ONION PRESERVATOR

A Project report submitted in partial fulfilment of the requirements for

the award of the degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

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ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY AND SCIENCES

(UGC AUTONOMOUS)

(*Permanently Affiliated to AU, Approved by AICTE and Accredited by NBA & NAAC with 'A' Grade*)

Sangivalasa, Bheemili mandal, Visakhapatnam dist. (A.P)

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CERTIFICATE

This is to certify that the project report entitled **"ONION PRESERVATOR"** submitted by **R. Ravindra (319126512112), J. Lokesh Kumar (319126512087), E. Pushparaj (319126512081), K. Gunadeep (319126512089)** in partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology** in **Electronics & Communication Engineering** of Andhra University, Visakhapatnam is a record of bonafide work carried out under my guidance and supervision

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ABSTRACT

Onion is one of the most cultivated crops in the world. China is the largest producer of onions followed by India, the USA and Egypt. In India, Maharashtra is the highest producer of onions. Every day large number of onions are consumed across the world. Onions contain a high amount of water and it is delicate to store onions. The onion storage structures were introduced, but due to lack of suitable storage facilities 25 to 30 percent of onions are wasted every year. To overcome this wastage, a model is proposed. This model helps in monitoring the temperature and humidity which are important for storing onions. In this model, a mesh is designed in a cylindrical shape in which another cylindrical mesh is placed and onions are placed in between these two cylindrical meshes where multiple AMT1001 sensors are placed on the outer wall of the external cylinder and inner wall of the inner cylinder which are connected through a multiplexer. This method monitors the temperature and humidity in the model and controls it by adjusting the air flow, which can be achieved by turning on or off the fan. .

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Chapter 1

Introduction

1.1 Introduction

A semi-perishable vegetable, onions are primarily produced between April and May and are harvested during the rabi season, which accounts for 65% of onion output. Every year, until the months of October and November, the same crop must continue to satisfy customer demand before the kharif crop is harvested and brought to market. To ensure a consistent supply, it is crucial to preserve onions effectively. According to observations, the crop loses between 30 and 40% of its weight during storage for a variety of causes, such as physiological weight loss, rotting, sprouting, etc. When unforeseen events, like natural disasters, occur, the losses might even exceed 50%, which puts great strain on both the supply and demand sides of the economy. The losses that happened during storage are both quantitatively and qualitatively significant. Therefore, it is essential to implement several important measures relating to onion storage with minimal losses in order to ensure the market has an adequate supply, thereby avoiding price swings.

Table 1.a: Current Quantitative losses and Expected Targets

	Type of loss	Reported losses	Expected loss with potential solutions
1	Physiological weight loss (PLW)	20-25%	15-20%
2	Rotting/ decay	10-12%	$\leq$ 7-10%
3	Sprouting	8-10%	$\leq$ 6-7%

1.2 Qualitative losses:

1. Removing the outer peel will decrease its market value by 25–30%.

2. Market value is reduced by 25–30% due to black mold.

1.3 Quantitative losses

For onions to be stored with the fewest losses, a variety of abiotic variables, such as temperature and relative humidity, must be in equilibrium.

Loss of weight when temperature is over 32 °C and relative humidity is below 60%

Low RH (over 70%) and low temperature (0–2 °C) result in sprouting.

High temperature (above 32 °C) plus high relative humidity (above 70%) results in rotting

- Temperature (25-30°C) + RH (60-65%) = Recommended

  OR

  *Temperature (0-5°C) + RH (65-70%) = Recommended

1.3.1 Sprouting

Sprouting of onions occurs when the onion bulb begins to send out a new shoot or green stem from the center of the bulb. This can happen naturally over time, especially if the onion is stored in a warm and humid environment.

While some people might discard sprouted onions, they are still edible and can be used in cooking. However, the texture and flavor of sprouted onions may be slightly different from fresh onions. The green shoots that sprout from the onion can be chopped and used in recipes as a substitute for green onions or scallions.

If you want to prevent onions from sprouting, it is best to store them in a cool, dry place with good air circulation, such as a pantry or root cellar. Avoid storing onions in the refrigerator, as the cold and damp environment can encourage sprouting. Additionally, make sure to use older onions before using newer ones, as older onions are more likely to sprout.

1.3.2 Rotting

Onions can rot when they are exposed to moisture, especially if they are stored in a damp or humid environment. The rotting process begins with a softening of the onion's outer layers, which may become discolored or slimy. Eventually, the rot can spread to the entire onion, causing it to emit a foul odour.

To prevent onions from rotting, it is important to store them in a cool, dry place with good air circulation. Avoid storing onions in plastic bags or containers, as these can trap moisture and promote rot. Instead, store onions in a mesh bag, a paper bag, or a well-ventilated container.

If you notice that an onion is beginning to rot, it is best to discard it. Rotting onions can attract insects and bacteria, which can spread to other onions and contaminate them. If you store onions with other fruits and vegetables, it is a good idea to separate them, as the ethylene gas produced by some fruits can cause onions to ripen and spoil more quickly.

1.3.3 Weight loss

Onions can lose weight due to various factors such as:

Moisture loss: Onions contain a high amount of water, which can evaporate over time if they are not stored properly. This can cause the onions to lose weight.

Respiration: Onions are living organisms, and like all living organisms, they undergo respiration, which involves the breakdown of sugars and other organic compounds to release energy. Respiration can cause onions to lose weight over time.

Transpiration: Onions also undergo transpiration, which is the loss of water vapor through their skin or surface. This can cause the onions to lose weight, especially if they are stored in a dry environment.

Dehydration: Onions can also lose weight due to dehydration, which can occur if they are exposed to high temperatures or low humidity levels. Dehydration can cause the onions to become dry and shriveled.

It is important to note that weight loss alone does not necessarily indicate spoilage or rotting. However, if onions appear to be discolored, soft, slimy, or emit a foul odor, they may be spoiled and should be discarded.

1.4 Scope of improvement

1. When tempering or conditioning, numerous abiotic elements should be optimized.
2. Creation of sensor-based onion weight loss, rotting, sprouting, decay, etc. detection systems.

1.5 Status of established onion storage structures and challenges

1.5.1 Naturally ventilated structures (Kanda Chawl):

A scientific onion hut with natural ventilation, the Kanda Chawl is designed to reduce storage-related losses. Most of the onion storage in India occurs in such uncontrolled buildings for temperature and relative humidity. Depending on the desired capacity, the farmers build various types of kanda chawl.

1.5.1.1 Low-cost thatched roof bamboo storage structure:

This style of storage building is favored for "on-farm" storage of onions and is often built with a bamboo framework and a roof made of sugarcane leaves. A single row storage structure with a 5- to 10-ton capacity can be created. The building's rafters are made of bamboo.

Fig.1. Low Volume Structure

At the base of each iron angle pillar, bricks are placed to enable bottom ventilation. Although similar forms of grass can be utilized in place of the sugarcane leaves that are typically used for the roof.

To stop rainwater leaks, a gunny fabric interior lining is offered. This kind of construction ought to be done from north to south. Although it is inexpensive and simple to build, this form of storage structure results in up to 40–42% losses of onions over the course of four months. Due to the usage of organic materials like bamboo, the structure has a low degree of durability. Since it relies on a natural ventilation process, the temperature and humidity cannot be adjusted.

Table 1.b: Challenges in the current designs and expected Targets.

Challenges in current designs	Scope of improvement in current design
1. Storage structure's resilience and strength	Construction materials
2. 40-42% losses	Range of loss mitigation must be 20–25%
3. Low storage duration	Increased storage time with minimal loss
4. Abiotic factors	Control over ventilation and environmental factors. Whenever necessary, inexpensive extras like a fan or tube light can be used. is suitable for usage in the storage structure.

1.5.1.2 Bottom and side ventilated storage structure:

This has a centrally located ventilated roadway, an expanded ceiling, and a ventilated floor composed of hardwood bantams. Galvanized iron channels were used to build the structure's framework. A spacing of 2.5 cm was maintained between each bantam when building the floor and side walls out of wood.

Fig. 2. High volume structure

Asbestos sheets are used in the roof's construction. To prevent rain splashes, the roof was raised to a height of one meter. This kind of building has bottom and side ventilation openings. The capacity and cost of the current structures may change in order to meet the needs of farmers and traders across all economic brackets. Even though these naturally ventilated storage structures are widely used, significant losses still happen because the temperature, relative humidity, and airflow cannot be controlled—three factors that are crucial for the successful and loss-free storage of onions. Approximately Rs. 7 lakhs are required for the building of the 50 MT double row modified bottom and side ventilated storage structure.

Table 1.c: Challenges in the Current designs and Expected Targets:

challenges	**Scope of Improvement in current design**
1. Reduction in cost	Cost should reduce (below 4-5 Lakhs)
2. Storage structure's resilience and strength	Components utilized in construction
3. Lowering of storage losses	In four months of storage, losses can reach 20–25%.
4. Abiotic factors	regulating environmental conditions and ventilation 65-70% RH 25 to 32 degrees Celsius
5. Components utilized in construction	Environmentally friendly roofing material is necessary to reduce heat buildup on the structure's top.
6. Sustainability of the environment	In a construction, an alternative to wood battens can be utilized.

Most Indian farmers use these kinds of naturally ventilated storage structures to keep their onions, but these types of buildings are unsuitable for areas with extremely high temperatures, high relative humidity, high temperatures with low relative humidity, or low temperatures with high relative humidity.

There is potential to enhance this structure by offering suitable ventilation, temperature management during the hottest summer days, relative humidity reduction using the right materials, and other techniques.

1.5.2 Controlled onion storage structures:

Due to poor economics and a lack of cold chain facilities needed to maintain the quality in the high ambient temperature common in our nation, India rarely adopts cold storage systems for onions, even though they are employed in certain other nations. When the temperature is kept between 25°C and 30°C with a relative humidity range of 65-70%, onion storage in ventilation settings is excellent. In contrast to ventilated storage buildings, controlled onion storage structures keep onions at 0-5°C and 60-65% RH, which results in significantly lower losses.

It takes a lot of energy to keep the storage facility at a temperature between 0 and 5 degrees Celsius, therefore the building cost (about 20 to 25 lakhs per 20 tons) and operating cost (around Rs 0.6 to 0.65 per kilogram per month) are very high. Condensation causes additional issues and takes a lot of effort and time. The moment the bulbs are taken out of the cold storage, they begin to sprout.

Fig. 3. Controlled storage structure

After being harvested, onions cannot be put in cold storage right away. Onions must first be dried for a couple of days. The maturing period that enables the development of the onion cultivar-specific skin and colour then begins. In order to get onions to the appropriate cold storage temperature gradually, the temperature is reduced by a maximum of 0.5 °C every day. In cold storage, onions are kept between 0 °C and +2 °C depending on the type. Up to 10 months of cold storage without degradation is possible for onions. When storing onions, ventilation is essential. To avoid condensation, onions are heated in temperature-controlled environments before being transported from the cold storage and placed on the market.

Table 1.d: Challenges in the Current designs and Expected Targets:

Challenges	Scope of improvement
1. Optimal movement of cold air inside the building	Chilly air being forcedly circulated Temperature optimization: Ambient temperature storage (25–32°C), cold storage (zero–five), and 67%–75% relative humidity
2. High energy requirement and power failure affect the storage life of onions	Method adopted must enable constant and cost-effective power supply.
3.High capital investment and operating cost	Should be cost effective. (Below 10-12 Lakhs/20 tons
4. Environmental sustainability issue.	It is necessary to offer a refrigeration system substitute.
5. High-skilled labour was needed	Reduced need for specialized labour due to the system's user-friendliness

Table 1.e: Economic Evaluation of Kanda Chawl

Particulars		**Double row storage building with a modified bottom ventilation**	
Other/ Common names			
Cost of construction (Lakh Rs)	0.06	2.0	1.26
Length (m)	4.8	9.8	9.9
Width (m)	1.3	6.1	3.7
Side height (m)	1.7	2.26	2.26
Central height (m)	1.8	4.6	4.0
Storage capacity (tones)	5	42	26
Expected life (years)	5	20	22
Cost of storage (Rs. /Kg/month)	~0.20	~0.23	~0.25
Economics of storage of onion			
Total expenditure (Rs)	12950	109050	82080
Total expenditure (Rs/ton)	2580	2546	2575
Total Return #(Rs)	18894	123310	98078
Net Profit (Rs)	6044	14170	15878
Net Profit (Rs/ton)	1208	338	499

Several losses have been reported pertaining to PLW, Rotting, scale removal, sprouting and black mold when onions are stored in storage structures like Low-cost thatched roof structure, modified bottom ventilated double row storage structure or structure with structure chain linked side walls etc.

Table 1.f: Different types of losses (average) are reported in Rabi Onion that are stored in different storage structures and expected outcomes from potential solutions.

<table>
<tr><td></td><td colspan="9">Expected Outcomes</td></tr>
<tr><td></td><td>PLW (%)</td><td>Rot (%)</td><td>Sprouting (%)</td><td>Black mold (%)</td><td>PLW (%)</td><td>Rot (%)</td><td>Scale removal (%)</td><td>Sprouting (%)</td><td>Black mold (%)</td></tr>
<tr><td>Low cost Thatched roof structure</td><td>17.5</td><td>10.9</td><td>1.34</td><td>2.12</td><td colspan="5" rowspan="3">Decrease of all kinds of losses by at least 40–55 percent from the loss as of the moment</td></tr>
<tr><td>Modified Bottom Ventilated double row storage structure</td><td>19.5</td><td>17.95</td><td>37.68</td><td>11.5</td></tr>
<tr><td>Modified Bottom ventilated storage structure chain linked side walls</td><td>22.4</td><td>14.18</td><td>3.28</td><td>5.58</td></tr>
</table>

Chapter 2
Literature survey

2.1 ONION STORAGE IN TROPICAL REGION-A REVIEW P.C. TRIPATHI AND K.E. LAWANDE

The onion (Allium cepa L) is one of the world's most extensively produced vegetables. Most of the world consumes it as a vegetable. The onion is thought to have originated in Central Asia. It was employed thousands of years ago in India, China, Egypt, and Persia, according to ancient documents. Despite its origins in temperate climates, it is now commonly used in tropical climates. It is now grown in over 170 countries throughout the world. Over the previous three decades, the global area under onion has steadily risen. From 7.5 million metric tons in 1960 to 51.9 million metric tons in 2002 and 92.64 million metric tons in 2015, global onion production has expanded dramatically. The four major onion-growing countries in the world are China, India, the United States, and Turkey. Other big producers are Russia, Japan, Spain, Pakistan, and Egypt. These eight countries account for more than 60% of global onion production. Although India has the most land (1.19 million hectares), China has the most production (23.93 million metric tons). Korea has the highest productivity (65 tons/ha). More than 70 tropical countries grow onions for domestic or export consumption. Tropical countries account for 61 percent of total land and 47 percent of total global onion output. Onion productivity was lower in tropical regions than in temperate locations. In contrast to temperate places, where onions are grown in a single season, most tropical countries grow them in multiple seasons. Despite being grown in more than one season, the onion is preserved for 1 to 6 months to meet market demands.

