Numerical design and optimization of portable dryer for cereals

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- In Uganda, the majority of the population (85%) lives in rural areas and depends almost entirely on agriculture for their livelihood and food security.

- However, inadequate capacity for postharvest management and marketing is a critical constraint to food security and income among smallholder farmers, especially in Northem and Eastern Uganda.

- The cumulative postharvest losses for grains in Uganda are estimated at 30-35% based on total production level and the situation for fruits and vegetables is even much worse.
- Postharvest and marketing has received very limited research and development Intervention.

- Although in many parts of Africa certain crops can be produced throughout the year, the major food crops such as cereal grains and tubers, including potatoes, are normally seasonal crops.

- Consequently the food produced in one harvest period, which may last for only a few weeks, must be stored for gradual consumption until the next harvest, and seed must be held for the next season's crops.

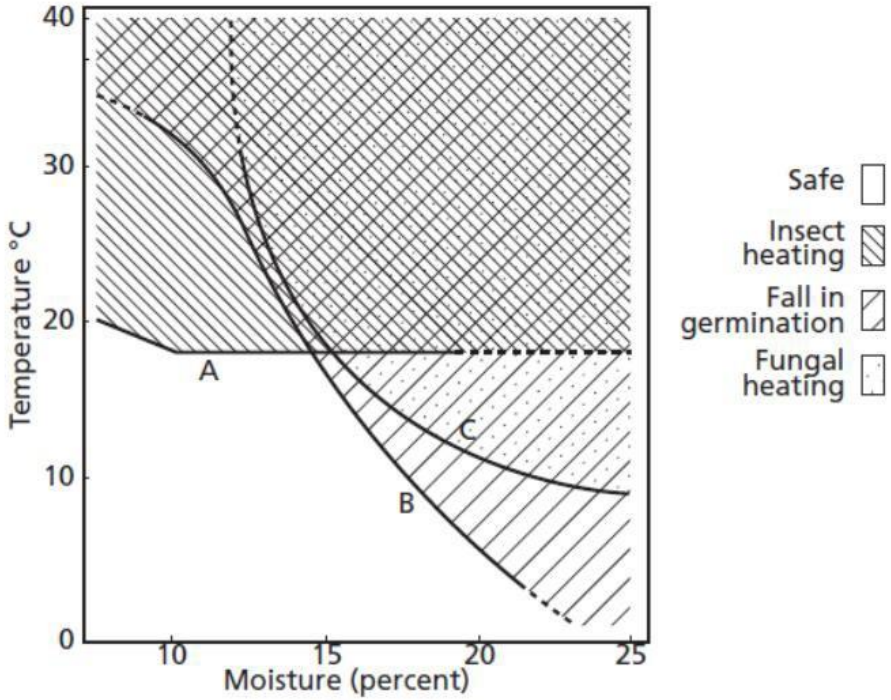
- In addition, in a market that is not controlled, the value of any surplus crop tends to rise during the off-season period, provided that it is in a marketable condition.

- Therefore the principal aim of any storage system must be to maintain the crop in prime condition for as long as possible. The storage and handling methods should minimize losses, but must also be appropriate in relation to other factors such as economies of scale, labour cost and availability, building costs and machinery cost.

- Two projects are operative: GULUNAP and SATTIFS

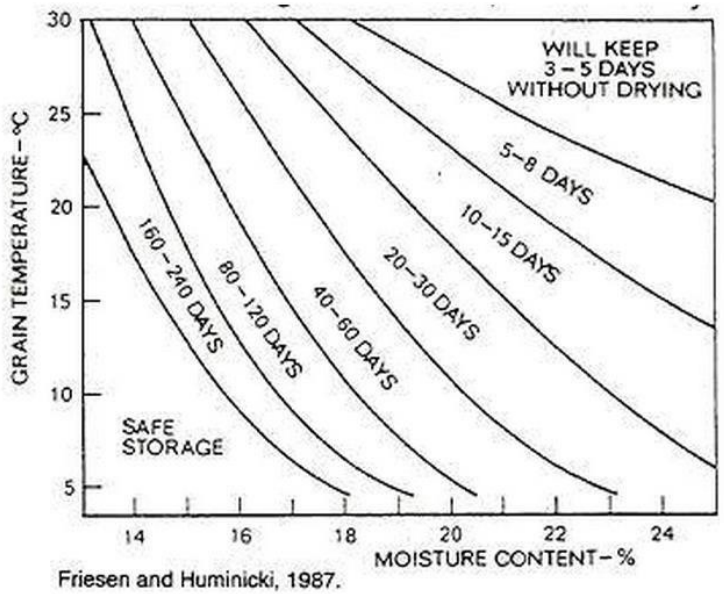
TARGETS:

- **To conduct field trials and disseminate the developed technologies.**
- **To establish socio-economic factors relevant for increased uptake of post-harvest management technologies.**
- **To develop a post-harvest training and services centre for the dissemination of appropriate technology and enhancing community outreach: from subsistence to market agriculture**



TARGET MC :12%

MC: 12% to 14% will be discounted at full value. Stocks containing moisture in excess of 14% are to be rejected. market



Friesen and Huminicki, 1987.

