MULTIPHYSICS MODELING OF A GRAIN STORAGE CHAMBER USING *COMSOL* SOFTWARE

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Aim

Temperature profiles are obtained so that a proper storage chamber for grains can be designed

Retain the quality of grains

Why this problem is chosen?

- **India has become an exporter of good quality food grains very rapidly.**
- **2nd largest rice produced and 3rd highest wheat producing country in world**
- **About 12-16 million metric tons of food grains is lost due to improper storage**
- **Challenging issues**
  - **thermal management**
  - **quality retention**
- **Aim is to develop temperature profiles of grain storage system based on COMSOL software technique**

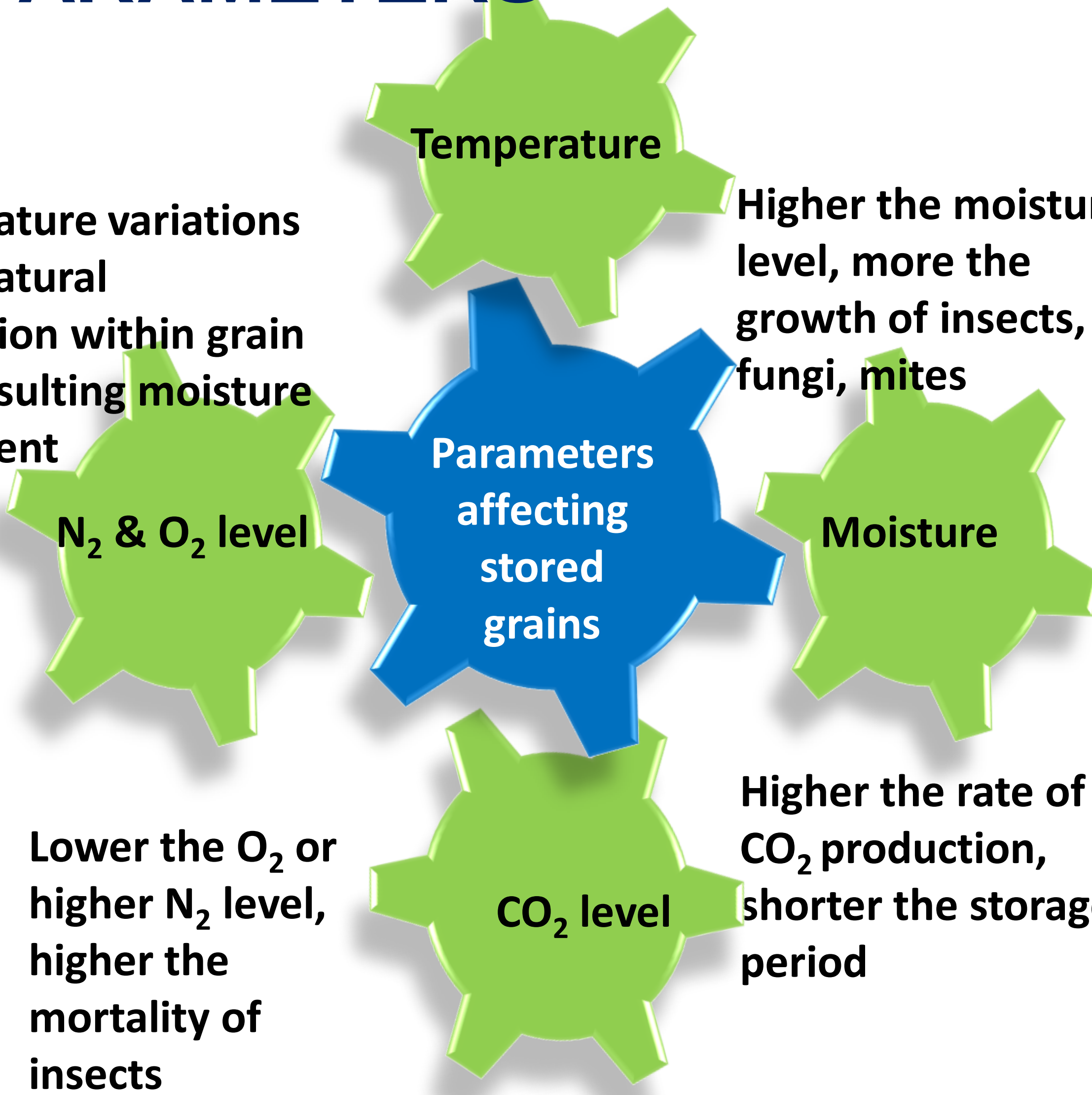
Factors Affecting Grain Losses

- Moisture
- Temperature
- Insects and Rodents
- Quality before storing
- Type of storage bin
- Use of pesticides and fumigants
- General condition of location of storage

