## 3.0 Introduction

The term fabric handle is used for the tactile sensations associated with fabrics and it markedly influences consumer preferences of textile products. The fabric handle is still being judged subjectively to a large extend, the need for objective methods to measure the fabric handle has always existed. In the subjective assessment process of textiles, fabric hand is understood as result of a psychological reaction through the sense of touch. There are variations in how individuals actually feel textiles because people do not have the same sensory perception of identical occurrences. Therefore, quantitative methods are needed to measure the effects of technological factors such as the use of microfibers, modern methods of textile finishing and consumer maintenance practices. Simple and quick objective screening techniques would be useful for quality control.

The main objective of the present study is to develop an instrument based on much acclaimed nozzle extraction principle to study the handle characteristics of fabric keeping in mind the followings:

1) The instrument must be a simple one for its application and interpretations of results.
2) The instrument should be low cost so that any small to medium sector of manufacturer can afford to have it and use it.
3) A major concern in textile material and its testing is low degree of reproducibility due to its inherent nature of variability. Therefore, major focus has been given to design and adjust the machine variables in such a way that provides reproducibility of the test results and establish the validity of the instrument.

4) To carry out a representative study of handle characteristics of fabric in the newly developed instrument to demonstrate the usefulness of the instrument and provide a quick guidelines for its uses and areas of applications.

### 3.1 Phase 1: Development of the Nozzle Extraction Instrument in research and Development stage

At present there are few instruments available for evaluating fabric handle objectively. Among the available instrument to measure fabric handle objectively the Kawabata evaluation system for fabrics is always at the centre of the stage. The main disadvantages of this instrument are high cost, complexity and the time consuming procedure that restrict its industrial applications, especially for small scale apparel and textile manufacturers, processors and merchandisers.

Therefore, as seen that the fabric handle is a complex phenomenon of deformations of fabric sample that relate to flexural rigidity, shear, drape, compressibility, surface roughness and friction. Therefore the objective in the present study is to develop a comprehensive system that would give a Handle value as well as project other mechanical specifications of a fabric in a single test. Looking to the various parameters that are associated in the present context and the knowledge gained from literature search, it was thought off to develop an instrument that will take care of all the above parameters. Based on the above fact and figure primarily it was thought of to pull out a fabric sample through a narrow space and measure the force exerted in the longitudinal as well transverse direction. It is expected, results from this apparatus to conform to actual values of fabric handle and give higher accuracy than that given by unidirectional force measured by Instron in the Direction of extraction.

Therefore, the objective is to fabricate an instrument to measure extraction force while extracting a fabric sample through a nozzle. The outline of the basic framework required for the operations is shown Fig 3.1 and the details of some of the important parts of the instruments are shown in the subsequent figures from Fig 3.2 to 3.12. In the Fig 3.13 a photograph of the instrument is shown. The instrument has been developed with the help of Autotest Mechanisms Pvt. Ltd., D-51, Sector-2, Noida, Uttar Pradesh (UP) – 201301.

### 3.1.1 Construction details of the instrument

As far as details of the construction is concern, it can be seen from the drawings that some of the details are already incorporated in the drawings itself. Apart from that here is the some more elaboration of the various parts in the constructions.

It can be seen that in the Fig 3.1 various parts are labeled as from 1 to 12. The Part No. 1 is base cabinet of the instrument. It consist of all the electrical connections, mother board of various modules the details of which given later on, main computer (CPU), etc.

Placement of load cell for radial force measurement was an important issue. Load cells should be placed in such a way, while extracting fabric, as mentioned above, there should be minimum influence of external force. To measure the radial force the nozzle is slit through the centre so that left and right radial force can be measured. The split nozzle is placed at the centre and supported by a cantilever mechanism. The base of that cantilever is on the top of the base cabinet as shown in the Fig 3.3. Cabinet top and vertical stand base dimensions are given in Part No. 2A which is shown in Fig 3.4. Part No. 3 is the vertical threaded bar stand base and Part No. 4 is the bolt dimension of the same. The detailed dimension of Part No 3 and 4 are given in Fig 3.5 and 3.6 respectively.

Part No. 5 is the main threaded chrome polished bar on which movable fabric holder mounted. The enlarged view with dimension of the same is given in Fig 3.7. This bar is specially designed and polished to avoid any vibration or uneven movement of the clamp. Part No. 6 is clamp holder mounting and the details of which with dimension is given in Fig 3.8. The clamp holder is shown in Part No. 7 and the enlarge view of the same is shown in Fig 3.9. Part no. 8 is the cantilever support for the clamp as shown in Fig 3.10. Part No. 9 is the side support of the clamp and the same is shown in details in Fig 3.11. Part No. 10 is the vertical support stand. Part No. 11 is the computer display unit mounting base and is shown in detail in Fig 3.12.

