Potato Post Harvest Management

Storage Design

1: Goals & Circumstances: local situation, background information;
2: Construction of building: quality, budget, preference;
3: Storage System: technical details: size of cells, storage capacity etc.

Based on these 3 pillars a storage facility is designed.

Storage Solution

Science
Research
Experience
Local Situation

Storage Solution

Scope of Supply

Sustainable storage

Omnivent

Dynamic modelling of potato storage: PhD by NikGrubben

Science
Research
Experience
Local Situation
Storage Solution

**Science**

**Research**

**Experience**

**Local Situation**

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Your Supply Chain

**Science**

**Research**

**Experience**

**Local Situation**

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Potato & Onion Supply Chain

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Storage Design

- Where to start?
- **Goal**: aim of client: minimize risks, minimize weight loss, control quality, control costs.
- **Circumstances**: location, climate, yield, capacity.
- **Building**: construction, budget, preference.
- **Storage system**: storage controls

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Storage Design: Goal

- Minimize risks
- Minimize weight loss
- Control product quality
- Control costs
- Control sugar levels of product
- Defects & diseases prevention
  - Pressure Bruises
  - Rot
  - Skin diseases
- Sprout Control
- Growth Vigour

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Storage Design: Circumstances

- What kind of crop (fresh, fries, crisps, starch)
- Variety
- Harvest method
- Harvest conditions
- Climate profile (rain, sun, snow, temperature, RH)
- Transport organized (time and conditions field to store)
- Quantity per day harvested
- Temperature during loading
- Outtake per day
- Outtake period
- Storage period
- Available services (forklifts etc)
- Power arrangement
- With price
- Onion/potato price
• What are the onion/potato varieties?
• Under what weather conditions are the onions/potatoes harvested?
• What are the growing regions of the onions/potatoes?
• Can you describe how the logistics from the field to the store is organised (means of transport, bags, bulk or big bags, how long does it take, maximum harvested rate per day in tons, etc.)?
• What is the onion/potato temperature at harvest?
• Are the onions/potatoes short or long day (growing season)?
• How mature is the onion/potato?
• What is the soil type?
• Are disease an issue? If yes, what kind of diseases are an issue?
• Do you currently have a store? If yes, what kind of issues do you experience and how do you operate it at the moment?
  — Do you experience issues during loading of the store? If yes, what kind?
  — What is the new store located?
• What is the kWh price
• What is the onion/potato price
Storage Design: Insulation

• Insulating materials, e.g. mineral wool, foam polystyrene;
  - PIR
  - PUR foam or panels
  - The resultant product of PIR product gives greater heat stability, increased flame resistance, chemical resistance and dimensional stability, than that of a PUR foam.
• Minimal heat transfer: $K$-Value : $0.03 \text{W/m}^2 \cdot \text{K}$.

Storage Design: Insulation

• It is all about the details:
  - Material (wood or steel)
  - Thickness construction (walls, ceiling)
• Possibility of condensation, dew point;
• Importance of proper insulation: $\text{CO}_2$ levels, energy consumption (heat-cold exchange)

Storage Design: Insulation

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Storage Design: Insulation

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Insulation

Storage Design: Insulation

SolidWorks Flow Simulation
SolidWorks Flow Simulation

Air distribution box storage

Ventilation Systems

Two choices:
- Bulk storage
- Box storage

Bulk Storage

- Fully ventilated floor
- Underground ducts
- Above ground ducts
  - Half round (steel)
  - Triangle ducts (wood)

Bulk Storage: Fully ventilated floor

Bulk Storage: Underground Ducts

Bulk Storage: Above ground Ducts
Bulk Storage: Above ground Ducts

Advantages
- Relative low investment
- Quick loading
- Flexible on set-up

Disadvantages
- Less flexible during outtake
- Bulksystem (pressure bruising)
- Quality loss

Bulk Storage: Ad & Disadvantages

Drying Walls
- 1-layer
- 2-layer

Suction system

Blowing system

Room ventilation / Overhead Throw

Box Storage: Options

Box Storage: Letterbox wall

Advantages
- Equal distribution of the air
- Flexibility: ventilation per row and layer per layer is one of the big advantages of the system
- Forced system with high air capacity
- Relatively low running hours

