DEVELOPMENT OF AN AUTOMATIC MULTIPLE FERTILIZER MIXING MACHINE

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Abstract: The main aim of the project is to design and develop an automatic fertilizer mixing machine to mix multiple proportion of fertilizers and form a complex fertilizer at different variance of NPK ratios. The project is initiated to solve the issue by designing a hopper to store fertilizer and load cell as a weighing measurement system to analyze the weight in the hopper as from the microcontroller act as a automation kit to subtract load from hopper according input given from the end user of the product to develop NPK ratios and rotary mixer is used to mix the three different types of fertilizers to form NPK at standard ratios. The Average time to produce the complex fertilizer is 145 seconds according to the test results and maximum average load produced by the machine is 9kg.

Index Terms **– NPK Ratio, Load Cell, Hopper Designing, Agricultural Machinery, Fertilizer Mixing Machine.**

1. Introduction

The Industry which is located in perudurai named as “Sree Sakthi Vinayaka Engineering Works” is to make about agricultural products like different types of cultivator, rotavator and tipping tractor, so they are willing to start a new project idea which is evolving in their village where they can make their own NPK fertilizers based on their own results found from their own soil with the soil fertility management team. The company decided to make a complex mini size fertilizer mixture machine which is about to have three different types of hopper which can carry three different types of fertilizers and rotary mixer to firmly mix the fertilizers.

It is about how to automate this total complex fertilizer mixing machine with a load measuring system, from that the team organized to match an idea which can measure the fertilizers with the amount of load it has in hopper using the load cell and also control the hopper valve system by using the microcontroller using the load cell initiated values and also the input added from the display with numerical values. Then the project is been overviewed with a greater number of literature review to overcome the problems faced in the fabrication process.

2. Objective

The main objective of the project is to make an automatic mini size fertilizer mixing machine which is used to mix the variant fertilizers to form a complex fertilizer which has standard ratios of nitrogen, phosphate, potassium.

3. Construction of complex fertilizer mixing machine

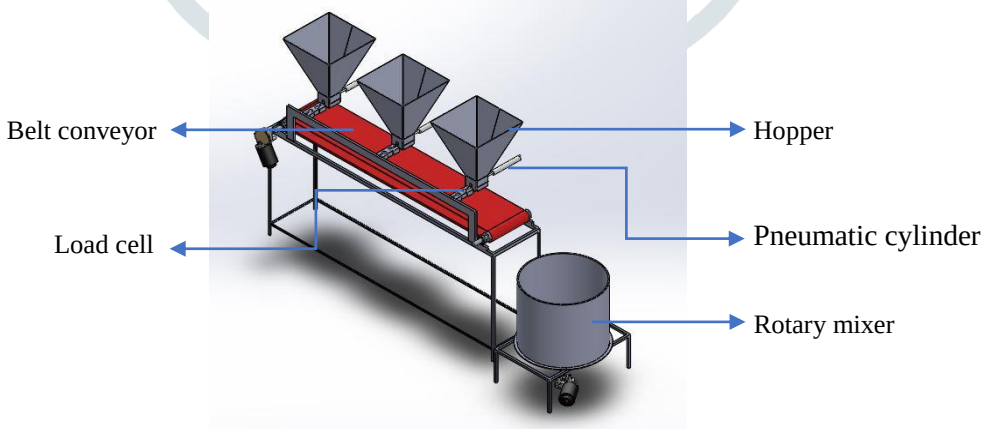

Fig.3.1. Construction of fertilizer mixing machine

The load cell is used to produce an analog signal which has properties to measure and calculate the load present on the hopper and a range to withstand 10kg of load, then the analog signal from the load cell is converted into digital signal by the A/D converter which is a weighing sensor used to calculate and evaluate the analog electric signals into a load in kgs which will be displayed in a LCD screen.

The microcontroller is used to analyze the data from weighing measurement system and from the receiver which is the input valve received from the ratios of amount of fertilizers needed, by this the microcontroller decides to open the valve by using a pneumatic actuator and ensures that how much load is discharged and again the valve is closed after the required load is attained to produce a

complex fertilizer. The conveyor is used to move the fertilizer to blender by using a rotary motor and rotary mixer is used to mix the NPK ratios to form a complex fertilizer.

