- By Prof. W. M. Okoth

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AERATION AND TEMPERATURE CONTROL

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Aeration system and Technology

- Seed aeration: process of moving air at ambient temperature through stored seed in order to control the temperature to the desired level.
- An aeration system includes a fan, an air supply duct, aeration ducts (or a perforated floor), and a controller.
- Aeration ducts are less expensive than perforated floor but course uneven distribution of air through the seed.

Aeration system and Technology…

- In small storage systems, aeration can be done by natural air circulation; allowing the wind to blow through the stored seed.
- In addition to temperature control, stored seed aeration also minimizes moisture migration within the grain bulk.

Temperature of stored seed grains

- The temperature of the harvested grain establishes the initial temperatures of stored seed.
- These initial temperatures can be equal to or considerably higher than the atmospheric air temperature.
- In one case the temperature of freshly harvested seed was found to be 30°C when the atmospheric temperature averaged 23°C.
- Such high initial temperatures encourage rapid deterioration of the stored seedif cooling is not rapid. Changes in diumal temperature affect seed temperatures in bins.

- Solar radiation incident on the bin wall causes its temperature to rise to a value much higher than that of the atmospheric air.
- Cases have been cited where when the atmospheric air temperature was 28°C, the temperatures of bin surfaces in contact with the stored seed varied from 37°C to 56°C,
- This varied depending on the material of construction and colour of the bin wall.

- Seasonal changes in atmospheric temperature cause changes in the temperature of stored seed.
- Weather conditions are in fact, the most important factors affecting storage seed temperatures.
- Changes in atmospheric air temperature and solar radiation have less effect on the temperatures near the centers of large bins than of small bins.
- However, heat in freshly harvested seed and heat generated in deteriorating seed are dissipated more rapidly from small bins than from large bins,
- This is because the distance form the centre of the bin to the wall is less in small bins than in large bins.

- As a result, temperatures will rise less above atmospheric air temperature and seed deterioration will be less in small bins than in large bins.
- Insulating a bin has a similar effect on the heat transfer in and out of the bin as increasing the bin size.
- Insulation reduces the temperature gradients throughout the seed bulk and therefore may reduce moisture migration within the bin.

- The rate of heat transfer into or out of seed store d in underground bins is slow and is similar to that in large bins and insulated bins,
- This is because soil is a good thermal insulator.
- If cold seed is stored in underground bins, it will normally remain at a low temperature if the soil temperature remains low.
- But in underground bins, as in large above-ground bins, heat in freshly harvested seed and heat generated in deteriorating seed is dissipated very slowly.
- Consequently, seed deterioration can occur very rapidly if the initial temperature of the seed is high or if the temperature of the seed begins to rise.

Moisture Migration

- Moisture may migrate from one part of the stored grain to another.
- migration is caused by differences in temperature in different parts of the bulk.
- Moisture in the vapor phase moves by diffusion along the vapor-pressure gradient coursed by a temperature gradient in material of fairly uniform moisture content.
- Convection currents also contribute to moisture migration. When saturated air moves from a warm to a cooler region condensation of some water vapour occurs since the water carrying capacity of the air is reduced. The condensed water is absorbed by the grain in the cool region whose equilibrium relative humidity (water activity) thus increases. Deterioration may thus occur in stored grain even if it is stored at a safe and uniform moisture content. Diffusion is said to be the dominant mechanism of moisture transfer, assisted by convection currents.

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PROCESSING AND TREATMENT PLANTS

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Introduction

- In a seed processing and treatment plant, the primary product is dry treated seed of the highest possible quality.
- This quality is largely determined at the farm.
- However, even within one farm there will always be defective plants that cannot produce seed of the desired quality.
- These inferior or defective seeds are often mixed with the good seed at harvest and have to be sorted out in the factory.
- They are a byproduct since they can be used for other purposes.

- It also happens that in the process of manufacturing good seed other components are separated from it.
- Some of these separated components can find use either in the same plant or elsewhere and thus form part of the byproducts form the factory.
- In this presentation we concentrate on the management of byproducts of maize seed processing.

