CFD Investigation on Horizontal Tube with Different Inserts

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Abstract. Increased heat transfer rates in industrial heat exchangers are the subject of ongoing research. The heat transfer augmented by passive technique and active technique especially at intermediate Reynolds numbers in pipe flow. Passive procedures include inserting various sorts of inserts into tubes. Active approaches, such as power work, that utilize external power input are less desired. The primary goal of this research work is to investigate heat transfer from a turbulent flow to a horizontal tube utilizing various inserts. Reynolds number is maintained as 12000. The two fluids namely water, 95 percent of water + 5% of Titanium Carbide. The three various sorts of inserts were considered as twisted, perforated twisted and double counter twisted tape. CFD analysis was conducted with the help of FLUENT data to determine friction factor and Nusselt number. Pro/Engineer is used to create three-dimensional horizontal tube with inserts.

Keywords: CFD, Tube Inserts and Heat Transfer Enhancement.

1 Introduction

Heat exchangers have a few modern and designing applications. The plan technique of intensity exchangers is very confounded, as it needs accurate examination of intensity move rate and strain drop assessments separated from issues like long haul execution and the financial part of the gear. Procedures for heat move expansion are pertinent to a few designing applications. Lately, the significant expense of energy and material has brought about an expanded exertion pointed toward delivering more productive intensity trade gear. Moreover, at times there is a requirement for scaling down of an intensity exchanger in unambiguous applications, for example, space application, through an expansion of intensity move. For instance, an intensity exchanger for a sea nuclear power transformation (OTEC) plant requires an intensity move surface region of the request for 10 000 m^2/MW. Prabhakar Ray et al.[1] noticed that wire loop gives better enhancement with large execution in the event that the tension drop punishment.[2] to [6] examined heat carried in more uniform by providing the holes. The blade effectiveness of punctured balance is more prominent than the strong blade. The punctured materials can have better strength. The copper has high conductivity than the aluminum. The wire curl of pitch proportion 0.88 better than every single curved tape. Saha et al. [12] reported that the decrease in the width of the curved tape isn't successful, contrasted and a turned tape of width

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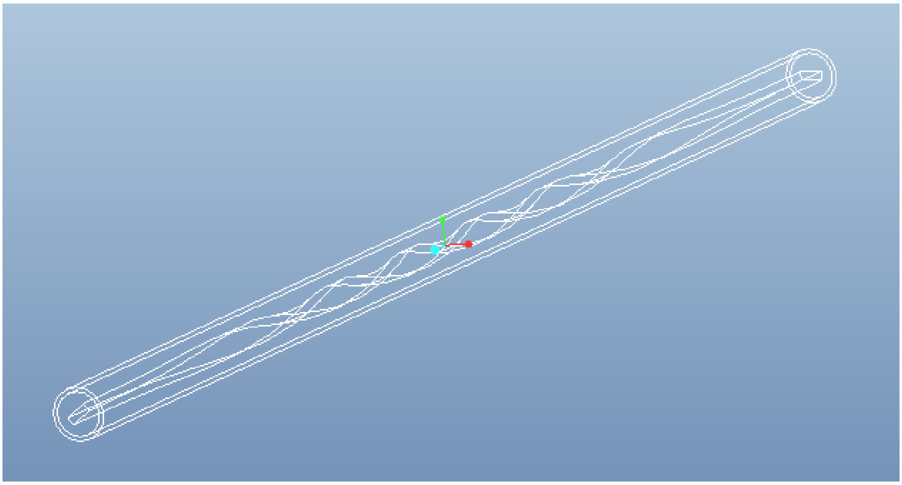
equivalent to within measurement of the cylinder.Liao and Xin [14] revealed that trial information on the compound intensity move improvement method and presumed that the upgrade of intensity move in a cylinder with three dimensional inward expanded surfaces by supplanting consistent curved tape with nearly portioned wound tape embeds brings about a lessening in the grinding factor yet with a similarly little reduction in the Stanton number. [15] to [20] have concentrated on laminar progression of water in loops and cylinders containing contorted tapes and helical static components Arkan Altaieet al. [22]examined the intensity move furthermore to thermal execution properties mathematically in a steel tube with length of 50cm, 60mm external breadth and 30mm inner diameter with consistent external surface temperature which is equivalent to 1,000, 1,200 and 1,400 K. Likewise, the ribs gathering (5mm x 5mm cross-segment) have been fitted in tube too as divided by an8cmpitch, while the outcomes in regards to temperature and speed conveyances along tube focus line as to a cylinder with inner ribs have been put to correlation with that connected with plain cylinder, such outcomes are showing that utilizing inside ribs is upgrading the intensity move rate and demonstrating for having most extreme execution factors for the violent stream. Moreover, the CFD forecasts concerning a cylinder with ribs have been set to examination against the cylinder without any ribs. [21] to [23]reported that the outcomes which are connected with joined mathematically and experimentally of stream as well as intensity move in straight channels, with the square cross section ribs.