3.1. Scope

The fertilizers are the additional nutrient added to the soil which stabilizes the soil fertility according to amount of which it is needed. In future the farmers can purchase the fertilizer according to their soil fertility test and add the amount of nutrients to enrich the soil and growth of plants at high production.

4. Experimental Procedure

4.1. Selection of Material

The components of complex fertilizer machine are made of two materials. They are:

1. Sheet metal.
2. Mild steel.

4.1.1. Sheet metal

Sheet metal is metal formed by an industrial process into thin, flat pieces. Sheet metal is one of the fundamental forms used in metalworking and it can be cut and bent into a variety of shapes. Countless everyday objects are fabricated from sheet metal. Thicknesses can vary significantly; extremely thin sheets are considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered plate steel or "structural steel."

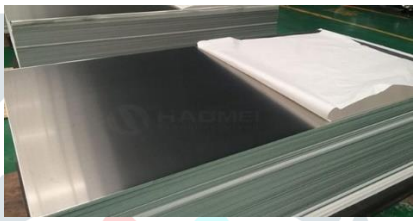

Fig.4.1. Aluminium Sheet Metal

There are many different metals that can be made into sheet metal, such as aluminium, brass, copper, steel, tin, nickel and titanium. These types of different metals differ in their properties. So, to choose a perfect sheet metal there are set of grades available which can be utilized based on the working nature of the machine. Aluminium sheet metal of grade 1100-H14 is used as a material for hopper, rotary mixer and mixer blades in complex fertilizer mixing machine due to its high chemical and weather resistant properties. It is ductile enough for deep drawing and weldable. It is commonly used in chemical processing equipment.

4.1.2. Mild steel

Mild steel also known as plain-carbon steel and low-carbon steel, is now the most common form of steel because its price is relatively low while it provides material properties that are acceptable for many applications. Mild steel contains approximately 0.05–0.25% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and easy to form.

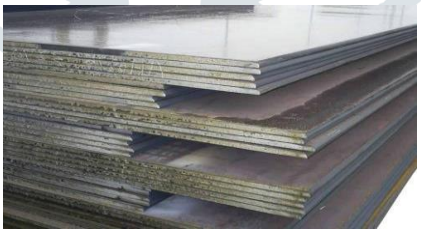

Fig.4.2. Mild Steel Plate

Less carbon means that mild steel is typically more ductile, machinable, and weldable than high carbon and other steels, however, it also means it is nearly impossible to harden and strengthen through heating and quenching. The components such as frame and base of the rotary mixer are made up of mild steel with a Composition of 0.05%-0.25%carbon and up to 0.4% manganese as it is a low-cost material that is easy to shape and it can be easily machined.

4.2. Components involved

The automatic fertilizer mixing machine consists of following parts,

1. Main Frame.
2. Actuators.
   - BLDC Motor.
   - Motor with geared control.
3. Pneumatic Cylinders.

4. Microcontroller.
5. Load Cell.
6. Weighing sensor.
7. Rotary mixer.
8. Solenoid valve.
9. Hopper Assembly.

4.2.1. Main frame

The main frame is the total setup which supports the load cell to carry the total weight of the hopper to place on it to produce a valid output. The frame also carries a conveyor with a rotary actuator placed on it, so the total frame used to support all electrical & electronics components with significant amount of space to bypass the connection without any short circuit as well as no more heat dissipation from one another. By using the design parameters and fabrication process the frame has been designed in solidworks with dimensions shown in the fig.3.15 and it is made up of mild steel with a Composition of 0.05%-0.25% carbon and up to 0.4% manganese as it is a low-cost material that is easy to shape and it can be easily machined.

4.2.2. Actuators

An actuator is a component of that is responsible for moving and controlling a mechanism or system, for example by opening a valve. In simple terms, it is a "mover".