2. By Products of Maize Seed Processing

- **2.1. Sorted out off-spec maize**
- This is maize that is not suitable for use as seed but is otherwise in good condition.
- It is separated from the rest of the raw material during sorting on the conveyor belt before drying of the unshelled maize.
- It should be dried separately, shelled, cleared and sold as a by-product to be used for food or feed or any other purpose.

2.2 Surplus Maize Cobs

- These are maize cobs over and above what is required as fuel for heating the drying air. It can be managed in a number of ways.
- It can be sold as it is without any processing for use as fuel or for conversion to other products.
- It can be used generate electricity that is used to provide power and lighting in the factory and the surplus sold.
- In this way there will be saving in the electricity bill as well generation of extra income.
- It can be converted to higher value products by treatments such as pyrolysis, gasification and composting

2.3 Shelling and aspiration DVST

- This can be collected by passing the exhaust air through a cyclone

- Can be sold for use as an ingredient in animal feed manufacture.

3. **Byproducts of other seeds**

  - Sunflower screenings:
  - Light and blank sunflower seeds, chaf, etc.
  - Used as livestock feed. High in oil and is an excellent fibre source.

- **Bean culls:**

  - Split and damaged beans.
  - Approximately 20% protein.
  - Used as livestock feed.

- **Sunflower Seeds:**

  - Seeds that are too small for seed planting purposes:
  - Recleaned and used as bird seed for birds such as parrots.

- **Others:**

  - Cotton Seed hulls
  - Cotton seed screenings
  - Barley screenings
  - Sunflower hulls
  - Peanut hulls

4. Concluding remarks

- Seed manufacture inevitably leads to production components other than the desired seed.
- Some of these components can be used directly, others can be used after further processing or conversion to other products.
- Efficient utilization of byproducts can go along way towards improving the profitability of seed processing and treatment plants.

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PROCESSING AND TREATMENT PLANTS

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Introduction

- There is no doubt that, compared to other continents, agricultural productivity is still very low in Africa.
- This is particularly true in sub-saharan Africa.
- The main reason for this is that there is poor adoption of modern improved technology.
- Small-scale farmers have not benefited from advances in plant breeding mainly because the seeds and the required inputs are perceived to be too expensive.

- For seed prices to be lowered, their production costs must come down.
- Seed processing and treatment contributes significantly to the final seed price.
- It is therefore important for seed processors to pay particular attention to cost management.
- Low production costs and hence low seed prices will not only expand the market but also lead to both higher productivity and higher profitability for the seed processors.

2. Factors affecting processing costs...

- Jugenheimer (1985) has listed the factors that must be considered in determining the costs of processing seed.
- I list these factors with brief comments.

2.1. Salaries and labour

- Increases the level of salaries and benefits is to a great extent determined by the market forces,
- The total wage bill can be controlled by the seed processors.
- The human resource requirements must be rationalized.

2.2. Supplies

- These include:
- a) Bags, tags
- b) Treating materials
- c) Thread
- d) Bag stencils
- All these factors are production dependent.
- However, the consumption of treating materials can be minimized by not exceeding the recommended levels of usage.

2.3. Buildings

- Including storage, processing plant, and other buildings used in the operation
- The factors include:
- a) upkeep and repairs
- b) insurance
- c) depreciation
- d) fuel
- e) power

- Upkeep and repairs of buildings must be regular to avoid very expensive extensive damage.
- Insurance and depreciation depend on the initial cost of putting up the buildings.
- The buildings must be professionally designed and constructed to minimize their costs.
- In addition insurance services must be professionally procured.

- Fuel refers to the fuel used in the boiler or drier furnace.
- Fuel cost can be minimized by ensuring that the boiler or furnace has higher thermal efficiency and the seed driers are also efficient in design and operation.
- There should be minimal heat energy losses throughout the processing plant.

- Power refers to electricity used for lighting and other non-processing applications.
- Energy efficient light bulbs and appliances should be used.
- Appropriate elective energy saving measures should be taken to minimize electricity costs.

