transverse ribs, with rib height of 1.4 mm, pitch of 10 mm and Reynolds number of 12,000, to ensure that the calculated results are grid independent.

B. Results of Double Duct Solar Air Heater with Square Transverse Continuous Ribs

In this section results of the double duct solar air heater are presented. First of all, results of variation of hydraulic diameter for the maximum thermal efficiency are presented comprehensively. Then the heat transfer and fluid flow characteristics in terms of Nusselt number and friction factor are described.

1. Optimization of double solar air heater

The effect of hydraulic diameter on the thermal performance of double duct solar air heater is considered. Three cases are studied for the double duct solar air heater on the basis of hydraulic diameter for the maximum thermal efficiency:

1. Same hydraulic diameter of the outer and inner ducts ($D_{h1} = D_{h2}$),
2. Hydraulic diameter of the outer duct is greater than inner duct ($D_{h1} > D_{h2}$),
3. Hydraulic diameter of the outer duct is less than inner duct ($D_{h1} < D_{h2}$).

As discussed in previous chapter, hydraulic diameter of the both duct is varied in order to get optimized duct for the current study. Thermal efficiency is calculated for all of the above three cases discussed at three different mass flow rates viz. 0.01, 0.015 and 0.02 and thermal efficiency is found to be maximum when the hydraulic diameter of the inner and outer ducts is same i.e. $D_{h1} = D_{h2}$. The results in case of varied hydraulic diameters is shown in fig. 9.

Hence it is found that when the hydraulic diameter of inner and outer duct is kept same, maximum thermal efficiency of the solar air heater is achieved and thus this duct is used for employment of artificial roughness.

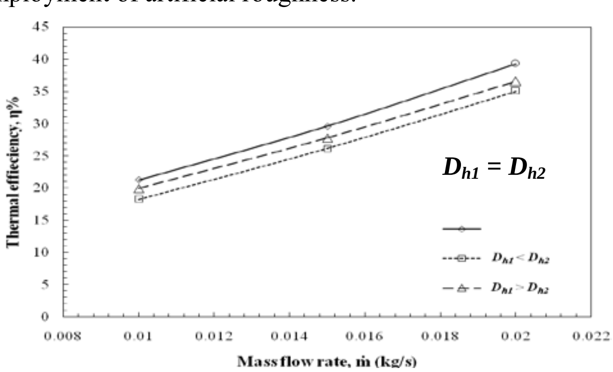

Fig. 9 Optimization of hydraulic diameter for inner and outer duct of solar air heater

VI. CONCLUSIONS

A numerical investigation on heat transfer and fluid flow characteristics of proposed solar air heater is performed. A detailed description of the average heat transfer and fluid flow characteristics in terms of Nusselt number and friction factor, are obtained. The effects of Reynolds number, relative roughness pitch (P/e) and relative roughness height (e/D) on the heat transfer and fluid flow process are discussed. The following conclusions has been drawn on the basis of the present numerical investigation :

1. The use of double duct and three sided artificially roughened solar air heater in the form of square rib roughness effectively enhances the convective heat transfer coefficient , therefore the rate of heat transfer in comparison with smooth solar air heater.
2. Renormalization-group (RNG) k-ε turbulence model gives results very close to the Dittus-Boelter empirical correlation for smooth duct of a solar air heater which yields confidence in the prediction done by numerical analysis in the present study.
3. For the maximum thermal efficiency of double duct parallel flow solar air heater, the hydraulic diameter of both inner and outer duct should be equal.
4. The maximum enhancement of average Nusselt number has been found to be 11.30 times higher than that of a smooth duct for the relative roughness pitch of 10 a nd relative roughness height o f 0. 06 at Reynold number of 4000.

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