An actuator requires a control signal and a source of energy. The control signal is relatively low energy and may be electric voltage or current, pneumatic or hydraulic pressure, or even human power. Its main energy source may be an electric current, hydraulic fluid pressure, or pneumatic pressure. When it receives a control signal, an actuator responds by converting the signal's energy into mechanical motion.

4.2.2.1. Motor with geared control

The conveyor is controlled with a wiper motor with geared connection and it is running according to the microcontroller commands which is to rotate when the load is fell into the conveyor after the hopper output valve is closed, the gear is placed to control speed according to different loads.

As we require minimum RPM to move a load with maximum of 10 kg, the wiper motor with 5volt and 60 RPM is used to move the conveyor.

4.2.2.2. Brushless DC motor

The brushless DC motor is used in rotary mixer to create a well-defined high torque against a weight ratio to mix the fertilizers. The specification of motor is 12V DC as input voltage with average speed of 1500 rpm to run a maximum load of 15kg.

4.2.3. Pneumatic cylinder

Pneumatic cylinder are mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion.

In this equipment the double acting cylinder with a maximum pressure of 10 bar is placed to control the opening and closing of the hopper valve to control the load from the hopper based on the values given to the microcontroller.

4.2.4. Microcontroller

A Microcontroller is an Integrated chip that executes programs for controlling other devices or machines. It is a micro device which is used for control of other devices and machines so why it is called 'Microcontroller'. It is having RAM, ROM and I/O ports.

The controller is the main core of this project to control the hopper valves as well as the load cell calculation it has so many inputs which are from load cell of three different hoppers and as well as from the pneumatic cylinders. Then the output will be to the conveyor, rotary mixer actuators and to pneumatic cylinder to close the valves.

4.2.5. Load cell

A load cell is a transducer that is used to create an electrical signal whose magnitude is directly proportional to the force being measured. The various load cell types include hydraulic, pneumatic, and strain gauge.

The load cell is used to generate the analog signal which is created by the load acting on it, so totally it converts analog signal into a perfect term in kg by the using the A/D converter as an additional unit to the microcontroller and to the load cell as well. The load cell used can withstand a maximum load of 10 kg.

4.2.6. Weighing sensor

The weighing sensor is an amplifier based on *HX711*, which consist of an amplifier and a precision 24-bit analog-to-digital convertor designed for weigh scale and industrial control applications to interface directly with load cell.

4.2.7. Rotary mixer

The complex fertilizers are about to mix with standard ratios of nitrogen, potassium, phosphate so this equipment need to make that as perfect, the mixer is made up of mild steel and blades are made as same as sand mixing machine in which there is a stopper at end of blades to dig up and fine the particles to mix well and a BLDC motor is tend to rotate the blade with a required torque.

4.2.8. Solenoid valve

Solenoid is the generic term for a coil of wire used as an electromagnet. The device creates a magnetic field from electric current and uses the magnetic field to create linear motion of the pneumatic cylinder. A 3/2 solenoid valve with electronic control with an input voltage of 5V is used to open and close the valves of the hopper for discharging the fertilizers.

4.2.9. Hopper assembly

The hopper is the main reservoir to store the fertilizers separately before it tends to become a complex fertilizer, so the hopper is made of some design calculations to reduce the wall friction in order to prevent the fertilizer from settling inside the hopper and it is powder coated to withstand the corrosion. The Setup has load cell, pneumatic cylinder, valves and solenoid valve.

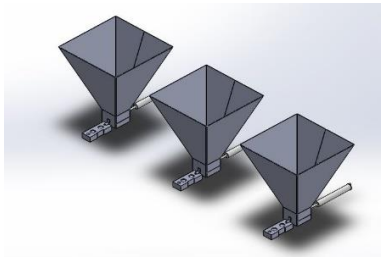

Fig.4.1. Hopper design

5. Electrical Architecture

The Architecture consists of following hardware listed below:

- PIC Microcontroller.
- LCD display.
- Load cell.
- Amplifier circuit.
- Oscillator Circuit.
- Relay driver.
- Relay.
- Keypad.
- Power Supply.