The above literature reveals that most of studies were reported on the rib turbulators with different geometries, but few of them are reported on three different twisted tape. Therefore, it is need to investigate these twisted tapes with water and combination of water with TIC nanofluid. So, the present paper reported on the numerical investigation on the effect of heat transfer enhancement with water and combination of water with TIC nanofluid for three different configurations of the twisted tapes.

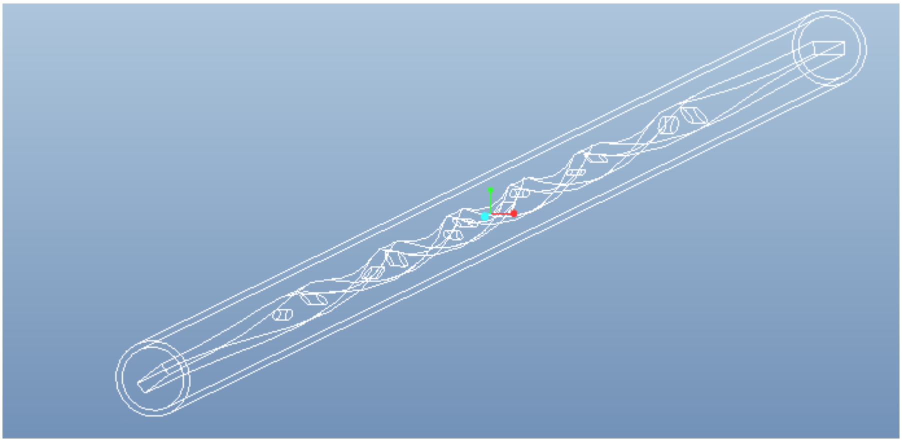
2 Numerical Modeling and Simulation

Pro-E modeling software was used to create three-dimensional horizontal pipe with three different inserts such as twisted tape, perforated twisted tape and double counter twisted tape. This modal was imported to FLUENT code. This analysis was performed with the help of FLUENT data to determine friction factor and Nusselt number. The boundary conditions were considered as pressure, velocity and temperature at the inlet and velocity at the outlet. The flow is considered as turbulent

