Computational Fluid Dynamics Modeling of Air Flow Through In-Shell Peanuts in a Drying Trailer

J.S. MCINTYRE*, USDA-ARS National Peanut Research Laboratory, Dawson, GA 39842

In-shell peanuts do not dry uniformly in drying trailers even when air is blown through them at recommended rates. Non-uniform drying causes deterioration in peanut quality during subsequent farmer stock storage and loss in value to processors. To understand the problem of non-uniform drying, a person must know what the air flow characteristics are in the interior of masses of peanuts in drying trailers. Direct measurement of air flow characteristics in the interior of masses of peanuts is very difficult. An alternative to direct measurements is Computational Fluid Dynamics (CFD) modeling which has proven valuable in other applications where an understanding of flow was required. Autodesk CFD modeling software was used to simulate air flow characteristics through peanut masses 1.24 m in depth in drying trailers. The modeled trailer was a typical 6.4 m (21 ft) long drying trailer 1.6 m (5.2 ft) high and 2.4 m (7.9 ft) wide. A perforated floor was located 0.2 m above the bottom of the trailer which formed an air plenum beneath the floor into which forced air could be blown from one end of the trailer. The 2.4 m end of the trailer where air was blown into the trailer was designated the air inlet wall. The 6.4 m long sides of the trailer were designated sidewalls. The forced air entered the plenum and then passed through the perforated floor upwards through the peanuts and out through the uncovered top of the trailer. Peanuts were modeled as a permeable resistance material using previously reported permeability parameters related to peanut depth and moisture content. Numeric solution process control parameters were adjusted to produce stable converging solutions. Model computed bulk air flow of 283 m^3/min, velocity distribution at the top surface of the peanut mass, and plenum static air pressure of 124 Pa at the experimental measurement point agreed favorably with reported experimental results which indicated model results should be representative of experimental results. Model results indicated air flow that started at the end of the air inlet ramp 0.37 m from the air inlet wall at the centerline of the trailer and proceeded from the trailer floor upwards through the peanut mass to the top surface of the peanuts had flow velocities that ranged from 22 m/s to 0.7 m/s and had static air pressures that ranged from 320 Pa to 1 Pa. Starting again at the end of the air inlet ramp at the centerline of the trailer and proceeding along the trailer floor toward a trailer sidewall, air flow velocities ranged from 22 m/s flowing away from the air inlet wall to 4 m/s flowing toward the air inlet wall. Starting again at the end of the air inlet ramp at the centerline of the trailer and proceeding along the trailer floor toward a trailer sidewall, static air pressure was 320 Pa at the centerline of the trailer then decreased to 92 Pa and then increased again to 126 Pa at a sidewall. Going to the opposite end of the trailer from the air inlet and starting 0.37m from the end wall at the centerline of the trailer and proceeding from the trailer floor upwards through the peanuts to the top surface of the peanuts, air flow velocities ranged from 1.4 m/s to 0.75 m/s and static air pressures ranged from 318 Pa to 5 Pa. Starting again at the previous point at the opposite end of the trailer from the air inlet at the centerline of the trailer and proceeding along the trailer floor to a trailer sidewall, air flow velocities ranged from 1.3 m/s to 0.9 m/s with all the air flowing upwards with a constant static air pressure of 318 Pa. The CFD modeling results indicate that air flow velocity and static pressure distribution patterns were three-dimensionally complex in a peanut mass and also in the air plenum beneath a peanut mass. The complex air flow indicated by modeling results had not been indicated by experimental measurements of air flow characteristics at the top surface of peanuts in a drying trailer. The next step in solving the non-uniform peanut drying problem is investigating if altering the air flow characteristics below and in a peanut mass would improve peanut drying. The CFD modeling of air flow in peanuts facilitates evaluation of peanut processing and storage methods and peanut handling equipment designs before

implementation. Design optimization using the CFD model can greatly reduce cost, increase understanding of the problem and expand freedom in design choices.