ANALYSIS OF HEAT TRANSFER CHARACTERISTICS OF NANOFLUIDS FOR COOLING APPLICATION

M. Kalyani [1] , Bala Krishna Inguva [2]

Department of Chemical Engineering, Chaitanya Bharathi Institute of Technology, Hyderabad,India.

ABSTRACT

A circular straight tube with constant heat flow in the laminar and turbulent fluid mode conducted an experimental analysis of the effect of nanofluids for convective heat transmission. The two- and one-phase methods used for stable nanofluid, water-based alumina and amorphous carbon nanoparticles are used. In various flux regimes the effects of thermal conductivity and surnatant nanofluid nanoparticles have been studied. For nanofluids containing 3% of particles, the increases for thermal conductivity and coefficient of convective heat transfer were 8% and 20% respectively. Recent studies into nanofluids, which also apply to such suspension, show that nanoparticles suspended greatly alter the characteristics of transportation and transmission of heat of the suspension. This analysis summarizes recent work into the properties of the fluids and heat transfer in forced and free convection flows and discusses potential prospects for investigation.

1. INTRODUCTION

Conventional fluids, inclusive of water, engine oil Normally ethylene glycol is used as fluids of heat switch. While special strategies are used to decorate heat transfer, those traditional fluids' low thermal transfer performance impede the overall performance and compactness of warmth exchangers. A method to boom warmth switch is the use of strong particles, as an factor suspended inside the foundation fluid. Enhancing thermal conductance is the main concept for reinforcing traditional liquid warmness switch traits. Because a stable metallic has a greater thermal conductivity than a base fluid, the thermal conductivity of the bottom fluid is meant to be progressed through postponing steel surface first-class particles. The thermal conductivity of cutting-edge fluids is understood for extra than 100 years for the suspension of small particles together with millimeters or micrometers. However, issues such as sedimentation, erosion, fouling and growing flow channel pressure have not proven an interest in realistic packages. The current advancement in cloth era has allowed nanometer particle size to be developed to clear up those issues. Innovative, nanometer-sized strong particle heat switch fluids are known as 'nanofluids.' The transport and thermal properties of the bottom fluid may be changed through those suspended nanoparticles. The goal of this text is to provide an overview of the to be had literature that describes latest traits in warmness transfer development thru the use of nano-fluids.

New opportunities for processing and generating substances with common crystallite sizes less than 50 nm are provided with modern nanotechnology. Fluids with suspended nanoparticles are referred to as the nanofluid term Choi proposed at the National Laboratory of Argonne within the United States in 1995[2]. The next generation of heat transfer fluids can be visible as nanofluids, as they offer interesting new methods of growing heat transfer overall performance in comparison to pure fluids. Its houses are considered to be advanced in assessment to normal heat switch fluids and fluids with micro-sized metal debris. Compared to traditional debris, the substantially larger relative floor vicinity of nanoparticles must now not most effective appreciably growth temperature switch functionality however must also growth suspension balance. In comparison with conventional strong / fluid combinations, nanofluids can also improve abrasion-associated homes. The cutting-edge trend toward factor miniatureization is supported through successful use of nanofluids by way of allowing the improvement of smaller and lighter warmth switch structures. Keblinski et al . Published an informative and clean evaluation to address the homes and potential problems of nanofluids. There are nonetheless several elements stopping the development of nanofluids, including loss of a concordance among effects, negative characterisation of suspensions and lack of information on the theoretical factors of the mechanisms. The fluid fluid float and warmth transfer properties of the base fluids are modified through suspended nanoparticles in diverse base fluids. Necessary research need to be finished before nanofluids are extensively applied.

In many industries, inclusive of strength, electronics and transport, improving thermal transfer traits is an incredibly critical difficulty, given the shortage of energy, the high overall performance warmness dissipation and the demand for compact structures. The traditional techniques for growing the warmth switch efficiency consist of passive floor or raw fabric programs and swirl flow and active floor or fluid vibration techniques and mechanical assist[1]. However, those strategies for enhancing the heat transfer charge have reached a flaw on the subject of similarly development. Several researchers have investigated Nanofluid characteristics concerning thermal conductivity after nanofluids with suspended nanometer debris were proposed by using Choi[2] as new engineering substances. We showed an increase in anomalous thermal conductivity with metal or non-metallic nanoparticles relative to the base fluids. However, nanoflows as heat transfer media have only been used for limited experimental studies on convective thermal transfer with nanoflows compared to many results on improving thermal thermal conductivity[3–9]. Therefore, more work and experimental data on convective heat transfer are required in heat transfer systems to apply nanofluids. We explain improved convective heat in this study

Two stable, amorphous, filling fluids, alumina (Al_2O_3) and carbohydrate switch. The effects of thermal conversion and supernatant nanoparticles on the convective heat transfer coefficient are examined with different flow regimes.

