Conclusions and scope for future work

The following conclusions are drawn based on the results of this study of Al-0.4Mg-8Si-xNi (x=0, 2, 4, 6, 8 and 10) and Al -0.4Mg-2Ni-xSi (x= 4, 8, 12 and 16) alloys.

10.1 Conclusions based on the effect of Ni content on the microstructure and hardness

The Ni addition leads to the refinement of eutectic Si morphology from elongated to particle shaped. Al$_3$Ni is the intermediate phase formed by the addition of Ni in the base alloy during solidification as observed from SEM image, EDS analysis, XRD results, TEM and SAED pattern analysis. Al$_3$Ni was the intermediate phase observed in all the Al-0.4Mg-8Si-xNi (x= 2, 4, 6, 8 and 10) alloys studied. Further, the Ni addition was found to significantly increase the hardness of the base alloy and the hardness obtained in this study was found to be significantly higher than those reported in the previous literature.

10.2 Conclusions based on the effect of Ni content on the mechanical properties

The UTS of the base alloy was found to increase with increasing Ni content in the base alloy. The increase in UTS was observed because of the formation of an intermediate phase Al$_3$Ni, occurred during solidification. The YS of the base alloy was also found to be increasing with increasing Ni content. The increase in YS was also because of the formation of an intermediate phase Al$_3$Ni formed during solidification. The %El remains a constant with increasing Ni content in the base alloy. Thus it could be seen that the Ni addition has no detrimental effect on the %El of the base alloy as well as on the Ni added alloys. Previous literature also reports an increase in the UTS and YS with Ni addition into various Al alloys. So it can be concluded that the Ni addition increases the mechanical properties of the base Al-8Si-0.4Mg alloy. Further, UTS was found to be an increasing function of the hardness. The YS was also found to be an increasing function of the hardness. Where as the %El was not observed to be a function of the hardness.

10.3 Conclusions based on the effect of Ni content on the wear rate and CoF

The wear rate was found to reduce with increasing Ni content and this behaviour was attributed to the formation of an intermediate phase Al$_3$Ni in the Ni added alloys. The wear rate was found to reduce with increasing hardness and this result was found to be
consistent with the Archard’s wear theory (1953) ref [47]. It is observed that the Ni addition significantly reduces the wear rate of the base alloy. Further, there was no significant change in the CoF values between the base alloy and the Ni modified alloys and the CoF was not found to be a function of hardness.

10.4 Conclusions based on the effect of Ni content on the hot tensile properties

The UTS increased with increasing Ni content in the Al-8Si-0.4Mg alloy, thus making the alloy more stable. The YS also increased with increasing Ni content in the Al-8Si-0.4Mg alloy. Whereas the %El showed an insignificant variation with increasing Ni content in the Al-8Si-0.4Mg alloy. The increase in the UTS and YS with increasing Ni content at elevated temperature was due to the presence of an intermediate phase Al₃Ni. With the increasing test temperature (200 to 350°C), UTS and YS decreased and %El showed an insignificant variation for all the alloys studied. Reduction in the hot tensile strength with increasing test temperature was due to the dynamic recovery brought about by the movement of dislocations to the sub-boundaries in the alloy. Further, the previous literature also reports an increase in the hot tensile properties with the Ni addition into various Al alloys. The %reduction in the UTS for the Ni added alloy was much lower compared to that of the base alloy. The %reduction in the YS for Ni added alloy was also found to be much lower compared to that of the base alloy. The %reduction in the UTS and YS for Ni added alloy was found to be lower than that for the base alloy due to the formation of stable Al₃Ni intermediate phase in the Ni added alloy. So it can be concluded that the Ni addition increases the hot tensile properties of the base Al-8Si-0.4Mg alloy.

10.5 Conclusions based on the effect of Si content on the microstructure, hardness and mechanical properties

Al₃Ni is the intermediate phase formed in all the Al-0.4Mg-2Ni-xSi (x= 4, 8, 12 and 16) alloys as observed from SEM, EDS, XRD, TEM and SAED pattern analysis. The increasing Si addition leads to an increase in the hardness of the Al-0.4Mg-2Ni-Si alloy. The UTS of the Al-0.4Mg-2Ni-Si alloy increases with increasing Si content. The increase in UTS was found to be because of the formation of an intermediate phase Al₃Ni. Further, the YS of the Al-0.4Mg-2Ni-Si alloy was also found increasing with increasing Si content in the base alloy. The increase in YS was also found to be because
of the formation of an intermediate phase $\text{Al}_3\text{Ni}$. Further, the $\%\text{El}$ remains a constant with increasing Si content in the Al-0.4Mg-2Ni-Si alloy and it could be seen that the Si addition has no detrimental effect on the $\%\text{El}$ of the Al-0.4Mg-2Ni-Si alloy. The UTS was found to be an increasing function of the hardness. The YS was also found to be an increasing function of the hardness. Whereas the $\%\text{El}$ was not found to be a function of hardness. So it was concluded that the Si addition increases the hardness and mechanical properties of the Al-0.4Mg-2Ni-Si alloy system significantly.

10.6 Conclusions based on the effect of Si content on the wear rate and CoF

The wear rate was found to reduce with increasing Si content in the base alloy and this behaviour was attributed to the formation of an intermediate phase $\text{Al}_3\text{Ni}$. The wear rate was found to reduce with increasing hardness and this result was found to be consistent with the Archard’s wear theory (1953) ref [47]. It could be observed that the increasing Si addition significantly reduces the wear rate of the Al-0.4Mg-Si-2Ni alloy. Further, there was no change in the CoF values with the increasing Si content in the Al-0.4Mg-Si-2Ni alloy. Thus CoF was found to be not a function of hardness.

10.7 Suggestions for future scope of work

The effect of cooling rate may be studied by using the various mould materials such as sand, metal and plaster. Wear test may be conducted by varying the parameters such as load, velocity, atmosphere and specimen heating. The Corrosion study may be conducted. The machinability of the Al-8Si-0.4Mg-Ni alloy may be studied. The regression analysis can be performed in order to find out which element (Ni/Si) is more contributing to the increase in the strength of the Al-Si-Mg alloy system.