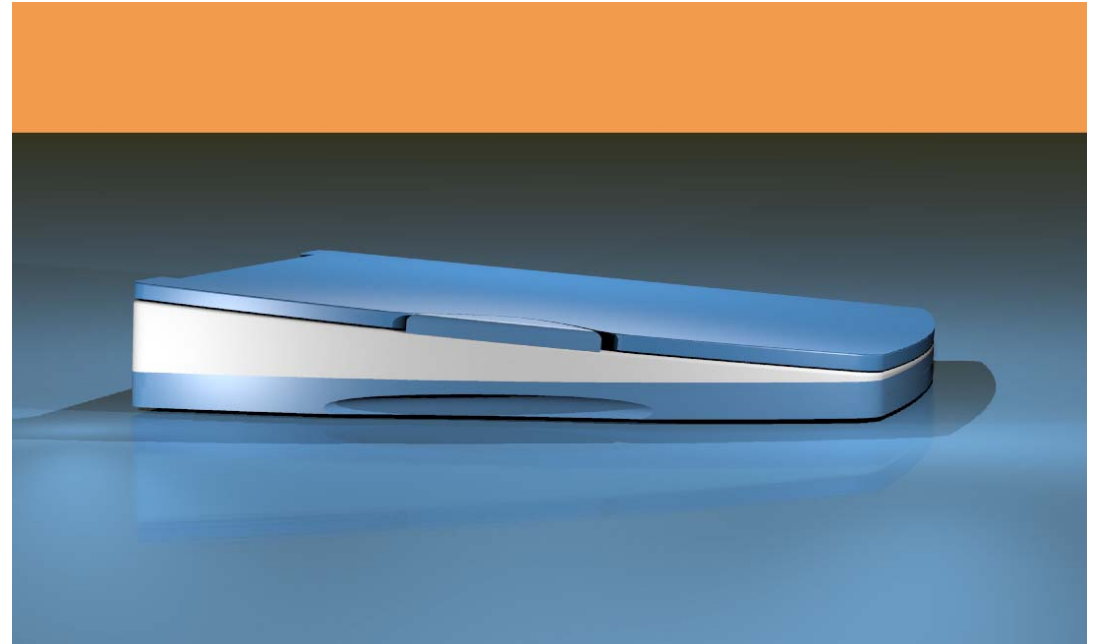
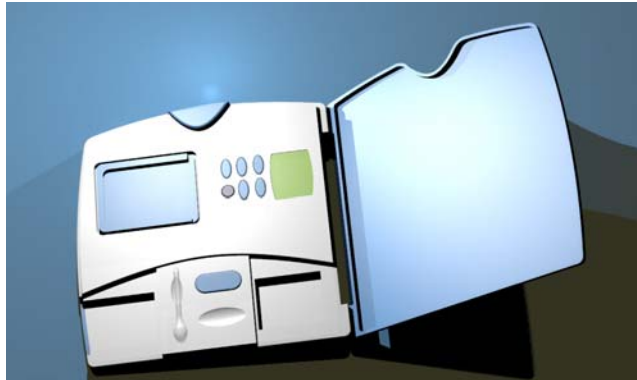
Then considering importance of each element and its functionality different layouts were generated in autocad to the dimension. Then out of which most functional and user friendly layout was chosen. Form was build over it. The caps for capsule and sensor open from the top so they donot hinder to much in operation. Sensor is slided in from top end and the blower blows air from the side. The blower is like bellow which are standard parts available in market. The layouts for inner PCB and batteries is used as decided earlier. Extra batteries can be provided alongwith product. The whole product is protected by giving big flap over it.



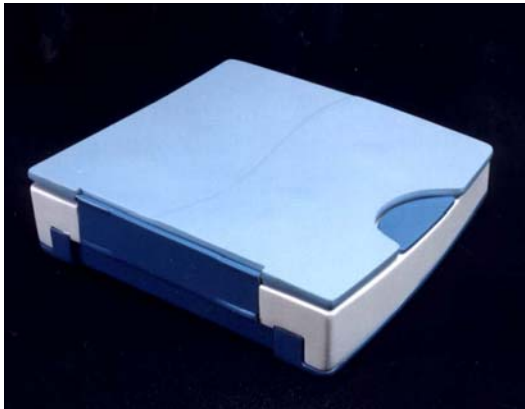
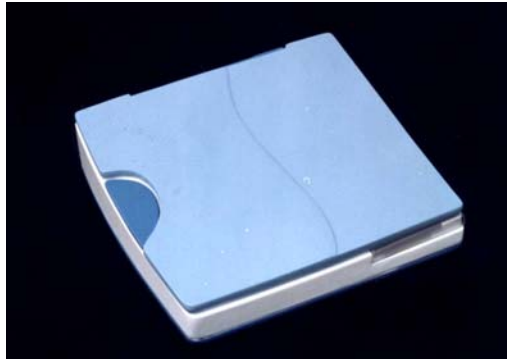
All elements integrated

In previous concept all the surface is flat so there is problem when user holds it. He holds product with some angle to see the display, that causes the water on the sensor to fall down to connector. This may affect the reading and the connector also. This problem can be solved by slight changes in it. The capsule block can be brought down and the display is shifted up to accommodate the dairy. Giving big flap to cover everything gives lot of load on hinge and it is troublesome. So the flap is divided in parts. The dairy in previous concept is disturbing overall form. It is to prominent element. One flap over display can be used to contain the dairy. This serves two purpose, one is it protects screen and it gives very compact look plus it avoids the big flap. Air bubble is shifted from top to the right middle portion which more logical as it is very easy to press it by thumb. Grip is nicely blended with form which can facilitate both right and left handed grips. Some more work is needed in the detailing of hinges for sensor and capsule caps.