Major Quality Changes During Storage

- Loss/gain of weight
- Change of physical appearance
- Loss of nutritional/ food value
- Loss of culinary properties
- Total destruction of grains

PARAMETERS



Temperature variations cause natural convection within grain bulk; resulting moisture movement

Higher the moisture level, more the growth of insects, fungi, mites

Lower the O_2 or higher N_2 level, higher the mortality of insects

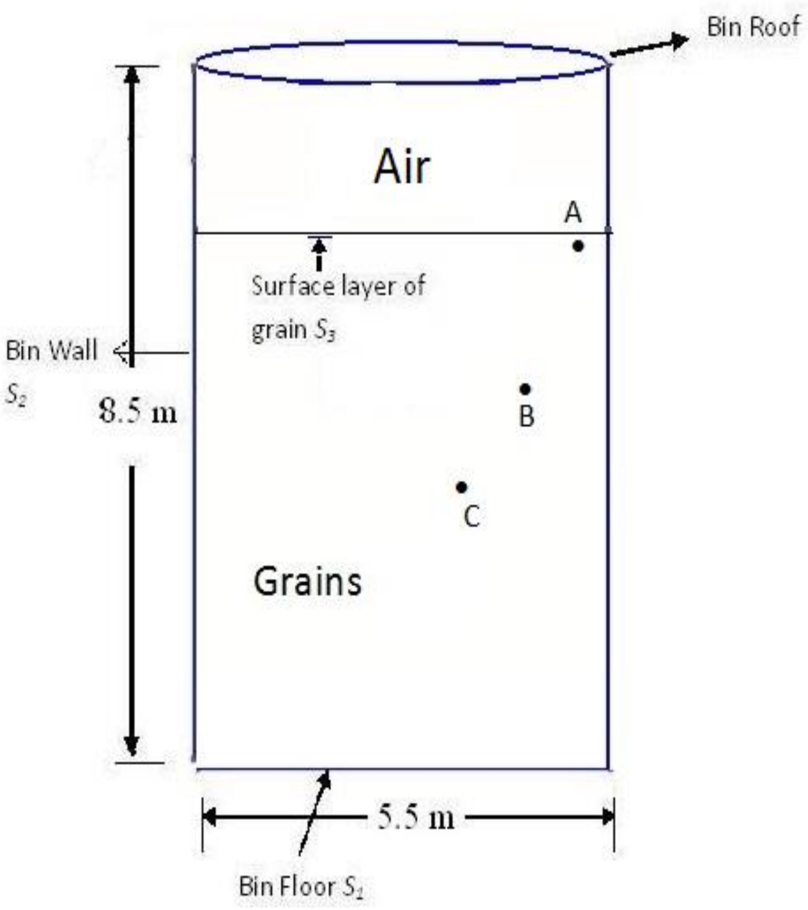
Higher the rate of CO_2 production, shorter the storage period

HEAT SOURCES

- Changes in storage temperature may occur due to several internal and external reasons.
- Internal sources of heat: respiration of grains, insects, mites etc.
- External sources: changes in ambient temperature, radiation through the bin walls.
- Mathematical modeling and numerical simulations important to predict the temperature & moisture distributions.
- Here only temperature distribution considered
- The transient heat flow due to external sources is modeled using COMSOL multiphysics software.