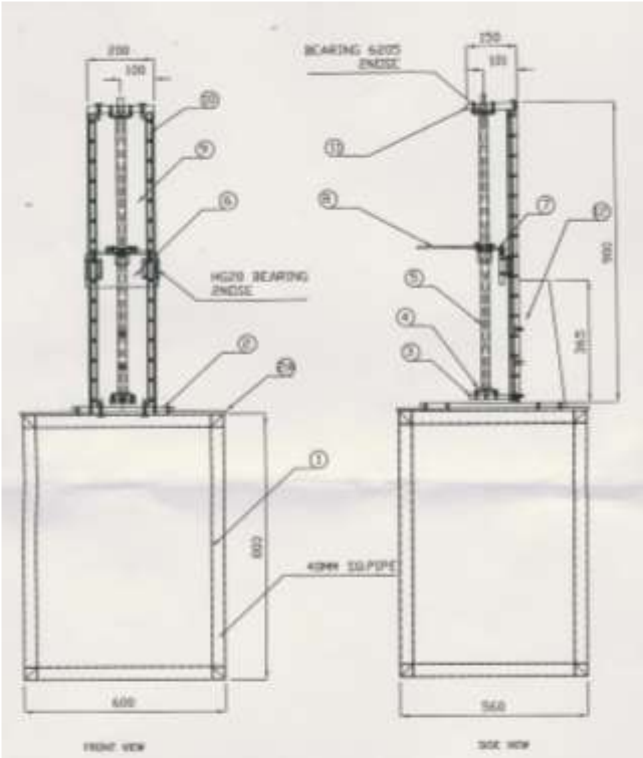


**Fig 3.1:** Line Diagram of the Instrument

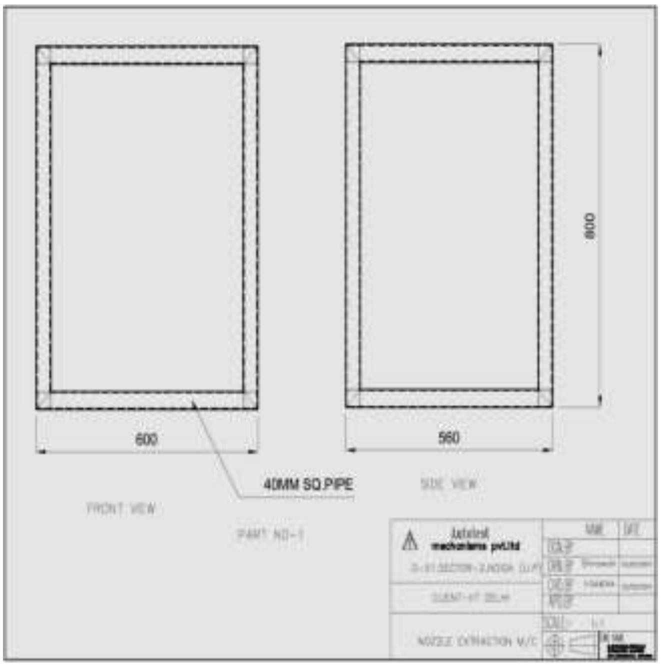


**Fig 3.2:** Base cabinet of the instrument

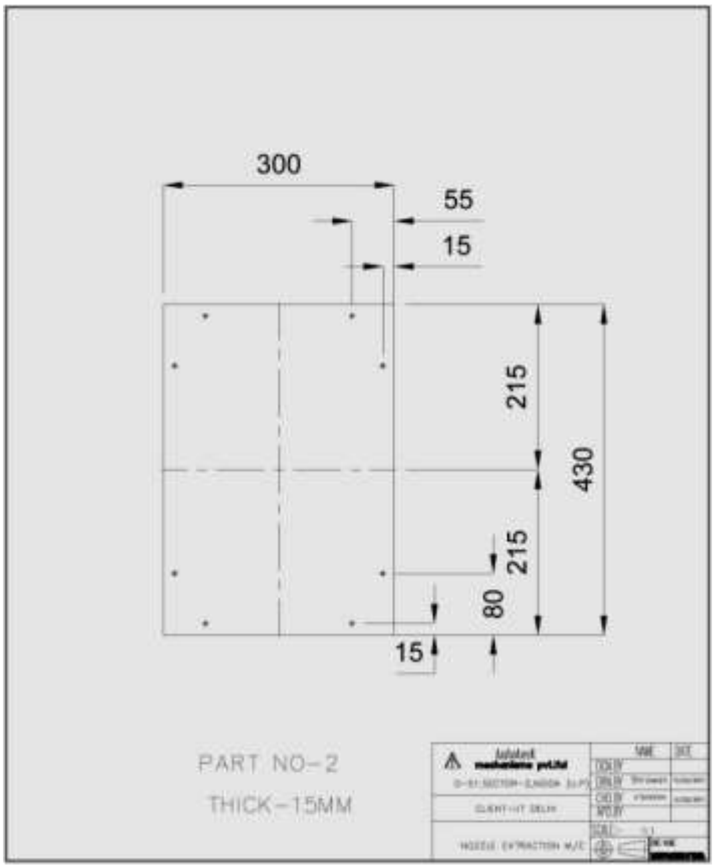


**Fig 3.3:** Load cell support base dimensions

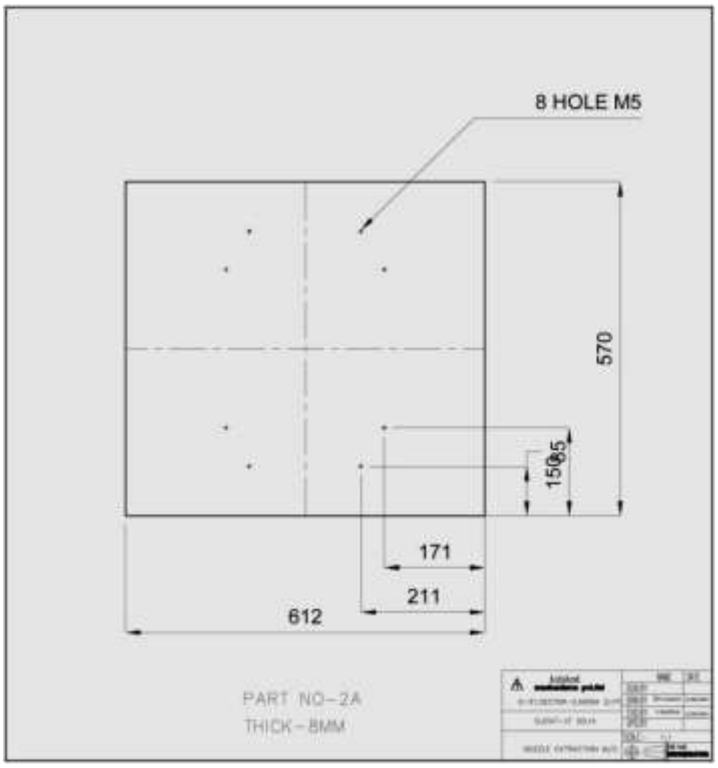


**Fig 3.4 :** Cabinet top and vertical stand base dimensions

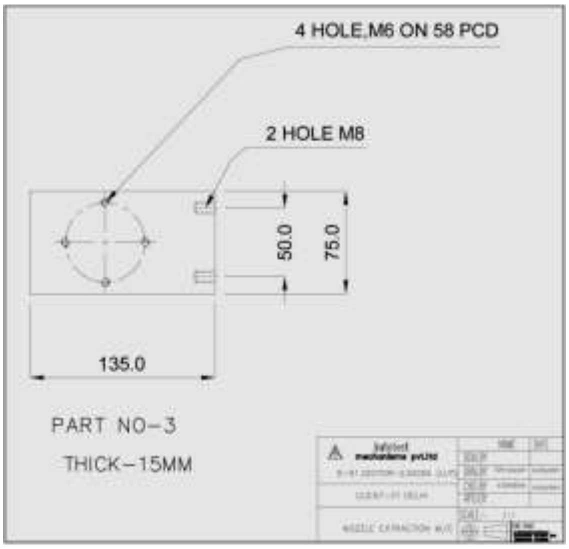


**Fig 3.5:** Vertical threaded bar stand base dimensions

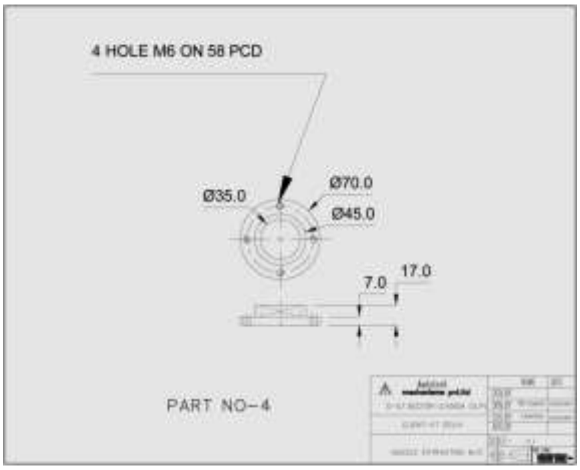


**Fig 3.6:** Vertical threaded bar stand base bolt dimensions

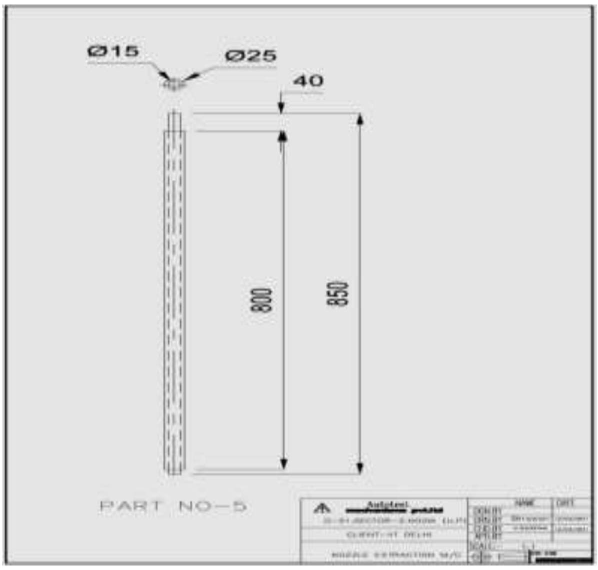


**Fig 3.7:** Threaded bar on which movable fabric holder mounted

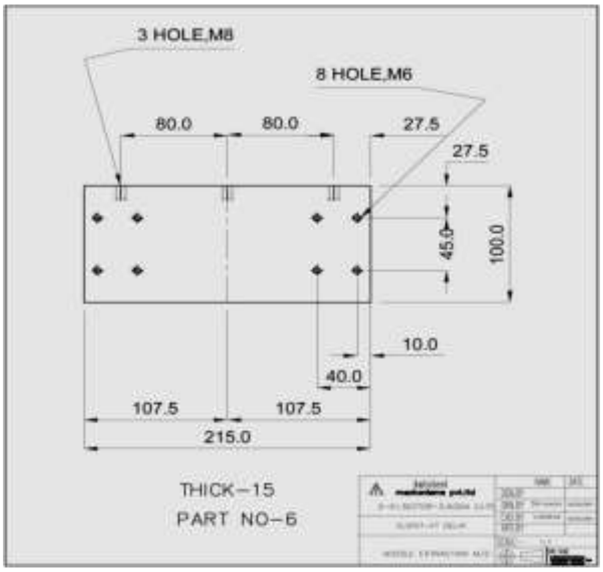


**Fig 3.8:** Clamp holder mounting dimensions

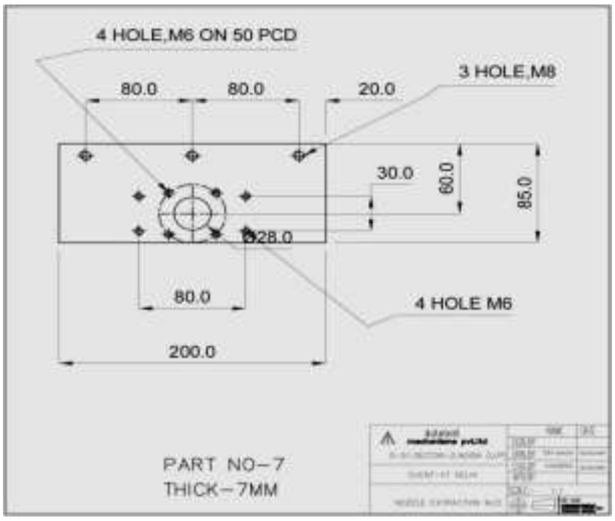


**Fig 3.9:** Clamp holder support bolt dimensions and positions

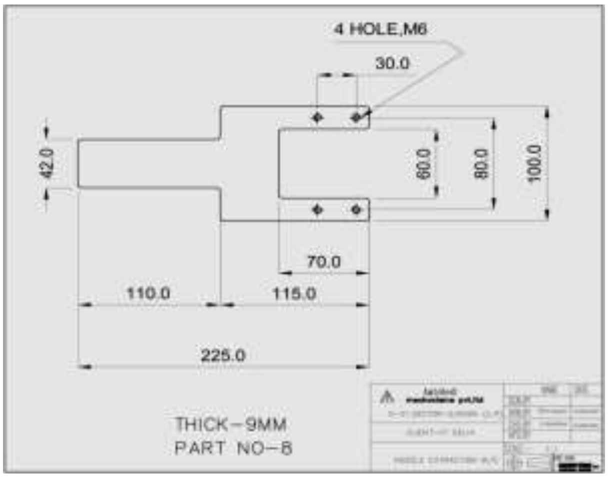


**Fig 3.10:** Cantilever support for clamp

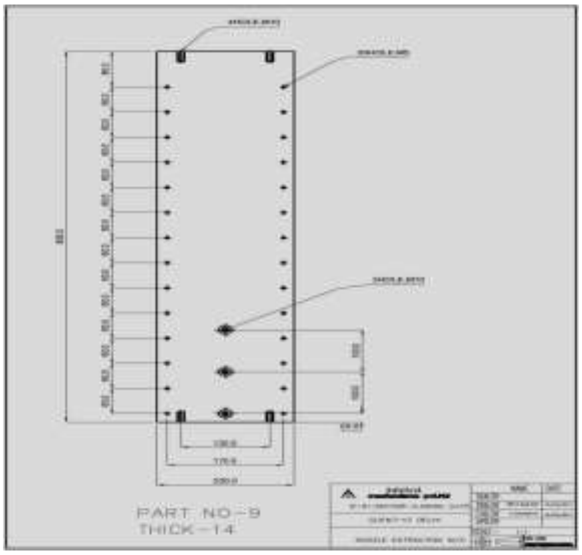


**Fig 3.11:** Side support of moving clamp

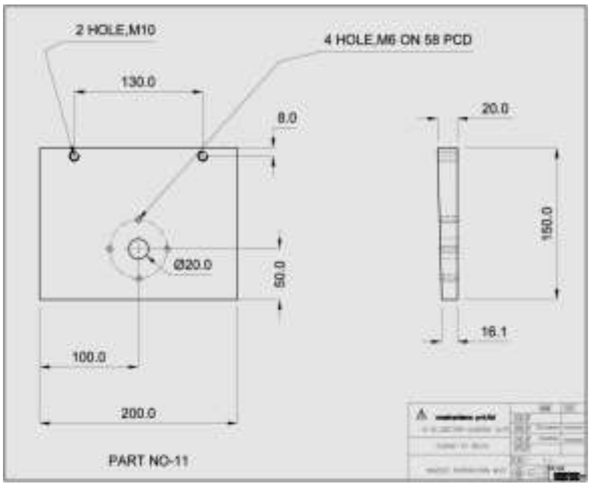


**Fig 3.12:** Computer display unit mounting

**Fig 3.13:** A photograph of the Instrument

### 3.1.2 Measurement of forces

The next task was to measure the force while it is being extracted i.e. to measure the force in two directions, one in the direction of extraction (which will give us the extraction force) and second in the radial direction i.e. the force exerted by the sample on the nozzle while it is being extracted. To measure the extraction force, a load cell above the clamp is attached, bolting the clamp on its one side and the moving panel on the other. So as drive moves the panel in the upward direction, the load cell, attached to the clamp moves up and the fabric while being extracted exerts a pull force on the clamp. This force is captured by the load cell attached to the clamp and we are thus able to measure the extraction force as given in Fig 3.14.