- TWO MAJOR PROBLEMS: CEREALS DRYING AND STORAGE

ENVIRONMENTAL ISSUES:

- **No paved or tarmac roads.**
- **No transportation trucks.**
- **No money to pay for industrial drying.**
- **(Almost) No storage bin**

PORTABLE DRYER TO BE LOCALLY DEPLOYED

- 3 STRATEGIES FOR TECHNOLOGY TRANSFER:

1 → THINK EASY:

- **Easy to build**
- **Easy to fix.**
- **Easy to deploy.**
- **Easy to run.**

- 3 STRATEGIES FOR TECHNOLOGY TRANSFER:

1 → THINK CHEAP:

- **Low construction cost.**
- **Low maintenance cost.**
- **Low operating cost.**

- 3 STRATEGIES FOR TECHNOLOGY TRANSFER:

1 → THINK LOCAL:

- **Build with local parts.**
- **Make replication possible.**

- PORTABLE DRYER LAYOUT:

1. BIOMASS DOUBLE DRUM HEAT EXCHANGER
2. HIGH PRESSURE CENTRIFUGAL FAN
3. PORTABLE FIXED BED DRYER

DESIGN SPECIFICATIONS:

- **Capacity of 2.5 tons/24 hrs. (depending on the initial m/c)**
- **Driven by 8HP Air Cooled diesel engine: fuel consumption ≈ 1L/Hr**
- **Bed Dryer Floor space of 2.4 x 4.0 M**
- **Dryer completely portable**
- **Capacity can be increased**

- PORTABLE DRYER LAYOUT:

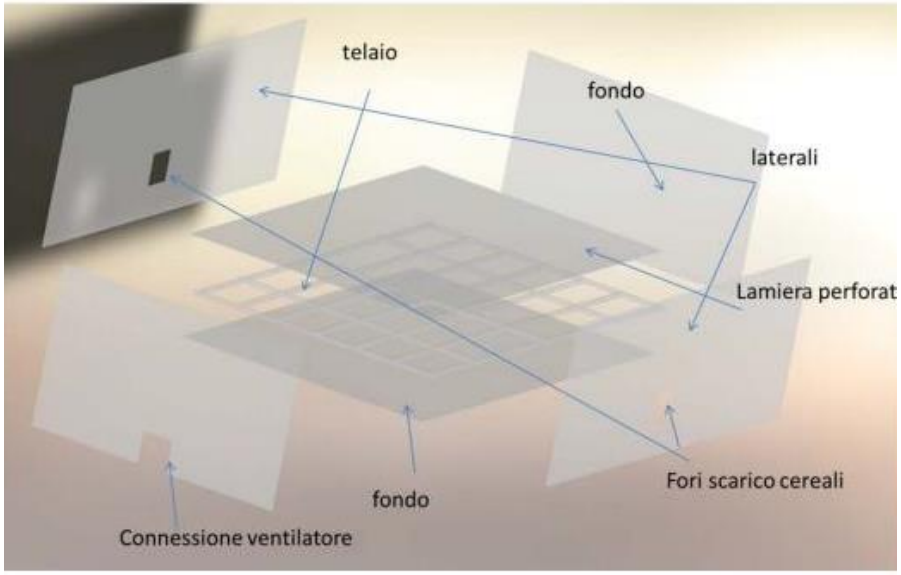
Fixed bed dryes

High pressure centrifugal fan (0.25-0.95 m^3/s)

Double drum heat exchanger/rice husk gasifier

- PORTABLE DRYER LAYOUT:

Fig.1 : esploso del cassone assemblato



- PROBLEMS TO ADDRESS:

ONE BATCH IN 8 HOURS!