Onion exports total 64,29147 metric tons worldwide. India, Pakistan, Indonesia, Bangladesh, Niger, Ethiopia, and other tropical onion-growing countries are listed below. These nations account for more than 70% of total onion exports. During the critical gap, these countries are key providers of onions to temperate countries. Onion has two unique storage temperature and humidity regimes: 0-2 Celsius and 70% RH and 25-30 OC and 70% RH. The second condition is prevalent in tropical nations, which promotes greater storage losses.

Furthermore, in tropical places, onion is maintained at room temperature because low temperature storage facilities are few ((Brice et al, 1997)).

2.1.1 Post–Harvest Losses

In most tropical areas, where storage losses are significant, onions are stored at ambient temperatures. It is estimated that 40 to 50% of stored onions never reach consumers due to a variety of losses. Steppe (1976) estimated that post-harvest spoiling accounted for 16 to 35% of onion losses. Such losses in tropical nations may be greater than estimated (Salunkhe and Desai, 1984). These losses include physiological loss in weight (PLW), which includes moisture losses and shrinkage (30-40%), rotting (10-12%), and sprouting (8-10%). The larger storage losses were caused by physiological weight loss, which occurs during the dry months when mean temperatures are high and humidity is low. In the humid months, rotting losses are considerable. When the bulb dormancy is over Physiological and the temperature falls below 20 degrees Celsius, onion sprouting begins.

2.1.2 loss in weight (PLW)

Onion bulbs are composed of 85-90% water. As an active stage, it generates and loses water through respiration and transpiration. The rate of water loss is affected by the storage state. Temperature, relative humidity, air movement, and atmospheric pressure all influence storage conditions (Ryall and Lipton, 1979). The injuries increase the rate of respiration and hasten the loss of weight. Weight loss in tropical environments may be 5-6 percent every month of storage at ambient temperatures. Storage losses grow with storage length due to an increase in rotting and sprouting. Tripathi and Lawande (2006) found that onions stored at room temperature lost 23 percent of their weight, while onions stored at low temperatures (0-2oC) lost 4.0%. The weight loss of onions rises with storage duration and is regulated by temperature, relative humidity, and rainfall variations (Abu-Goukh et al., 2001). Storage also has an impact because it is greater in Kharif (rainy) season crops than in late kharif (late rainy) and rabi (winter) crops. The physiological weight loss for ambient and cold stored onions with Hessian fabric bags and Nylon net bags was 19.29 to 20.87 percent and 6.14 to 4.97 percent, respectively. Ambient stored onions lost much more physiological weight than cold stored onions treated with maleic hydrazine (MH-40) and gamma irradiation (60 Gy from cobalt - 60 source) (Tripathi and Lawande, 2007). After five months of storage, total storage losses were decreased to 39.23% in ventilated bamboo buildings compared to 53% in traditional storage structures (Subbaram et al., 1990). Tripathi and Lawande (2008,2015) discovered that the overall losses of onion bulbs stored in low-cost bottom ventilated structures and recommended bottom ventilated structures were 35.17 and 44.96%, respectively.

2.1.3 Sprouting

One of the primary issues affecting onion bulb storage life is sprouting. Sprouting is caused by normal physiological changes in stored bulbs, which grow reproductive branches in their second year as biennials. The storage state has little effect on sprouting, but solely on its rate (TDRI, 1986; Ryall and Lipton, 1979). The percentage of sprouted bulbs differed significantly amongst onion varieties during storage, and sprouting rises with storage length (Abu-Goukh et al., 2001). Wright et al. (1935) investigated the effect of storage temperature and humidity on onion keeping quality. They concluded that the extent of sprouting in stored onions was largely unaffected by humidity, but increased with increasing temperature (from 0 to 10 degrees Celsius) .According to Abu-Goukh et al. (2001), the increase in sprouting percentages near the end of the storage period could be due to a drop in temperature or the loss of dormancy in the bulbs. Many researchers reported that if storage time is extended into the winter season and the temperature is reduced to intermediate levels, sprouting occurs quickly (Abdalla and Mann, 1963; Musa et al., 1973). Tripathi and Lawande (2004c) discovered lesser sprouting of onion bulbs in a low-cost bottom ventilated structure. Adamicki (2005) investigated the sprouting of onion bulbs at 18-20°C during storage. After 5 months of storage in air ventilated storage, the lowest amount of sprouting (4.2%) was reported in the 'Sochaczewska' onion variety.

2.1.4 Rotting

Improper curing, field injuries, and a thick neck allow infections to enter during curing and shipment. These pathogens produce scale blackening and bulb rotting. In tropical settings, the most common diseases of preserved onion are Fusarium bulb rot and neck rot. Ryall and Lipton (1979) identified frequent storage illnesses as bacterial soft rot (Erwinia carotovora), black mold rot (Aspergillus Niger), and Fusarium bulb rot (Botrytis spp). These are the most damaging onion bulb post-harvest infections. Various portions of the bulbs, ranging from the base to the neck, may be attacked. In the advanced stages of infection, the afflicted tissues are water-soaked and appear withered and reddish. decayed in dry conditions tissues are papery and dry. Mycelia development is common in impacted areas. Following the veins, black mold rot creates black powdery lumps on the exterior scale. Certain fungi may simply cause discolorations or flaws on onions, decreasing their market value. The rotting rate for 'Rumba' onion bulbs held for 252 days at atmospheric storage conditions was around 50.8 percent (Adamicki, 2005). Tripathi and Lawande (2007) and Tripathi et al (2008) investigated the rotting of onion bulbs stored at ambient temperatures during cold storage and post-cold storage with sprout suppressant and packaging materials. After four months of cold storage, there was no decaying of bulbs. Even after four months of post-storage at room temperature, rotting was higher in ambient storage than in cold storage. During four months of post-cold storage and ambient storage, the rotting rate in cold stored onions was 4.44% and 16.04%, respectively. Under ambient storage settings, leno bags rotted faster than hessian fabric bags (Tripathi and Lawande, 2013).

2.1.5 Root Growth and other disorders

The main cause of root growth is high relative humidity and poor ventilation. Kaufman et al. (1953) discovered that roots grow in a matter of days under humid and high temperature conditions. Bulb rooting is often poor. When onions are exposed to direct sunshine, the bulbs turn green. It is particularly noticeable in white onions. The bulb's outer fleshy scales turn pale to dark green and may have an unpleasant flavor (Salunkhe and Desai, 1984).

2.2 Storage environment and Storage method

2.2.1 Storage environment

From a trading standpoint, large-scale onion storage was not an important concept. However, as domestic and export trade developed, storage became increasingly important. There are two distinct temperature regimes with the lowest losses. One is a high temperature regime in which the storage temperature ranges from 25 to 300 degrees Celsius, and the other is a low temperature regime in which the temperature ranges from 0 to 20 degrees Celsius. When humidity is kept between 65 and 70% in both temperature regimes, the best results are obtained. Storage losses are substantial (30-35%) in high temperature environments (25-300C), while storage costs are minimal. Low temperature (0-20C) or cold storage conditions result in lower losses (0.5%) and a longer storage period. However, storage charges are prohibitively expensive. Temperatures above 300°C in ambient storage buildings result with more weight loss, while temperatures below 100°C increase sprouting losses. Higher humidity (above 70%) combined with higher temperature improves lower humidity promotes weight reduction while increasing storage disorders. Every farmer used to keep these items in tiny quantities for personal consumption. Anything extra was sold at weekly bazaars in larger villages and cities. Slowly holding onions during the monsoon season and selling during lean periods in the country or export to gulf countries initiated by traders may have driven farmers and dealers to store the stock for a period till prices rise. Initially, storage conditions and structures were basic and, for the most part, unscientific. Maintaining the bulbs within the store at appropriate temperatures and humidity levels is critical for efficient onion preservation. If the storage temperature or humidity is too high or too low, fast deterioration will ensue, followed by significant or total losses. Storage conditions influence sprouting, roots, weight loss, respiration rate, rot occurrence and severity, and a variety of other quality features of stored bulbs (Brice et al., 1997). Onions sprout as a result of typical physiological changes in stored bulbs, which generate reproductive shoots in the second year as biennials. Thus, storage conditions have no effect on sprouting, but only on its rate (Ryall and Lipton, 1979). Bulbs are naturally inactive as they reach maturity, and the length of this dormancy varies depending on cultivar and environment (Thompson et al., 1972). 16 According to Aoba (1955), the true rest period in onions is around one month, however it may be followed by one or two months before sprouting occurs. Wright et al. (1935) investigated the effect of storage temperature and humidity on onion keeping quality. They concluded that the degree of sprouting in stored onions was largely unaffected by humidity, but increased with increasing temperature, ranging from 0 to 10o C. It was discovered that lowering the temperature to intermediate levels promotes rapid sprouting (Abu-Goukh et al., 2001; Abdalla and Mann, 1963; Musa et al., 1973). According to Wright et al. (1935), onion root growth in storage rose with humidity and was unaffected by temperature. Onion roots grow several centimetres in length during storage after emerging from the base of a truncated stem. The principal cause of root growth is high relative humidity (over 85%) with insufficient ventilation. Kaufman et al. (1951) demonstrated that roots grow in a matter of days under humid and high-temperature conditions. Bulb weight loss rose as storage temperature climbed from 0 to 10o C, with further increases recorded at higher temperatures. This impact was attributed in part to increased sprouting and root growth at temperatures ranging from 5 to 20o C and 0 to 10o C, respectively (Karmarker and Joshi, 1941). Wright et al. (1935) noticed a significant reduction in weight loss of onion bulbs at increasing relative humidity. Kapour et al. (1953) discovered that as storage temperatures climbed from 0 to 10o C, onion root development increased. According to Karmarker and Joshi (1941), the percentage of total sugars in onions did not change while stored above 30o C, but the percentage of reducing sugars fell. The temperature and relative humidity are the two most significant elements in onion storage. A high relative humidity (more than 75%) is the most dangerous enemy of onion storage because it encourages root growth and the development of storage illnesses. In contrast, low humidity (less than 65%) causes excessive moisture loss from the bulbs, causing shriveling and weight loss. Bulb dormancy, which prevents sprouting, is primarily temperature dependent. Sprouting rates are high between 50 and 200 degrees Celsius. Weight loss is less at 0-20 degrees Celsius and moderately reduced at 25-300 degrees Celsius. Temperatures ranging from 5 to 250 degrees Fahrenheit and higher than 300 degrees Fahrenheit stimulate weight loss. As a result, there are two distinct temperature conditions and one specific humidity range ideal for onion preservation.

2.3 Storage methods

An assessment of onion storage structures in India's key onion growing states of Maharashtra, Gujarat, and Karnataka indicated that temporary, semi-permanent, and permanent storage structures are employed for onion storage. Out of 270 farmer structures in three 17 states, 34.4 percent were permanent, 30.74 percent were semi-permanent, and 38.52 percent were temporary. Only 22.96% of the structures were bottom ventilated. Fifty-six percent of permanent structures were bottom ventilated, but just 8.43 percent of semi-permanent structures and 0.2 percent of temporary structures were. In terms of capacity, many temporary structures had fewer than 10 tons of capacity, whereas most permanent structures had more than 30 tons of capacity. The temporary shelters were composed of wooden logs with thatched roofs and plastic covers. The temporary constructions' sidewalls were built of pigeon pea stems or wheat straw. In many cases, the floor of these constructions was kuchcha but raised. Wooden logs or galvanized iron pipes/angles were used to construct semi-permanent buildings. Most of the semi-permanent constructions are erected on raised platforms made of kutcha or filled with coarse sand. These constructions' side walls were formed of pigeon pea stalks, wooden bantams, and bamboo. Most of the semi-permanent constructions had Mangalore tiles on their roofs. Permanent constructions were built with galvanized iron pipes/angles and R.C.C. pillars. These constructions' roofs were built of galvanized iron sheet or asbestos sheets.

The sidewalls were constructed of wooden bantam, chain link, and bamboo. In terms of storage capacity, most of the temporary structure and 40% of the semi-permanent structure were of capacity is less than 10 tons. In contrast, 90% of the permanent structures had a capacity of more than 10 tons. Despite a longer time of storage, total losses in permanent structures were lower. The percentage of suggested bottom ventilated type structure was less than 35 in permanent type and less than 10% in semi-permanent type. Tripathi et al. (2003; 2004). In other tropical nations, the onion is typically preserved in temporary structures built of thatch, wooden longs, and other natural materials.

The onion storage structure should be developed and designed in such a way that it can attain and maintain the appropriate storage conditions at the lowest possible cost within the constraints of available resources.