The Software used to program the PIC Microcontroller are listed below:

- MPLAB Software.
- Embedded C.

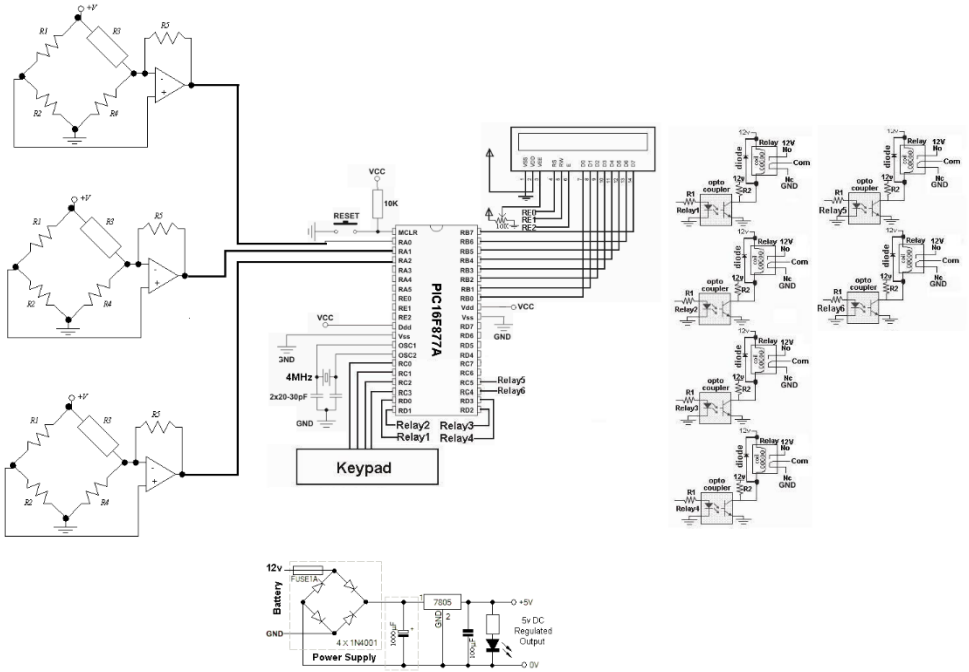

Fig 5.1. Circuit diagram of fertilizer mixing machine

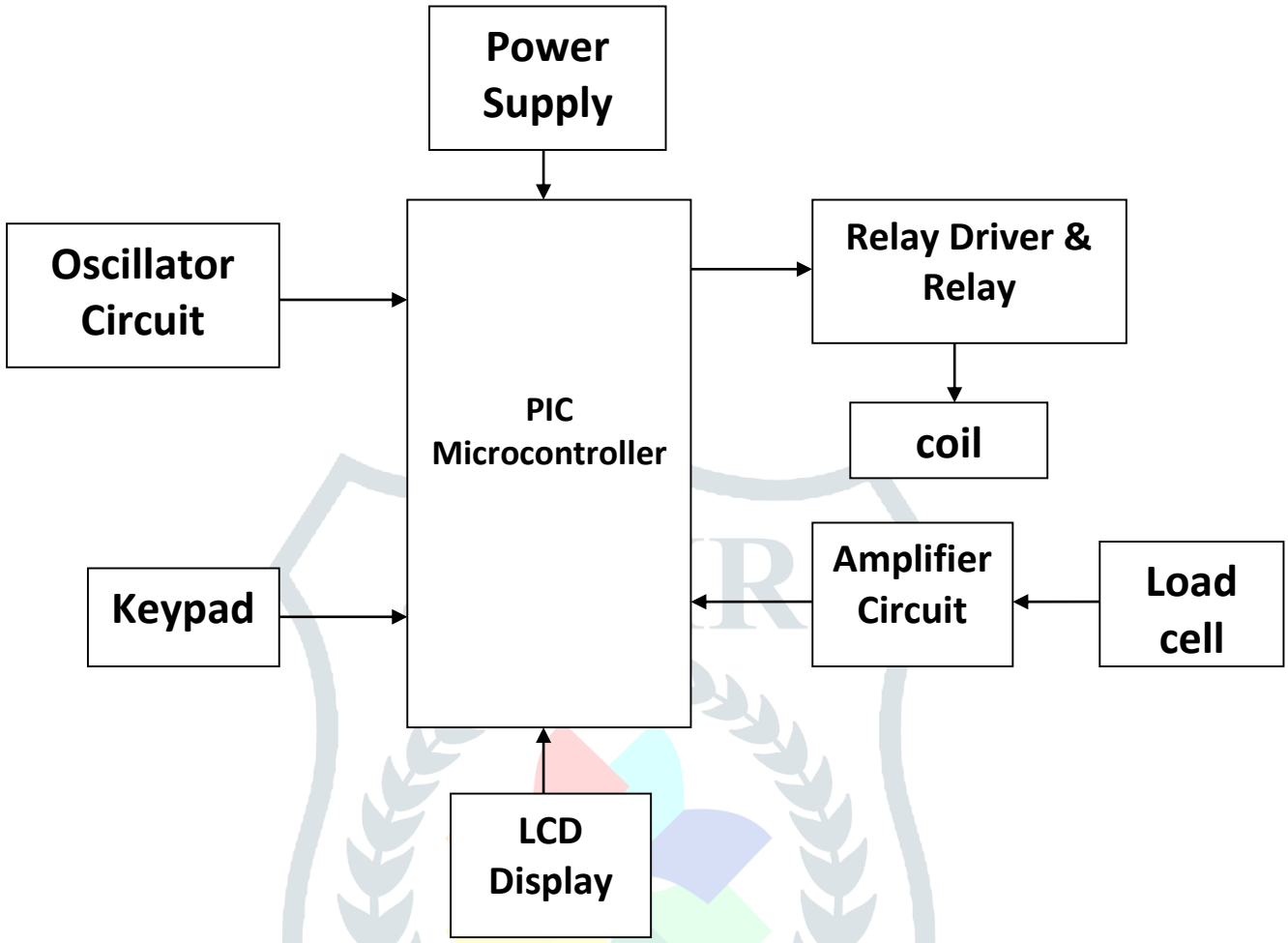

Fig 5.1. Block diagram of Electrical Architecture of complex fertilizer machine.

6. Fabrication process

The Fabrication processes has some design calculations to solve the errors while fabricating the equipment to mold up to a set of assembly and not involving any resistance to each other to form a problem to the project and it is well analyzed in the design software also.

6.1.1. Universal bending machine

The Hopper is design to be bend while the material is sheet metal which will be easily bendable so bending tools are used according to 90^0 angles of hopper into three individual cuts. The basic machine consists of a CNC-operated side stop, a work bench, and software for programming and operating. Its modular construction offers an affordable entry into the bending technology, because after an initial investment the machine can be customized and extended later without any conversion. That means the basic machine delivers a bending stroke, and the tool determines the kind of bending.

6.1.2. Laser cutting machine

The Laser cutting machine is used to cut the thin materials as mentioned in the previous chapter with some references so the sheet metal, mild steel is cut for the hopper design of transition duct and blender. Laser cutting is a technology that uses a laser to cut materials, and is typically used for industrial manufacturing applications. Laser cutting works by directing the output of a high-power laser most commonly through optics. The laser optics and CNC (computer numerical control) are used to direct the material or the laser beam generated. A typical commercial laser for cutting materials involved a motion control system to follow a CNC or G-code of the pattern to be cut onto the material.