2. LITERATURE REVIEW

Thermal conductivity implies the inherent heat transfer capacity and is extremely necessary for all fluid thermal applications. Thermal conductivity depends on heat conduction. Comprehensive Thermal conductivity studies of nanofluids are consequently paramount. To date, many researchers have performed research to increase thermal conductance of baseline fluids at different concentrations of volume of different nanoparticles and sizes in order to improve thermal transmission properties. Evil and Wrong. (2008) says Maxwell (1873) is one of the first to analyzes suspended particulate conduction. When Maxwell ignores particle interactions taken into consideration a completely diluted round particle suspension. It is understood that the Maxwell equation is simply an approximation for the primary order and handiest refers to combos with small concentrations of particulate count number. Since Maxwell's initial study a massive wide variety of extensions to the Maxwell equation had been made. These augmentations don't forget the one-of-a-kind components recognized with compelling heat conductivity, such as molecule Form of atomic shell structures (Benveniste 1987, Hasselman and JohntSon 1987), atomic shell structure (Benveniste and Davidson 1987) and atomic barrier (Benveniste 1987, Hamilton & Crosser 1962), Taylor 1965 and Taylor 1966; Granqvist & Hunderi 1977, Granqvist and Hunderi 1978, and Qingzhong 2000), particle moving structure (Rayleigh, 1892 and Landauer,1952).

Although these circumstances adequately foresee the fun and comfortable conductivity of weakened blends of relatively large beverage particles, it is generally no longer appropriate to test exploratory data and hypothesis of nanofluids. Both of these conditions underestimate the test information for spherical particle containing nanofluid and over-predict the exploratory information for tube-formed nanoparticles containing nanofluid. A large number of structures have been explicitly identified and designed for nanoscale improvements, including the effect of the dispersal of suspended scrap by (Jang and Choi, 2003), Kuo and Kleinstreuer in 2004, Prasher et al. in 2005, and Preashe et al., 2006, as well as the Brownian process and Thermophoresis and Diffusiophoresis in 2004. In general, only limited records have all of the special consequences, and so far no indicated equipment available to foresee a warm upgrade in the use of nanofluids is available. Research is planned. Be that as it could, the situation is higher inside the take a look at sector in which heat conductivity improve consequences have been accounted for via numerous experts for an assortment of nanofluids.

Choi et al . (2001) have shown that the distribution of carbon nanotubes into engine oil has improved the good and comfortable conductivity by 100% and 60%. With 4 percent centralisation of CuO scattered with ethylene glycol, Lee et al (1999) saw 20 percent of improvements. Fe_2O_3 nanofluid 6.7 nm in size and 6.3 percent of the volume component conductively was studied by Philip et al . (2007) and found 300 percent development.

Peyghambarzadeh et al . (2011) conducted a test on radiators for the improvement of cooling of solid cars and rock vehicles on water-ethylene glycol. The effects have shown that the warm temperature motion coefficient has improved by 40 per cent within the range of Nusselt. Lee et al . (2011) have reported a 7.2 percent improvement in thermal conductivity in SiC-water nanofluid at 3.0 percent volume fixation. Aluminum nitride nanoparticles applied by Yu et al (2011) to improve the comfortable, pleasant conductivity of ethylene glycol and propylene glycol. As the amount of convergence of nanoparticles inside the basis liquid increased, both drinks increased their warm conductivity, it became obvious from the consequences.

The warm conductance and consistency of different surfactive arrangement types were investigated by Mingzheng et al . (2012). From the study it has been assumed that the use of a surfactant can restrict the collection of nanoparticles. It also turned into a fact that the estimation of warm conductivity increases or diminishes as much as a selected phase of cognition of a surfactant.