**Fig 3.14:** Load cell attached to clamp

To measure the radial force exerted on the nozzle by the fabric, a split nozzle is designed. To make this nozzle, a steel square block is used and a nozzle is prepared and then split it into exactly two halves. Designing of the nozzle was a big task. Nozzle should be such that it will have minimum interference of external force. Also it was kept in mind that throughout the movement of the fabric through the nozzle also there should be minimum interference of any external force or obstruction.

### 3.1.3 Designing of Nozzle

It can be seen from the design that the dimension of the nozzle is decided to get the uniform bending of 60° covering the full radius of a circle i.e. 360°. To study the effect of diameter it was decided to construct nozzle with different diameters. It was also thought of that for various nozzles the fundamental principle and type of bending should be kept constant. Therefore as mentioned above about the initial bending at the bottom of nozzle at 60°, the bottom opening i.e. diameter at the bottom of the nozzle kept constant at 60mm for all the nozzles, whereas the top diameter from where the final exit of the fabric takes place varied from 20mm to 30mm at an interval of 5mm. Dimensions of the nozzles are given in the Fig 3.15 to 3.17. All the nozzles were made up of stainless steel and chrome plated to minimize the frictional force between the fabric and the metal while it is being extracted. It was also thought of to study the effect of surface characteristics on fabric one nozzle is manufactured of nylon and another nozzle is made up of stainless steel with corrugated surface.

