CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

The accelerated oil prices which have brought the economics of transportation to public consciousness have triggered significant interest and urgency for search in lightweight materials in automotive industries. Aluminum alloy reinforced with ceramic constituent offers superior mechanical properties inclusive of improved thermal stability. Although the metals reinforced with micro-sized ceramic particles offer significant improvement in yield and ultimate strength of the metal, but the ductility of the MMCs (metal matrix composites) deteriorates with high ceramic particle concentration. Among all aluminum based composites reinforced with various kinds of reinforcement only nano-sized-reinforced aluminum based NMMCs have exhibited their significant improvement in mechanical properties with weight savings.

The significant properties of ceramic materials such as high hardness, high strength (compressive) and refractoriness remains attractive choice to be used as reinforcement in aluminum alloy-based composites as they offer unique integrated properties of both metallic and ceramic properties, emerging as ideal candidate for automotive application. The potential advantages of these metal matrix nanocomposites (MMNCs) have generated more excitement and challenges in both academia and industries. The demands for cast structural components of high-performance Al alloy based
composites is expected to increase as automotive industries are forced to improve the fuel efficiency of their products.

1.2 ALUMINUM SILICON ALLOY

A hypereutectic Al-Si alloy is considered to be as an in-situ natural metal matrix composite with primary silicon acting as the reinforcing phase, offering superior properties inclusive of toughness, ductility, wear resistance, yield strength, thermal and electrical conductivity with low thermal expansion. Particularly, these materials have significant scope in automotive applications especially, in heavy wear components, such as pistons, cylinder blocks, pump bodies and compressors. Aluminum-silicon alloy have also attracted increasing interest in engineering industries due to high strength-to-weight ratio, as the silicon has a low density (2.34 gms/cc) which may be an advantage in reducing the total weight of the cast component. Though there exists enough investigation in open literature search and also it is more evident from the above mentioned significant properties of aluminum silicon alloy in terms of both mechanical and thermal capabilities, still provide wide scope for further exploration these properties.

1.3 OBJECTIVE OF THE RESEARCH WORK

The main objective of this research work was to produce aluminum alloy based nano metal matrix composites (NMMCs) reinforced with nano ZrO2 particulates using chilling technique, which remains an attractive choice among all the solidification processing routes due to its capability of bringing together the
advantages of both stir casting with directional solidification. The commercially available casting Al-alloy (LM 13) (Aluminum with 12 % Silicon) was used as the matrix material.

The nano-sized ZrO$_2$ particulates ranging from 70-100nm was used as reinforcing phase. The primary process consists of synthesis of nano-sized ZrO$_2$ reinforced Al composites (NMMCs) containing five different weight percentage of ZrO$_2$ ranging from 3 to 15 Wt. % in steps of 3% produced via vortex route. The process involved, heating of Al alloy in a graphite crucible up to 650°C using electric resistance furnace to which the preheated reinforcement was added and uniformly stirred by a mechanical impeller to create vortex in order to distribute the reinforcement uniformly in the aluminum alloy melt.

The reinforcement treated matrix alloy was then poured into the dry sand mould (prepared as per AFS standards) containing silicon carbide as end chill and allowed to solidify under atmospheric conditions. In the secondary processing, the deposited matrix alloy and nano-sized ZrO$_2$ reinforced Al-alloy-matrix were hot extruded to 2mm (thickness reduction from 25mm to 23mm) in a hydraulic press at 250°C. Ageing was carried out in a heat-treatment furnace soaked for four hours followed by ambient cooling. Microstructural characterization investigations were conducted on the polished specimens of NMMCs and matrix alloy to explore presence and distribution of reinforcement particulates,
grain refinement and interfacial integrity between matrix and the reinforcement.

Hardness evaluations were explored for the developed NMMCs and matrix alloy at both macro and micro levels in conformance to AFS standard. Tensile behavior of the developed NMMCs and matrix alloy was evaluated in conformance to IS 1608-2005-ISO 6892 standards to explore its integrated properties associated with increasing amounts of reinforcement content present in the matrix alloy. Fracture toughness behavior of developed NMMCs and the matrix alloy was evaluated in conformance to ASTM E 399-1990 standards to explore its integrated properties associated with increasing amounts of reinforcement content present in the matrix alloy.

Aluminum matrix composites reinforced with hard ceramic particulates have emerged as a potential material especially for wear resistant in critical applications such as brake drums, cylinder liners, pistons, cylinder blocks, connecting rods, etc. these components are subjected to sliding type of wear with the outer bodies. In this view the research work was also focused to explore the dry sliding wear characteristics of the developed NMMCs and matrix alloy under varying loads by using Ducon-make computerized pin-on-disc wear test-rig in conformance ASTM-G99 standards.

To know the thermal capability of the NMMCs developed in order to suit its application in thermal field a final attempt was
made to evaluate its thermal property viz. thermal conductivity. A standard test method for evaluating thermal conductivity of solids by means of Guarded-Comparative-Longitudinal heat flow technique in accordance with ASTM E1225-09 was developed in the laboratory and the thermal conductivity of developed NMMC and matrix alloy were evaluated. The flow chart of the present research work is as shown in the Fig 1.1.

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**Fig: 1.1 Flow chart of the research work**