Sundar and others. (2013) the warm conductivity in multiple mixtures of Fe_2O_4 ethylene-glycol-water nanoparticles was investigated at a mass of 20:80

20:80%, 40:60% and 60:40% individually, at different temperature ranges from 20 to 60 ° C.The trial outcomes indicated an upgrade of forty six % whilst 2 % nanoparticles are scattered in 20:eighty % ethylene glycol-water combination. It turned into likewise visible that warm conductivity extended with the enlargement within the molecule fixation and temperature. The good and comfortable conductability of $A_{12}O_3$ water nanofluids was tentatively pondered by Ghanbarpour et al . (2014) and 87 percent improved warm conductance at 293 knots with 50% by weight of $A_{12}O_3$ nanoparticles.

3. PREPARATION OF NANOFLUIDS

Nanofluid course of action is the main strength with nanofluids in some time. Nanofluids are not all solid blends of material. Some excellent conditions, such as uniform and strong suspension, heart-felt suspension, immaterial particle agglomeration, fluid change without any substance, etc. Dissipation into basic liquids, such as bodies, water, ethylene glycol (EG), oils, and so on by a solid waste nanometer scale. Agglomeration is a remarkable problem when amalgamating nanofluids. In general, the single-step and 2-creation procedures are two methods used to convey nanofluids. This one-step direct dispersal approach has been transformed into the Akoh et al. method [4] and is known to be the VEROS approach. This technique was primarily developed to create nanoparticles, but it is difficult to keep the particles out of drinks so that dry nana-particles can be transmitted. The approach of Wagener et al . [5] suggests a healthy VEROS process. For suspensions with steel nanoparticles like Ag and Fe, for example, they applied high-weight magnetron flounders. Eastman, etc. [6] have developed a changed VEROS strategy, whereby Cu smolder is clearly united with a bubbling fluid (EG) in nanoparticles. Zhu et al [7] have produced a new, one-upgrade blend method for the purchase by decreasing $CuSO_4 \cdot 5H_2O$ under microwave light in ethylene glycol with $NaH_2PO_2 \cdot H_2O$. The results have shown that $NaH_2PO_2 \cdot H_2O$ production and microwave illumination collection are huge elements affecting nanofluid sensitive rates and homes.

Lo etcetera[8] has been used in plotting Cu-Based Nanoparticles (e.g. de-ionize water with 30 percent, 1/2, 70 percent ethylene glycol and non-adulterated ethylene glycol) with a vacuum SANSS approach (decreased round stage nanoparticle blending system). The different morphologies, which can be obtained, have been mostly affected and directed by a method of conducting the dielectric liquids very comfortably overall. Similarly, nano-fluids based on CuO, Cu_2O, and Cu could be established using this method. The key technology technique has been assisted by restricting nanoparticles agglomeration, while the lesion is that singular low smoke drinks are good with the form of approach. From late on, an NI nanomagnetic fluid was also transmitted using the SANSS approach via Lo et al.[9].

In the combination of nanofluids, the growth strategy is widely used, provided the nanopowders supplied by a few firms. In this strategy, nanoparticles was first added and later on scattered the bottom beverages. Ultrasonic equipment for the most part is used to disperse the particles significantly and reduce waste agglomeration. For eg, Eastman et al., Lee et al., and Wang et al., and Lee et al. This process was used to supply nanofluid Al_2O_3. Murshed et al. likewise. The two-developed approach was arranged for TyO_2 suspension in water. Gold (Au) , silver (Ag), silica and carbon nanotubes are the various nanoparticles introduced into the script. When contrasted with the single-step strategy, the two-advance method capabilities admirably for oxide nanoparticles, even as it's miles less powerful with steel debris.

Aside from the usage of ultrasonic hardware, some unique strategies, for instance, manipulate of pH or enlargement of floor dynamic operators, are moreover used to achieve dependability of the suspension of the nanofluids in opposition to sedimentation. These techniques exchange the floor residences of the suspended particles and on this way stifle the inclination to frame molecule bunches. It must be observed that the determination of surfactants ought to depend basically upon the residences of the preparations and debris. The salt and oleic corrosive chosen by Xuan and Li to raise, one by one, the power of transforming oils – Cu and water – Cu nanofluids. Murshed et al. were using surfactants of oleic corrosive and cetyl trimethyl ammonium bromide (CTAB). To ensure the increased solidity of TiO_2-water nanofluids and their valid dispersion. Hwang et al. are used to produce sodium dodecyl sulfate (SDS). The water-based primarily MWCNT nanofluids have been mixed because the strands are trapped within the watery suspension.