- ANISOTROPY OF AIR DISTRIBUTION
- ANISOTROPY OF MOISTURE REMOVAL
- UNEVEN FINAL QUALITY
- MINIMIZATION OF FUEL COMBUSTION

- Non – equilibrium equations model

$$\frac{\partial X_a(x,t)}{\partial t} + \frac{V_a}{\varepsilon} \cdot \frac{\partial X_a(x,t)}{\partial x} = -\frac{\rho_{dp}}{\varepsilon \rho_a} \cdot \frac{\partial X_p(x,t)}{\partial t}, \quad (1)$$

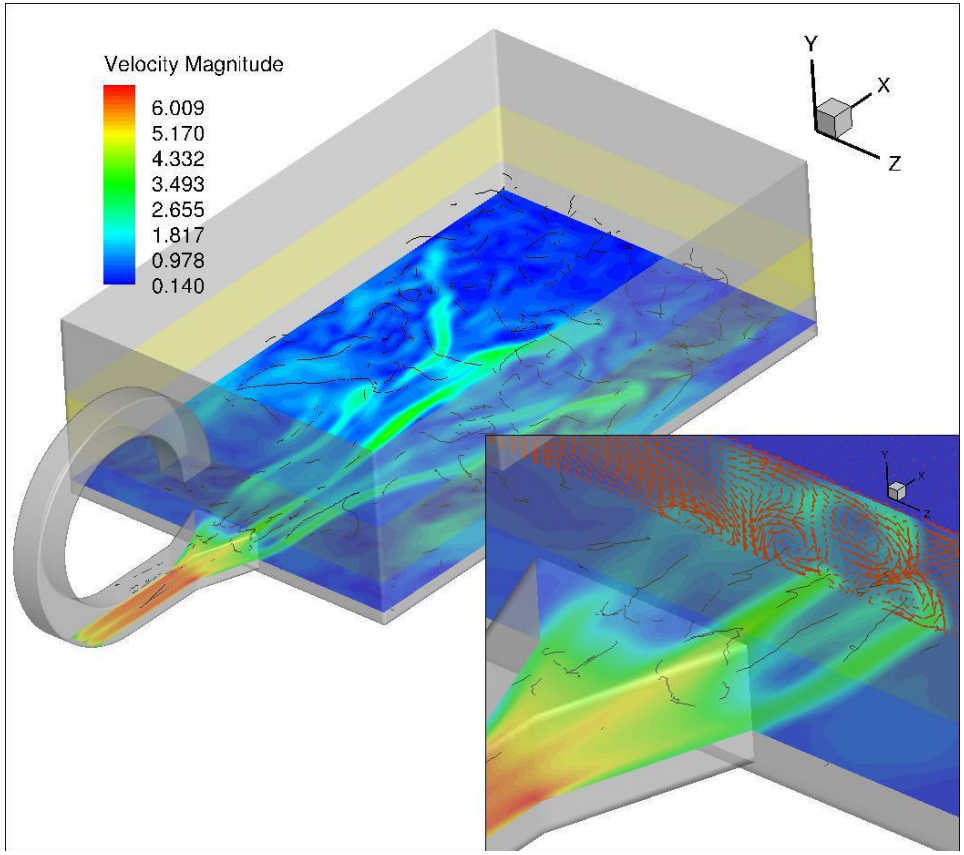
$$\frac{\partial T_a(x,t)}{\partial t} + \frac{V_a}{\varepsilon} \cdot \frac{\partial T_a(x,t)}{\partial x} = -\frac{h_T a_p (T_a(x,t) - T_p(x,t))}{\varepsilon \rho_a (C_{p_{da}} + C_{p_v} X_a(x,t))}, \quad (2)$$

$$\frac{\partial X_p(x,t)}{\partial t} = -(X_p(x,t) - X_{eq}) \cdot \frac{\pi^2}{9} a_p^2 D_c, \quad (3)$$