2.3.1 Reduction in losses by modification in storage environment

Cure bulbs were traditionally strung into bunches with leaves. These bundles are connected to the pole. Bunches were positioned such that bulbs received optimum aeration. The inspection of bulbs is simple; however, this procedure can only be used for a limited number of bulbs. Onion storage structures come in a variety of shapes and sizes. Most of these structures are of the traditional variety. Several modified onion storage structures have been constructed and tested (Skultab and Thompson, 1972; Krishnamurthy et al., 1988; Subbaram et al., 1990a, 199b; Kale et al., 1992a; Shukla and Gupta 1994; Bhonde et al., 1996; Maini et al., 1997; Warade et al., 1997; Tripathi and Lawande, 2004). These structures aid in lowering storage losses. The Nasik type storage construction was superior to the native thatched bamboo structure. At the end of 18 months, the overall storage loss was 21% of the cv. Bellary Onion, red (Krishnamurthy et al., 1988). Shukla and Gupta (1994) created two perforated concentric storage structures. It is made up of 25 × 25 x 25 mm welded wire mesh panels, each with a capacity of one tonne. Outside the shed, one of the buildings was used for natural ventilation. Another was hooked up to a fan to circulate air within the shed. After three months of storage, the quality of onion bulbs was recorded as 10% loss and 5-8% loss in natural air ventilation type buildings and forced - air circulation structures, respectively. According to Maini et al. (1997), two-tier storage structures outperformed single or bamboo storage structures in terms of minimising physiological loss in weight and storage. Traditional single-tier storage structures have corrugated cement roofs or RCC ceilings. Windward sides were constructed in a single tier from bamboo splits. The loading height was 1.5 to 2 m in all areas, and adequate ventilation was given by windows in the walls and raised flooring. The physiological weight in losses of these structures ranged between 30 and 50%. (Tripathi and Lawande, 2004 a,b,c, 2015) developed and constructed seven storage structures, including the traditional double row storage structure, Bottom ventilated storage structure, modified Modified bottom ventilated storage structure with chain linked side walls, Traditional single row storage structure, Modified bottom ventilated single row storage structure, Bottom ventilated single row low-cost thatched roof storage structure, at NRC for Onion and Garlic, Rajgurunagar. Bottom ventilated structures were found to be superior to traditional storage without bottom ventilated storage structures in terms of reducing physiological weight loss (PLW) and rotting. Storage losses in single row buildings were smaller than in double row structures. Overall, among the double row structures, the Top and bottom ventilated storage structure with mud-plastered walls performed best with 23.82% quantitative losses and 13.75% qualitative losses after 5 months of storage, compared to 46.11% quantitative losses and 5.21% qualitative losses in the

Traditional double row storage structure. Bottom ventilated single row low-cost thatched roof structure was determined to be the best among single row structures, with 28.66% quantitative losses and 3.46% qualitative losses, compared to 38.88% quantitative losses and 7.89% qualitative losses in traditional single row storage structure. The top and bottom ventilated storage building with mud-plastered walls had the highest net profit (Rs.33892/-), whereas the bottom ventilated single row thatched roof structure had the highest net profit per ton (Rs.1207/-). Low-cost bottom is one of these. Low-cost bottom ventilated storage buildings for small and marginal farmers, as well as top and bottom ventilated mud plastered structures for hot and humid climates and modified bottom ventilated structures with extended roofs, have been identified as promising. The bamboo-constructed bottom ventilated storage 19 building has a thatched roof. This construction has a life expectancy of 3 to 5 years. This is ideal for small and marginal farms. The top and bottom ventilated buildings are made of iron and have an asbestos roof. This structure's sidewalls are made of bamboo coated with mud. This construction has a life expectancy of more than 20 years. This structure contains control flaps that can be opened and closed as needed. This construction was ideal for hot, humid environments. Bottom ventilated structure with expanded roof is superior to bottom ventilated structure. It has an expanded roof to keep rain splashes at bay. This construction has a life expectancy of more than 20 years. Many state and federal government agencies are giving incentives for the construction of modern storage structures.

2.4 ONION STORAGE by SANDEEP BHARDWAJ

India is the world's second largest producer of onions, behind China, accounting for 16% of global area and 10% of production. It is planted on 0.39 million hectares in India, with an annual production of 4.30 million tons of bulbs (FAO, 1995). The current year's output is expected to be 4.7 million tons. It is one of our country's most significant vegetable crops, and it is included in practically every household's daily diet. global output of the onion weighs around 43 million tons. China, the United States, the Soviet Union, the Netherlands, Spain, and Turkey are among the major producers. The states of Maharashtra, Gujarat, Uttar Pradesh, Orissa, Karnataka, Tamil Nadu, Madhya Pradesh, Andhra Pradesh, and Bihar generate most of the onion produced in India. . Maharashtra is the main producer, accounting for 20% of the land area and 25% of the total output.

2.4.1 Extent of Storage Losses

From May to November, onion bulbs are typically preserved for four to six months. However, depending on the genotype and storage circumstances, storage losses range from 50 to 90 percent. Physiological loss in weight (PLW), i.e., moisture loss and shrinkage (30-40%), rotting (20-30%), and sprouting (20-40%) comprise the total storage losses. Harvesting at the right time, effective curing of onion bulbs, and subsequent storage at desired temperature and humidity conditions can all help to reduce PLW. In general, rotting losses are highest in the first months of storage, particularly in June and July, when high temperatures combined with high humidity cause the losses. However, proper bulb grading and selection, as well as good ventilation conditions, can limit rotting losses. Post-harvest fungicidal sprays can also help to reduce rotting; however this is not done in India. Sprouting losses are typically documented at the end of a storage period or when exposed to hot, humid air. Significant sprouting losses have been recorded as a result of the storage of poor-quality bulbs with short rest and dormant periods and thick necks. Dark red and white onion cultivars experience larger sprouting losses than light red onion cultivars.

2.4.2 Storage method and storage environment

The temperature and relative humidity are the two most significant elements in onion storage. A high relative humidity (more than 75%) is the most dangerous enemy of onion storage because it encourages root growth and the development of storage illnesses. In contrast, low humidity (less than 65%) causes excessive moisture loss from the bulbs, causing shriveling and weight loss. The dormancy of bulbs, which prevents sprouting and is primarily temperature dependent. Sprouting rates are strong between 50o F and 200o F. Weight loss is less at 0-20 degrees Fahrenheit and moderately lower from 25-300 degrees Fahrenheit. Weight loss is increased by temperatures ranging from 5 to 250 degrees Fahrenheit and exceeding 300 degrees Fahrenheit. As a result, there are two distinct temperature conditions and one set humidity range ideal for safe onion storage. As a result, the onion storage structure should be developed and designed in such a way that it can attain and maintain the appropriate storage conditions at the lowest possible cost using the available resources. In our country, onions are stored in heaps/stakes under ambient conditions. Onion storage structures come in a variety of shapes and sizes. Most of these structures are of the traditional variety. Several onion storage structures that have been modified have been devised and tested. These structures aid in lowering storage losses. Many state and federal government agencies are giving incentives for the construction of modern storage structures.

2.4.3 Traditional storage structure

Farmers designed these shelters based on their needs and the availability of resources. These constructions lack bottom ventilation. These are made of wooden logs or bamboo, with a roof made of grass, Mangalore tiles, or asbestos sheets. Depending on the breadth of the structure, these structures may have one or two rows/stakes of onions. These structures are often transient, and storage losses in these structures exceed 50% after four months of storage. Bottom ventilated storage structures are permanent structures that are typically built with a galvanised iron framework. The floor is usually made of hardwood bantams or bamboo and has bottom ventilation. The sidewalls are similarly made of wooden bantams or bamboo. The roof is constructed of asbestos sheets. This structure's increased aeration aids in the minimization of losses. In general, storage losses in this structure range from 30 to 40% after 4 months. Storage structure with top and bottom ventilation This is a unique onion storage structure created and tested by the NRC (National Research Centre) for onion and garlic storage. This structure is made of G.I. framework. The floor is ventilated and made of hardwood bantams.

The bamboo sidewalls are coated with clay and cow dung paste. The ventilation is given at the bottom of the western sidewall and the top of the eastern sidewall. The lower portion of a western sidewall ventilator contains control flaps to manage the intake of hot breezes in the summer and heavy humid winds during the rainy season. Plastered sides prevent dampness on wet days while keeping the indoor temperature stable in the summer. The structure can be built with a capacity of 25 to 50 tons. The building cost would be around Rs. 3600/ton. For four months of storage, the storage losses in this structure are 28-30%. This construction may be better suited to humid and hot climates.

Many of these structures are of the traditional variety. Several onion storage structures that have been modified have been devised and tested. These structures aid in lowering storage losses. Many state and federal government agencies are giving incentives for the construction of modern storage structures.

Avoid direct sunlight or rainwater splashes on onion bulbs to prevent sun burn, colour depreciation, and quality damage.

2.4.3 Low-cost bottom ventilated structure

NRC created a low-cost bottom ventilated structure for onion and garlic for small and marginal farmers. Farmers can simply build this using their own farm resources. The building is made of bamboo/wooden framework and has bottom ventilation. The floor and sidewalls can be built of bamboo or wooden bantams. The roof is built of thatch made from dried sugarcane leaves or grasses. The structure would cost roughly Rs. 800 per ton. Storage losses in this arrangement are 30-35% after four months of storage. Considerations for Storage Structure Construction 1. It should be built in such a way that it can maintain the required temperature and relative humidity. 2. One stake should not be wider than four feet. The maximum height and length shall not exceed 5 and 15 feet, respectively. 3. A bottom ventilated of 1 to 12 feet is required for adequate aeration. 4. The floor and sidewalls should be made of bantam or bamboo wood. 5. The roof should be built with asbestos sheeting, Mangalore tiles, or thatched galvanized iron sheeting; galvanized iron sheeting is not suitable for roofing material for storage structures. 6. The structures should be built on a high ground. There should be no bodies of water around the storage. The single row should be built in the north-south direction, while the double row should be built in the east-west direction.

2.4.4 Cold storage

The onion may be kept cold at temperatures ranging from 0 to 20 degrees Fahrenheit and humidity levels ranging from 65 to 70%. However, the biggest issue in cold storage of onions is expense and sprouting. The problem of sprouting can be reduced by using gamma irradiation. Onion cold storage is successful when paired with gamma-irradiation procedures.

2.5 Improved Panipat Type Low-Cost Onion Storage Structure

The National Horticulture Research and Development Foundation (NHRDF) has created a model for two tiers in Panipat and a single tier in Nashik. This structure provides optimal ventilation from all sides, including the bottom, reducing storage losses. This construction is being promoted by KVK, Ujwa (NHRDF) in onion-growing areas of Delhi. Farmers may easily build the enhanced low-cost structure, which is often made of bamboo or sarkanda nets and has a thatched roof made of sirki that is wrapped on top with jute fabric.

. The following dimensions are necessary for keeping 4 tons of onion: Length 20 feet, Width 4 feet, Side Height 5 feet, Height (Center) 6.5 feet, Height (from ground level) 30 cm. The low-cost structure can be of various capacities, with a life of 2-3 years and a cost of Rs 7000 - Rs 8000 for a capacity of 4 tons. The cost of the structure is determined by the materials and labour accessible locally.

Improved Panipat type low-cost onion storage structure features

• Building on a raised platform with bottom ventilation to reduce moisture and dampness by avoiding direct contact between bulbs and soil.

• Increased center height and slope for improved air circulation and the prevention of a humid environment inside the godown.

• Bottom ventilation allows for free and faster air circulation, preventing the formation of hot and damp pockets between the onion layers. • Providing cubicles rather than a continuous stack, as well as enough space for ventilation on all sides.

• Avoid direct sunlight or rainwater splashes on onion bulbs to prevent sun burn, colour depreciation, and quality damage.

• Limit stacking width to 60-75 cm for chilly humid weather, 75-90 cm for mild and humid weather, and 90-120 cm for mild and dry weather conditions. • Limit stacking height to 100 cm for small and multiplier onions in hot weather. 120 cm for warm weather and large onions for pressure bruising.

Chapter 3
Hardware components

3.1 AMT1001 SENSOR

The AMT1001 is a rotary encoder sensor manufactured by CUI Devices. Rotary encoders are sensors that convert rotational motion into electrical signals, which can then be used to measure or control the position, speed, or direction of a rotating shaft or device.

The AMT1001 specifically is a non-contact encoder, meaning that it does not require physical contact with the rotating shaft, which can make it more reliable and durable in certain applications. It uses a magnetic encoder technology to detect and measure the rotation, and it has a resolution of up to 12 bits

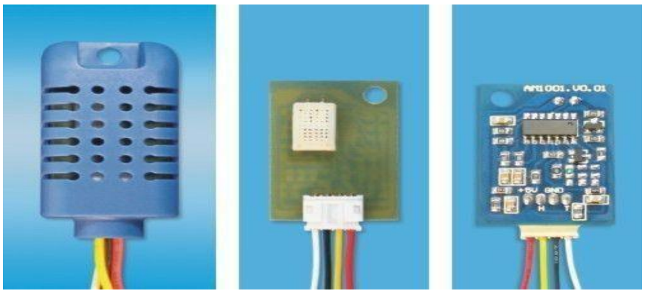


Fig.4. AMT 1001 Sensor

3.1.1 Applications

HVAC (heating, ventilation, and air conditioning) systems, humidifiers, dehumidifiers, communications, atmospheric environmental monitoring, industrial process control, agricultural, measuring devices, and other uses.

3.1.2 Product Highlights

Low power requirements, compact size, temperature adjustment, linear output calibration microcontroller, simplicity of use, low cost, complete interchangeability, extended signal transmission distance, and accurate calibration.

3.1.3 Product Selection

Apart from single wet and humid, which just cause an increase in body temperature, other features like, then not be repeated, are included in the AM1001 single wet, AMT1001 for temperature and humidity of a body, a common specification.

Table 3.a: Product Selection:

Product Model	Type of product	DC voltage	Output range	Sensor Specifications
AM1001	Resistive	4.76~5.26 V DC	0~4V	Single wet
AMT1001	Resistive	4.76~5.25 V DC	0~5V	Integrated temperature and humidity

3.1.4 Dimensions（unit: mm）

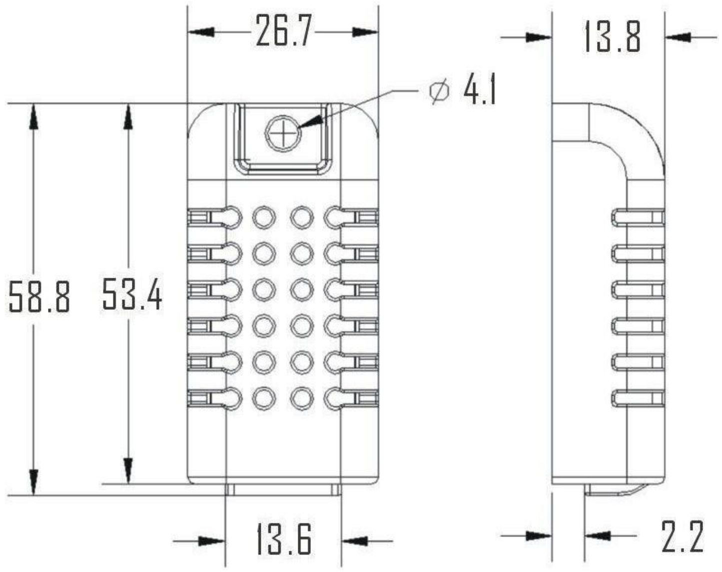


Fig.5. Dimensions

3.1.5 Interface Definition

Table 3.b: pin assignment:

Pin	color	name	Description
1	Red	VDD	Powersupply（4.76V-5.26VDC)
2	Yellow	Hout	Humidityoutput（0-4VDC）
3	Black	GND	Ground
4	White	Tout	NTC10KThermistor

3.1.5.1 Power supply pins（VDD GND）

The module's supply voltage range is 4.76V - 5.26V, recommended supply voltage is 6.0

3.1.5.2 Voltage output signal line（Hout）

Humidity signal from the signal line in the form of voltage output, voltage output range of 0-3V, specific humidity and voltage reference voltage and humidity relations Please characteristics

3.1.5.3 Temperature output signal line（Tout）

Temperature interface for 10K thermistor, connection mode as shown below.