When all is stated in carried out, techniques, for example, change of pH regard, development of dispersant, and ultrasonic vibration target changing the surface living arrangements of suspended flotsam and jetsam and smothering course of action of particles association to get normal suspensions. Be that as it may, the expansion of dispersants can influence the warmth move execution of the nanofluids, particularly at high temperature.

4. MECHANISMS IN NANOFLUIDS

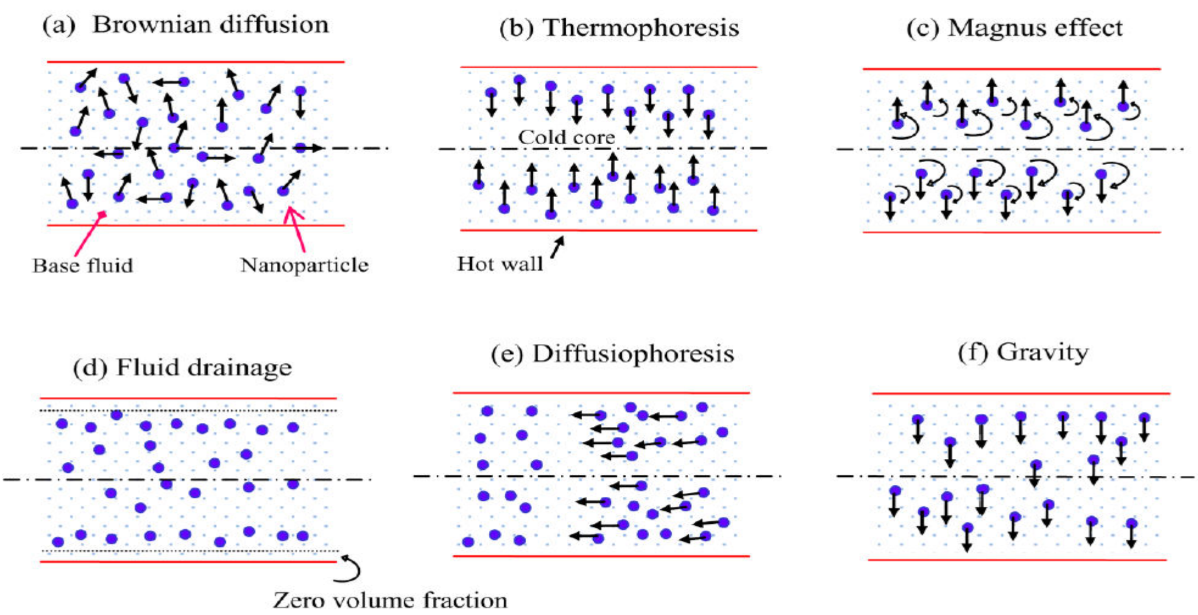

Figure 1. Graphical representation of slip mechanisms

In general, the nanofluid is known to be used as a single or two-stage combination. The speed of the fluid atoms and nanoparticles is expected to differ in a single phase model , i.e. it is uniform and thermally constant. However, this supposition that isn't correct on account of constrained convection. The single stage model can't clarify the tremendous improvement in the warmth move coefficient because of constrained (Heris, Etemad, Esfahany, 2006). Convection. Many analysts (Xuan and Roetzel 2000), (Wen and Ding, 2005), (Behzadmehr, Saffar-Avval and Galanis, 2007) show relative speeds between nanoparticles and the bottom of liquid particles that are known as the slip rate (Bahiraei and Hosseinalipour, 2013), recommending the nanofluid as a combination of two degree values. Heat upward pull, heat disposition, number fixation, incline to cognition, shear stress, coherence and gravity are the primary purposes at the back of the slip event. Because of the slip velocity, the nanoparticles waft or relocate starting with one locale then onto the next or/all around. The molecule relocation is credited to be the purpose behind the upgrade in convective warmth move coefficient. Coming up next are a portion of the notable slip systems. The Brownian dispersion or movement Is the development of nanoparticles in short and irregular fashion within the base liquid as appeared in Figure 1(a). Brown's spread increases as temperatures rise and particle lengths are reduced; the volume centering of nanoparticles increases as well. Due to the temperature angle of the base liquid in Figure 1(b) the nanoparticle passes from the nearby temperature to the district of a temperature, which is called thermophoresis. During the channel phase, nanoparticles move from the hot mass of the channel to the inner center of the channel activating non-uniform molecular knowledge. Due to the inclination of speed, the debris swing approximately turns a hub in contrast with a hub movement that instigates lift energy in the debris, known as the Magnus impact (Figure 1(c)). The volume department of nanoparticles inside the divider floor is sort of nil in view of liquid seepage; which due to the load difference on the liquid waste movie framed within the place of the divider (Figure 1(d)). Diffusiophoresis is the improvement to the fixed position by nanoparticles in the base liquid of waste from the higher concentration area (Figure 1(e)). The particle settlement results in increased gravity (Figure 1(f)). The fundamental functions behind mass movement of debris are the Brownian dissemination and thermophoresis (Buongiorno 2006).

