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Shrinkage Characteristics of Pine Leaves in Fluidized Bed Combustor

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Abstract—*In this paper, shrinkage characteristics of pine leaves during devolatization under conditions similar to the fluidized bed combustor have been presented. Effect of bed temperature and particle length on longitudinal, transverse and volumetric shrinkage of pine leaves has been studied. Pine leaves have been subjected to temperature between 250-450°C in a muffle furnace under the condition similar to the fluidized bed. The fuel particle length ranged from 2 to 6 cm. Various Shrinkages have been measured with the help of NI vision builder 2013.*

1. INTRODUCTION

Increasing prices and decreasing availability of fossil fuels is forcing developing countries to explore alternative fuels for fulfilling their energy requirements. Biomass is emerging as a promising alternative fuel due to its availability in abundance in agricultural countries like India. Burning biomass in open fields leads to environmental pollution and dumping biomass under the earth can lead to generation of poisonous gases like methane. For efficient combustion of biomass fluidized bed combustors (FBC) are the best among all available choices.

The performance of biomass fired fluidized bed combustor, largely depends upon the combustion characteristics of the biomass fuel. Fuel particles shrink due to moisture removal and then due to release of the gases. R. Renu Kumar [1], studied the effect of shape and size of casuarina wood on the longitudinal, transverse and volumetric shrinkage during devolatization in a lab scale FBC. They found that for various shapes and sizes of casuarina wood, change in shrinkage values was due to variation in the heating rate. Bed temperature had negligible effect on wood shrinkage rates. Shreekanth [2] found that wood shrinks due to shrinkage and primary fragmentation. Shreekanth [3] found that for a cylindrical wood in a bubbling fluidized bed, the longitudinal shrinkage begins only after 50% of conversion, whereas radial shrinkage started from the very beginning.

Pine trees are found in the lower Shivalik hills. Pine trees have acicular shaped leaves instead of flat leaves of most tree species, which are usually referred to as needles. The pine leaves are generally found in a group of two to eight depending on the type of species. Pine leaves have an average life for about two years, after which they turn brown and fall down. Since pines are evergreen trees, they constantly replace the dead leaves with new ones. This gives an endless supply of pine leaves. Pine leaves have an immense energy stored in them [4], due to which they are excellent biomass fuel. Needle shaped pine leaves, after falling from the pine trees cover the forest ground and hinders the growth of the vegetation. Many farmers use this vegetation for feeding their cattle and put these pine leaves on fire. This is a major cause for forest fires. This leads to a danger to wildlife, forests, environment and human beings also. In this paper, shrinkage characteristics of pine leaves under conditions similar to fluidized bed have been studied. Pine leaves have been collected from the pine forests of district Hamirpur, Himachal Pradesh, India.

2. EXPERIMENTAL PROCEDURE

A sample of 2 cm length was cut from a pine leaf and was kept in a mild steel crucible having 170 number of 1 mm diameter holes at the base. Holes were provided to make the conditions nearly similar to fluidized bed conditions. Fig. 1 shows the sample of pine leaves and crucible used for the analysis. Crucible with pine leaf sample was kept in the muffle furnace at 250°C for two minutes and then it was kept in the desiccator for some time. The length and diameter of the sample was measured using NI vision builder 2013. The same sample was subjected to higher temperatures of 300°C, 350°C, 400°C and 450°C every time for two minutes and change in length and diameter were measured using NI vision builder 2013. Experiment was repeated five times to minimize the chances of error. Same experiment was conducted for pine leaves with 4 cm and 6 cm length.

NI Vision Builder gives an easy way to conFig. and deploy a system that addresses vision application from pattern matching and presence detection to precision alignment and classification. An external camera connected to a laptop on a fixed height captures an image of the pine leaf in 8 bit (256

color combinations). Since the software cannot process the image in 8 bit scale, it converts the image to gray scale image. The image is then enhanced in vision assistant in red plane. The image masked is selected and extracted from the region of interest. The initial length and diameter of the parent leaf is measured and classified by image processing. The lengths and diameters of the leaf are measured after shrinkage at various temperatures. Flow chart in Fig. 2 shows the steps of working of NI vision builder 2013.

Fig. 1: Samples of Pine leaves and crucible.

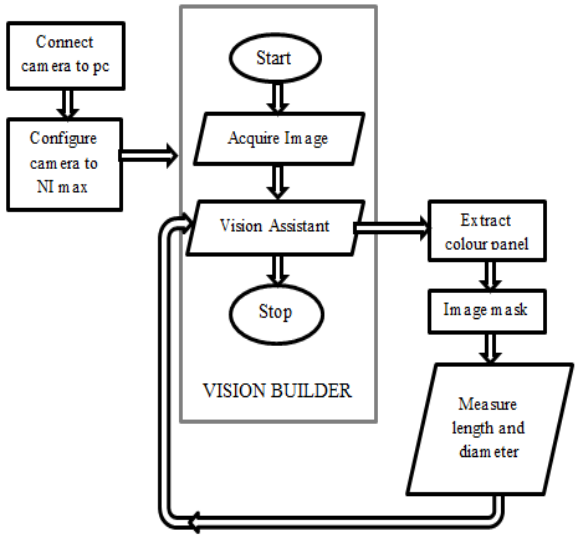

Fig. 2: NI Vision Builder 2013 flow chart.