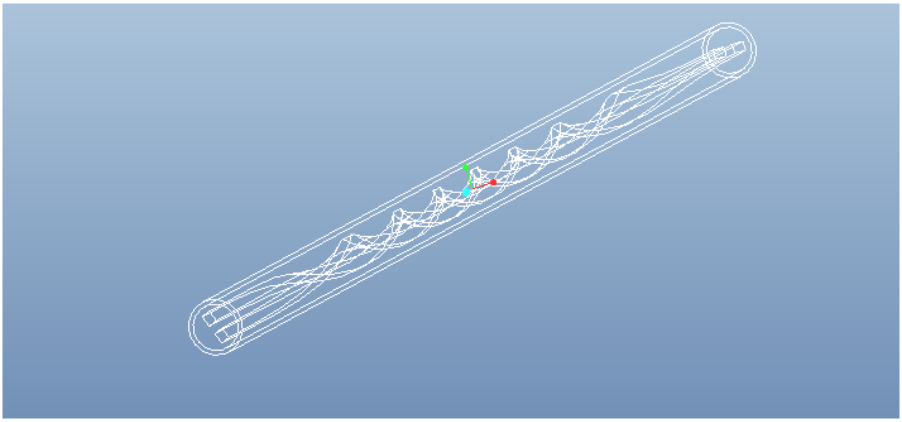
2.1 Twisted Tape



2.2 Perforated Twisted Tape



2.3 Double Counter Twisted Tapes



3 Calculations To Determine Properties Of Nano Fluid By Changing Volume Fractions

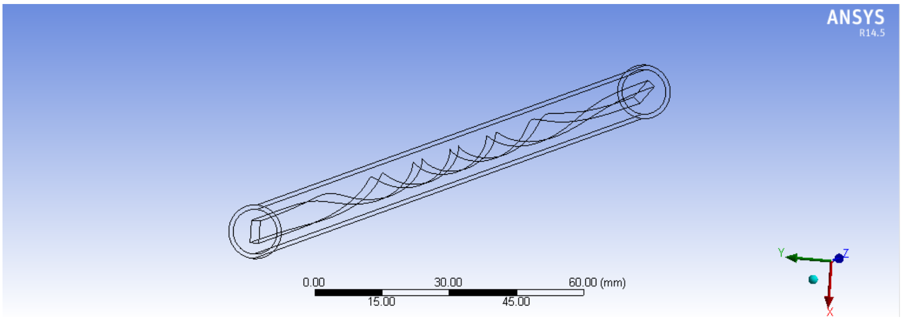
Material Properties

Water : Density = 998.2 kg/m^3, Thermal conductivity = 0.6 W/m.k , Specific Heat =4182 J/kg.K, Viscosity =0.001003 kg/m.s

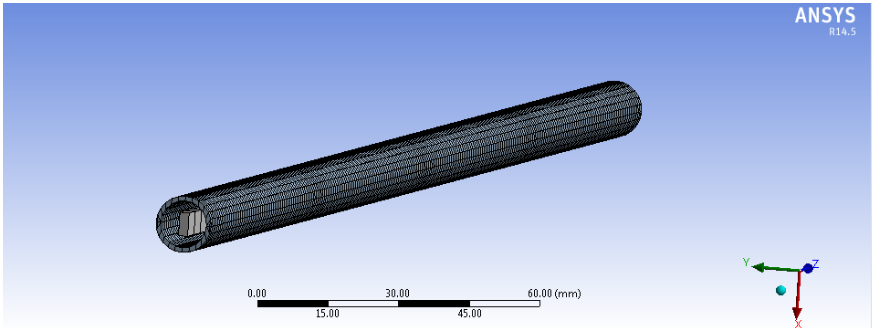
Titanium Carbide : Density = 4930 kg/m^3, Thermal conductivity = 330 W/m.k , Specific Heat =711 J/kg.K,

Velocity at Reynolds Number= 87.64 m/s

Fluid -Water : Case1 : Twisted Tape



Meshed model



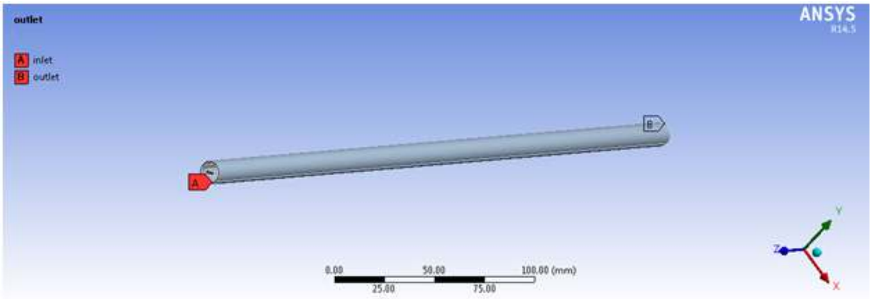


Table 1. Thermo-physical properties of fluids

Properties	Water	Water 0.95% +TiC 0.05%
Density(kg/m^3)	998.2	344.829
Thermal conductivity (W/m.k)	0.6	1.107
Specific Heat (J/kg.K)	4182	3429.394
Viscosity (kg/m.s)	0.001003	0.0011283