5. EXPERIMENTAL SETUP FOR CONVECTIVE HEAT TRANSFER STUDY

Figure 2 displays the scheme of the measuring system, such as the phase view, the nanofluid loop, the water loop and the log acquisition device. Look at a 2.5 m long concentrated tubular heat exchanger, where nanofluid flows across the internal copper tube of a smooth 10.7 mm diameter while the water flows into the external tube with an external diameter of 25.4 mm. The view of the section is divided into five segments of the same duration and the whole segment is covered in the isolation tissue (foam rubber).

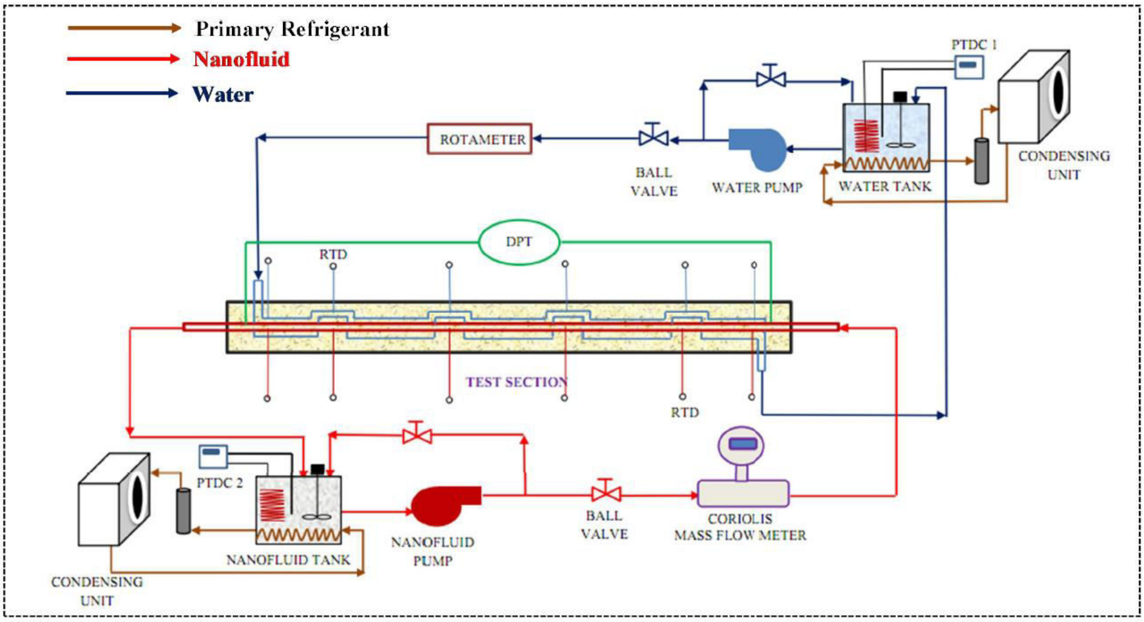

Figure 2: schematic of the experimental apparatus

The protected test segment is set Inside a timber container loaded up with glass fleece. This guarantees there may be no loss of heat from the take a look at place to the air, or there may be no warm temperature penetration from the air to the test phase. In the fluid stream at the channel and outlet of each location, the RTDs (PT a hundred) are directly embedded in a massive temperature quantification of the nanofluid and water using the Serpentine collection in Figure 3 (b).