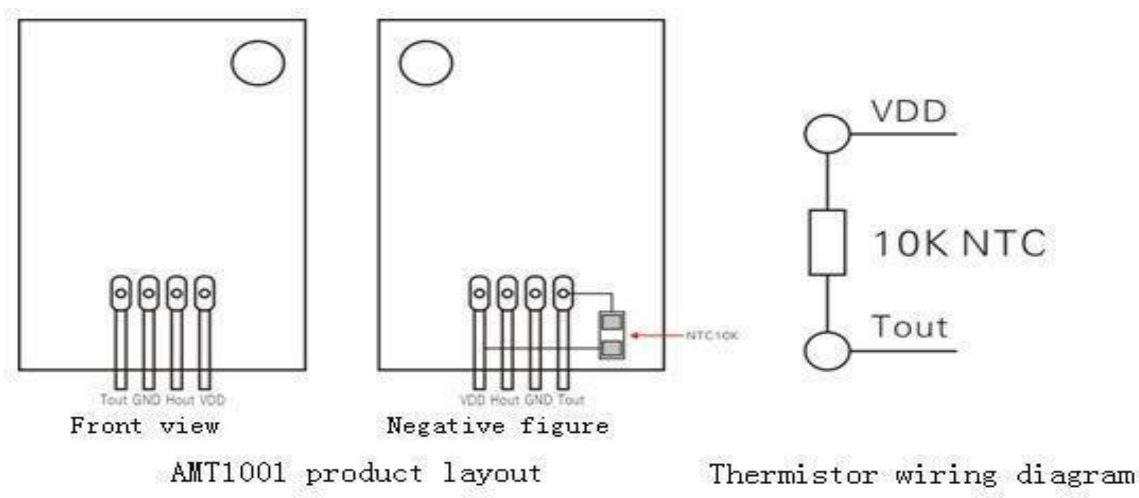


Fig.6: Temperature wiring schematic

3.1.6 Sensor Performance

3.1.6.1 Humidity

Table 3.c: Relative Humidity Performance:

Parameters	Conditions	min	type	max	unit
Range		21		85	%RH
	25.1 ℃		±6		%RH
Repeatability			±1		%RH
Interchangeability		Completely interchangeable			
Response time [2]	1/e (63%)		<5.5		S
Hysteresis			±0.4		%RH
Drift [3]	Typical values		<0.6		%RH/yr.

3.1.6.2 Temperature

Table 3.d: 10K NTC B3435 technical parameters:

Specification	Rated zero power Resistance (R25)	B （K）	Dissipation Factor (mw/℃）	Thermal time constant （S）	Rated Power （mw）	Operating Temperature Range （℃）
SNE103B13435AS150EF	10KΩ	3436	≥2.6	≤19	140	-40~155

3.1.7 Electrical Characteristics

Dependent on the power source, electrical attributes like power usage, input and output voltage, etc. The sensor's electrical specs are listed in Table 3.e; unless otherwise noted, supply voltage is 5V. Please design in strict adherence to the conditions listed in Table 3.e for the optimum sensor performance.

Table 3.e: AM1001 / AMT1001 sensor DC characteristics.

Parameters	Conditions	min	type	max	unit
Supply voltage		4.76	6.0	5.26	V
Voltage output range of humidity		0		5	V
Consumption of power	Measurement		3.0		mA
Sampling period of humidity			3		S
Measurement range of humidity		21		80	%RH
Temperature range		0		50	℃
Measurement range of temperature	NTC10K	0		50	℃

3.1.8 Application Information

1. Working and storing circumstances

The anticipated scope of operations beyond the sensor could result in a temporary drift signal of up to 3% RH. When operating conditions return to normal, the sensor calibration state will gradually recover. To hasten the recovery process, look up "recovery process." Prolonged use under unusual operating circumstances will hasten ageing.

Avoid placing components in long-term condensation and dry conditions, as well as the settings listed below.

A. Smoke

B. An acid or oxidising gas such as sulphur dioxide or hydrochloric acid Storage Recommendations Environment

The temperature is 10-40°C. 60% relative humidity or less

2. The effect of chemical exposure

Chemical vapour diffusion in the sensing layer of chemicals may induce drift and measurement sensitivity if the resistive humidity sensor sensing layer is disrupted. It will gradually release toxins in a clean environment. Restore the processing outlined below to speed up the process. High amounts of chemical contaminants (such as ethanol) can entirely destroy the sensor detecting layer.

3. The Influence of Temperature

Temperature has a considerable influence on the relative humidity of the gas. As a result, when measuring humidity, it should be able to ensure that the sensors are at the same temperature. If you share a printed circuit board and electronic components, the heat emitted by the sensor should be positioned as far away from the electronic components as feasible, and installed under the heat, in a well-ventilated enclosure. To prevent heat transfer to other portions of the sensor and copper plating on printed circuit boards to be the smallest possible and leaving a gap between.

4. Lighting effects

Prolonged exposure to sunlight or high levels of UV radiation would degrade performance.

5. Recovery procedure

When exposed to harsh working circumstances or chemical vapour sensors, the following processing programme can restore them to a state of calibration. <2 hours (drying) at a humidity of 10% RH, followed by 20-30 °C, > 45 °C, and 5 hours at a humidity of 70% RH.

6. Wiring Safety Precautions

The quality of the signal wire will affect the voltage output quality; it is advised that high grade shielded cable be used.

7. Welding Information Manual soldering at temperatures up to 300 °C requires a contact time of less than 3 seconds.

8. Product enhancements Please contact the Aosong electronic technology sector for more information.

3.2 ARDUINO

Arduino is an open-source electronics platform that is based on easy-to-use hardware and software. It consists of a microcontroller, development board, and a programming language, which makes it easy for people to create interactive electronic projects.

The microcontroller used in Arduino is typically an Atmel AVR microcontroller, although other microcontrollers can also be used. The development board usually includes input/output pins, power regulators, and a USB interface for programming and communication.

Arduino programming language is a simplified version of C++ language, and it is designed to make it easy for people with little or no programming experience to create their own electronic projects. The language comes with a set of libraries that make it easy to interface with sensors, motors, displays, and other components.

Arduino is widely used in various fields, including robotics, automation, Internet of Things (IoT), and education. It is popular because of its affordability, simplicity, and versatility. There are many different types of Arduino boards available, each with different features and capabilities, making it easy to choose the right board for a specific project.

Furthermore, the open-source nature of the Arduino platform means that there is a large community of developers and enthusiasts who are constantly developing new libraries, projects, and tutorials, and providing support to other users.

3.2.1 COMPONENTS OF ARDUINO

The Arduino Uno is a microcontroller board based on the ATmega328P. It has the following components:

1. Microcontroller: The main processing unit of the board is the ATmega328P, an 8-bit AVR microcontroller.
2. Digital I/O Pins: There are 14 digital input/output pins on the board, which can be configured as either inputs or outputs.
3. Analog Input Pins: There are 6 analog input pins on the board, which can be used to read analog signals from sensors or other devices.
4. Power Supply: The board can be powered using a USB cable or an external power supply. It has a voltage regulator that can accept input voltages between 7 and 20 volts and provide a stable 5V output for the microcontroller.
5. USB Connector: The board has a USB connector that can be used to connect it to a computer for programming and serial communication.
6. Reset Button: The board has a reset button that can be used to reset the microcontroller.
7. Crystal Oscillator: The board has a 16 MHz crystal oscillator that provides the clock signal for the microcontroller.
8. LED Indicators: The board has several LEDs that can be used for visual feedback. There is a power LED, a TX LED, and an RX LED.
9. ICSP Header: The board has an ICSP header that can be used for programming the microcontroller using an external programmer.
10. Voltage Regulator: The board has a voltage regulator that can provide a stable 5V output for the microcontroller, even when the input voltage varies.
11. Serial Interface: The board has a UART serial interface that can be used for communication with other devices.

Overall, the Arduino Uno is a versatile microcontroller board that can be used for a wide range of projects and applications.

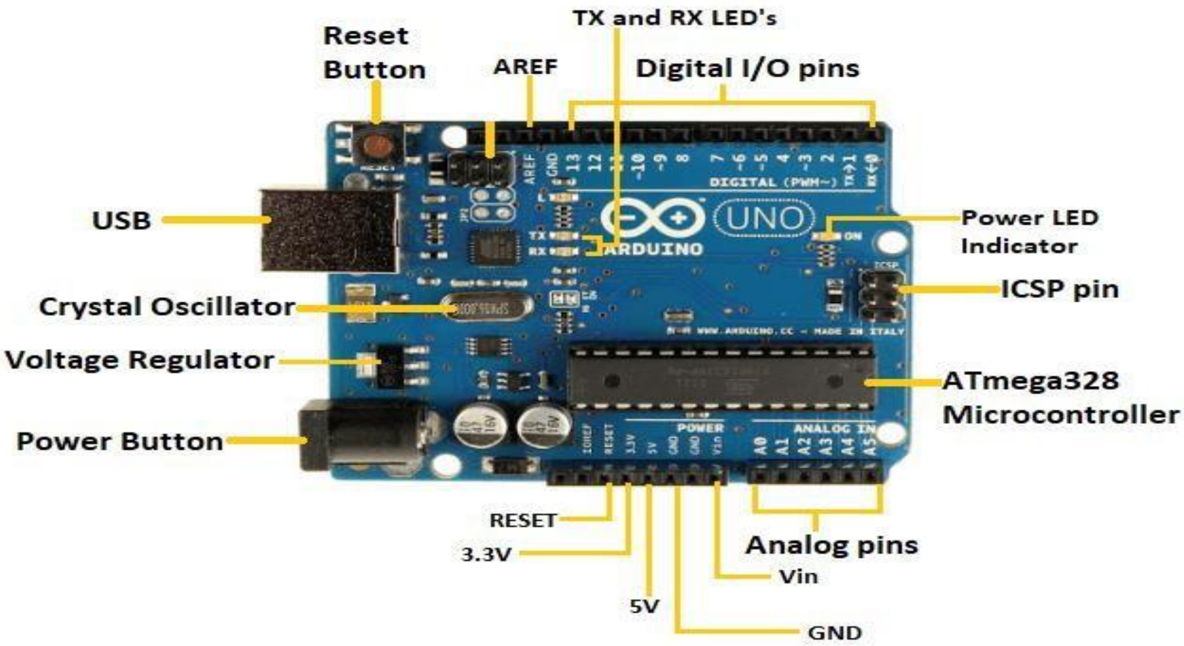


Fig.7: Arduino Configuration

3.2.2 PIN DIAGRAM OF ARDUINO

The Arduino Uno has a pinout diagram that shows the location and function of each pin on the board. Here's a brief explanation of each section of the pinout diagram:

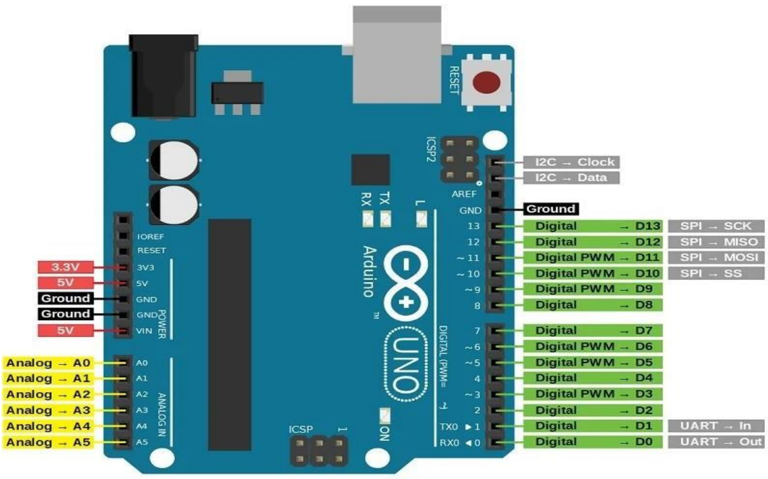


Fig.8: Arduino pin diagram

1. Power Pins: The power pins provide power to the board and connected components. The Arduino Uno has a 5V pin and a 3.3V pin, which can be used to power external components. It also has a VIN pin that can be used to power the board using an external power source.
2. Analog Input Pins: The Arduino Uno has six analog input pins labelled A0 through A5. These pins can be used to read analog signals from sensors or other devices.
3. Digital I/O Pins: The Arduino Uno has 14 digital input/output pins labelled 0 through 13. These pins can be configured as either inputs or outputs.
4. PWM Pins: The digital pins 3, 5, 6, 9, 10, and 11 on the Arduino Uno can be used as PWM (Pulse Width Modulation) pins. These pins can output a variable voltage to control the brightness of an LED or the speed of a motor.
5. Reset Pin: The Reset pin is used to reset the microcontroller.There will be one reset pin.
6. ICSP Pins: The In-Circuit Serial Programming (ICSP) pins can be used to program the microcontroller using an external programmer.
7. UART Pins: The UART pins, labelled RX and TX, can be used for serialcommunication with other devices.
8. External Interrupt Pins: The Arduino Uno has two external interrupt pins, labelled 2and 3, which can be used to trigger an interrupt when a certain event occurs.

3.2.3 ARDUINO IDE

`The Arduino Integrated Development Environment (IDE) is a software application used to write, compile, and upload code to Arduino boards. Here is an overview of the main features of the Arduino IDE:

1. Code Editor: The code editor is the main interface of the IDE. It provides a simple text editor where you can write your code in the Arduino programming language.

2. Library Manager: The Library Manager allows you to browse and install libraries that can be used in your Arduino projects. These libraries contain pre-written code for specific functions and devices, which can save you time and effort when programming.

3. Serial Monitor: The Serial Monitor is a tool that allows you to communicate with your Arduino board over a serial connection. It can be used to send and receive data from your board, which can be useful for debugging and testing your code.
4. Board Manager: The Board Manager allows you to select the type of Arduino board you are using and install the necessary drivers and software for that board.
5. Sketchbook: The Sketchbook is a folder where you can save your Arduino sketches, which are the code files that you write for your projects
6. Examples: The Examples section provides a range of pre-written code examples that demonstrate how to use various Arduino features and components.
7. Tools: The Tools menu provides access to various settings and preferences for the IDE, such as the serial port, compiler options, and programmer settings.

Overall, the Arduino IDE is a powerful tool for programming and developing projects with Arduino boards. It's easy to use and provides a range of features and resources that can help you get started quickly and efficiently.

