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Studies and Research on Friction, Friction Factor and Affecting Factors : A Review

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Abstract

The friction and friction factors are very significant factors in flow through pipes, channels, heat exchangers . From the pumping cost point of view, minimum friction is desirable as it will decrease the energy loss. In the rotating components like axle-shaft arrangements, the friction and slip are important factors. In case of heat exchanger, the friction factor is important as the heat transfer depends on it. The research was also reported on effect of submerged vegetation on friction for river. The friction coefficient was a function of flow depth and velocity. Also various models were suggested by investigators to predict friction coefficient based on their research related to factors affecting the friction coefficient and the nature and gravity of their effect on friction.

Keywords: friction, energy, heat, coefficients.

Introduction

Friction plays very vital role in effectiveness and efficiency of many materials with respect to economy and heat losses. The friction affects the life of materials, formability and fatigue resistance. It was observed that the variation of friction and wear rate depends on many factors like load geometry,surface motion, temperature, slip, humidity, lubrication etc. In heat transfer also friction is very important parameters as many heat transfer enhancement methods includes imparting turbulence by roughening the surface and introducing the inserts for increasing heat transfer coefficient. The friction becomes important in the rotating devices. The study on reducing friction by using appropriate lubricant is also important aspect. The current review is aimed at emphasizing the importance of friction and friction factors in various fields and summarizing the research carried out to study factors affecting the friction in various applications and to improve friction characteristics according to the requirement. Also some study related to modeling and analytical computations of friction factor and related parameters is reported.

Research On Friction Factor And Related Parameters

Dehkordi et. al. used intelligent active force control (AFC) with piezoelectric actuators for reducing friction induced vibrations [1]. They simulated and analyzed the model (two degree-of-freedom mathematical model of a friction-induced vibration system) by PID controller. They observed that by using the new technique noise was considerably reduced.Li et.al. investigated the friction coefficient in hot compression of cylindrical sample [2]. They carried out compression tests in order to analyze the evolution behavior of friction coefficients during large strain hot forging processes. Also they compared the simulated results for friction factors with experimental results. The simulation results also indicated that the friction coefficient is not a factor for shape of deformed sample. Instantaneous friction coefficient and the strain had exponential relationship. An investigation was carried out on development of low-friction factor sliding isolation device by Hamaguchi and Higashino by using Poly Tetra Fluoro Ethylene (PTFE) [3]. They developed some new additives and coating materials with heat-stiffened resin. The friction coefficient of new material was 0.03, less than pure PTFE. Newly developed epoxy resin adhesive between PTFE and steel plates was weather resistant and durable. Hargreaves and Tang carried out investigation on friction factor characteristics of liquid lubricants [4]. Reducing friction is very important from energy point of view. It also essential

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to measure friction characteristics of lubricating oils. During their investigation it was observed that the lubricants exhibit reducing friction coefficient with increase in the temperature. They observed that the mineral oil exhibited lowest friction coefficient. An investigation on friction coefficent of rough in-house materials was carried out by Ezzat et.al [5]. According to their investigation, friction coefficient of rubber decreased with increasing surface roughness for dry sliding. Friction coefficient decreased down to minimum and then increased with increasing the surface roughness for bare foot and polymeric socks. With applied load, friction factor decreased. At water and detergent sliding, the friction coefficent decreased with with roughness. An investigation on estimates of non-ideal effects on the friction coefficient of agglomerates was carried out by Shin et.al [6]. As the agglomerate size increases from the free molecular regime into the transition regime, 15 percent decrease in scaling exponents for friction coefficient (η) was observed.Chaudhary et.al. investigated experimentally the effect of sliding speed and normal load on friction and wear property of an aluminum disc sliding against stainless steel pin [7]. They carried out experiments under normal load (10-20 N) and 500-2500 rpm. According to their investigation, the friction coefficient decreased with increase in the speed and load. Also wear rate increases with the increase of normal load. They also observed that coefficient of friction decreases with normal load. In their study, Ogugbue and Shah investigated the effect of eccentricity, flow-behavior index, and diameter ratio [8]. They used the results from a series of numerical simulations for the fully developed laminar flow of non-Newtonian power-law fluids in this study. It was confirmed, during the investigation that friction losses reduce with increase in eccentricity. Lower frictional loss was predicted by CFD at high eccentricities than predicted by other models. Nyarko carried out studies on effect of heat load on friction factor in corrugated pipes [9]. They used energy balance and momentum balance equation to estimate the heat loss. They observed for the fully developed flow, periodizing of temperature doesn't have any significant effect. With heat load, the drastic transition from laminar to turbulent flow was observed and friction factor reduced with heat load. The friction factor of non submerged vegetation for river flow was determined by Fathi-Moghadam et.al [10]. The aim of their research was to develop a relationship for estimation of non-submerged vegetation roughness in the flood plains and river banks. They conducted close to 200 experiments for this purpose. They observed that roughness coefficient decreased with flow velocity. It increased linearly with flow depth. Rao and Kumar studied various aspects related to friction factor in pipes with turbulent flow [11].For all three regimes i.e. smooth, transition and rough, they proposed a universal resistance equation. Their equation predicted friction factors for turbulent flow accurately. The values estimated were in agreement with other data.Zehsaz and Shahriary carried out investigation on the effect of friction coefficient and interference on the freight fatigue strength of railway axle assembly [12].This was very significant research considering the importance of the axle and its exposure to repeated cyclic loads. They carried out finite element analysis for railway using computer code. They divided the analysis into two steps one applying interference and second load. They observed that the relative sleep between the wheel hub and axle occurs when the frictional shear traction equals the contact pressure times the coefficient of friction. Micro slippage increases the friction wear than other places. It was also concluded that, increase in friction coefficent reduces the amplitude of slip. But it intensifies the fretting wear damage.