3. RESULT AND DISCUSSIONS

3.1 General observation

The pine leaf upon heating in muffle furnace under FBC conditions shrinks due to the loss of moisture and volatile contents. Longitudinal, transverse and volumetric shrinkage is noted due to the contraction in length and diameter of the leaf. It is observed that shrinkages in different directions were dependent on the lengths of the leaf placed in the muffle furnace.

3.2 Longitudinal shrinkage

Fig. 3 shows the effect of pine leaf length and the effect of temperature on longitudinal shrinkage. The longitudinal shrinkage for a particular length increased on increasing the temperature. The highest variation in shrinkage was observed for 2 cm long pine leaf i.e. from 0.26% to 3.42% and the least variation was observed for 6 cm long pine leaf i.e. from 0.17% to 1.36%. This is because of the increase in amount of volatile release with increase in temperature. At a particular temperature, the percentage shrinkage decreased with an increase in leaf length. This may be due to the fact that along longitudinal direction, the thermal resistance increases with increase in length and hence the longitudinal shrinkage decrease with increase in leaf length. Fig. 4 shows a decrease in percentage average shrinkage with an increase in length. The highest average percentage shrinkage was for 2 cm i.e. 1.7112% and least average percentage shrinkage was for 6 cm i.e. 0.7276%.