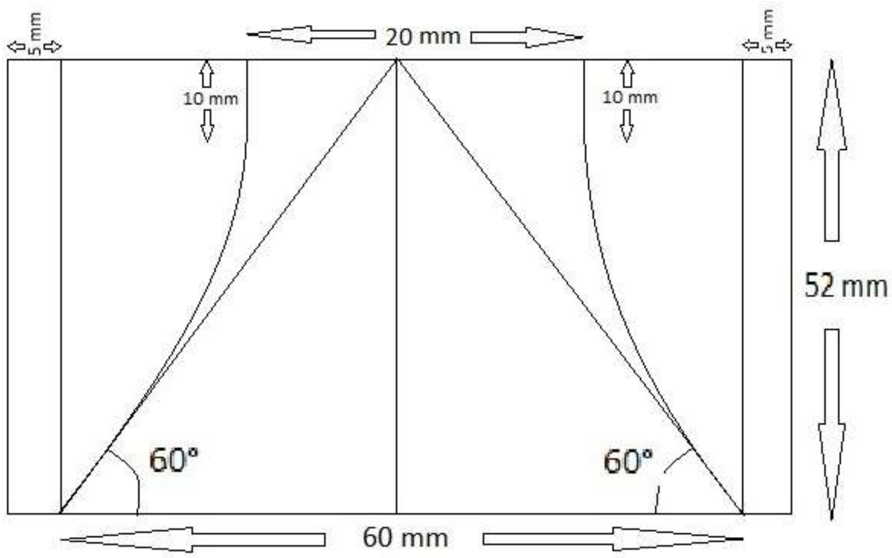


**Fig 3.15:** Nozzle with 20 mm top diameter

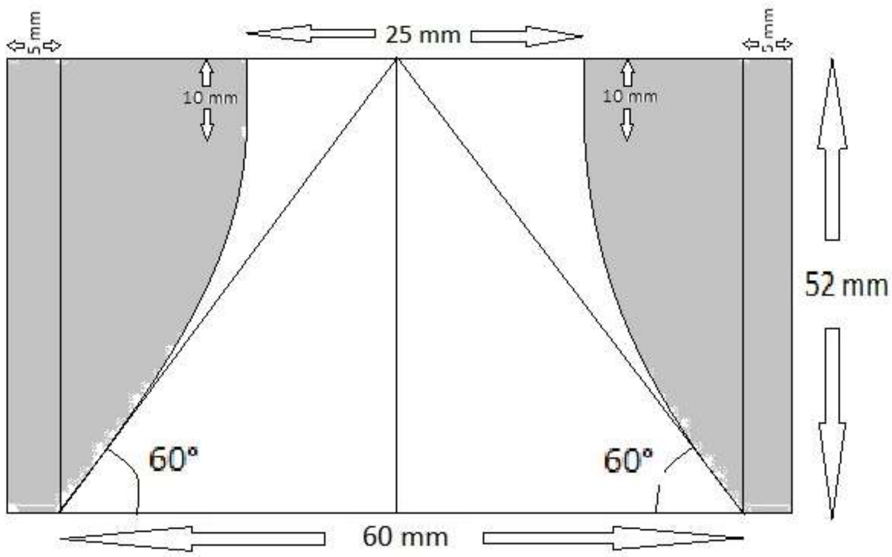


**Fig 3.16:** Nozzle with 25 mm top diameter

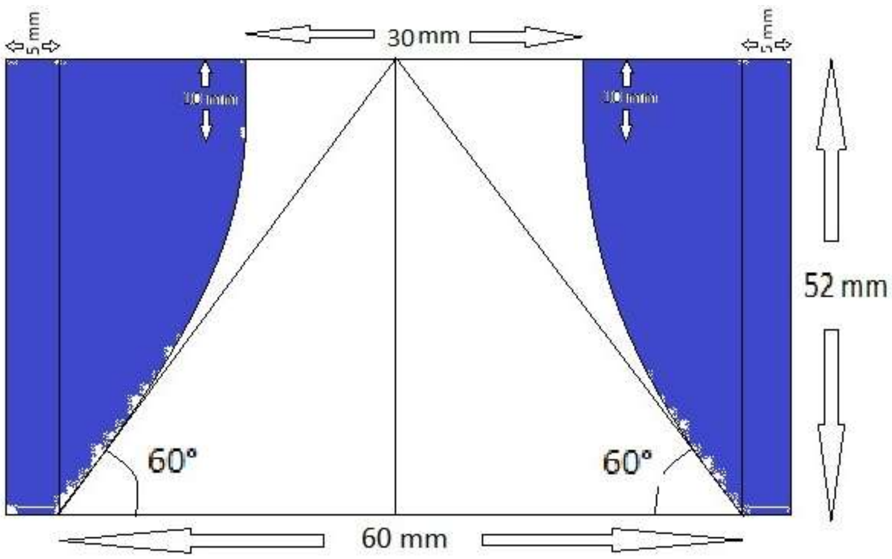


**Fig 3.17:** Nozzle with 30 mm top diameter

Once the nozzle is ready with the dimensions mentioned above it was slit in to two pieces. Then these halves on the base plate is mounted with the help of a metal piece and two load cells in the cantilever arrangements as mentioned above in the instrument drawing panels. The load cells were connected to the back of these halves and the halves were mounted such that they form a closed nozzle loop when joined as seen in the sketch from Fig 3.15 to 3.17. This kind of a nozzle would provide us radial force exerted on the nozzle by the fabric in two directions, thus averaging out any variations owing to orientation of the samples while mounting. The photographs of the nozzle are given Fig 3.18 and in Fig 3.19 radial load cells mounted with nozzle are shown.

**Fig. 3.18:** Photograph of nozzle

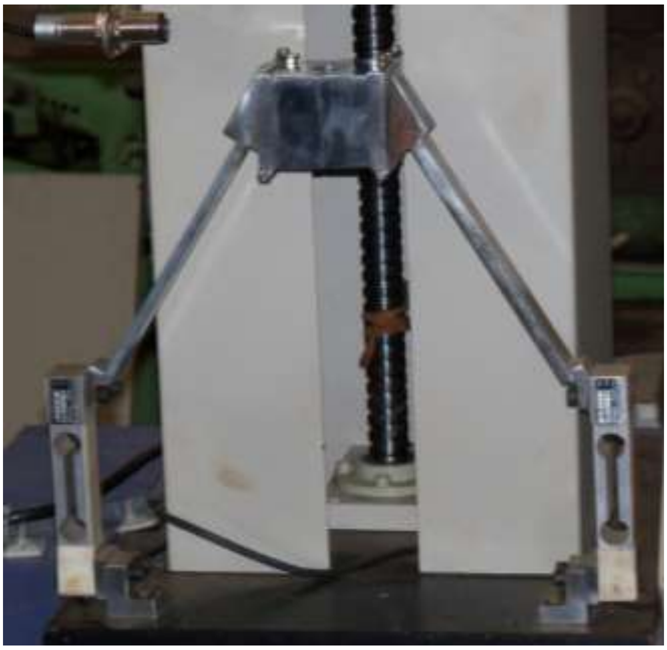

**Fig 3.19:** Radial load cells

### 3.1.4 Fabric holder design

Next very important task was to design fabric holder or clamp to hold the fabric pull out through the nozzle. The considerations was that the holder should be such that it will have minimum impact on three dimensional deformation of fabric while passing through the nozzle, at the same time there should not be any slippage throughout the test conducted. If there is any slippage during the test it will be a disastrous. Based on these considerations few designs were thought off, trials were carried out and arrived at the final design as shown in the Figure 3.20.

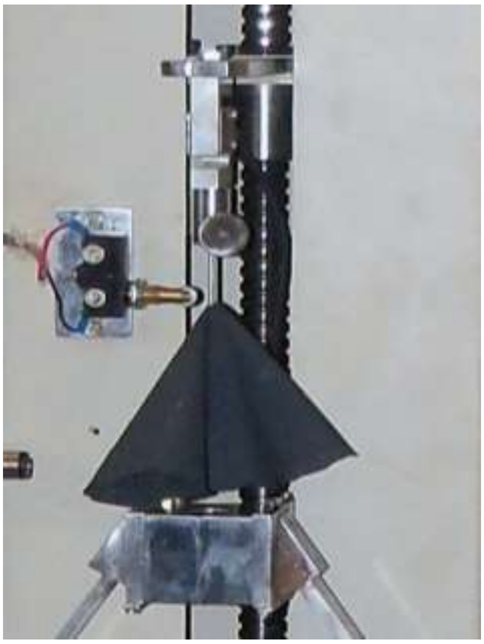

**Fig 3.20:** Fabric holder

### 3.1.5 Traverse by Servo Motor

Estimation of required traverse and the rate of traverse of the clamp are very important in this context. Initially it was proposed to use of pneumatic cylinders for the movement of the clamps, but faced with certain shortcomings of the pneumatic cylinder. It was not possible to regulate the speed with which the clamp would move while extracting the fabric from the nozzle. This was essential for the design, as it was preferred having a design that would have the liberty to change the extraction speed thus open another window of correlating the extraction forces at various speeds with the other properties of the fabric. Therefore, switched to another system and finally the mechanism adopted was a gear drive motor which moves the clamp up and down, along a guide, which is held by two C channels on both sides to prevent any alignment issues as shown in Fig 3.21. With the gear motor drive, it was possible to regulate the speed of the clamp, ranging from 1mm/min to 200mm/min, thus lining up another variable which can be varied to check for optimum correlation as shown in Fig 3.21.

**Fig 3.21:** Servo motor

### 3.1.6 LabJack device for data management

The next task was to convert the analog signal generated by the load cells to a digital from. LabJack device, model U3-HV used for this purpose. Fundamentally, it is a process of converting analog signal to electrical signal and then electrical signal to digital form by an analog to digital card. Therefore, in the whole process power supply is very important. Any small amount of power fluctuation will give error in reading. As envisage it was found that when the power supply was given from an ordinary line conditioner there is lot of spikes in the load cell reading. Therefore, a suitable high quality switched-mode power supply (SMPS) had to arrange to overcome the problem.

LabJacks are USB/Ethernet based measurement and automation devices which provide analog inputs/outputs, digital inputs/outputs, and more. They serve as an inexpensive and easy to use interface between computers and the physical world. Read the output of sensors which measure voltage, current, power, temperature, humidity, wind speed, force, pressure, strain, acceleration, RPM, light intensity, sound intensity, gas concentration, position, and many more. A LabJack brings this data into a PC where it can be stored and processed as desired. Control things like motors, lights, solenoids, relays, valves, and more.

In this case the load cells used are of beam type. Generally a load cell is a transducer that is used to convert a force into electrical signal. This conversion is indirect and happens in two stages. Through a mechanical arrangement, the force being sensed by way of deforms of a strain gauge. The strain gauge measures the deformation (strain) as an electrical signal, because the strain changes the effective electrical resistance of the wire. A load cell usually consists of four strain gauges in a Wheatstone bridge configuration. Load cells of one strain gauge (quarter bridge) or two strain gauges (half bridge) are also available. The electrical signal output is typically in the order of a few millivolts and requires amplification by an instrumentation amplifier before it can be used. The output of the transducer is plugged into an algorithm to calculate the force applied to the transducer. The LabJack module is used to manage all this input/output signals.