7. Design Calculations

Motor torque calculation used in conveyor belt

Rated current of the motor, I = 10A
Rated voltage of the motor, V = 2V

Speed of the motor, N = 60 rpm
Diameter of the roller, D = 0.05m
Maximum load on conveyor = 10kg
Gravity of acceleration, g = 9.8m/s^2
Coefficient of friction, μ = 0.75
External force needed to run the conveyor = 7.34N

Torque of the motor

Input power = Rated current X Rated voltage
= 10 X 12
= 120 watts
Power = 2πNT/60
Torque, T = Power X (60/2πN)
= 120 X (60/376.8)
Torque, T = 6.36 Nm

Torque required to move the conveyor

Torque, T = ½ D(F+μW_g)
D = Diameter of the roller
F = External force
μ = Coefficient of friction
W = Weight on the conveyor
g = Gravity of acceleration

To calculate external force

External force, F = Torque / (Length of the conveyor X Sin of angle)
= 6.36 / (1 X Sin 60^0)
= 7.34 N

By substituting the value of external force in torque equation
We get,

Torque, T = ½ X 0.05 (7.34+0.75(10 X 9.81))
Torque, T = 2.02 Nm.

Motor torque calculation used in rotary mixer

Rated current of the motor, I = 0.75A
Rated voltage of the motor, V = 230V
Speed of the motor, N = 6500 rpm

Torque of the motor

Input power = Rated current X Rated voltage
= 0.75 X 230
= 172.5 watts
Power = 2πNT/60
Torque, T = Power X (60/2πN)
= 172.5 X (60/40,820)

Torque, T = 0.25 Nm

The motor with such specification is choose as 0.25 Nm torque is enough to mix a load maximum of 10 kg.

8. Results and discussion

8.1. Load cell configuration

The initial stage of the process the load cell is placed under no weight where even there is no hopper, under this condition load is calculated. The load cell measurement is zero in values, after that hopper is placed each carries a load of 3-5kg of load to withstand a load of 7 kg of fertilizers to produce 7-7-7 NPK ratio.

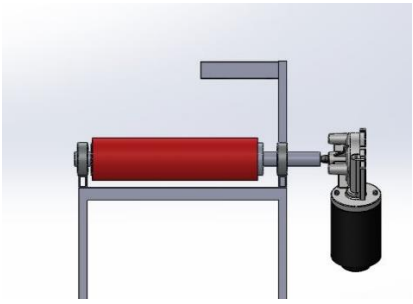

Fig.8.1. Load cell under no weight

The microcontroller is used to calibrated the load with the values by changing them into 0,0,0 when the initial load is 7,7,7 which is hopper load, so total load will be 7kg but controller sets them to zero. So, the load cell is maximum of 10kg load initial which is 7 kg but a load of 3 kg can be added to the hopper for producing 3,3,3 NPK ratio.

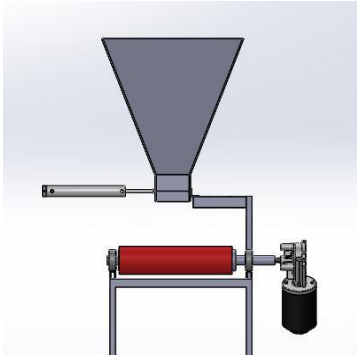

Fig.8.2. Load cell underweight with its hopper

But for each initial weight we need to calibrate the load cell by using the controller when the load is 1 kg poured to the hopper the load cell may show a variance load which can be for e.g.5-7 kg, so by using the microcontroller the load is to be set as 1kg when it shows as 5-7 kg of load to load cell, for each weights and each load cell the configuration is done by using the microcontroller.

8.2. Pneumatic actuation

The pneumatic cylinders are controlled and actuated by the microcontroller and magnetic electrically controlled solenoid valves which plays a best part in this prototype which is the more complicated part also. The air pressure is produced in a compressor with a maxi range of 500psi-1000psi power to actuate the cylinders, then the circuit design for pneumatic is designed and developed according to the release of load and signal from the load cell to actuate the cylinder to release the load according to it. As the range from the release of load to conveyor is to low so the conveyor motor is kept on running to produce a gap at stopping the load from release or from hopper.

8.3. Test results

The combination of different complex fertilizers is tested during the session of initial output over the product efficiency, so the results are displayed in the below bar chart Fig.4.4. with table values listed in it.