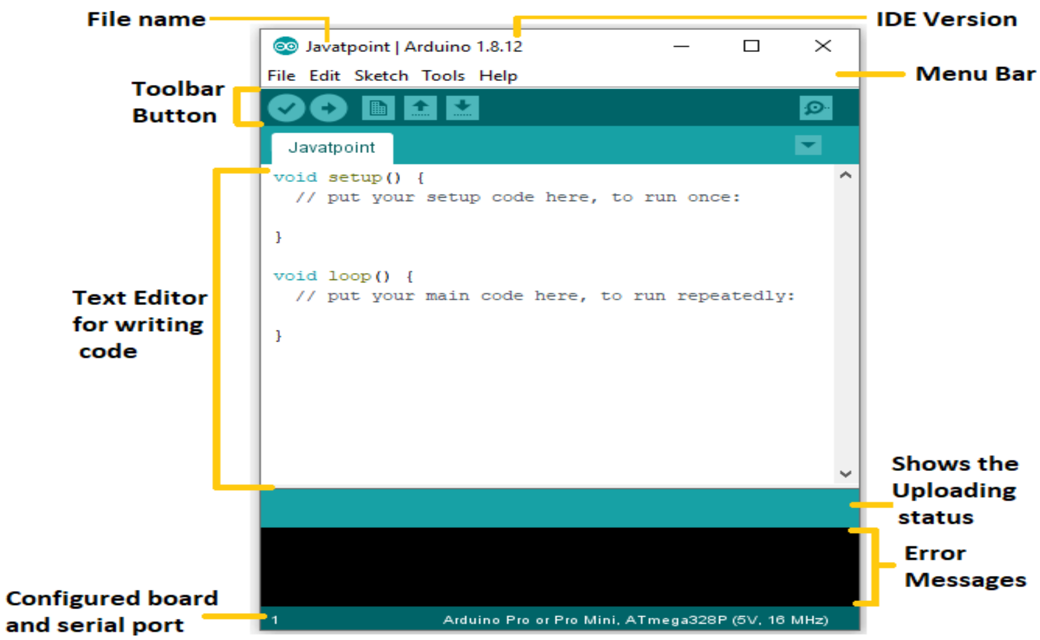


Fig.9: Arduino IDE

3.2.4 FEATURES OF ARDUINO

Arduino is a popular open-source electronics platform that provides a range of features that make it an ideal choice for hobbyists, makers, and professionals alike. Here are some of the key features of Arduino:

1. Ease of Use: Arduino is easy to use and accessible for beginners. The Arduino IDE provides a user-friendly interface for programming and uploading code to the board. Additionally, the Arduino community provides extensive documentation and support, making it easier to get started with the platform.
2. Open-Source: Arduino is an open-source platform, which means that the hardware and software designs are freely available to the public. This allows for customization, modification, and expansion of the platform to suit specific needs.
3. Cost-Effective: Arduino is an affordable platform compared to other microcontroller platforms. This makes it accessible for beginners and those on a tight budget.
4. Versatile: Arduino can be used for a wide range of projects, including robotics, home automation, wearable technology, and more. The platform provides a range of input and output options, including digital and analog pins, PWM, and serial communication.
5. Compatibility: Arduino is compatible with a wide range of sensors, shields, and other add-on modules. This makes it easy to integrate different components into your projects.
6. Community: Arduino has a large and active community of users and developers. This community provides support, resources, and inspiration for new projects.

Overall, Arduino provides a range of features that make it a versatile, affordable, and accessible platform for electronics and microcontroller projects.

3.3 MULTIPLEXER

1. The CD74HC4067 is a 16-channel analog multiplexer/demultiplexer IC (Integrated Circuit) that allows multiple analog signals to be transmitted over a single channel. It is a part of the HC4067 series of ICs manufactured by Texas Instruments.

2. The CD74HC4067 multiplexer is commonly used in electronic circuits to simplify complex wiring connections and to reduce the number of components required. It operates on a supply voltage range of 2V to 6V and can handle analog signals within a range of 0V to VCC.

3. The CD74HC4067 consists of 16 single-ended analog input/output channels that can be switched through a single digital input pin. It has a typical on-resistance of 70 Ohms and an off-isolation of -62 dB at 1 MHz. The IC also has a built-in protection against electrostatic discharge (ESD), making it more robust and reliable in demanding electronic applications.

4. The CD74HC4067 multiplexer is widely used in electronic circuits such as audio mixers, data acquisition systems, and other applications where multiple analog signals need to be combined or switched between different channels. Its compact size, low power consumption, and high reliability make it a popular choice among electronic engineers and hobbyists.

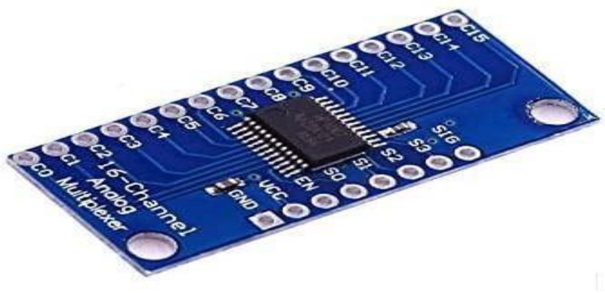


Fig.10: Multiplexer

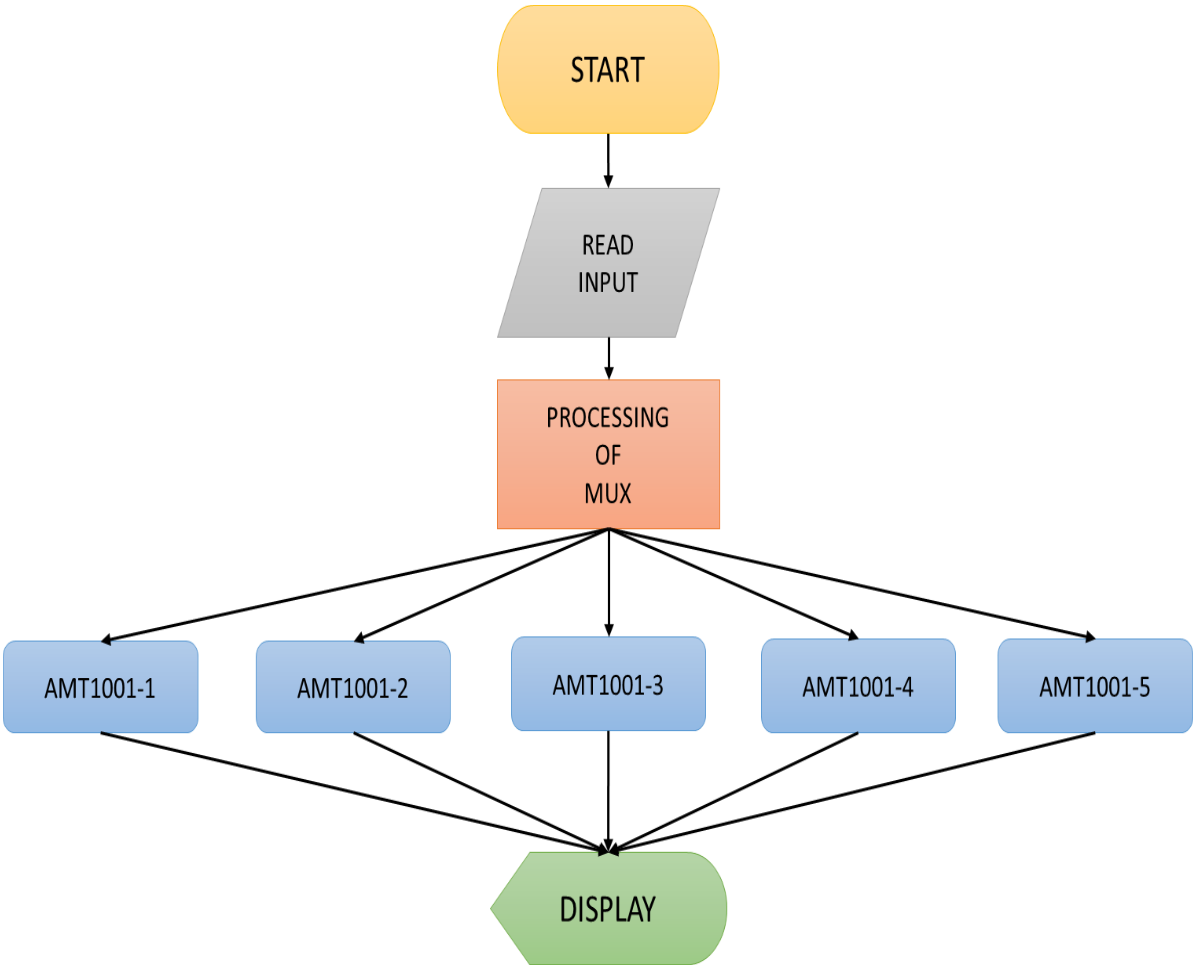
3.4 CYLINDRICAL MESH

Fig.11: Cylindrical mesh

This is the model designed by us. This is a mesh in the shape of a cylinder that contains another cylindrical mesh inside. Onions are kept in between two cylindrical meshes. There will be a fan on the top of the inside cylindrical mesh for ventilation. Multiple AMT1001 sensors are placed at different places in a cylinder Connected through a multiplexer.

Chapter 4
Methodology

4.1 FLOW CHART



4.2 ALGORITHM:

- Start
- Based on mux selection inputs (S_0 , S_1 ,S_2 ,S_3)
- If $S_0 = 0$, $S_1= 0$, $S_2= 0$, $S_3= 0$

  Sensor1 is activated, select C_0.

  Display temperature (AT0) and humidity (AH0)

  If $S_0 = 1$, $S_1 = 0$, $S_2 = 0$, $S_3 = 0$

  Sensor2 is activated, select C_1.

  Display temperature (AT1) and humidity (AH1)

  If $S_0 = 0$, $S_1 = 1$, $S_2 = 0$, $S_3 = 0$

  Sensor3 is activated, select C_2.

  Display temperature (AT2) and humidity (AH2)

  If $S_0 =1$, $S_1 = 1$, $S_2 = 0$, $S_3 = 0$

  Sensor4 is activated, select C_3.

  Display temperature (AT3) and humidity (AH3)

  If $S_0 =0$, $S_1 = 0$, $S_2 = 1$, $S_3 = 0$

  Sensor4 is activated, select C_3.

  Display temperature (AT4) and humidity (AH4)

- End

4.3 CODE:

```
#defineATpin A0
#defineAHpin A1
#defineLEDpin 13
float AT1=0,AH1=0;
float AT2=0,AH2=0;
float AT3=0,AH3=0;
float AT4=0,AH4=0;
float AT5=0,AH5=0;

void setup() {
Serial.begin(9600);
pinMode(LEDpin,OUTPUT);

pinMode(9,OUTPUT);
pinMode(10,OUTPUT);
pinMode(11,OUTPUT);
pinMode(12,OUTPUT);
}
void loop()
{
digitalWrite(9,LOW);
digitalWrite(10,LOW);
digitalWrite(11,LOW);
digitalWrite(12,LOW);

delay(100);
AT1=analogRead(ATpin);
AH1=analogRead(AHpin);
AT1=(((AT1*5)/1024)*5.5);
```

```
AH1=((AH1*5)/1024)/0.065;
Serial.print("temperature sensor 1:");
Serial.print(AT1);
Serial.print("C | himidity:");
Serial.print(AH1);
Serial.println("%");
if(AT1>30){
digitalWrite(LEDpin,HIGH);
Serial.println("LED : ON");
}
else{
digitalWrite(LEDpin,LOW);
Serial.println("LED : OFF");
}
delay(1000);

//read second sensor
digitalWrite(9,HIGH);
digitalWrite(10,LOW);
digitalWrite(11,LOW);
digitalWrite(12,LOW);

delay(100);//allow address to settle
AT2=analogRead(ATpin);
AH2=analogRead(AHpin);
AT2=(((AT2*5)/1024)*5.5);
AH2=((AH2*5)/1024)/0.065;
Serial.print("temperature sensor 2:");
Serial.print(AT2);
Serial.print("C | himidity:");
```

```
Serial.print(AH2);
Serial.println("%");
if(AT2>30){
digitalWrite(LEDpin,HIGH);
Serial.println("LED : ON");
}
else{
digitalWrite(LEDpin,LOW);
Serial.println("LED : OFF");
}
delay(1000);

//read 3rd sensor

digitalWrite(9,LOW);
digitalWrite(10,HIGH);
digitalWrite(11,LOW);
digitalWrite(12,LOW);

delay(100);
AT3=analogRead(ATpin);
AH3=analogRead(AHpin);
AT3=(((AT3*5)/1024)*5.5);
AH3=((AH3*5)/1024)/0.065;
Serial.print("temperature sensor 1:");
Serial.print(AT3);
Serial.print("C | himidity:");
Serial.print(AH3);
Serial.println("%");
if(AT3>30){
```

```
digitalWrite(LEDpin,HIGH);
Serial.println("LED : ON");
}
else{
digitalWrite(LEDpin,LOW);
Serial.println("LED : OFF");
}
delay(1000);
//READ 4TH SENSOR
digitalWrite(9,HIGH);
digitalWrite(10,HIGH);
digitalWrite(11,LOW);
digitalWrite(12,LOW);

delay(100);
AT4=analogRead(ATpin);
AH4=analogRead(AHpin);
AT4=(((AT4*5)/1024)*5.5);
AH4=((AH4*5)/1024)/0.065;
Serial.print("temperature sensor 1:");
Serial.print(AT4);
Serial.print("C | himidity:");
Serial.print(AH4);
Serial.println("%");
if(AT4>30){
digitalWrite(LEDpin,HIGH);
Serial.println("LED : ON");
}
else{
digitalWrite(LEDpin,LOW);
```

```
Serial.println("LED : OFF");
}
delay(1000);
//READ 5TH SENSOR
digitalWrite(9,LOW);
digitalWrite(10,LOW);
digitalWrite(11,HIGH);
digitalWrite(12,LOW);

delay(100);
AT5=analogRead(ATpin);
AH5=analogRead(AHpin);
AT5=(((AT5*5)/1024)*5.5);
AH5=((AH5*5)/1024)/0.065;
Serial.print("temperature sensor 1:");
Serial.print(AT5);
Serial.print("C | himidity:");
Serial.print(AH5);
Serial.println("%");
if(AT5>30){
digitalWrite(LEDpin,HIGH);
Serial.println("LED : ON");
}
else{
digitalWrite(LEDpin,LOW);
Serial.println("LED : OFF");
}
delay(1000);

}
```