2.4. Processing and handling equipment

- These contribute to processing cost in the following ways:
- a) depreciation
- b) upkeep and repairs
- c) insurance
- d) power
- e) gasoline and oil for trucks

- Depreciation and insurance costs should be reduced by ensuring that the processing and handling equipment are not over designed.
- Planned preventive maintenance will keep the costs of upkeep and repairs low.
- Electrical power costs can be reduced by ensuring that, among other measures,
- The equipment is not over designed, energy efficient electric motors are used,
- The equipment is properly maintained, and no equipment is left to run when idle.
- Efficient layout design will minimize the cost of gasoline and are for trucks.

2.5. Other processing and handling costs

- These include:
- Insurance on inventory
- Taxes on inventory
- Transportation costs for moving seed to and from the processing plant.
- Loss due to seed stocks going out of condition
- Handling and disposing of screenings
- Quality control costs, including purity and germination tests
- Certification cists
- Record-keeping
- Warehouse handling and shipping costs
- Other items, such as insect bird, and rodent control

- Appropriate location of the plant and good transport management can reduce costs for moving seed to and from the processing plant.
- Production planning and good sales and marketing can minimize loss due to seed stocks going out of condition.
- If market is found for screenings they may become a source of income rather than a cost item.
- Rationalization of personnel establishment and appropriate training programmes can reduce many of the processing and handling costs mentioned above.

2.6. General expenses

- Listed under this are:
- a) interest on investment
- b) taxes on property
- c) advertising and promotion
- d) General overhead.

- Optimization of the processing plant at the design stage can reduce interest on investment as well as taxes on property.

- Advertising and promotion activities need to be very closely monitored and regularly reviewed to ensure that they do not become counterproductive.

2.7. Additional costs of buying and selling

- Other costs of buying and selling include losses due to seed deterioration during storage and marketing, and shrinkage while cleaning.

- These costs can be reduced by proper quality control when buying the seed and following recommended storage practices.

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1. Why Instrumentation and Control?

- There are many reasons for instrumentation and control in a seed processing plant.

- These include:-

- To ensure safety of workers, visitors neighbours and passers-by
- Safety of equipment, machines, buildings and other structures
- Efficient use of utilities such as steam, water and electricity
- Increase productivity of machines
- Increase product quality regularity
- Increase flexibility of machines and processes
- Meet regulatory requirements such as consistent package weights within specifications

2. Boiler instrumentation and Control

- The use of boiler is preferable to direct mixing of maize cob combustion products with air

(i) Steam pressure

- The steam pressure must meet the processing requirement,
- i.e. the drying air must be heated to the desired temperature and other steam using operations such as cleaning and disinfection must be effective.
- This means that there is a minimum pressure.

- Boilers always have a maximum allowable steam pressure beyond which material failure leads to boiler explosion with dire consequences.
- In an oil-fired boiler, an automatic control system that measures the steam pressure and turns the fuel flow on when it is tat the minimum and off when it is at the maximum level.

- In seed processing plants, the boiler is often fired by maize cobs.
- The on-off control described above is therefore not easy to implement.
- The minimum steam pressure is assured by maintaining adequate fire.
- A safety value that releases steam to the atmosphere ensures that the maximum allowable pressure is not exceeded.
- In all cases a steam pressure gauge is installed.

(ii) Boiler water level

- The boiler tubes must always be covered with water to avoid overheating that leads to material failure and release of steam in the working environment. Two measures are taken:

1. An automatic control system measures the water level and switches the water feed pump on when it is at the specified minimum value.
2. A sight glass gauge is installed to enable the boiler operator to monitor the water level and to intervene when necessary.

3. Control of in-bin aeration

- The main objective of aeration is to maintain seed grain stored at 12-15% moisture content to within 3-6oC of ambient temperature.
- An aeration controller decides if, when, and for how long air blowing is needed.
- Sophisticated aeration controllers measure the temperature and relative humidity of the ambient air and the temperature and equilibrium relative humidity of the grain.
- Less sophisticated aeration comptrollers base their decisions solely on the air and grain temperature.

4.Control of in-bin supplemental heat drying

- The objective of in-bin supplemental heat drier controllers is to dry seed grain at minimum energy use without significantly affecting the storability and quality.
- Control of drying air temperature is important to ensure that the drying is effective and seed quality is maintained.
- An automatic control system measures the drying air temperature and adjusts the steam flowrate to maintain it at the desired value.