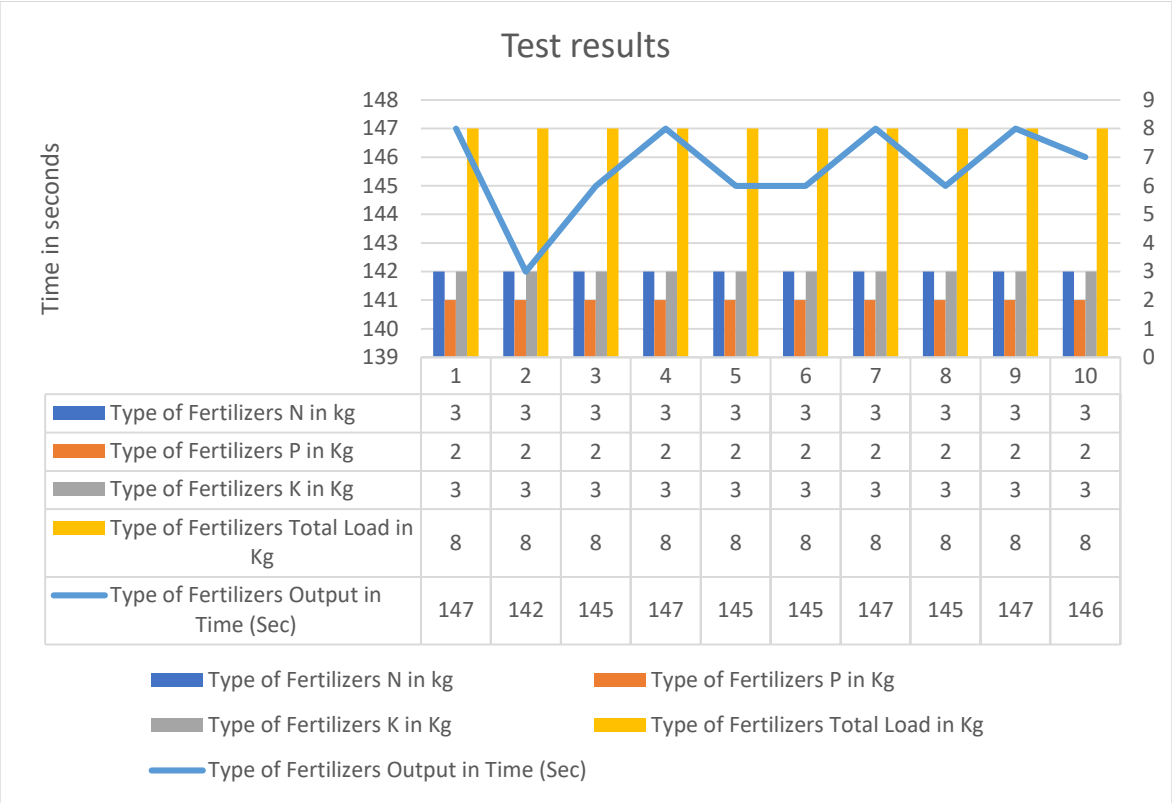

Fig.8.3. Test Results.

9. Conclusion

Initially while starting the project work, the availability of spare parts was checked in the market and the parts which were not readily available were designed separately and then manufactured. E.g. hopper. All the parts and components used in the project were designed and analyzed with the help of solid works 2017. Each part was initially designed and then assembled into a single component. The correct material was chosen and selected once the design and analysis of the design was over.

The dimensions were then marked on the raw material bought for manufacturing the manufacturing the machine and a number of processes were carried out. The manufacturing process was done with all safety measures required. Once the machine is ready and fabricated, a trail run was conducted and the results are tested till successful outcomes. Various input load of fertilizers was tested and the NPK ratio is attained. Once the results were obtained the components like hopper and mixer are powder coated and all other components were painted.

Thus, an automatic complex fertilizer mixing machine was designed and fabricated for manufacturing of fertilizers with proper NPK ratio. The project was completed within the given amount of time and the project ended on a successful note that the fertilizers are mixed with proper NPK ratio. The project was completed with keeping in mind all the safety measures that are required while carrying out the pertains on the machine.

10. References

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