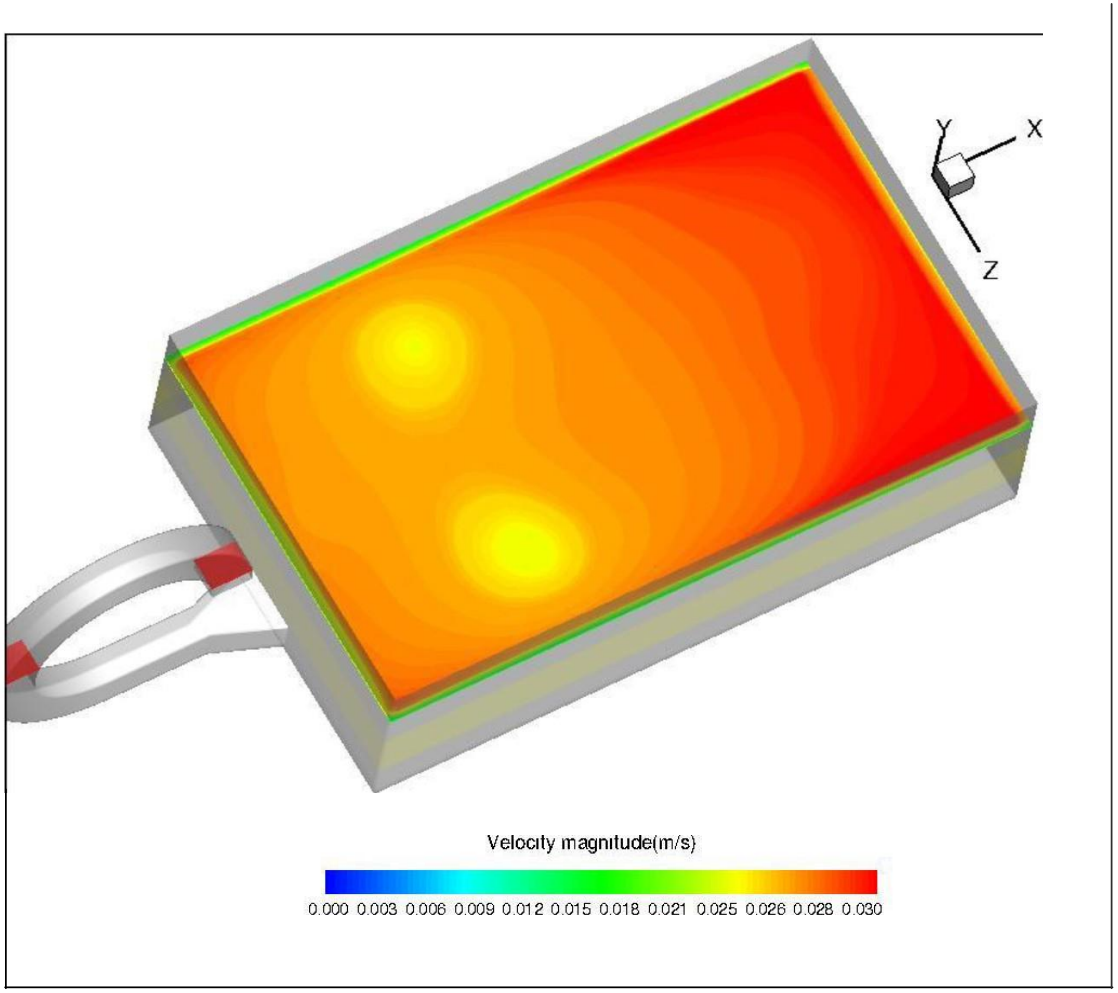
$$\frac{\partial T_p(x,t)}{\partial t} = \frac{1}{\rho_{dp}\left(C_{p_{pd}} + C_{p_w} X_p(x,t)\right)} \left[h_T a_p (T_a(x,t) - T_p(x,t)) - \rho_a V_a \frac{\partial X_a(x,t)}{\partial x} \cdot (L_v + C_{p_v}(T_a(x,t) - T_p(x,t))) \right]. \quad (4)$$

$$h_T = 172.2 \cdot (\rho_a V_a)^{0.5}$$

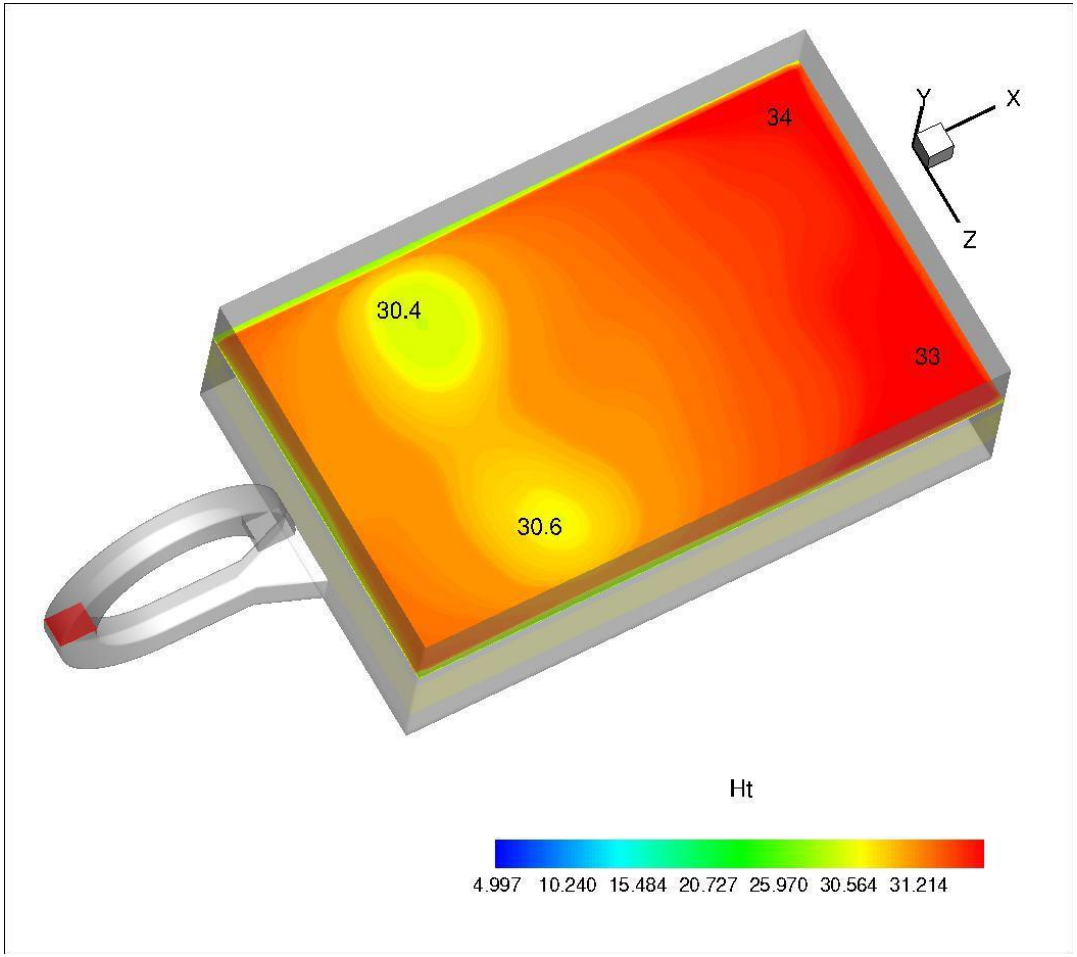
- Local velocity contours in standard configuration