The serpentine is placed in the center of regions, using two T segments (brazed, one at one phase outlet and the second one at the following phase) brazed with elbows. A connector is about to form a serpentine in the center of those two elbows. The sheathed RTDs are placed through penetrated openings in the serpentine at each segment of the rounded heat exchanger as set out in Figure3(a). The weight check is carried out with DI water to ensure that the entire control area is water resistant.

Figure 3 Serpentine arrangement photographic view (a) naked (b) isolated

The circuit is made of polyurethane protected tempered steel compartment of 0.003 m3 volume to store the nanofluid, and a divergent siphon of the limit 600 LPH to flow the nanofluid through the inward container of the test segment. The temperature of the nanofluid is kept up at the ideal incentive with the assistance of a 4.3 kW cooler and 1 kW warmer, through a proportionate temperature differential controller (PTDC). The PTDC manages the yield of the warmer, as per the temperature of the nanofluid estimated by the sheathed RTD, which is kept inside the nanofluid compartment. A mechanical stirrer turning at 1500 rpm is put at the highest point of every holder, and it is constantly in activity during the trial, to accomplish uniform temperature of the nanofluid. The nanofluid is taped from the base of the cylindrical heat exchanger, which runs on the counterflow route into that of water. It is siphoned into the internal box. A mass circulation meter of

Coriolis form is about to measure the mass stream rate of nanofluid soon after the siphon along the header of the liquid stream. In order to manage nanofluid progression a ball valve is placed before the weight circulates. The nanofluid compartment will be controlled by a transfer valve. An overpass valve. A differential weight transmitter (DPT) is prepared to quantify the drop in nanofluid during the analysis of this segment.

CONCLUSION

This paper provides an summary of the ongoing developments in the work on nanofluid thermal movement. Numerous significant, mind boggling and fascinating wonders including nanofluids have been accounted for in the writing. Specialists explore have given a lot of consideration on the warm conductivity as opposed to the warmth move attributes. The use of nanofluid in a wide range of applications seems promising, but there are some problems with the development of the field: I the absence of a knowledge between the exploratory effects of many gatherings; ii) the often horrible demonstration of suspensions; and the lack of hypothetical understanding of the tools. The warm-rising qualities of nanofluids and the differentiation of fresh and exciting applications would be expected from additional hypothetical and exploratory exams.

REFERENCES

[1] Lee S, Choi SUS, Li S, Eastman JA. Measuring thermal conductivity of fluids containing oxide nanoparticles. ASME J Heat Transfer 1999;121:280–9.

[2] Xuan Y, Li Q. Heat transfer enhancement of nanofluids. Int J Heat Fluid Flow 2000;21:58–64.

[3] Das SK, Putra N, Roetzel W. Pool boiling characteristics of nano-fluids. Int J Heat Mass Transfer 2003;46:851–62.

[4] Das SK, Putra N, Roetzel W. Pool boiling of nano-fluids on horizontal narrow tubes. Int J Multiphase Flow 2003;29:1237–47.

[5] Das SK, Putra N, Thiesen P, Roetzel W. Temperature dependence of thermal conductivity enhancement for nanofluids. ASME J Heat Transfer 2003;125:567–74.

[6] Wang X, Xu X, Choi SUS. Thermal conductivity of nanoparticle–fluid mixture. J Therm Phys Heat Transfer 1999;13:474–80.

[7] Eastman JA, Choi SUS, Li S, Yu W, Thomson LJ. Anomalously increased effective thermal conductivities of ethylene glycol-based nanofluids containing copper nanoparticles. Appl Phys Lett 2001;78: 718–20.

[8] Xie H, Wang J, Xi T, Liu Y, Ai F, Wu Q. Thermal conductivity enhancement of suspensions containing nanosized alumina particles. J Appl Phys 2002;91:4568–72.

[9] Patel HE, Das SK, Sundararajan T, Nair AS, George B, Pradeep T. Thermal conductivities of naked and monolayer protected metal nanoparticle based nanofluids: manifestation of anomalous enhancement and chemical effects. Appl Phys Lett 2003;83:2931–3.

[10] Choi SUS, Zhang ZG, Yu W, Lockwood FE, Grulke EA. Anomalous thermal conductivity enhancement in nanotube suspension. Appl Phys Lett 2001;79:2252–4.