There are different data acquisition modules of LabJack like U3, U6, UE9, U12 are available. Initially U12 was tried and later on upgraded with U3 module with high voltage option. The U3 is newer than the U12, and in general is faster, more flexible, and less expensive. The U3 is about half the size of the U12. The enclosure can be mounted using a couple screws or DIN rail, whereas the U12 enclosure has no mounting options. Command/response functions on the U3 are typically 5-20 times faster than on the U12. The U3 has up to 16 analog inputs compared to 8 on the U12. Any channel can be measured differentially versus any other channel. Accuracy specs are better than the U12.

The U3-LV has single-ended ranges of 0-2.4 or 0-3.6 volts, and a differential range of ±2.4 volts (pseudobipolar only). The U3-HV has 12 flexible I/O capable of those same low-voltage ranges, and 4 high-voltage analog inputs with a range of ±10 volts or -10/+20 volts. The U12 has a ±10 volt single-ended input range, and differential input ranges varying from ±20 volts to ±1 volt (all true bipolar). The circuitry used by the U12 to provide those high bipolar ranges is simple and inexpensive, but has drawbacks including relatively poor input impedance and errors which are different on every channel. There are many devices on the market now that have copied the same circuitry from the U12 and have the same drawbacks.

The U3 supports input streaming with a max rate of up to 50,000 samples/second, compared to 1200 samples/second for the U12. The U3 achieves the full 12-bit resolution up to 2500 samples/second, and then as speed increases the effective resolution drops to about 10 bits due to noise. The U3 has two 10-bit digital to analog convertors (DAC) as does the U12. The DACs on the U3 are derived from a regulated voltage, whereas the U12 DACs are derived from the power supply, so the U3 DACs will be more stable. The digital I/O on the U3 use 3.3 volt logic, and are 5 volt tolerant. The U12 has 5 volt logic.

The U3 can have up to 2 timers and 2 counters. The timers have various functionality including period timing, duty cycle timing, quadrature input, pulse counting, or pulse-width modulation (PWM) output. The U12 has 1 counter and no timers. The U3 has master support for serial peripheral interface (SPI), inter-integrated circuit known as I2C, and asynchronous serial protocols. The U12 does not support I2C, but does have some SPI and asynchronous support.

The U3 is supported on Windows, Linux, Mac OS X, and PocketPC. The U12 has full support for Windows, limited support for Linux, and limited public support for the Mac. On Windows, the U3 uses the flexible driver which also works with the UE9. There is a specific separate driver for the U12. Some of the exclusive special features of U3 are listed below.

**Features of LV (Low-Voltage) Version:**

- 16 Flexible I/O (Digital Input, Digital Output, or Analog Input)
- Up to 2 Timers (Pulse Timing, PWM Output, Quadrature Input, ...)
- Up to 2 Counters (32-Bits Each)
- 4 Additional Digital I/O

- Up to 16 12-bit Analog Inputs (0-2.4 V or 0-3.6 V, SE or Diff.)
- 2 Analog Outputs (10-Bit, 0-5 volts)
- Supports SPI, I2C, and Asynchronous Serial Protocols (Master Only)
- Supports Software or Hardware Timed Acquisition
- Maximum Input Stream Rate of 2.5-50 kHz (Depending on Resolution)
- Capable of Command/Response Times Less Than 1 Millisecond
- Built-In Screw Terminals for Some Signals
- OEM Version Available
- USB 2.0/1.1 Full Speed Interface
- Powered by USB Cable
- Drivers Available for Windows, Linux, Mac and Pocket PC
- Examples Available for C/C++, VB, LabVIEW, Java, and More
- Includes USB Cable and Screwdriver
- Free Firmware Upgrades
- Enclosure Size Approximately 3" x 4.5" x 1.2" (75mm x 115mm x 30mm)
- Rated for Industrial Temperature Range (-40 to +85 Degrees C)

**Differences with the HV (High-Voltage) Version:**

- ✓ First 4 Flexible I/O are Changed to Dedicated HV Analog Inputs.
- ✓ 4 HV Inputs have ±10 Volt or -10/+20 Volt Range.
- ✓ 12 LV Inputs (Flexible I/O) Still Available, for 16 Total Analog Inputs.

**Flexible I/O:**

The first 16 I/O lines (FIO and EIO ports) on the LabJack U3-LV can be individually configured as digital input, digital output, or analog input. In addition, up to 2 of these lines can be configured as timers, and up to 2 of these lines can be configured as counters. On the U3-HV, the first 4 flexible I/O are replaced with dedicated high-voltage analog inputs.

The first 8 flexible I/O lines (FIO0-FIO7) appear on built-in screw terminals. The other 8 flexible I/O lines (EIO0-EIO7) are available on the DB15 connector.

**Analog Inputs:**

The LabJack U3 has up to 16 analog inputs available on the flexible I/O lines. Single-ended measurements can be taken of any line compared to ground, or differential measurements can be taken of any line to any other line.

Analog input resolution is 12-bits. The range of single-ended low-voltage analog inputs on the U3-LV is typically 0-2.4 volts or 0-3.6 volts, and the range of differential analog inputs is typically ±2.4 volts (pseudobipolar only). For valid measurements, the voltage on every analog input pin, with respect to ground, must be within -0.3 to +3.6 volts.

On the U3-HV, the first 4 flexible I/O are replaced with dedicated high-voltage analog inputs. The input range of these channels is ±10 volts or -10/+20 volts. The remaining 12 flexible I/O are still available as described above, so the U3-HV has 4 high-voltage analog inputs and up to 12 low-voltage analog inputs.

Command/response (software timed) analog input reads typically take 0.6-4.0 ms depending on number of channels and communication configuration. Hardware timed input streaming has a maximum rate that varies with resolution from 2.5 ksamples/s at 12-bits to 50 ksamples/s at about 10-bits.

**Analog Outputs:**

The LabJack U3 has 2 analog outputs (DAC0 and DAC1) that are available on the screw terminals. Each analog output can be set to a voltage between 0 and 5 volts with 10-bits of resolution.

The analog outputs are updated in command/response mode, with a typical update time of 0.6-4.0 ms depending on communication configuration. The analog outputs have filters with a 3 dB cutoff around 16 Hz, limiting the frequency of output waveforms to less than that.

**Digital I/O:**

The LabJack U3 has up to 20 digital I/O channels. 16 are available from the flexible I/O lines, and 4 dedicated digital I/O (CIO0-CIO3) are available on the DB15 connector. Each digital line can be individually configured as input, output-high, or output-low. The digital I/O use 3.3 volt logic and are 5 volt tolerant.

Command/response (software timed) reads/writes typically take 0.6-4.0 ms depending on communication configuration. The first 16 digital inputs can also be read in a hardware timed input stream where all 16 inputs count as a single stream channel.

**Timers:**

Up to 2 flexible I/O lines can be configured as timers. The timers are very flexible, providing options such as PWM output, pulse/period timing, pulse counting, and quadrature input.

**Counters:**

Up to 2 flexible I/O lines can be configured as 32-bit counters.

**I/O Protection:**

All I/O lines on the U3 are protected against minor over voltages. The FIO lines can withstand continuous voltages of up to ±10 volts, while the EIO/CIO lines withstand continuous voltages of up to ±6 volts.

**High Channel Count Applications:**

By using USB hubs, many LabJacks can be interfaced to a single PC, providing an inexpensive solution for high channel count applications.

**OEM Version:**

The U3-LV-OEM or U3-HV-OEM includes the board only without the enclosure and without most through-hole components. See Section 2.12 of the U3 User's Guide for more information.

### 3.1.7 Electrical interface of the instrument

The electrical interfaces diagrams of the instrument with LabJack are shown in the following Fig 3.22 to 3.25 as mentioned above. The input output voltage ranges also shown in the said diagrams. Also power factors are mentioned in many places as required.

The details of electrical diagrams are shown in Fig 3.22 to 3.25. In the subsequent three figures i.e. Fig 3.26, 3.27 & 3.28 actual photographs of main board, LabJack U3-HV and A2D card interface with LabJack respectively are shown.