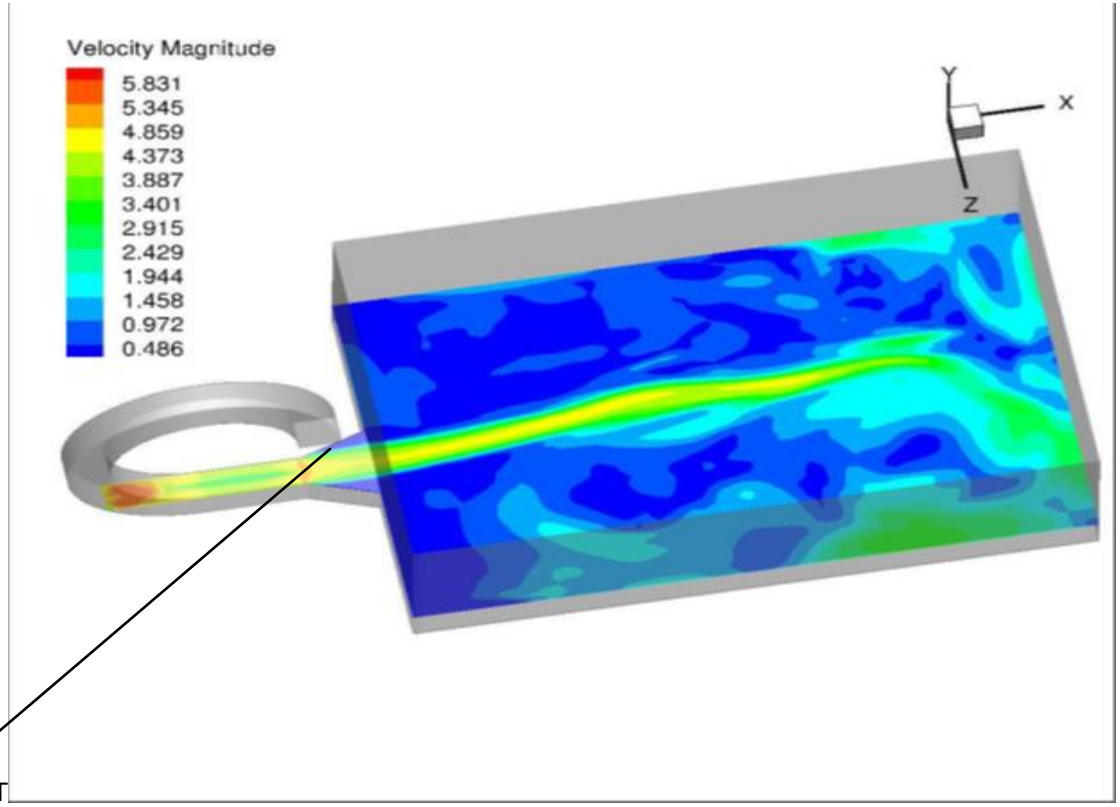
- Local velocity contours in standard configuration