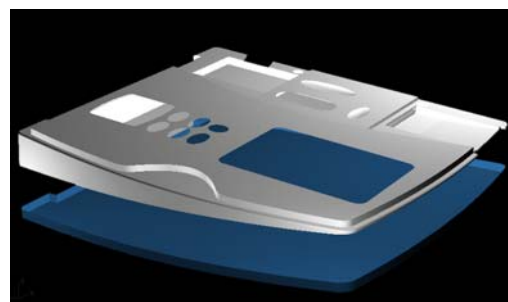
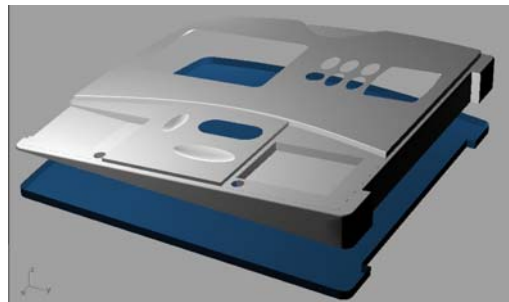
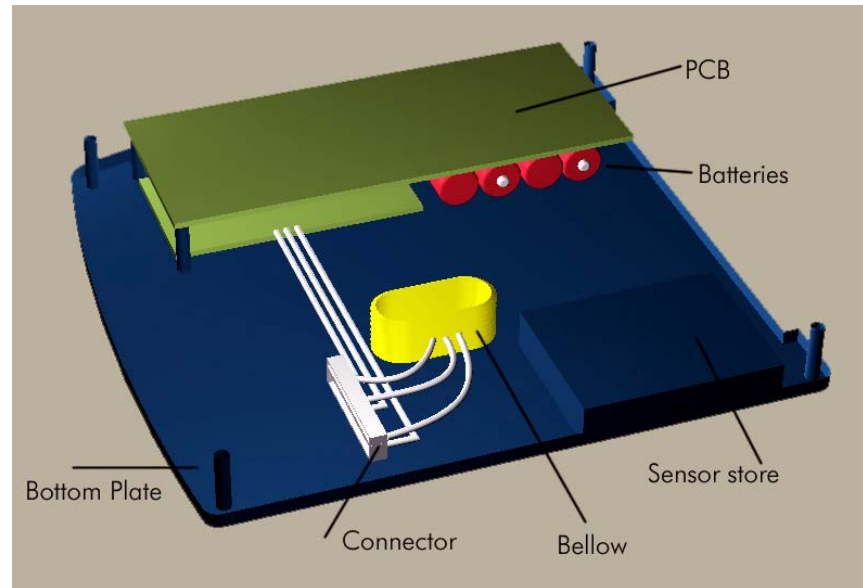
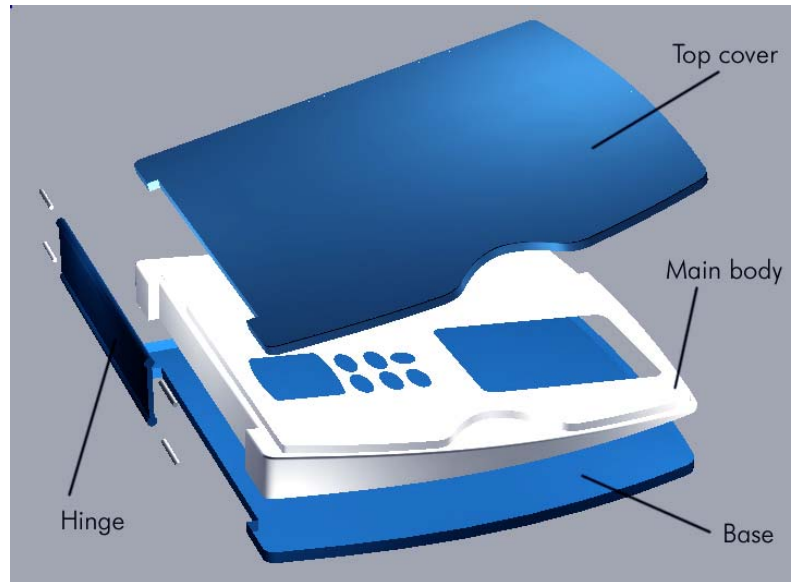