Constraints
- Limited box length (10 for potatoes, 8 for onions)
- Special boxes required
- For optimal efficiency, design, condition and uniformity of the boxes is crucial
- High investment per ton

Box Storage: Drying wall – 1 layer

Box Storage: Drying wall – 2 layer
Box Storage: Drying wall

Advantages:
- Long box rows (max 20)
- High efficiency for drying and storage with minimal storage losses
- Even air distribution → low delta temp. and running hours
- Easy installation on site with prefab units

Constraints:
- Limited access to system
- Equal row length required
- In- and outlet hatches in same wall
- Put on and off the suction sheet (can be automated but has extra investment)
- Needs a separate room to function properly

Box Storage: Suction wall

Advantages:
- Long box rows (max 20)
- High efficiency for drying and storage with minimal storage losses
- Even air distribution → low delta temp. and running hours
- Easy installation on site with prefab units
- Easy operation, manual coverage of pressure duct not required
- Can be used in an open area or packing bay

Constraints:
- Limited access to system
- Equal row length & height required

Box Storage: Blowing wall
Advantages:
• Equal distribution of the air
• Flexibility: no boxes required
• Low investment per ton
• Easy to implement in existing buildings
• Minimal additional requirements for adjustment of building

Constraints:
• Not suitable for drying
• Stacking pattern important for product quality
• More running hours
• Most effective, efficient and flexible storage system is the suction system
• Most flexible is drying wall system
• Alternative for suction when in need of other hatch arrangement or not willing to put covers on or off is the blowing system
• Room ventilation/Overhead throw is not a drying system but a storage/cooling system

Storage Systems: Conclusions

Storage Design: Lay-out

Storage Design: Lay-out

Storage Design: Lay-out

Storage Systems

Group Case

• Designing a potato store, based on the following details:
  • Intake, information client:
  • Store capacity: 20.000 ton (1.920 boxes)
  • Suction system
  • 8 cells: 2.500 ton per cell
  • New building
Storage Design: System

- Air Quantity
  - Quality demands
  - Harvest circumstances
  - Climate profile
  - Speed Control
- Refrigeration
  - Direct
  - Indirect (natural or chemical)
- Heating
- Humidification
- CO2 control

Air Quantity

- Control on temperature & quality
  - Limited temperature variations
  - Efficiency using cold outside air
  - Reducing risk on rot development
  - Control on sugar development
  - Control on respiration

Return on Investment: Speed Control

Cost development

Refrigeration

- Factors influencing quality
  - Delta temperature of system
  - Influences dehydration losses
  - Direct or indirect system
  - Assistance of supporting ventilation system

Refrigeration Solutions

- Thermera chiller cooling machines
- Compact turn key coolers
- DX cooling installations (Direct Expansion)

Refrigeration Solutions: Indirect

- Thermera cold transfer fluid
- Low dehydration by controlling DT1 max delta Temperature of 7 degrees
- 100% food safe
- Environmentally friendly
- Higher thermal performance than propylene glycol
- Not corrosive
- High efficiency
- Easy installation
- Low maintenance
Return on Investment: Heating

Fossil Fuels, Central Heating or Electric: Cold and Wet climates

- Low to no drying effect

Return on Investment: OmniRecup

CO2 heat exchanger (tropical and subtropical climates)

Innovation: Smart Control

Storage

Smart Control: concept idea

- Modern simulation technologies: visualise analytical mathematical equations.
- Computational Fluid dynamics
Smart Control: concept idea

- Design quality model

Smart Control: Implementation

- Validation

Smart Control: Result

- Strategy, moisture losses and running costs

Net bulk value = (bulk mass – dehydration) * market value
Ventilation cost = energy consumption * energy cost
Net profit = net bulk value – ventilation cost

Smart Control: Result

- Return on Investment
  - Less Defects
  - Reducing running costs
  - Reducing weight losses
  - Increase Efficiency of Store
• Which challenges do you face concerning your climate when it comes to ventilation technology?
• How do you see the future of storage technology in 10 years time?
• How can you be more effective in your Sales and how can we (Omnivent) be of assistance in this?
• What is positive in our partnership?
• What can be improved and what can we do better?