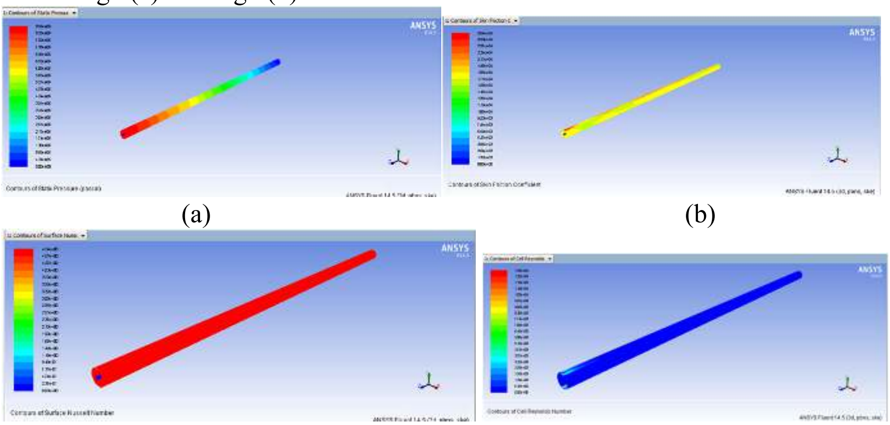
Boundary Conditions: Inlet Temperature = 331 K,
Inlet Pressure = 101325 Pa ,
Inlet Velocity =87.64 m/s

From this average intensity values of concerned portions of the input image, the Hash bits can be calculated according to the (1) and (2). And the Hash sequence for the image can be grouped as the calculated hash bits of the portions like [0, 1, 0, 1, 1, 0, 0].

From this hash sequence the hash code for the image will be 0101100.

4. Results and Discussions

The maximum values of pressure are noticed at the beginning and the minimum values are noticed at the end of the twisted tape, when water flows in it as shown in Fig.1 (a). whereas, the variation of skin friction coefficient was almost constant throughout the length of the pipe as shown in Fig.1 (b). The Nusselt number and Reynolds number variations were achieved as a constant throughout the pipe as shown in Fig.1(c) and Fig.1(d).



(a) (b)

(c) (d)

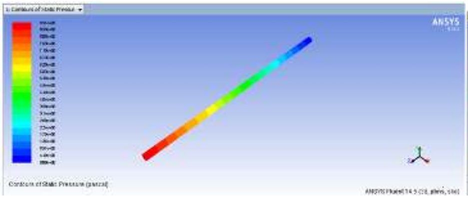
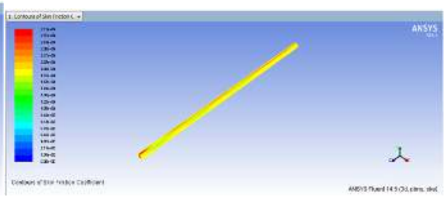
Fig.1. TWISTED TAPE variations under the water (a) contours of Pressure (b) contours of skin Friction Coefficient (c) contours of Nusselt Number and (d) contours of Reynolds number.

The trends for the perforated twisted tape are similar to the twisted tape, except that the Nusselt number, pressure and Reynolds number will increases as shown in the Fig.2. The perforation holes made in the twisted pipe will enhance the heat transfer coefficient

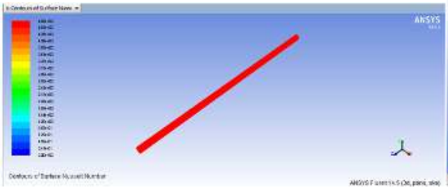
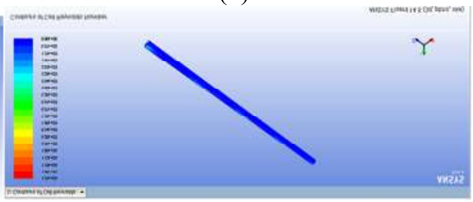
The trends obtained for the double counter twisted tape are similar to the earlier. In this arrangement, the highest magnitudes of pressure, Reynolds number and Nusselt number were observed compared to the earlier two methods as shown in Fig.3(a) to Fig.3(d).

The water 95% and nanofluid Titanium Carbide 5% mixture of fluid flows inside the twisted tape, the maximum pressure values are noticed nearly about 50% from beginning of the pipe, later on these magnitudes will decreases as shown in Fig.4(a).

While, the skin friction coefficient, Nusselt number and Reynolds number variations were achieved as a constant throughout the pipe as shown in Fig.4(b) to Fig.4(d).