Chapter 5
Results

5.1 Proposed System

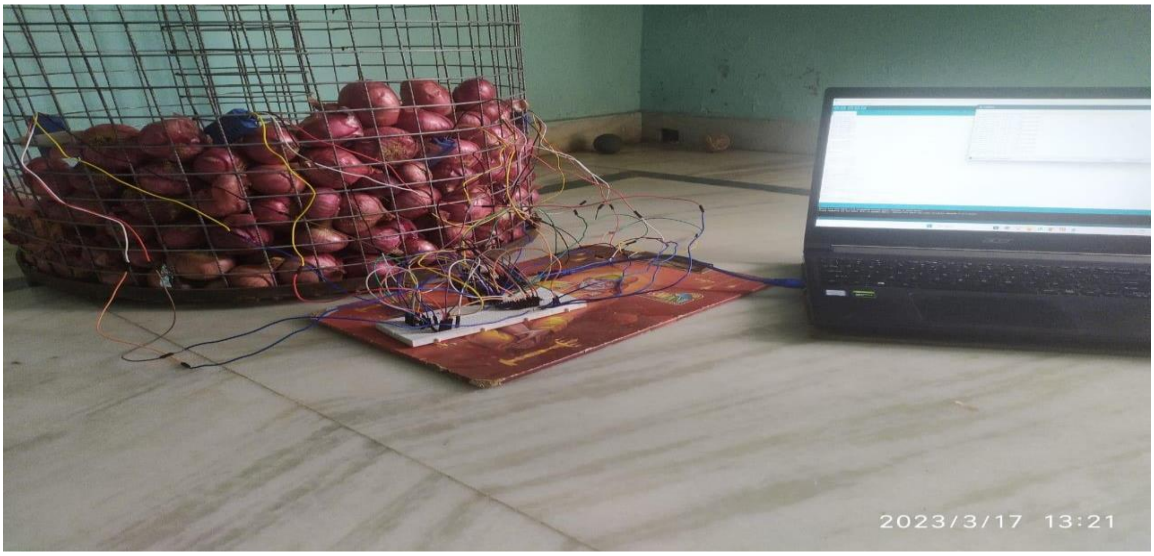


Fig.12: Proposed system

5.2 Few outputs

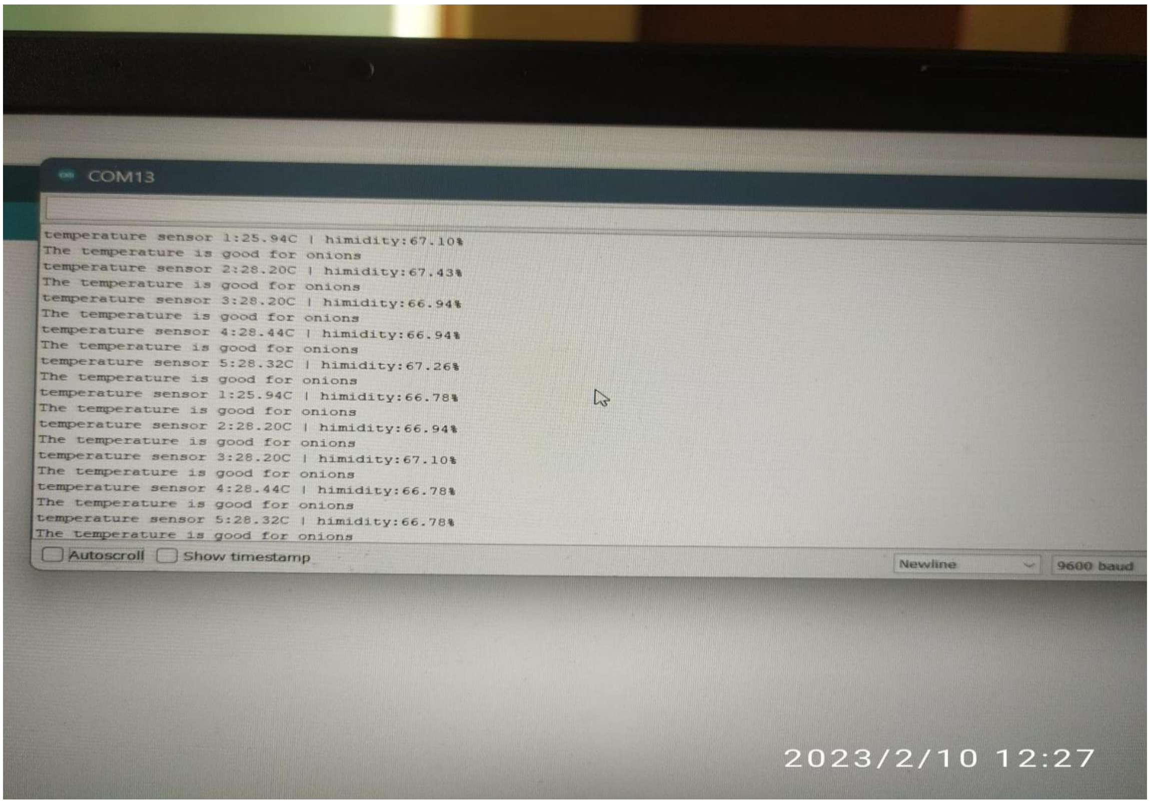


Fig.13: Temperature and Humidity on 10/2/2023 showing temperature less than 30 c

Fig. 13 shows the temperature and humidity readings on February 10, 2023. The temperature of the 5 sensors is above 25 degrees Celsius and below 30 degrees Celsius and the humidity is in between 65-70%. The readings are suitable for the growth of onions.

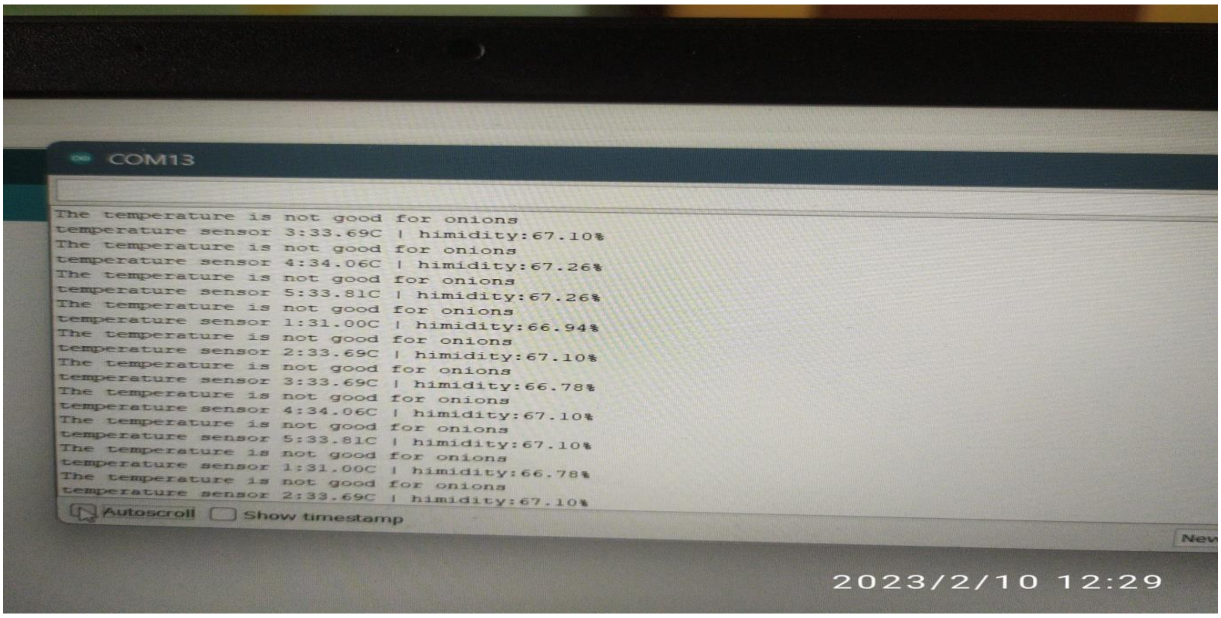


Fig.14: Temperature and Humidity on 10/2/2023 showing temperature greater than 30 c

Fig. 14 shows the temperature and humidity readings on February 10, 2023. The temperature of the 5 sensors is above 30-degree Celsius and the humidity is in between 65-70%. The temperature is not suitable for the growth of onions.

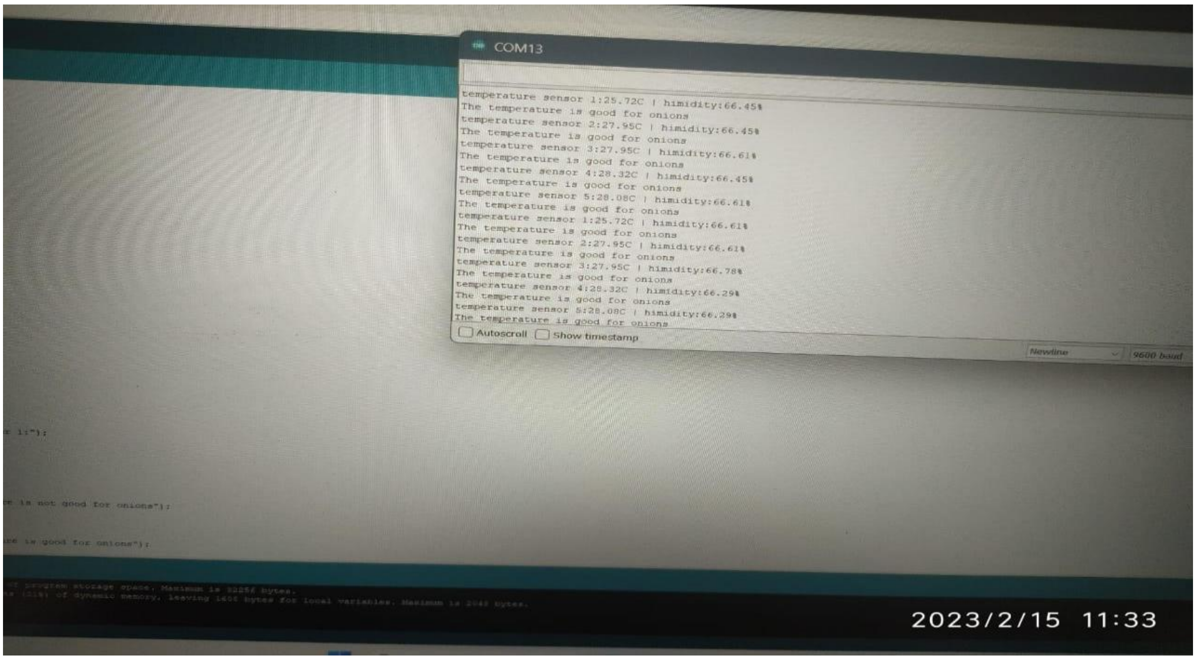


Fig.15: Temperature and Humidity on 15/2/2023

Fig. 15 shows the temperature and humidity readings on February 15, 2023. The temperature of the 5 sensors is above-25 degree Celsius and below 30-degree Celsius and the humidity is in between 65-70%. The readings are suitable for the growth of onions.

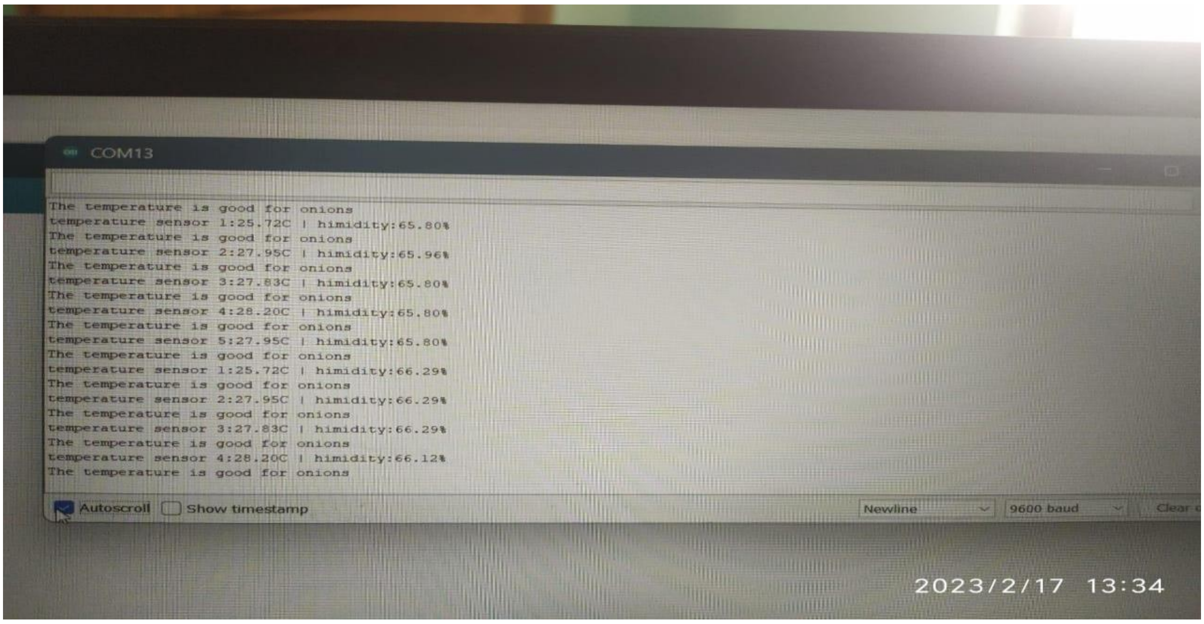


Fig.16: Temperature and Humidity on 17/2/2023

Fig. 16 shows the temperature and humidity readings on February 17, 2023. The temperature of the 5 sensors is above-25 degree Celsius and below 30-degree Celsius and the humidity is in between 65-70%. The readings are suitable for the growth of onions.