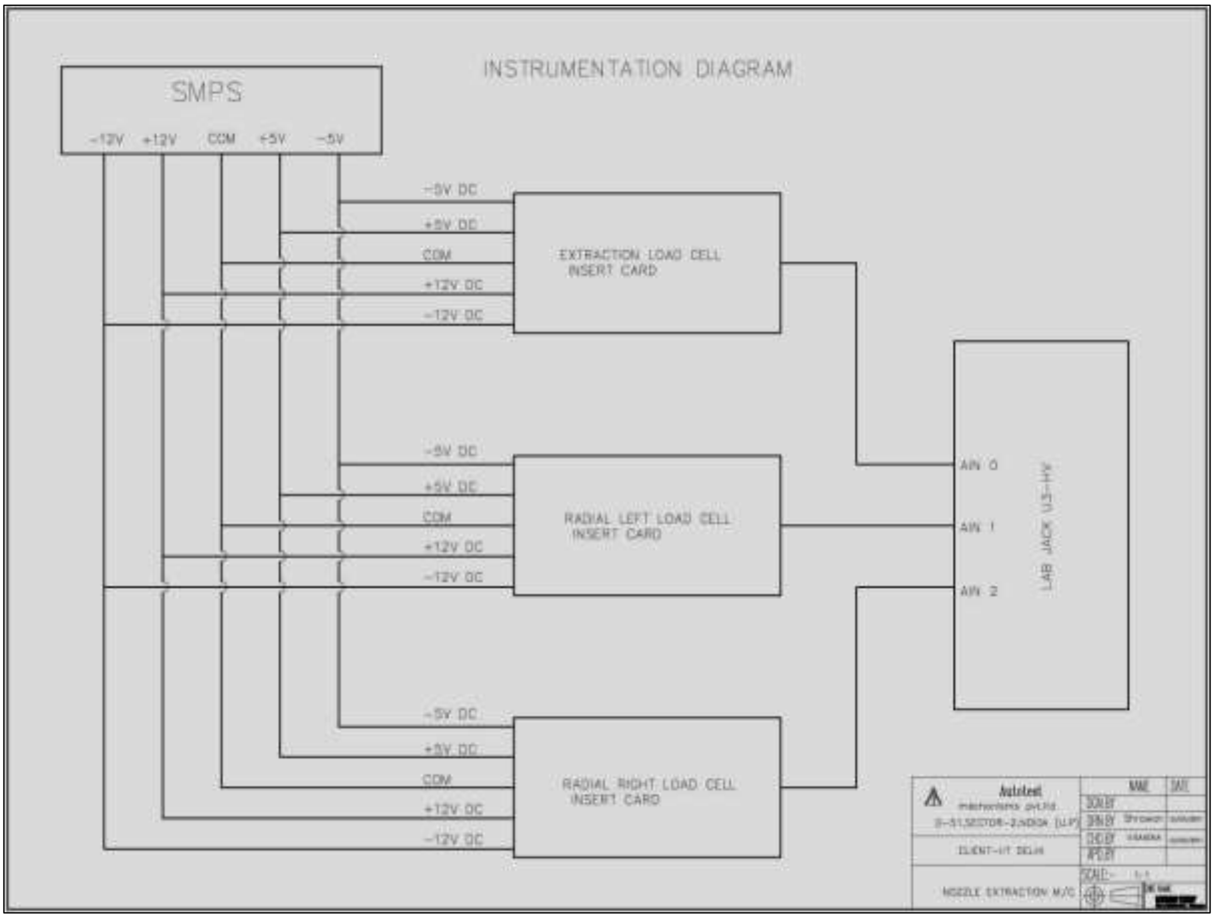


**Fig 3.22:** Complete electrical interface diagram

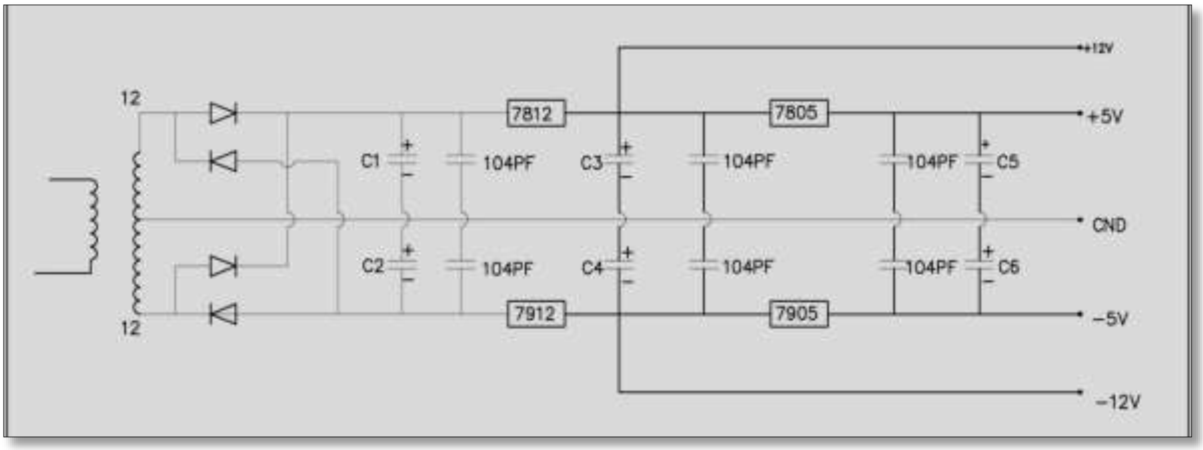


**Fig 3.23:** Electrical diagram for SMPS power distribution

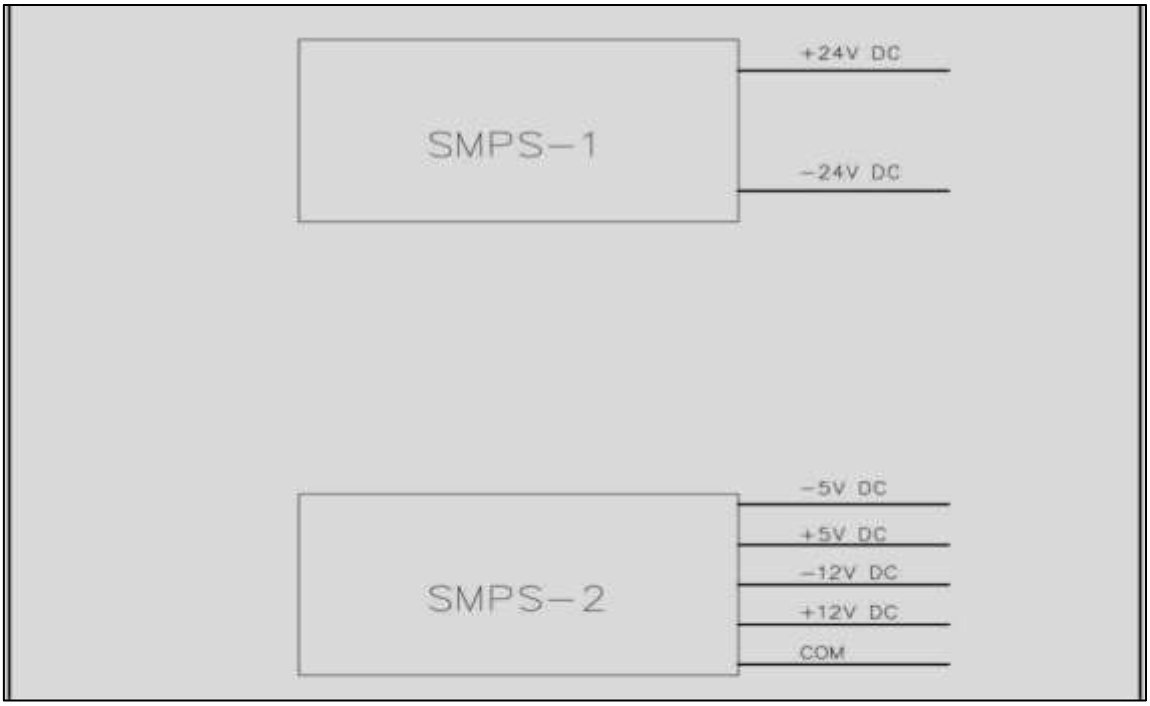


**Fig 3.24:** Electrical diagram for SMPS power input/output

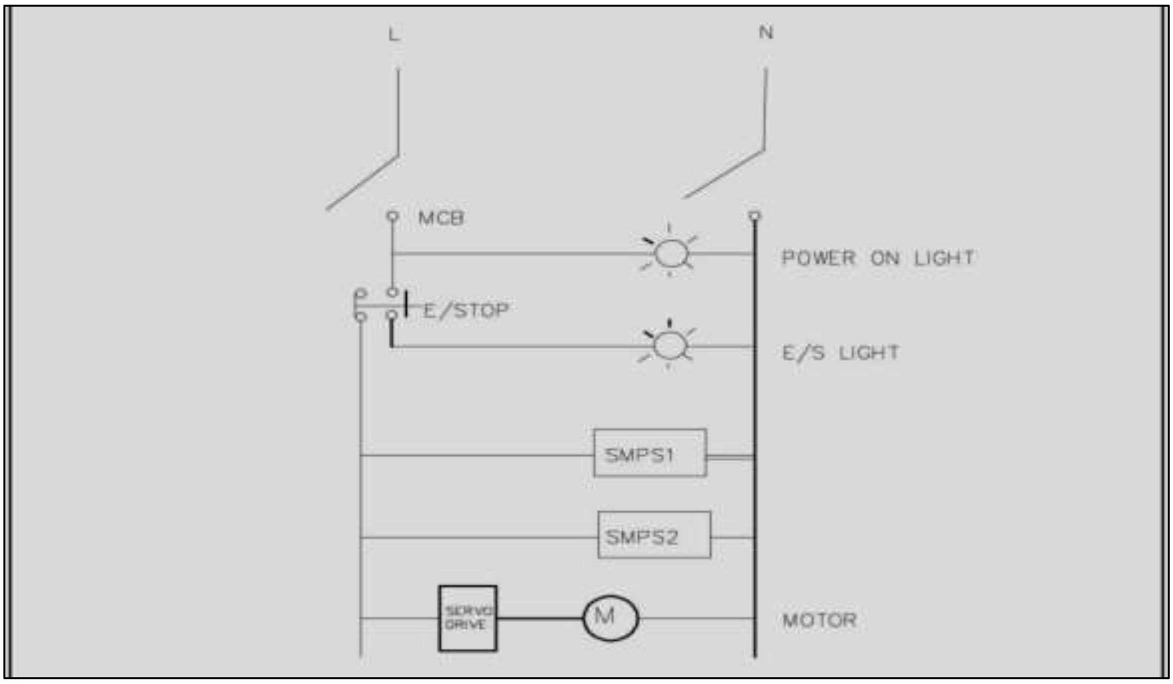


**Fig 3.25:** Electrical diagram for power system

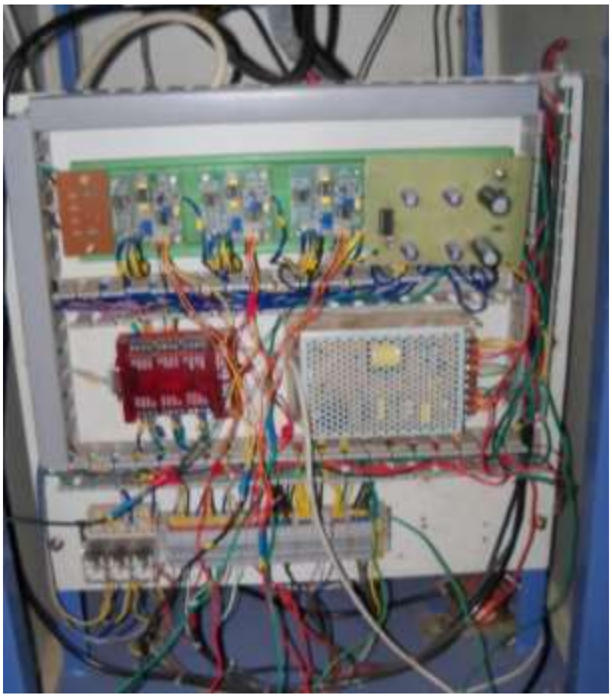

**Fig 3.26:** Main board connections

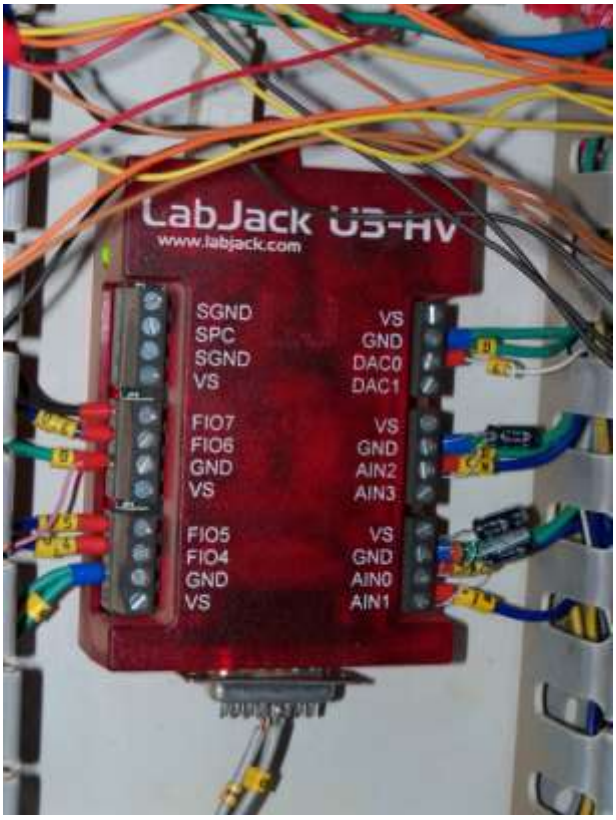


**Fig 3.27:** LabJack U3-HV

**Fig 3.28:** Analog to digital card interface with LabJack

Instrument has been designed so that all the function and operations are controlled through commands from a computer. The computer interface is simple yet effective in fulfilling all the basic requirements of our testing and validation procedure. The user interface has been designed in Visual Basic and the functions incorporated in such a way it becomes user friendly. As the start button is pressed, the system would ask for the extraction speed and the test time would like to put. But as such the last data fed is automatically stored in the memory. Therefore, if one needs to continue with the same data it will be savings of time. All this options are programmable in the visual basic program easily.

The output format and the samples of testing are also programmable. All the data is also stored in a data sheet (Microsoft Excel) automatically. Therefore, one can use the data later on as required. The only hitch in this aspect is the data sheet records the data in cumulative fashion. The latest test data is just appended at the bottom of the last data, so one has to be very careful about the corresponding test data.

The platform i.e. operating system compatibility of the system is also wonderful. It supports Windows, Linux, Mac OS X, and PocketPC. In this case the instrument have been connected a dedicated standby desktop personal computer with windows platform for hassle free operations.

One of the typical actual command prompt menus is shown hereunder in the Fig 3.29. It can be seen that the command prompt has many user interface options like opening an existing file, print a file, saving of the current test results, taking down the jaw, starting of the test, stopping it manually if required, etc icons.