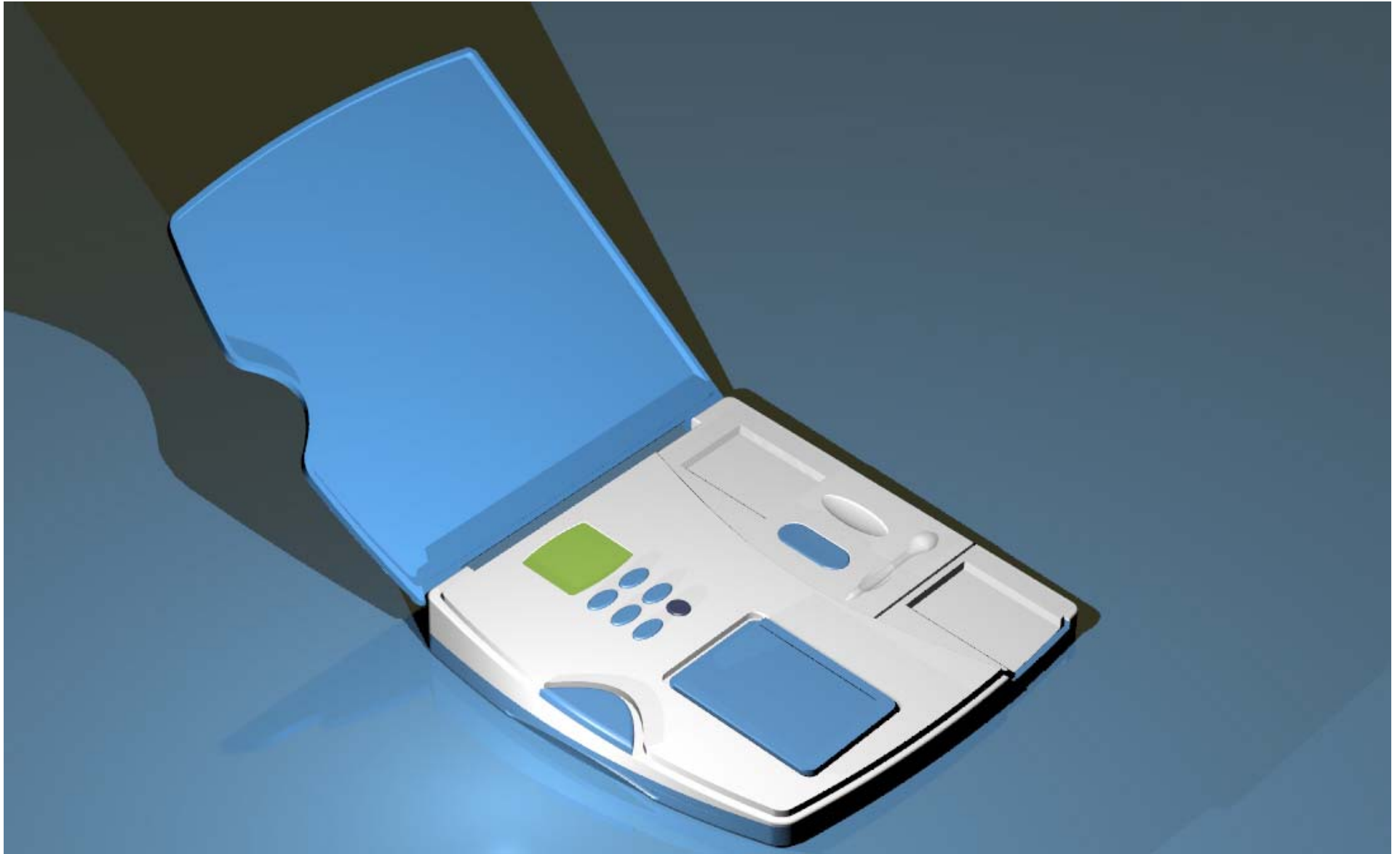
The final concept was made considering user analysis, activity analysis and ergonomics. First the layouts for PCB and batteries were finalised and then other elements were arranged according to it. Sensor and capsules are kept on one side whereas the display, buttons and diary are kept on other side. Thus the input and output side are kept different. On both sides grips are given to facilitate different grips reducing fatigue on user. When water drops are put on sensor strip and appropriate buttons are pressed user gets reading on display in the form values with proper units. As the user is moving from one place to another place he has to keep the track of readings so one diary is provided to note down all details like place name, day, date, time etc. The diary is made up of two compartments one on top of other. The diary can be swiveled at the center. When one reading is taken user presses the diary bottom end and then puts the paper back. This arrangement avoids use of spiral bound diary. The dropper and blower bubble is in between two compartments. Dropper is required to take sample water and put drops on sensor while the blower is used to throw out water drops from sensor. Cover is attached to main body with double hinge which allows the it to turn around and go below base.



The final model was done in one to one scale. Most of the parts of model were made by fabrication technique. Remaining parts were made by vacuum forming. The two pictures to the side show how the product is to be held and what are different grips.



Product is made up three parts . The uppermost part is cover which is attached to the main body by double hinged cover . The Middle one is the important part containing all interface. The bottom most part holds PCB, battery and connectors.



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