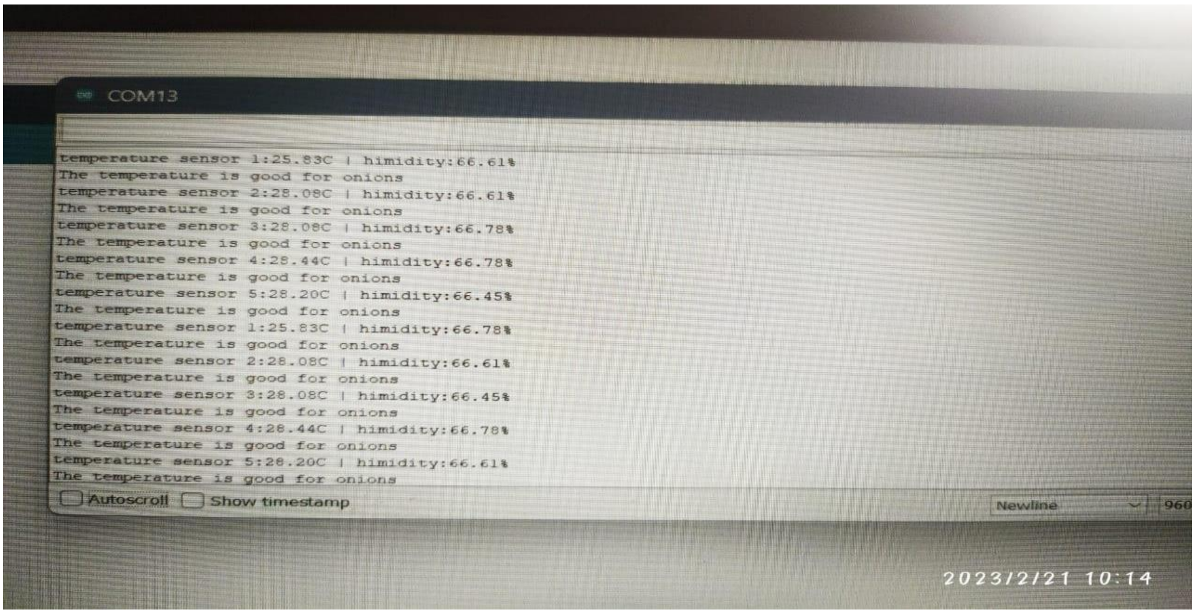


Fig.17: Temperature and Humidity on 21/2/2023

Fig. 17 shows the temperature and humidity readings on February 21, 2023. The temperature of the 5 sensors is above-25 degree Celsius and below 30-degree Celsius and the humidity is in between 65-70%. The readings are suitable for the growth of onions.

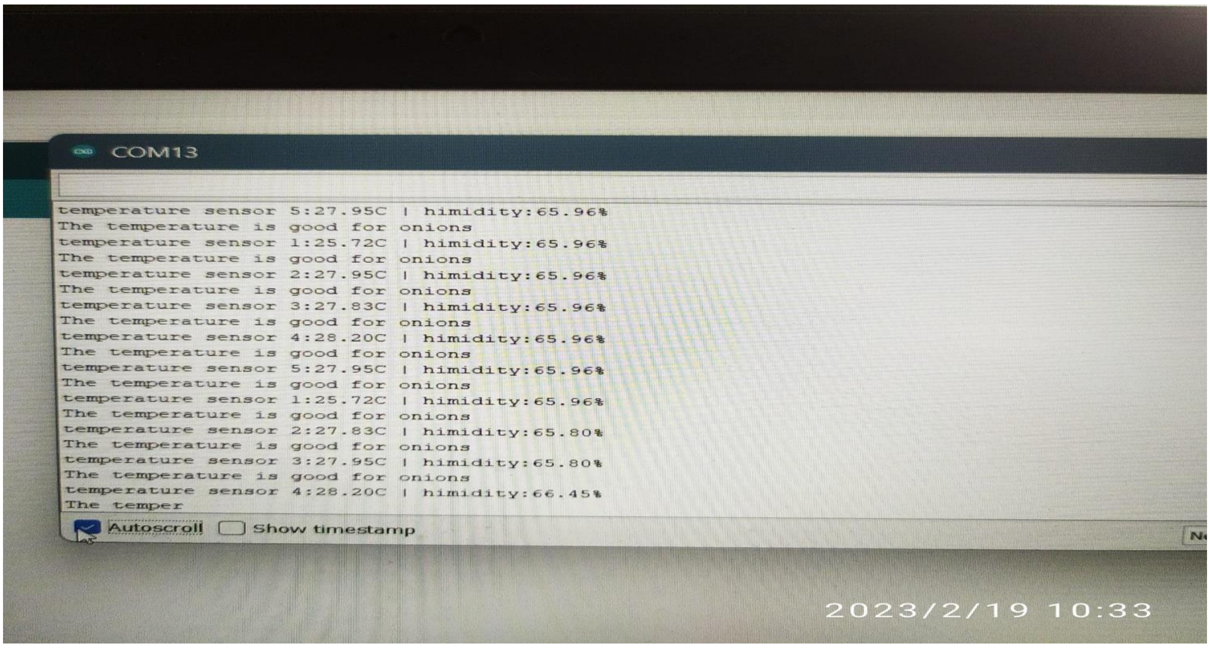


Fig.18: Temperature and Humidity on 19/2/2023

Fig. 18 shows the temperature and humidity readings on February 19, 2023. The temperature of the 5 sensors is above-25 degree Celsius and below than 30-degree Celsius and the humidity is in between 65-70%. The readings are suitable for the growth of onions.

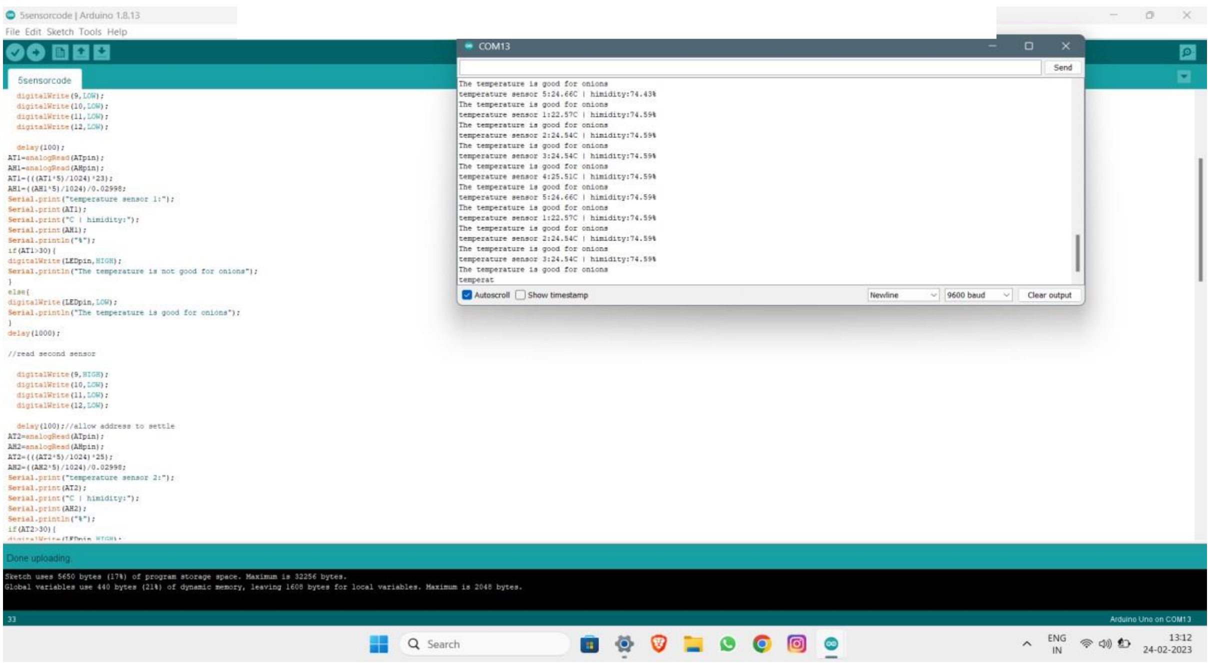


Fig.19: Temperature and humidity on 24/02/2023

Fig. 19 shows the temperature and humidity readings on February 24, 2023. The temperature of the 5 sensors is above-25 degree Celsius and below 30-degree Celsius and the humidity is above 70%. The humidity readings are not suitable for the growth of onions.

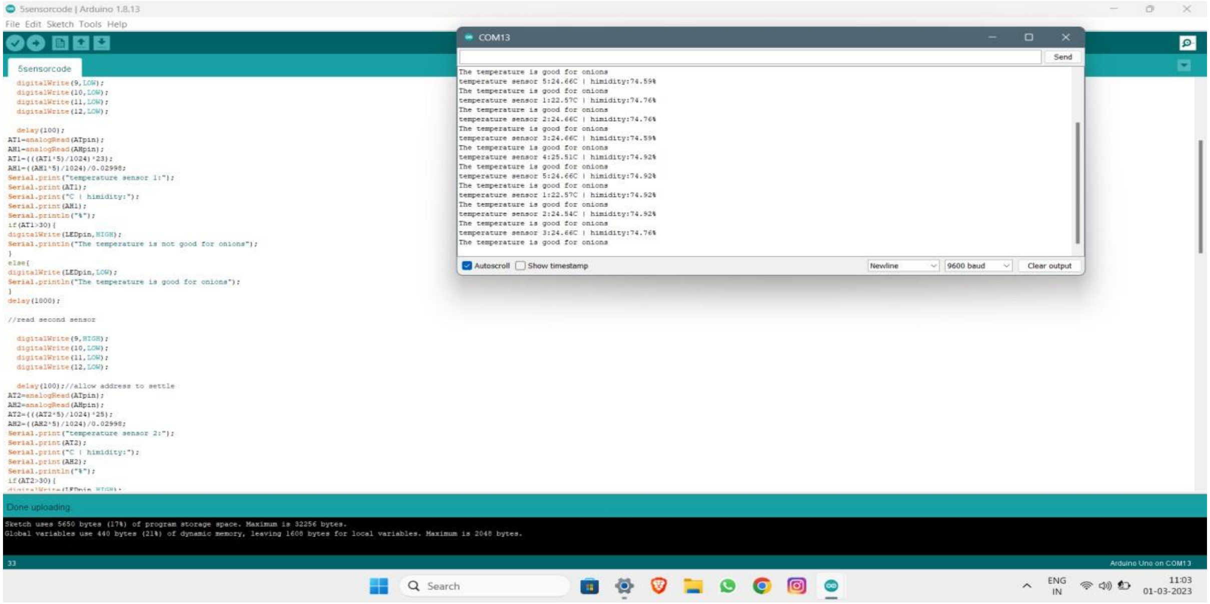


Fig.20: Temperature and Humidity on 1/3/2023

Fig. 20 shows the temperature and humidity readings on march 1, 2023. The temperature of the 5 sensors is below 25 degree Celsius and the humidity is above 70%. The temperature and humidity readings are not suitable for the growth of the onions.

The temperature and humidity have been monitored for 45 days continuously. After successful monitoring of temperature and humidity, the losses were observed from the model and compared with previous model's losses. The losses in the previous models are in between 25-30% whereas the loss in the designed model is 20%.

5.3 Data Sheet

The data sheet gives information about the temperature and humidity of 5 sensors from February 10, 2023 to march 26, 2023. The readings were taken during the three sessions. Mostly, the temperature was high during the afternoon session and the humidity was high during the afternoon session. The highest temperature recorded by the sensor 1 is 33.3 on march 6, 2023. The highest temperature recorded by the sensor 2 is 34.4 on march 6, 2023. The highest temperature recorded by the sensor 3 is 34 on February 21, 2023. The highest temperature recorded by the sensor 4 is 33.3 on February 26, 2023. The highest temperature recorded by the sensor 5 is 35.3 on march 6, 2023.

day	Sensor 1			Sensor 2			Sensor 3			Sensor 4			Sensor 5		
	Mor	Aft	Eve	Mor	Aft	Eve	Mor	Aft	Eve	Mor	Aft	Eve	Mor	Aft	Eve
1	T-25.3 H-68.3	T-31 H-66.9	T-26 H-67	T-27 H-67.1	T-33 H-67.1	T-27 H-70	T-27.3 H-68	T-33 H-66.7	T-27.6 H-69	T-27.0 H-69	T-34 H-67.1	T-27.6 H-67.1	T-26.6 H-66.7	T-33 H-66.7	T-28 H-70
2	T-26.3 H-69.7	T-29.2 H-65.0	T-27.2 H-69.3	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2	T-26.7 H-66.0	T-29.0 H-65.6	T-27.0 H-72	T-27.0 H-68.0	T-30.0 H-64.7	T-27.0 H-69.0	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2
3	T-27 H-67.1	T-33 H-67.1	T-27 H-70	T-27 H-67.1	T-33 H-67.1	T-27 H-70	T-27.3 H-68	T-33 H-66.7	T-27.6 H-69	T-27.0 H-69	T-34 H-67.1	T-27.6 H-67.1	T-26.6 H-66.7	T-33 H-66.7	T-28 H-70
4	T-26.3 H-69.7	T-29.2 H-65.0	T-27.2 H-69.3	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2	T-26.7 H-66.0	T-29.0 H-65.6	T-27.0 H-72	T-27.0 H-68.0	T-30.0 H-64.7	T-27.0 H-69.0	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2
5	T-27.2 H-67.0	T-30.5 H-64.2	T-28.1 H-74.0	T-27.8 H-66.6	T-29.9 H-63.0	T-27.0 H-69.9	T-27.8 H-66.6	T-29.9 H-63.0	T-27.0 H-69.9	T-27.8 H-66.6	T-29.9 H-63.0	T-27.0 H-69.9	T-28.0 H-72.5	T-31.0 H-64.0	T-28.0 H-1.2
6	T-26.3 H-69.7	T-25.7 H-66.4	T-28.1 H-74.0	T-26.3 H-69.7	T-27.9 H-66.4	T-27.9 H-66.6	T-26.3 H-69.7	T-28.3 H-66.6	T-28.1 H-74.0	T-26.3 H-69.7	T-28.3 H-66.1	T-28.1 H-74.0	T-26.3 H-69.7	T-28.0 H-66.6	T-28.1 H-74.0
7	T-26.3 H-69.7	T-25.7 H-66.4	T-28.1 H-74.0	T-26.3 H-69.7	T-27.9 H-66.4	T-27.9 H-66.6	T-26.3 H-69.7	T-28.3 H-66.6	T-28.1 H-74.0	T-26.3 H-69.7	T-28.3 H-66.1	T-28.1 H-74.0	T-26.3 H-69.7	T-28.0 H-66.6	T-28.1 H-74.0