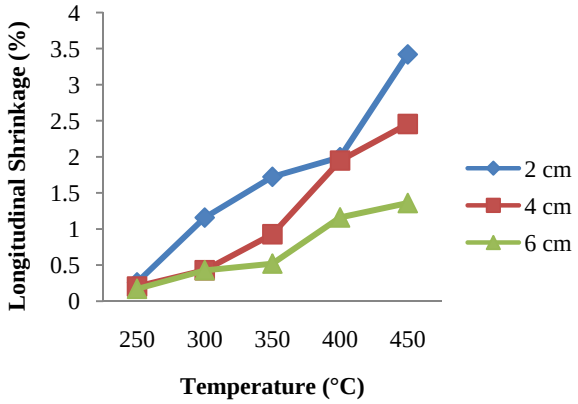

Fig. 3: Longitudinal shrinkage variation with leaf length and temperature

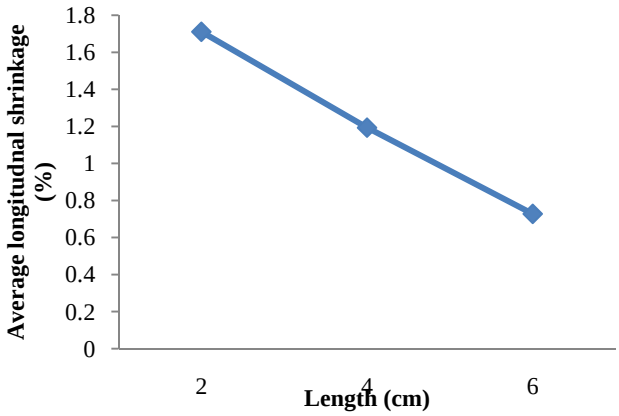

Fig. 4: Average Longitudinal shrinkage variation with leaf length

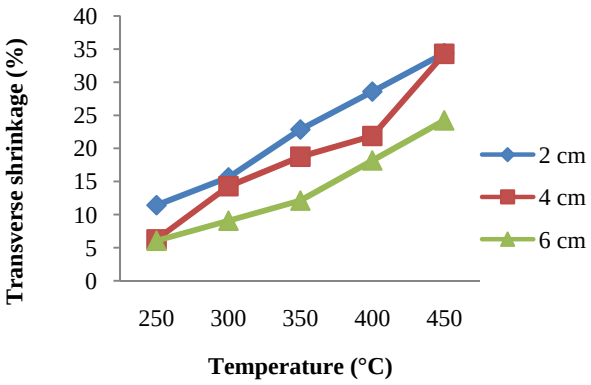

Fig. 5. Transverse shrinkage variation with leaf length and temperature

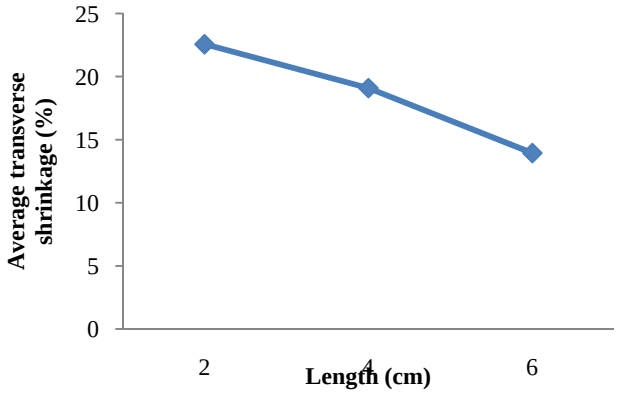

Fig. 6. Average transverse shrinkage variation with leaf length

3.3 Transverse shrinkage

Fig. 5 shows the effect of pine leaf length and the effect of temperature on transverse shrinkage. The transverse shrinkage for a particular length increased on increasing the temperature. The highest deviation in shrinkage was seen for 2 cm i.e. from 11.428% to 34.375% and the 6 cm leaf showed the least variation i.e. from 6.06% to 24.24%. This is due to the fact that with the increase in bed temperature the amount of volatiles released also increases and this lead to increase in transverse shrinkage. At a particular temperature, transverse shrinkage decreased with an increase in length of leaf. Fig. 6 shows a decrease in percentage average shrinkage with an increase in length. The highest average percentage shrinkage was for 2 cm i.e. 22.571% and least average percentage shrinkage was for 6 cm i.e. 13.94%.

3.4 Volumetric shrinkage

The effect of pine leaf length and the effect of temperature on volumetric shrinkage is shown in Fig. 7. The volumetric shrinkage for a particular length was observed to increase with increasing the temperature. The highest deviation in volumetric shrinkage was observed for 2 cm long pine leaf i.e. from 21.68% to 58.29% and the least variation in volumetric shrinkage was observed for 6 cm long pine leaf i.e. from 11.9% to 43.38%. At a particular temperature, the volumetric shrinkage was found to decrease with an increase in leaf length. From Fig. 8, a decrease in average volumetric shrinkage with an increase in pine leaf length can be observed. The highest average percentage shrinkage was for 2 cm i.e. 40.194% and least average percentage shrinkage was for 6 cm i.e. 26.648%. This was expected as the same trend has been observed in longitudinal shrinkage and transverse shrinkage.

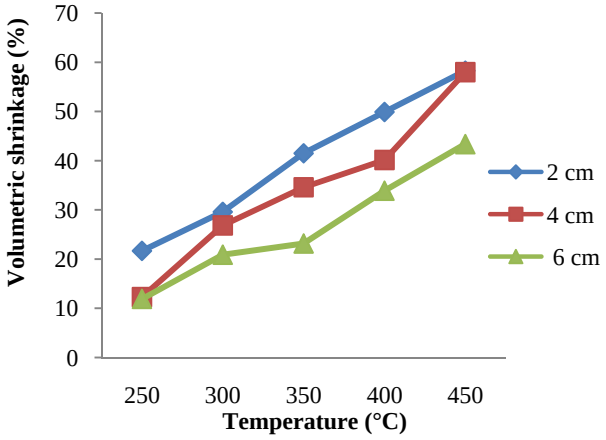

Fig. 7: Volumetric shrinkage variation with leaf length and temperature

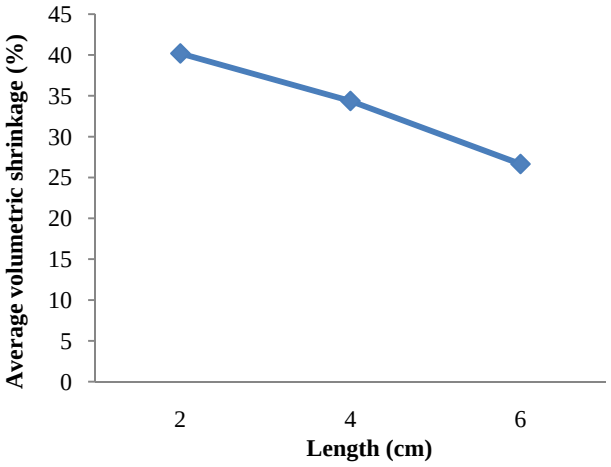

Fig. 8: Average volumetric shrinkage variation with leaf length

4. CONCLUSION

Effects of temperature and pine leaf length on longitudinal, transverse and volumetric shrinkages under conditions similar to fluidized bed combustor were measured. Pine leaf becomes fragile after devolatization and measurement of dimensions using vernier calliper or any other instrument become difficult. Therefore, NI vision builder 2013 has been used to measure the dimensions. Following conclusions may be drawn:

- The pine leaf upon heating in muffle furnace under FBC conditions shrinks due to the loss of moisture and volatile contents.
- Longitudnal, transverse and volumetric shrinkages of pine leaf depends upon the pine leaf length. Smaller the length, largers are the values of these shrinkages.
- Temperature also has significant effect on pine leaf shrinkage. Longitudnal, transverse and volumetric shrinkages increase with increase in temperature.

5. ACKNOWLEDGEMENT

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