CHAPTER-6

CONCLUSIONS AND SCOPE

6.1 Main Conclusions

Some major conclusion of the present study are as follows:

1. Microstructural examinations exhibit refinement of aluminium matrix grains due to *insitu* formed ZrB_2 particles.

2. ZrB_2 particles are within the size range of 25nm–2µm.

3. Ultimate tensile strength, Yield strength, and % Elongation of AA5052-9 vol.% ZrB_2 composite at ambient temperature are improved remarkably as compared to base alloy.

4. AA5052-9 vol. % ZrB_2 composite retains 72% of its room temperature strength even at 200°C.

5. Predicted values of yield strength are very close to theoretical ones.

6. AA5052-9 vol. % ZrB_2 composite shows the highest wear resistance and load bearing capacity at room as well as at high temperature (200°C).

7. With the incorporation of 9 vol. % ZrB_2 particles in the base alloy, transition load at which wear mode changes from mild-oxidative to severe-metallic increased from 20 N to 30 N and transition temperature increases from 100°C to 150°C. This indicates that with 9 vol. % of ZrB_2 the working range of the alloy is extended.

8. AA5052-9 vol. % ZrB_2 composite shows the maximum value of coefficient of friction when compared with base alloy and other compositions.

9. Lowest wear rate and highest coefficient of friction is obtained for 9 vol. % ZrB_2 composite which may be used as tribological material to fulfil the requirement of high friction and low wear applications such as bakes and clutch system.

10. The findings are very helpful to widen the application area of AA5052 based composites and make them suitable for tribological application at ambient as well as at high temperature within the test range.

6.2 Scope of the Work

Table 6.1-6.3 gives the comparison of tensile, wear and friction properties evaluated in present study at ambient temperature with the earlier studies.

Table 6.1- Comparison of tensile properties with previous studies on AMCs

Material	UTS (MPa)	YS (MPa)	Elongation (%)	% Improvement in properties over base alloy	Reference
AA5052-9 vol.% ZrB_2 (*insitu* composite)	**161**	**112**	**12**	**81%UTS,83%YS,93 % in ductility**	**Present work**
AA6061-10wt.% ZrB_2 (*insitu* composite)				31.77% UTS, 38.22% lower elongation	[Dinaharan et al., 2011]
Al–2Mg–2.5FeCu (*exsitu* composite)	98	74	4.45		[Mandal et al., 2008]
Al–2Mg–5Fe (*exsitu* composite)	112	74	1.65		[Mandal et al., 2006]
Al–2Mg–5FeNi (*exsitu* composite)	105	69	1.26		[Mandal et al., 2006]
AlSi5/SiC/13p (*exsitu* composite)	148	49	2		[Cöcen and Önel, 2002]
Al-20vol.%SiC (*exsitu* composite)	127	64.6	7.2		[Min, 2009]

Table 6.2- Comparison of wear properties with previous studies

Alloy/composite	Wear rate* ($x10^{-12}$ m^3/m)	% reduction in wear rate than base alloy	Reference
AA5052-9 vol.% ZrB_2 (*insitu* composites)	**1.54**	**53.3**	**Present work**
AA6061-10 wt.% ZrB_2 (*insitu*)		38.87	[Dinaharan et al., 2012]
A356 alloy	2.1		[Mandal et al., 2009a]
LM 13 alloy	3.8		[Akubulut et al., 1998]
LM 13- 25 vol.%Al_2O_3 composite (*exsitu*)	2.1		[Akubulut et al., 1998]
LM 13-4 wt.% B_4C composite (*ex situ*)	4.85		[Radhika and Raghu ,2015]
Al-20 wt.%Al_3Fe composite (Powder-metallurgy)	3.01		[Agarwal et al., 2014]

*** At Load 40 N, sliding velocity 1m/s, Disc (62 HRC)**

Table 6.3- Comparison of COF with previous studies [Carvil, 1994]

Material (Brakes and Clutches)	Coefficient of friction (Dry)
AA5052-9 vol.% ZrB_2 composite/Steel (EN31)	**0.5**
Cast iron/ Cast iron	0.15-0.2
Cast iron/Steel	0.15-0.2
Powder metal/Cast iron or steel	0.1-0.4
Powder metal/Chrome plated hard steel	0.1-0.3
Woven asbestos/Cast iron or steel	0.3-0.6
Molded asbestos/ Cast iron or steel	0.2-0.5
Impregnated asbestos/ Cast iron or steel	0.32
Steel band/Cast iron	0.18

It is clear from Tables 6.1, 6.2 & 6.3 that present *insitu* composite with 9 vol. % ZrB_2 particles exhibits maximum ultimate tensile strength and yield strength as compared to all other composites. Ductility which is generally a bottleneck in composites has also improved in present composite and it is about 12%. Further, high wear resistance and coefficient of friction as compared to other materials mentioned in Table 6.2 and 6.3 is indicative of its suitability in Tribological applications specially in clutch and brake systems.