8	T-25.1 H-60.0	T-25.7 H-65.8	T-28.1 H-74.0	T-26.3 H-69.7	T-27.9 H-65.9	T-28.1 H-74.0	T-26.3 H-69.7	T-28.2 H-65.8	T-28.1 H-74.0	T-26.3 H-69.7	T-28.2 H-66.2	T-28.1 H-74.0	T-26.3 H-69.7	T-27.9 H-66.2	T-27.0 H-72
9	T-26.3 H-69.7	T-29.2 H-65.0	T-27.2 H-69.3	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2	T-26.7 H-68.0	T-29.0 H-65.6	T-27.0 H-72	T-27.0 H-68.0	T-30.0 H-64.7	T-27.0 H-69.0	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2
10	T-27 H-67.1	T-33 H-67.1	T-27 H-70	T-27 H-67.1	T-33 H-67.1	T-27 H-70	T-27.3 H-68	T-33 H-65.7	T-27.6 H-69	T-29.0 H-69	T-34 H-67.1	T-27.6 H-67.1	T-26.6 H-69.7	T-33 H-66.7	T-28 H-70
11	T-26.3 H-69.7	T-29.2 H-65.0	T-27.2 H-69.3	T-27.0 H-68.0	T-29.5 H-64.9	T-31.2 H-65.2	T-26.7 H-66.0	T-29.0 H-65.6	T-27.0 H-72	T-27.0 H-68.0	T-30.0 H-64.7	T-27.0 H-69.0	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2
12	T-27 H-67.1	T-33 H-67.1	T-27 H-70	T-27 H-67.1	T-33 H-67.1	T-27 H-70	T-27.3 H-68	T-34 H-66.7	T-27.6 H-69	T-27.0 H-69	T-34 H-67.1	T-27.6 H-67.1	T-26.6 H-66.7	T-33 H-66.7	T-28 H-70
13	T-26.3 H-69.7	T-29.2 H-65.0	T-27.2 H-69.3	T-28.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2	T-26.7 H-66.0	T-29.0 H-65.6	T-27.0 H-72	T-27.0 H-68.0	T-30.0 H-64.7	T-27.0 H-69.0	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2
14	T-27 H-67.1	T-33 H-67.1	T-27 H-70	T-27 H-67.1	T-33 H-67.1	T-27 H-70	T-27.3 H-68	T-33 H-66.7	T-27.6 H-69	T-27.0 H-69	T-34 H-67.1	T-27.6 H-67.1	T-26.6 H-66.7	T-33 H-66.7	T-28 H-70
15	T-26.3 H-69.7	T-29.2 H-65.0	T-27.2 H-69.3	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2	T-26.7 H-66.0	T-29.0 H-65.6	T-27.0 H-72	T-27.0 H-68.0	T-30.0 H-64.7	T-27.0 H-69.0	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2
16	T-26.3 H-69.7	T-29.2 H-65.0	T-27.2 H-69.3	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2	T-26.7 H-66.0	T-29.0 H-65.6	T-27.0 H-72	T-27.0 H-68.0	T-30.0 H-64.7	T-27.0 H-69.0	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2

17	T-27 H-67.1	T-33 H-67.1	T-27 H-70	T-27 H-67.1	T-33 H-67.1	T-27 H-70	T-27.3 H-68	T-33 H-66.7	T-27.6 H-69	T-27.0 H-69	T-35 H-67.1	T-27.6 H-67.1	T-26.6 H-66.7	T-33 H-66.7	T-28 H-70
18	T-26.3 H-69.7	T-29.2 H-65.0	T-27.2 H-69.3	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2	T-26.7 H-66.0	T-29.0 H-65.6	T-27.0 H-72	T-27.0 H-68.0	T-30.0 H-64.7	T-27.0 H-69.0	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2
19	T-27.2 H-67.0	T-30.5 H-64.2	T-28.1 H-74.0	T-27.8 H-66.6	T-29.9 H-63.0	T-27.0 H-69.9	T-27.8 H-66.6	T-29.9 H-63.0	T-27.0 H-69.9	T-27.8 H-66.6	T-29.9 H-63.0	T-27.0 H-69.9	T-28.0 H-72.5	T-31.0 H-64.0	T-28.0 H-1.2
20	T-26.3 H-69.7	T-25.7 H-66.4	T-28.1 H-74.0	T-26.3 H-69.7	T-27.9 H-66.4	T-27.9 H-66.6	T-26.3 H-69.7	T-28.3 H-66.6	T-28.1 H-74.0	T-26.3 H-69.7	T-28.3 H-66.1	T-28.1 H-74.0	T-26.3 H-69.7	T-25.7 H-66.4	T-28.1 H-74.0
21	T-27.4 H-67.1	T-32.6 H-67.1	T-27.0 H-70	T-27.0 H-67.1	T-31.7 H-67.1	T-27.8 H-70	T-27.3 H-68	T-31.9 H-66.7	T-27.6 H-69	T-27.0 H-69	T-32.0 H-67.1	T-27.6 H-67.1	T-27.4 H-67.1	T-32.6 H-67.1	T-27.0 H-70
22	T-26.2 H-70.3	T-30.0 H-65.5	T-27.0 H-67.7	T-27.8 H-66.6	T-29.9 H-63.0	T-27.0 H-69.9	T-26.2 H-70.3	T-30.0 H-65.5	T-27.0 H-67.7	T-27.8 H-66.6	T-29.9 H-63.0	T-27.0 H-69.9	T-26.2 H-70.3	T-30.0 H-65.5	T-27.0 H-67.7
23	T-27.3 H-68	T-31.6 H-66.7	T-27.6 H-69	T-27.0 H-69	T-31.0 H-67.1	T-27.6 H-67.1	T-26.6 H-66.7	T-31.4 H-66.7	T-28.2 H-70	T-27.2 H-67.1	T-31.3 H-67.1	T-27.4 H-70	T-27.2 H-67.1	T-32.0 H-67.1	T-27.4 H-70
24	T-27 H-67.1	T-29.9 H-67.1	T-27.4 H-70.3	T-27.5 H-67.1	T-28.9 H-67.1	T-27.3 H-70.3	T-27.3 H-68.4	T-30.2 H-66.7	T-27.6 H-69.3	T-27.0 H-69.5	T-30.5 H-67.1	T-27.6 H-67.1	T-26.6 H-66.7	T-31.0 H-66.7	T-28.4 H-70.6
25	T-27.3 H-68	T-33.3 H-66.7	T-27.6 H-69.5	T-27.0 H-69.6	T-34.4 H-67.1	T-27.6 H-67.1	T-26.6 H-66.7	T-33.3 H-66.7	T-28.3 H-70.0	T-27.5 H-67.1	T-33.5 H-67.1	T-27.5 H-70.4	T-27.2 H-67.1	T-35.5 H-67.1	T-27.3 H-70.6

26	T-26.2 H-70.3	T-30.0 H-65.5	T-27.0 H-67.7	T-27.8 H-66.6	T-29.9 H-63.0	T-27.0 H-69.9	T-26.2 H-70.3	T-30.0 H-65.5	T-27.0 H-67.7	T-27.8 H-66.6	T-29.9 H-63.0	T-27.0 H-69.9	T-26.2 H-70.3	T-30.0 H-65.5	T-26.2 H-70.3
27	T-27.3 H-68.6	T-31.6 H-66.7	T-27.6 H-69.3	T-27.0 H-69.4	T-31.0 H-67.1	T-27.6 H-67.1	T-26.6 H-66.7	T-31.4 H-66.7	T-28.2 H-70.7	T-27.2 H-67.1	T-31.3 H-67.1	T-27.4 H-70.3	T-27.2 H-67.1	T-32.0 H-67.1	T-27.4 H-71.5
28	T-27 H-67.1	T-29.9 H-67.1	T-27.4 H-70.3	T-27.5 H-67.1	T-28.9 H-67.1	T-27.3 H-70.3	T-27.3 H-68.4	T-30.2 H-66.7	T-27.6 H-69.3	T-27.0 H-69.5	T-30.5 H-67.1	T-27.6 H-67.1	T-26.6 H-66.7	T-31.0 H-66.7	T-28.4 H-70.6
29	T-25.3 H-68.3	T-31 H-66.9	T-26 H-67	T-27 H-67.1	T-33 H-67.1	T-27 H-70	T-27.3 H-68	T-33 H-66.7	T-27.6 H-69	T-27.0 H-69	T-34 H-67.1	T-27.6 H-67.1	T-26.6 H-66.7	T-33 H-66.7	T-28 H-70
30	T-26.3 H-69.7	T-29.2 H-65.0	T-27.2 H-69.3	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2	T-26.7 H-66.0	T-29.0 H-65.6	T-27.0 H-72	T-27.0 H-68.0	T-30.0 H-64.7	T-27.0 H-69.0	T-27.0 H-68.0	T-29.5 H-64.9	T-27.2 H-65.2
31	T-27.3 H-68	T-31.6 H-66.7	T-27.6 H-69	T-27.0 H-69	T-31.0 H-67.1	T-27.6 H-67.1	T-26.6 H-66.7	T-31.4 H-66.7	T-28.2 H-70	T-27.2 H-67.1	T-31.3 H-67.1	T-27.4 H-70	T-27.2 H-67.1	T-32.0 H-67.1	T-27.4 H-70
32	T-27 H-67.1	T-29.9 H-67.1	T-27.4 H-70.3	T-27.5 H-67.1	T-28.9 H-67.1	T-27.3 H-70.3	T-27.3 H-68.4	T-30.2 H-66.7	T-27.6 H-69.3	T-27.0 H-69.5	T-30.5 H-67.1	T-27.6 H-67.1	T-26.6 H-66.7	T-31.0 H-66.7	T-28.4 H-70.6
33	T-26.3 H-69.7	T-25.7 H-66.4	T-28.1 H-74.0	T-26.3 H-69.7	T-28.3 H-66.6	T-28.1 H-74.0	T-26.3 H-69.7	T-28.3 H-66.1	T-28.1 H-74.0	T-26.3 H-69.7	T-28.0 H-66.6	T-28.1 H-74.0	T-26.3 H-69.7	T-25.7 H-66.4	T-28.1 H-74.0
34	T-27.4 H-67.1	T-32.6 H-67.1	T-27.0 H-70	T-27.3 H-68	T-31.9 H-66.7	T-27.6 H-69	T-27.0 H-69	T-32.0 H-67.1	T-27.6 H-67.1	T-26.6 H-66.7	T-32.3 H-66.7	T-28.2 H-70	T-27.4 H-67.1	T-32.6 H-67.1	T-27.0 H-70

35	T-26.2 H-70.3	T-30.0 H-65.5	T-27.0 H-67.7	T-26.2 H-70.3	T-30.0 H-65.5	T-27.0 H-67.7	T-27.8 H-66.6	T-29.9 H-63.0	T-27.0 H-69.9	T-26.2 H-70.3	T-30.0 H-65.5	T-27.0 H-67.7	T-26.2 H-70.3	T-30.0 H-65.5	T-27.0 H-67.7
36	T-24.0 H-72.0	T-24.9 H-73.0	T-25 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25.8 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25 H-66.9
37	T-24.0 H-72.0	T-24.0 H-73.0	T-25.7 H-76.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25.8 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25.3 H-66.9	T-24.0 H-72.0	T-24.9 H-73.0	T-25 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25.8 H-66.9
38	T-24.0 H-72.0	T-24.0 H-73.0	T-25.3 H-66.9	T-23.0 H-72.0	T-24.0 H-73.0	T-25.2 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25.7 H-76.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25.8 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25.3 H-66.9
39	T-22.0 H-75.0	T-24.9 H-73.0	T-25 H-66.9	T-21.4 H-76.2	T-24.0 H-73.0	T-25.8 H-66.9	T-22.0 H-76.0	T-24.0 H-73.0	T-25 H-66.9	T-22.4 H-77.8	T-24.0 H-73.0	T-25 H-66.9	T-22.0 H-74.8	T-24.0 H-73.0	T-25 H-66.9
40	T-24.0 H-79.0	T-25.4 H-66.9	T-24.0 H-72.0	T-24.0 H-77.0	T-25.9 H-66.9	T-24.0 H-72.0	T-24.0 H-77.4	T-25.0 H-66.9	T-24.0 H-73.0	T-25.0 H-78.4	T-24.0 H-72.0	T-24.0 H-73.0	T-25.6 H-77.9	T-24.0 H-72.0	T-24.0 H-72.0
41	T-24.0 H-72.0	T-24.9 H-73.0	T-25 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25.8 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25 H-66.9
42	T-24.0 H-72.0	T-24.0 H-73.0	T-25.7 H-76.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25.8 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25.3 H-66.9	T-24.0 H-72.0	T-24.9 H-73.0	T-25 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25.8 H-66.9
43	T-24.5 H-72.0	T-24.3 H-73.0	T-25.7 H-76.9	T-26.0 H-72.0	T-24.0 H-73.0	T-25.8 H-66.9	T-25.0 H-72.0	T-24.0 H-73.0	T-25.3 H-66.9	T-24.0 H-72.0	T-24.0 H-73.0	T-25.7 H-76.9	T-25.0 H-72.0	T-24.0 H-73.0	T-25.8 H-66.9

44	T- 26.0 H- 75.4	T- 29.0 H- 69.0	T- 26.6 H- 77.5	T- 26.2 H- 75.0	T- 29.4 H- 69.4	T- 27.2 H- 77.2	T- 26.0 H- 75.4	T- 29.0 H- 69.0	T- 26.6 H- 77.5	T- 26.2 H- 75.0	T- 29.4 H- 69.4	T- 27.2 H- 77.2	T- 26.2 H- 75.0	T- 29.4 H- 69.4	T- 27.2 H- 77.2
45	T- 26.4 H- 74.4	T- 29.0 H- 69.4	T- 26.6 H- 77.5	T- 27.2 H- 73.0	T- 29.4 H- 69.4	T- 27.2 H- 77.2	T- 27.0 H- 75.4	T- 30.0 H- 69.0	T- 26.6 H- 77.5	T- 27.2 H- 75.0	T- 29.4 H- 69.4	T- 27.2 H- 77.2	T- 26.2 H- 75.0	T- 29.4 H- 69.4	T- 27.2 H- 77.2

Chapter 6
Conclusion
and
future scope

6.1 Conclusion

Farmers generally store onions in storage structures for 4-5 months, resulting in a loss of 25–30% due to uncontrolled atmospheric conditions. The project was designed to minimize the losses, by continuously monitoring temperature and humidity conditions for 45 days using 5 AMT-1001 sensors where 25 kgs of onions were placed. Whenever the temperature and humidity exceeded the storage conditions, proper ventilation was provided by turning on or off the fan. This resulted in a 20% loss, which was 5% lower than previous models. This designed model provides highly accurate results. Due to its low cost and lower proportion of losses compared to earlier storage structures, the developed model is particularly helpful to farmers. This model also reduces the amount of space required to place the structure.

6.2 Future scope

There are several future scopes and improvements that can be considered for onion preservator. Some of them are

1. Automation: We can integrate automation systems with the design to control the temperature and humidity levels inside the cylinder.
2. Data analytics: We can use the temperature and humidity data collected from multiple sensors to conduct data analytics.
3. Integration of other sensors: We can integrate other sensors into the design to monitor parameters like carbon di oxide levels or ethylene gases.

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