Model of a storage chamber

Pictorial view of a practical storage chamber



2D Pictorial view of storage chamber

Governing equations

- The 2D heat model for grains:

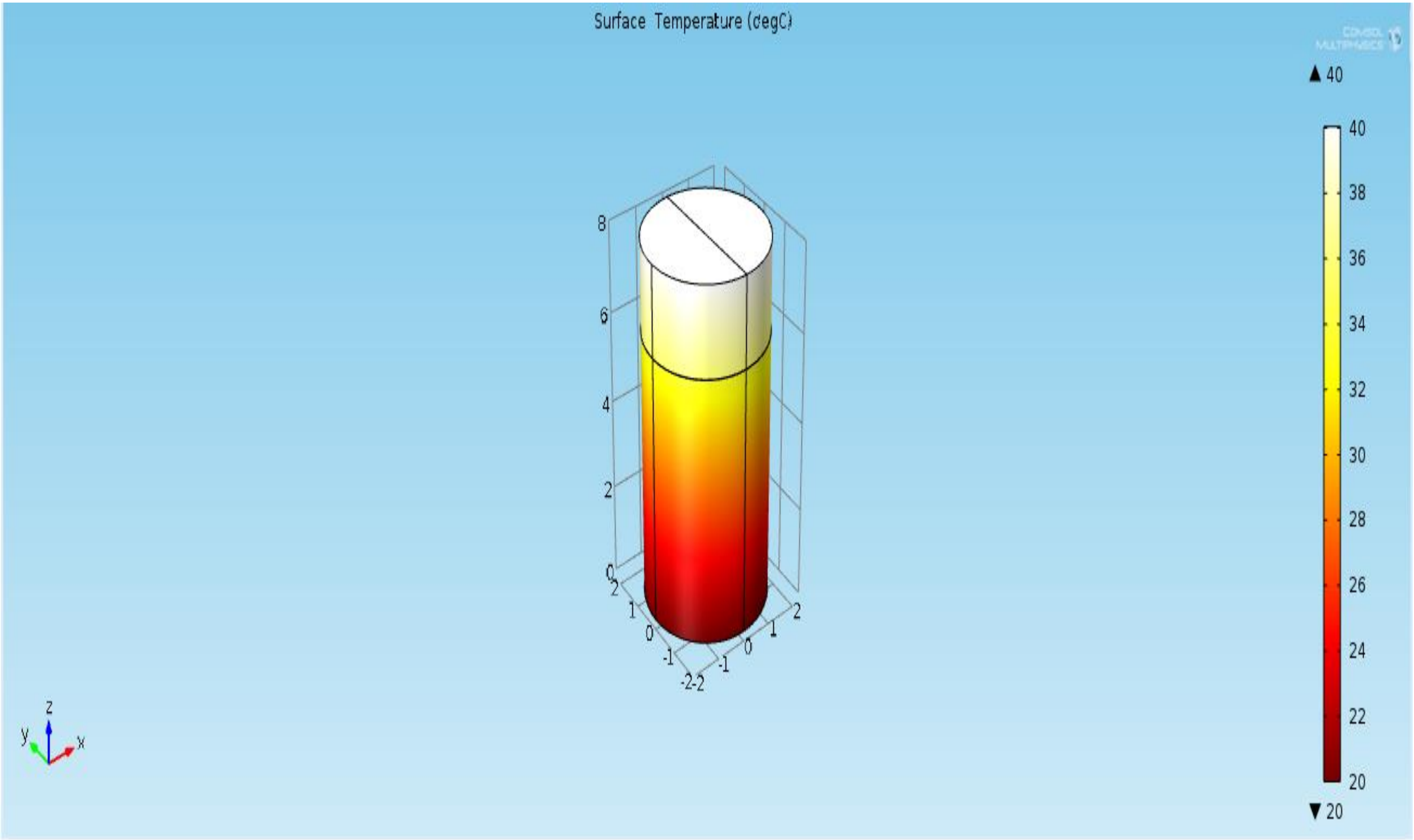
$$\rho_{grain} C_{grain} \frac{\partial T}{\partial t} = \nabla(\kappa_{grain} \nabla T) + Q_r$$

- The 2D heat model for head space:

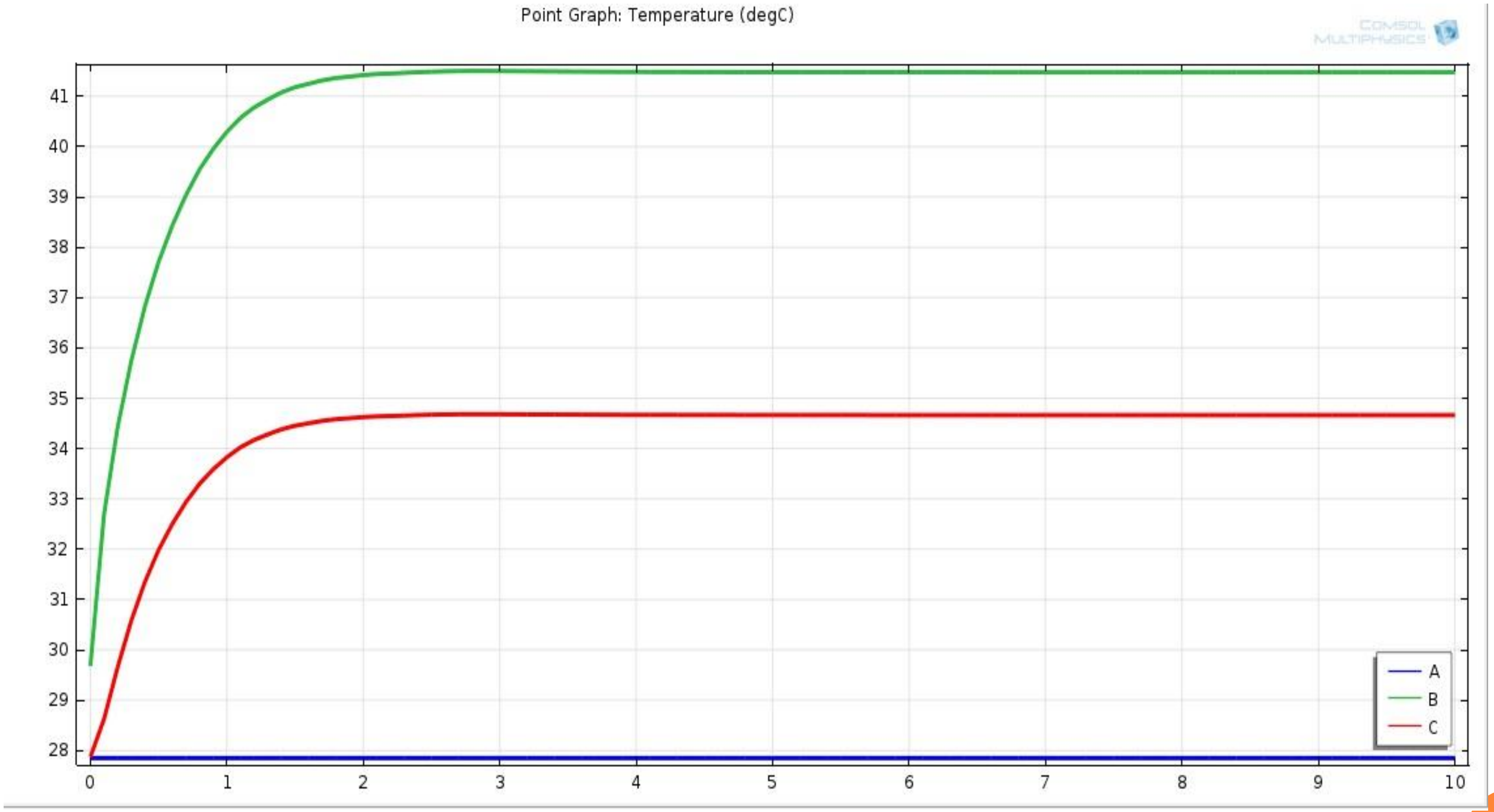
$$\rho_{air} C_{air} \frac{\partial T}{\partial t} = \nabla(\kappa_{air} \nabla T)$$

- Boundary conditions:
  - For S1 layer: $$-\kappa_{s1} \frac{\partial T}{\partial n} = h_{s1}(T - T_{s1})$$
  - For S2 layer: $$-\kappa_{s2} \frac{\partial T}{\partial n} = h_{s2}(T - T_{s2}) - q_w$$
  - For S3 layer: $$-\kappa_{s3} \frac{\partial T}{\partial n} = h_{s3}(T - T_{s3}) - q_b$$

TEMPERATURE DISTRIBUTION (3D)



TEMPERATURE DISTRIBUTION (2D)



Conclusion

- Modeling strategy of a grain storage system is presented.
- Temperature is taken as variable to be modelled
- The storage system is placed on the ground, boundary s_1 is subjected to only convective heat transfer
- Other boundaries will have both convective as well as radiative heat transfers
- COMSOL software is used for the simulation purpose
- Temperatures at several arbitrarily chosen points are observed
- It is advantageous to have a prior knowledge about the outputs before actually modeling a system

Thanks!