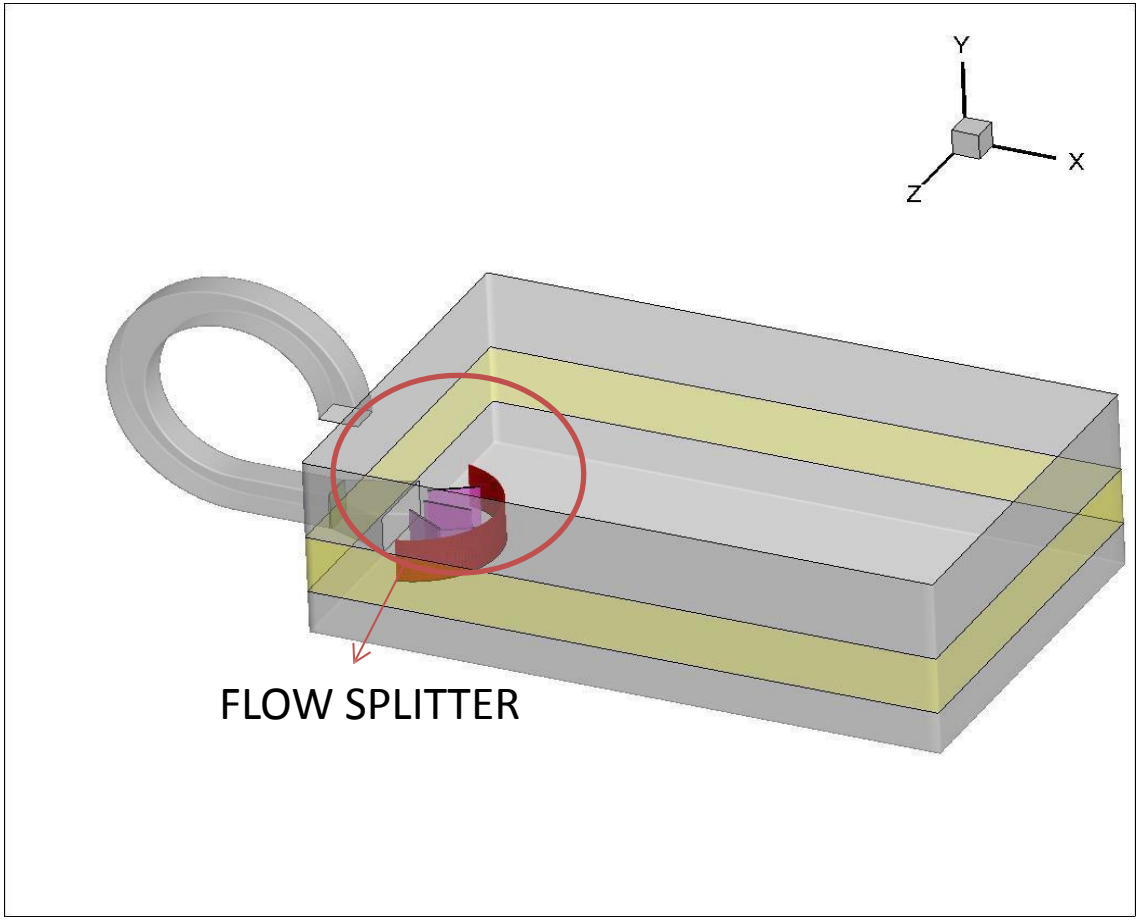
- Local ht contours in standard configuration