- Fan control is also important to ensure that it stops operating when the seed moisture content reaches a specified minimum value and starts operating when it reaches a specified maximum value.
- Indirect heating systems, a mixing valve connects the hot and cold channels and controls the drying air temperature.
- The required drying conditions (T and RH) can be programmed based on the desired equilibrium moisture of the seed.
- The air flow is dynamic: higher at the beginning of the process and lower at the end of the process as the seed gets drier.
- Relative humidity of the incoming air is compared with that of the exhaust air. The drying process stops when the former is higher than the latter.
- Measuring and parameter settings are read out on a control screen and PC.
- Graphics are used to visualize the drying process.

5. Control of Seed cleaning and treatment

- The seed feed rate is determined by the speed of the bucket elevators which can be controlled if variable speed drives are used.
- Control of air flow rate in the aspiration cleaner is important to ensure that the impurities are adequately removed without blowing away the good seed grains.
- Control of closing of the treatment chemicals is important to ensure that good seed quality is achieved without excessive use of chemicals.

6. Control of seed packaging

- Instrumentation and control enables the selection of throughout and packaging size and maintenance of package weights consistently within specifications.

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- Water exists as solid (ice), liquid or vapor

- At the temperature at which seeds are stored in Africa, only liquid and vapor phases of water are important

- If liquid water is introduced into an enclosed vacuum space at constant temperature, evaporation takes place until equilibrium vapour pressure is reached.

- Let us say at temperature To, equilibrium vapour pressure is Po.

- If the water is in an air space or is in contact with air at temperature To, the water evaporates into the air until the partial pressure of water vapour is Po; the equilibrium vapour press at temperature To.

- The equilibrium vapour pressure increases with increase of temperature.
- Seeds contain varying quantities of water. If instead of water we introduce seeds into a vacuum space or an air space, the equilibrium vapour pressure developed at temperature To is Pe where Pe < Po.
- Pe depends on the temperature, the nature of the seeds and the seed moisture content.

- We define a parameter water activity (air) as follows:
- Aw = Pe/Po
- At a given temperature, aw depends on the nature of the seed and its moisture content
- Water activity of a seed can be interpreted as availability of water to microorganism.
- It is 1 when the water is completely available and O when is completely unavailable, i.e. it varies between 0 and 1.

- A minimum value of water activity is required for spoilage microorganisms to grow on stored seed.
- The minimum value of water activity for moulds is 0.70 – 0.90.
- For cereal seed, this corresponds to a moisture content of 14.0 – 20% while for peanuts it is 8.5 -15%
- Each seed has a specific relationship between moisture content and water activity.
- In all cases water activity increases with increase in moisture content, and vice versa.

- Seed must therefore be dried and stored at a moisture content that corresponds to a water activity that does not exceed the minimum required for spoilage by microorganisms.
- Seed absorbs or loses moisture depending upon the relative humidity of the surrounding air.
- If the relative humidity (decimal) is less than the water activity it loses water through evaporation and it is greater than the water activity it absorbs water vapour from the air and its moisture content increases.

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considerations

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1. Pilot Plan

- Pilot plan shows how the buildings, parking lots and driveways fit on the lot. It also shows highways, utilities drains, electrical systems, and any other relevant information.
- Starting with the plot plan, add the main roads that border the property.
- Determine where access roads will enter the property
- Indicate the utilities on the plant
- Plate the building so that the front faces a road; expansion will occur behind the building.
- Indicate where receiving and delivery will be, and connect this area to the main road.

2. Materials handling considerations

- Materials handling should be part of the planning from the start.
- Product movement costs money, and it must be kept to a minimum.
- The most efficient materials handling involves raw materials being received at one end of the plant with the final product emerging at the other and without backtracking or sidetracking.

- Planning should reduce the travel of product, people, and handling equipment. This will:
- -increase material flow
- -reduce bottlenecks and stoppages
- -reduce unsafe situations and practices
- -increase product quality

- Consideration should also be given to the type of equipment to be used in materials handling,
- e.g. if forked trucks are to be used, the passages should be wide enough for the truck to pass workers at a safe distance.
- These passages (aisles) must also be kept free of any obstacles or overhanging machinery and be well lit so that the truck operators can see limiting clearances easily.