(a) (b)

(c) (d)

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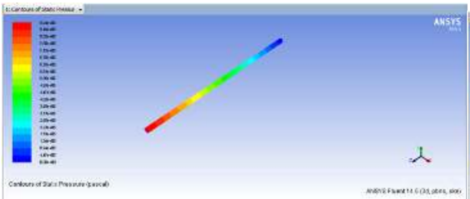
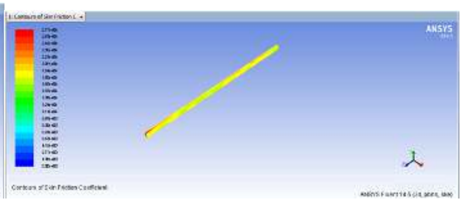
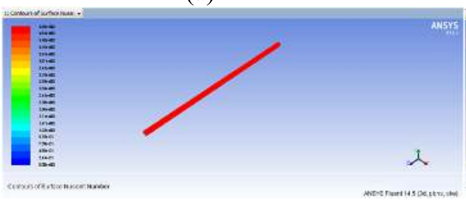
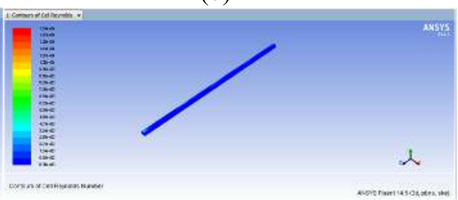
Fig.2. PERFORATED TWISTED TAPE variations under the water (a) contours of Pressure (b) contours of skin Friction Coefficient (c) contours of Nusselt Number and (d) contours of Reynolds number

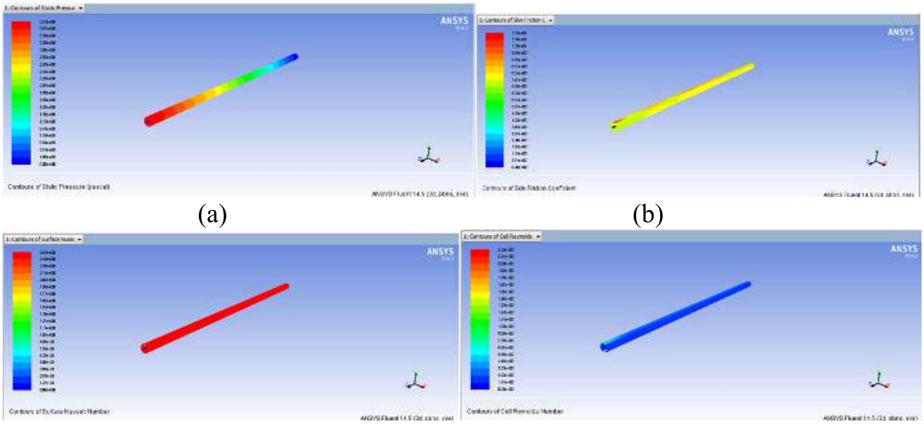



(a) (b)

(c) (d)

Fig. 3. DOUBLE COUNTER TWISTED TAPE variations under the water (a) contours of Pressure (b) contours of skin Friction Coefficient (c) contours of Nusselt Number and (d) contours of Reynolds number.

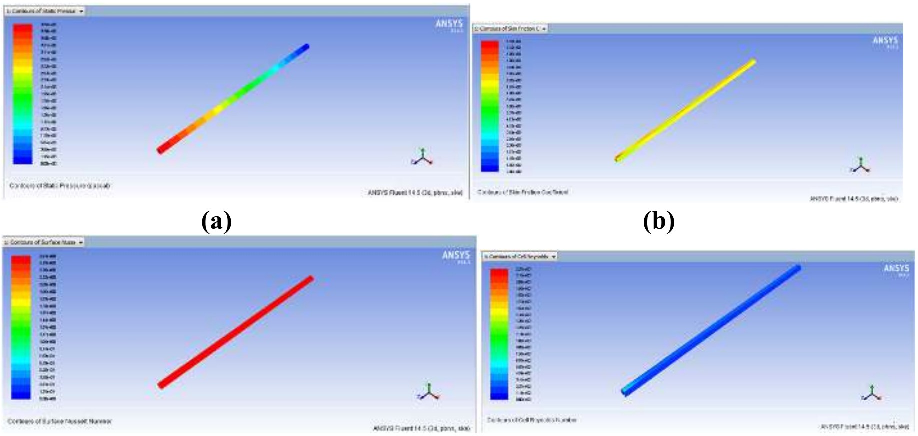


(a) (b)