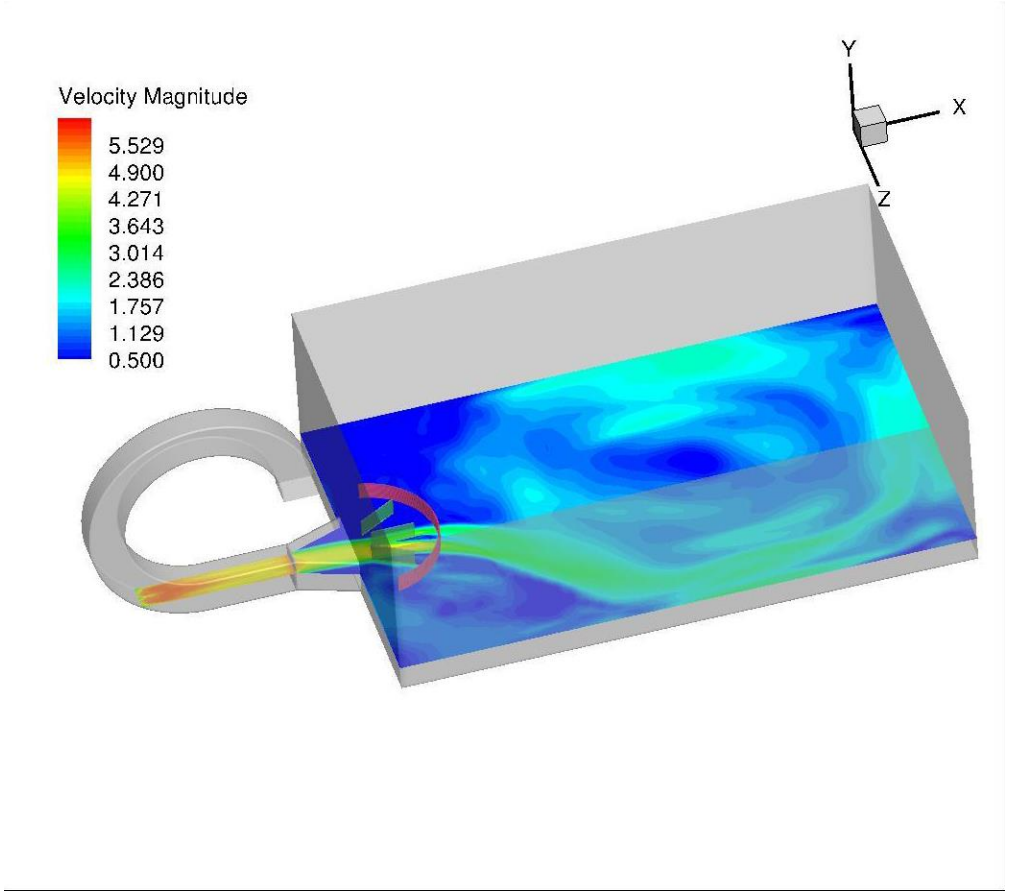
- Local velocity contours in one screen configuration



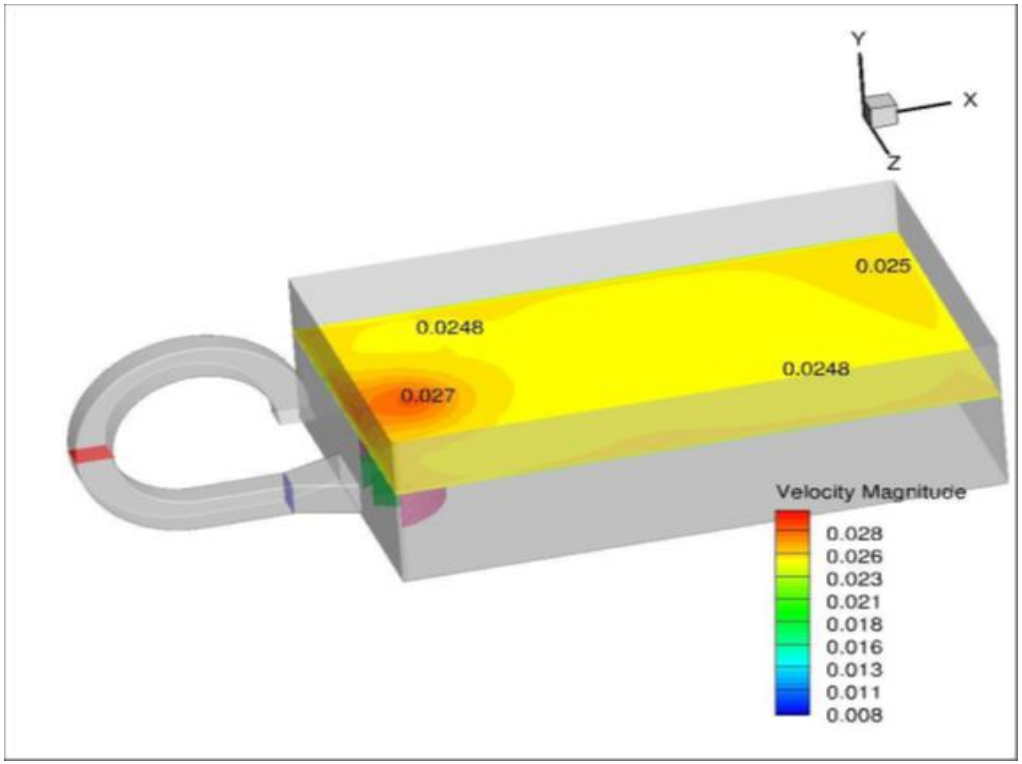
- Local ht velocity contours in standard configuration