3. Processing plant layout

- Three main types of processing plant layouts are multistory, single level and combination
- Multistory: Here seed is carried by elevators to the top floor and stored in large bins.
- Processing machines are arranged in a vertical series on the lower floors.
- Flow of seed from one machine down to the next is by gravity.

- Single Level: In this system, seed is moved from one machine to the next by elevators place between the machines.
- This layout enables one person to supervise the processing line without running up and downstairs.
- Closer supervision of all operations can thus be maintained.

- Combined Designs: These involve a compromise between the single and multistory system.
- Whatever the design, equipment should be arranged to provide:
- 1. a sequence of cleaning and handling that is proper, efficient, complete, and as simple as possible.

- 2. economical distribution and maintenance of space
- 3. orderly and continuous flow of seed and waste products with a minimum cost
- 4. flexibility to handle different seed that require different processing.
- 5. possibility of orderly expansion as capacity needs increase.
- 6. maximum safety and comfort of operating personnel
- 7. effective and economical means of handling waste products

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PROCESSING AND TREATMENT PLANTS

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1. WHY WASTE MANAGMENT

- Seed processing and treatment produces solid, liquid and gaseous wastes.

- Each of these has its problems. We focus on maize seed.

1.1. Solid Waste

- The main solid waste is excess maize cobs from the maize shelling process.

- It, as often happens, it is simply dumped on land in the vicinity of the factory it causes a number of problems

- It lowers the aesthetic appeal of the environment.
- It is a source of obnoxious smell
- It harbors rodents that are a health risk in addition to being a nuisance
- It promotes proliferation of insects such as flies and mosquitoes that are known to be disease vectors.
- It is a fire hazard.
- It occupies valuable space

1.2 Liquid Wastes

- Liquid wastes in seed processing and treatment plants include:
- waste water from cleaning operations and sewerage from washrooms and kitchens.
- If not properly treated and disposed of waste water causes a number of undesirable effects.

- It lowers the aesthetic appeal of the environment.
- It causes obnoxious smells
- It promotes proliferation of insects that may be disease vectors.
- It lowers the quality of receiving water such as rivers and groundwater
- It lowers the level of dissolved oxygen in the receiving water and therefore adversely affects aquatic life such as fish.
- It may contain toxic chemicals that harm aquatic life, human beings and animals.

1.3 Gaseous Wastes

- Gaseous wastes from seed processing and treatment plants include:
- Flue gases from boilers, furnaces and standby generators as well as exhaust gases from aspiration, aeration and drying processes.
- Gaseous emissions cause a number of undesirable effects.

Effects of gaseous emissions

- Eye and skin irritation
- Allergic reactions
- Lowered aesthetic appeal of the environment
- Lower visibility
- Increased green house gases such as carbon dioxide
- Increased acidic gaseous emissions such as sulphur dioxide

2. Waste Management

- **2.1 Solid Wastes**
- Maize cobs are often used as fuel for air heating in drying operations.
- This may involve direct mixing of incoming air with the hot products of combustion.
- This leads to a load of suspended particulate matter in the drying air that finds its way to the drier exhaust gases.
- There is however, always excess maize cobs to be disposed of. Dumping on land is not recommended. It could be sold as a by product of converted to other higher value by-products.

- One such by-product is electricity that can be generated by burning all the maize cobs in a high pressure boiler and using the steam to generate electricity as well as provide process heat such as drier air heating.
- Ash from the furnace can be given out or sold as a sold conditioner or dumped in a landfill.
- Dust from seed cleaning operations should be collected and sold as a by-prodduct to be used in feed manufacturing.

2.2. Liquid wastes

- Waste water can be discharged to the municipal/city waste treatment plant or an in-house waste treatment plant.
- Sewerage can be discharged to the municipal/city waste treatments plants or suitably designed and constructed septic tanks
- Wash waters containing treatment chemicals should be incinerated.

Gaseous Emissions

- Boiler/furnace and generator flue gases should be managed by ensuring that there is efficient combustion and by designing and constructing the chimney correctly.
- Exhaust gases from aspiration, aeration and drying operations should pass through cyclones to minimize dispersal of particulate matter to the environment.

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