Wallman and Astrom carried out literature review on Friction measurement methods and the correlation between road friction and traffic safety [13]. This was very significant study considering the relation between friction and the accidents. They concluded that the relation between friction and accident rate is certainly no easy problem to explain. This problem is more complex at winter conditions. They also found that the surveys of winter accidents provided varying results, but always with higher risk than normal bare road conditions. Stelmakh et.al investigated the nanoscale polished surface in boundary lubrication conditions for reduction of friction and wear by grooves applied on them [14]. According to them, when the orientation of grooves coincides with the direction of sliding, reduced wear and friction was observed. They proposed a new compressive-vacuum hypothesis of friction force nature under a condition of boundary lubrication. Their results were useful in developing optimized roughness profiles of friction surfaces.Al-sarkhi et al developed two correlations predict the effect of drag-reducing polymers, DRP on friction factor of two-phase flow for any pipe diameter[15]. In order to verify the results, they added DRP to air–liquid annular flow and for oil–water flows with any flow pattern at the asymptotic state. These correlations assume significance as such correlations are not available in literature.Pawar et.al studied the Nusselt number and friction factor for solar air heater duct

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[16]. The duct had diamond shaped rib roughness on absorber plate. Creating artificial roughness on absorber plate increases thermal efficiency of solar air heater. They also compared the heat transfer from smooth and roughened surface. It was observed that Nusselt number increased with Reynolds number. The Nusselt number and friction factor was a very strong function of roughness parameters (pitch and height.Gao used lactic acid for reduction of friction between two solid surfaces, silica glass against silicon nitride [17]. They achieved the sliding friction coefficent as low as 0.02. The surface adsorption combined with the surface hydroxylation was predicted reasons for the low friction.

Rajesh and SivaPrakash performed the ring compression test under different lubricants for analyzing friction factors[18]. They observed that the friction coefficient was very sensitive to surface geometry.They observed that friction coefficient decreases with reduction in height and outer radius; with inner radius, it increases. Friction reduction of automotive engines was tried by Morita et. al by a computational chemistry approach[19]. In their study, they analyzed the low-friction mechanisms of carbon films using molecular dynamics simulations and density functional theory calculations. They observed that the termination of OH groups on the surface of the diamond substantially reduced the friction coefficient from 0.07 to 0.01. The weakened interaction between Fe and C atoms was predicted to be reason for this.Shivamani et.al investigated the impact of hydration and moisturizer on skin friction[20]. It was observed that the application of water increased the friction and application of isopropyl alcohol decreased it. Also the friction coefficient increased with fast acting moisturizers .Sudip et al carried out review on use of nanomaterials in reducing friction and wear[21]. Kiolene,nanoclay,nanodimonds,Polytetrafluoroethylene(PTFE),graphite,Molybdenum disulphide as lubricants in various applications were discussed by them. According to their discussion,addition of inorganic nanoparticles significantly improves their lifetime and performance. Most energy loss in piped system is due to friction. An investigation on flow and friction for internally grooved pipe was done by Sunu et.al[22]. They observed that as the size of vortices formed were greater than groove widths, reduction in friction factors for fluid flow was observed. The reason for this was formation of larger vortices than groove widths. They concluded that the choice of appropriate number of grooves is important in reducing the energy losses. Steinke and Kandlikar carried out studies on friction factor in microchannels[23]. They reviewed available literature for single phase flow and also presented new experimental data. The pressure drop components were also analyzed. They inferred that not accounting the entrance and exit losses might be the reason for the deviating results in some investigations. According to them the components contributing to total pressure drop across microchannel heat exchanger are inlet and outlet losses, the developing flow losses, and the fully developed flow losses.

Conclusion

The studies on friction, friction factor are very important in many applications of materials. The aspects such as noise in rotating parts, slip, energy loss, life of materials, heat transfer, and effect of heat on friction are very important parts of studies and research carried out in this field. Various lubricants were suggested for reducing friction. Many nonmaterials were used successfully for improving friction properties. For energy loss through grooved pipes, it is very important choose appropriate number of grooves for reducing the energy losses. Investigations also reiterate that the friction coefficient depends on surface geometry. The research was also reported on effect of submerged vegetation on friction for river. The friction coefficient was a function of flow depth and velocity.

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