(c) (d)

Fig. 4. Twisted Tape variations under the nano fluid water 95%+TiC-5% (a) contours of Pressure (b) contours of skin Friction Coefficient (c) contours of Nusselt Number and (d) contours of Reynolds number

The trends for the water 95% and nanofluid Titanium Carbide 5% mixture in perforated twisted tape are similar to the twisted tape, except that the Nusselt number, pressure and Reynolds number will increases as shown in Fig.5(a) to Fig.5(d). The perforation holes made in the twisted pipe will enhance the heat transfer coefficient



(a) **(b)**

(c) **(d)**

Fig. 5 Perforated Twisted Tape variations under the nano fluid water 95%+TiC-5% (a) contours of Pressure (b) contours of skin Friction Coefficient (c) contours of Nusselt Number and (d) contours of Reynolds number

The trends for the water 95% and nanofluid Titanium Carbide 5% in a double counter twisted tape, are similar to the earlier one. In this arrangement, the highest magnitudes of pressure, Reynolds number and Nusselt number were observed as shown in Fig.6(a) to Fig.6(d).

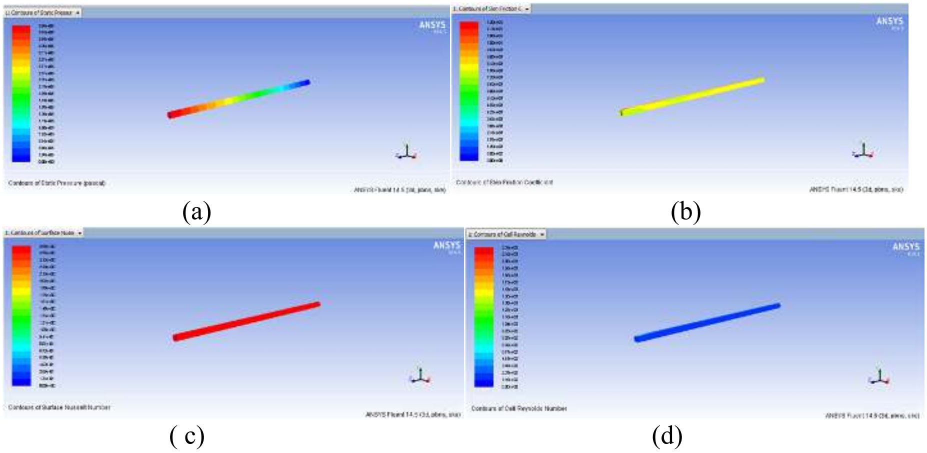


Fig. 6 Double Counter Twisted Tape variations under the nano fluid water 95%+TiC-5% (a) contours of Pressure (b) contours of skin Friction Coefficient (c) contours of Nusselt Number and (d) contours of Reynolds number

Table 2. Results of water

Geometry	Pressure (kPa)	Friction Coefficient	Reynolds Number	Nusselt Number
Twisted Tape	8960	26400	12900	4.74
Perforated Twisted Tape	8970	27100	13100	4.82
DoubleCounter Twisted Tape	8950	27700	13400	4.89

Table 3. 95% of water + 5% of Titanium Carbide Results

Geometry	Pressure (kPa)	Friction Coefficient	Reynolds Number	Nusselt Number
Twisted Tape	376	11500	2230	2.53
Perforated Twisted Tape	389	11800	2270	2.61
DoubleCounter Twisted Tape	396	12000	2310	2.69

4 Conclusion

CFD analysis was conducted on the three different inserts namely twisted, perforated twisted and double counter twisted tapes. Reynolds number was considered as 12X103. Two distinct fluids were water alone, mixture with 95% of water + 5% of Titanium Carbide. This analysis was performed with the help of FLUENT data to determine friction factor and Nusselt number. Pro/Engineer was used to create 3D models of the horizontal tube with inserts. The highest Nusselt number was noticed for the double counter twisted tape with water alone mixture with 95% of water + 5% of Titanium Carbide. The three different cases of inserts would exhibit reduction of Nusselt number and friction factor values using water 95% and TiC-5%,

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

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