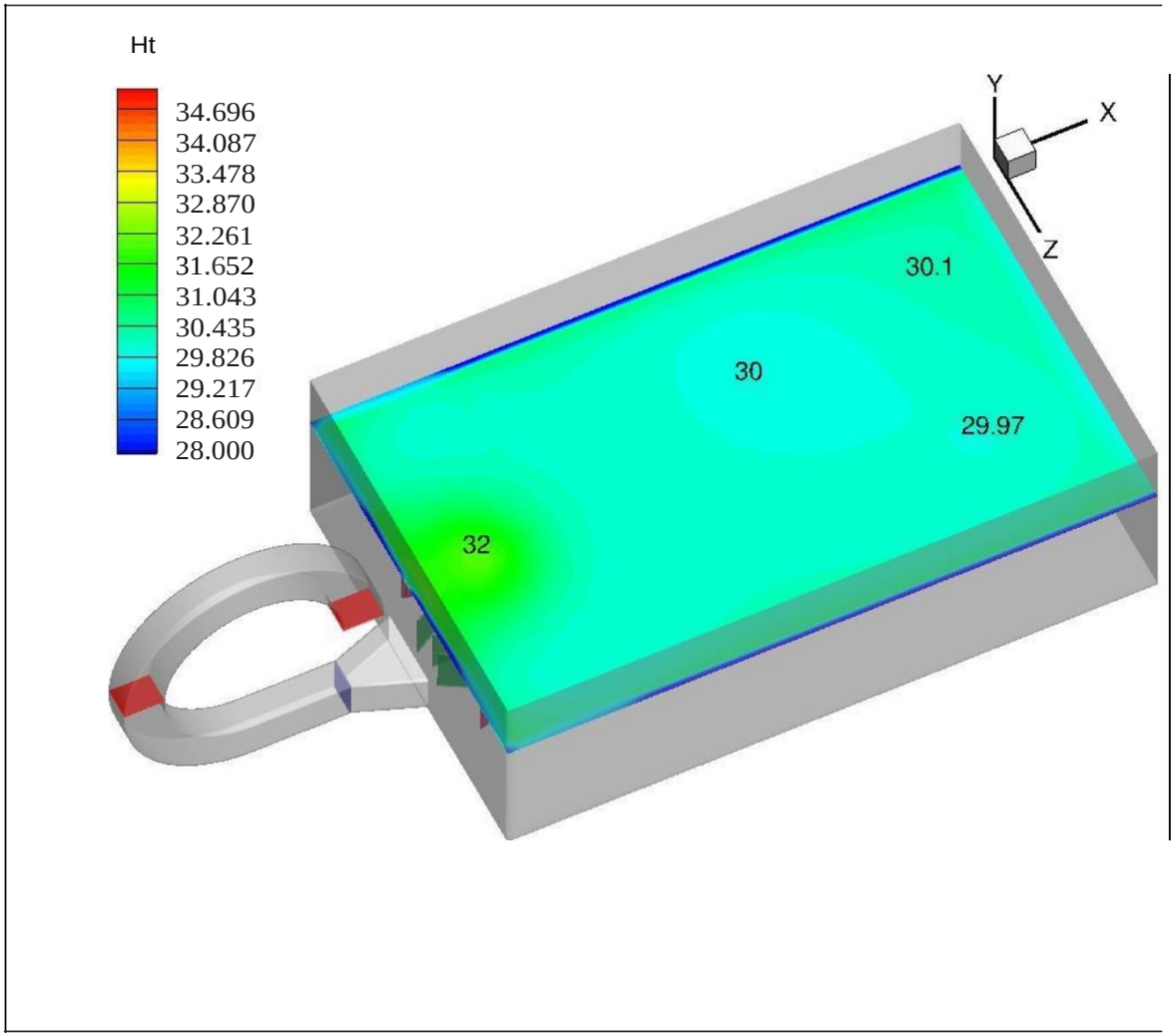
- Local velocity contours in splitter vane configuration: porosity 1



- Local velocity contours in splitter vane configuration : porosity 2



- Local ht contours in splitter vane configuration: porosity 2



- CONCLUSIONS

1. TECHNOLOGY TRANSFER IN DEVELOPING COUNTRIES IS OFTEN A <<DOWNGRADE>> PROBLEM.
2. TO ANSWER TO LOCAL COMMUNITIES NEEDS A PORTABLE CEREAL DRYER WAS DEVELOPED
3. USING CFD TECHNIQUES NON UNIFORMITY IN HEAT TRNSFER AND CONSEQUENTLY IN FINAL MOISTURE CONTENTS WAS REDUCED FROM 10% TO 3.5 %
4. THE PROTOTYPE IS CURRENTLY UNDER CONSTRUCTION AND WILL BE TESTED SOON
5. A CONTINOUS MULTIPLE CROP DRYER IS UNDER DEVELOPMENT