ABSTRACT

Copper is identified as the chief fresh water pollutant in urban areas, which endangers the marine life and has become a focus of concern for friction material (FM) industry. Worldwide efforts are being made to find the substituent for Cu, which will be environment friendly, cost effective, easily available and will impart all the functions of Cu in FM. Thus, the theme of the research is based on development of more efficient and environment-friendly non-asbestos-organic (NAO) brake-pads in the laboratory. Based on critical literature survey, few critical issues need to be addressed.

Generally metallic fillers are used in FMs to improve thermal conductivity (TC) of pads but the problem with any fillers is they are involving in tribo-performance apart from TC improvement. Thus, its role as TC booster on altering tribo-performance is never clear. Hence, Cu fabric was embedded in the body of brake-pad at a particular distance from the tribo-surface to keep the positive effect of TC improvement only without directly involvement in tribological activity. The developed pads were evaluated on brake inertia dynamometer. It was observed that Cu fabric embedment proved successful. It improved fade resistance ($F_R$) by increasing TC of the composite and showed slight improvement in wear resistance ($W_R$).

Hydrated Calcium Silicate has very good properties, which justifies its use in FMs, but still not researched in adequate depth. Hardly any papers are reported on its exploration in Cu-free FMs. Hence three brake-pads were developed with increasing amount of hydrated calcium silicate to optimize its content for best performance. Also, they were compared with the Cu containing pads to find out the potential of hydrated calcium silicate for Cu replacement. Results showed that hydrated calcium silicate proved successful in Cu replacement almost in all respects barring wear. With increase in amount of hydrated calcium silicate, most of the properties improved.

Stainless Steel (SS) appeared to be a good choice for replacing copper in brake-pads with added advantage of corrosion resistant. Since no research papers could be available on its potential exploration in brake-pads or FMs, a series with increasing amount of SS swarfs, which would enable to examine effect of amount of SS swarfs on performance properties, was prepared. Also, they were compared with the Cu containing pads to find out the potential of SS swarfs for Cu replacement. Developed pads were evaluated for the tribo-performance. Results showed that with increase in amount of SS swarfs, most of the properties improved including $W_R$. It was concluded that SS swarfs proved successful in Cu replacement almost in all respects barring...
wear. Since the SS containing pads showed higher wear, more pads were developed with improved Cu-free formulations and with air-plasma treated SS swarfs. It was observed that plasma treatment was successful for improvement in adhesion. Plasma treated pads showed lower wear than the untreated pads.

Though potassium titanate (KT) is used in some formulations of commercial FMs, little is reported on its influence on performance properties of NAO FMs in open literature. Hence, KT was explored as a functional filler and evaluated for its effect in terms of particle size and crystalline structure on performance properties. Efforts were also focused to investigate the and optimum amount for best performance. From tribo-evaluation it was concluded that inclusion of KT powder played important role in improving wear and fade performance. With increase in amount, most of the properties improved. Overall 12% KT powder showed best performance. Nano-KT particles proved significantly better to improve the performance $\mu$ and $W_R$ as compared to its micro-partner. Also, potassium hexa-titanate proved best in overall tribo-performance followed by octa-titanate and then tetra-titanate.

Despite various tools available for performance ranking of FMs based on several conflicting criteria; no efforts are reported to employ newer, simple and more efficient tools in recent years for performance analysis of FMs. Thus, a technique ‘multiple objective optimization on the basis of ratio analysis’ (MOORA) has been first time employed for performance ranking of FMs and it was proved as very simple, flexible and less time-consuming tool for performance ranking of FMs.