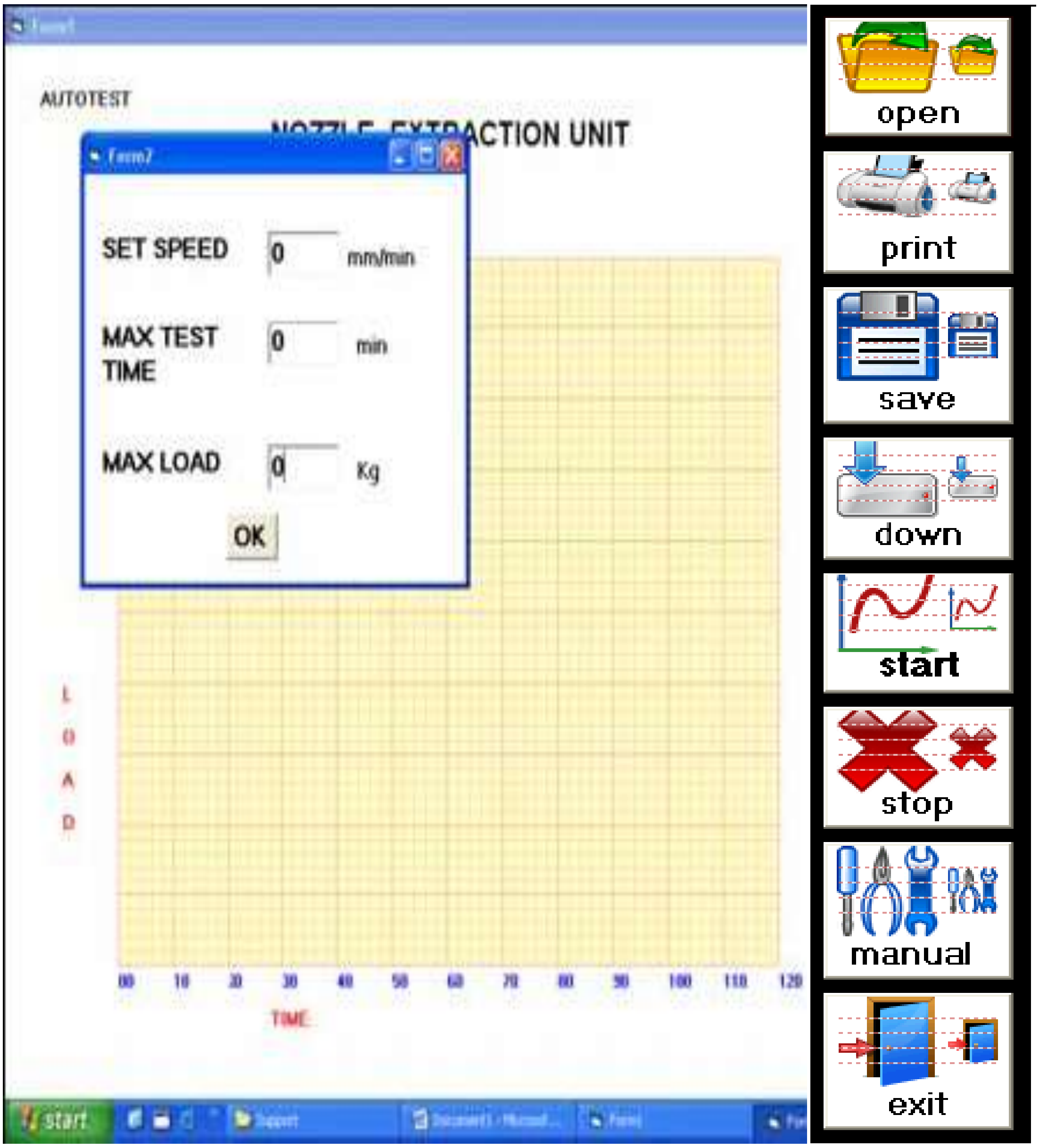


**Fig 3.29:** Dialog box with command prompt

As mentioned above the default menu option saves the last data fed automatically. If one wants to change the data it can be done. Once feeding these variables is done, the test would start on clicking the start button or icon and the clamp would start moving upward. As it does so, the three load cells measure the force being exerted upon their respective parts and is thus taken by the software. These values are then used to plot individual graphs i.e. force exerted vs. time.

Thus, three different graphs for three different load cells are obtained, which are given different colour coding so as to assist in identification of different forces as given in Fig 3.30.

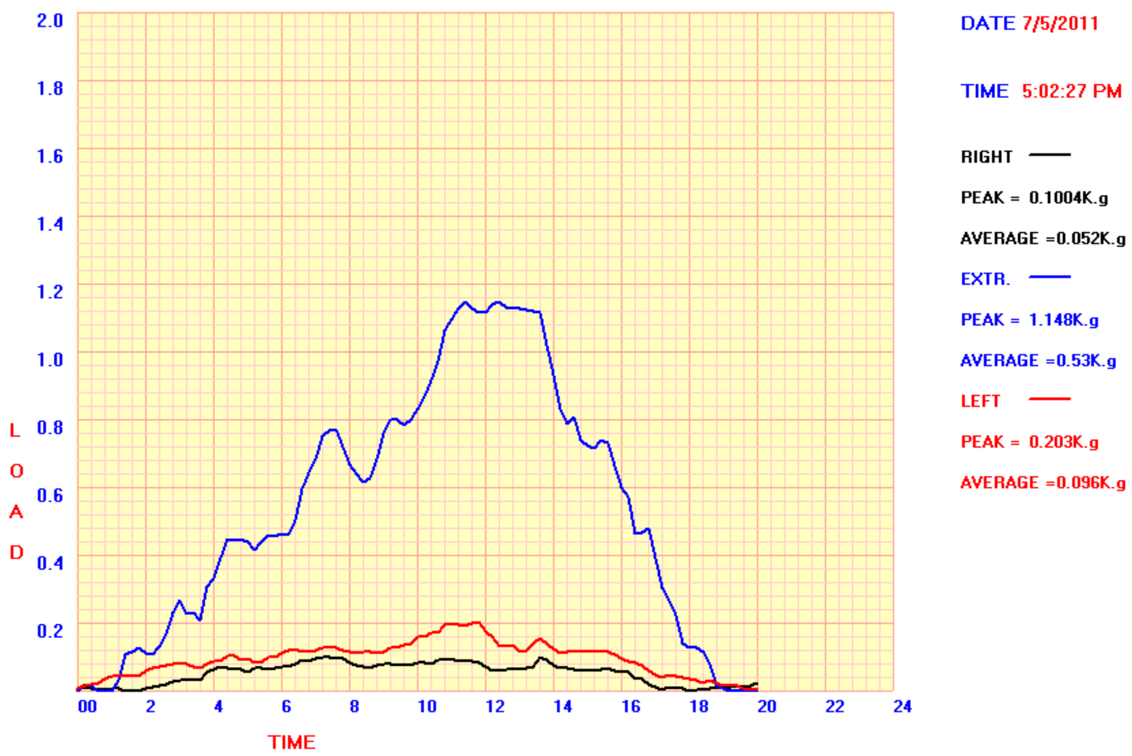


**Fig 3.30:** Output Graph

## 3.2 Phase 2: Technology Transfer of the Nozzle Extraction Instrument for Commercial Production of the Instrument

Technology transfer and commercial production is an integrated part of any research and development; so is here. A workshop was conducted at IIT, Delhi on Dec. 3, 2011 for the awareness of the new development of the instrument. The newly developed instrument was named as **'IITD Fabric Feel Tester'**. The purpose of the instrument was highlighted as to measure the fabric feel directly from one test. Therefore, in Indian Diaspora first time an indigenously developed instrument was presented in an open platform to evaluate by the various experts in the industry. If not exaggerated, there was overwhelming response from the various stakeholders.

After due discussions and negotiations with the instrument manufacturer and administrative authority from IIT, Delhi; licensee to manufacture the instrument was given to Texlab Industries Ltd, Ahmedabad, Gujarat. The success of any technology depends on its techno-economic parameters. Therefore, during the first commercial development, primary focus was given to the cost aspect.

The LabJack that were used initially was replaced by indigenously manufactured card locally with open source data acquisition software system MODBUS. A photograph of the developed instrument is shown in Fig 3.31


**Fig 3.31:** IITD Fabric Feel Tester

### 3.2.1 ITME Exhibition and media attention

The development of the new instrument was exhibited in India ITME 2012. There was overwhelming response among the various stakeholders viz fabric manufacturer/ weaving industries, dyeing & finishing industries, garment manufacturing industries, testing laboratories as well as academic and research institutes. The India ITME exhibition brief coverage of the same is given in Annexure-I.

### 3.2.2 Latest development of the instrument

At this juncture it is worth to do brief comparison of the IITD Fabric Feel Tester and the instrument developed during basic research and development stage. It can seen from the photograph of the instrument from the Fig 3.31 and Fig 3.13 respectively that the IITD Fabric Feel Tester is much more compact, require very less space and a perfect table top instrument. This was possible due to series of discussions and brain storming with the technicians at Texlab, Ahmedabad. Te placement of the data acquisition card, servo motor and the relevant parts of the instrument has been done beautifully to save the space without compromising the functioning of the instrument. A glimpse of the placement of the abovementioned parts can be seen from the following Fig. 3.32.

**Fig 3.32(a):** An overview of placement of parts for IITD Fabric Feel Tester

**Fig 3.32(b):** A close view of placement of parts for IITD Fabric Feel Tester

The other difference is that most of the costly parts Labjack, analog to digital card, power supply etc. have been replaced and made it economical. Approximately the said instrument price tag is below 2 lacs, which is very much lucrative in Indian industries perspective.

At the end of this chapter here is some information on latest development which is in the pipe line.

It has been observed that due to the various operative conditions; the indigenously developed data acquisition card and the open source MODBUS software demand frequent attention. Hence maintenance of the instrument is an issue. To overcome the same we are trying to replace the MODBUS with powerful SCADA (Supervisory Control and Data Acquisition) system for robust functioning of the instrument.

Looking in to the present day scenario, Android based application interface is also under considerations. In due course of the time appropriate decision will be taken based on the techno-economic viability