CHAPTER XI

CONCLUSION

The Taguchi based grey relation analysis was employed for optimizing the PVD process parameters of coating ZrO$_2$ on AZ91D Mg alloy. The results can be summarized as follows:

- In Taguchi method the optimal parameter for each characteristic performance was different.
- The Taguchi grey relation analysis method found out that the optimal process parameter levels were argon gas, chamber pressure of $2 \times 10^{-3}$ in bar and power input of 200 W.
- The validation experiment shows improvement in the performance characteristics.
- The result proves that the surface properties of coated material are better than the uncoated material.

For coating ZrN on AZ91D Mg alloy the PVD process parameters were optimized using Taguchi Genetic Algorithm method.

- The optimal combination achieved are $G_2 = \text{Nitrogen gas}, CP_1 = 0.001 \text{ bar}, PI_2 = 200 \text{ W}$
- Delamination, adhesion, oxidation and plastic deformation are some of the wear mechanisms identified.
- Taguchi GA method has given two different optimal solutions for micro hardness and wear rate.

The metallurgical Characterization study reveals the following:

- SEM image of heat treated AZ91D Mg alloy shows the presence of intermetallic compound Mg$_{17}$Al$_{12}$and this is further confirmed through XRD and EADX.
- The ZrO$_2$ coating on AZ91D Mg alloy, shows the presence of $\delta$ phase compound Mg$_2$Zr$_5$O$_{12}$. In order to confirm this XRD and EDAX analysis was done and it confirms the same. This intermetallic compound enhances the thermo mechanical properties of the coating.
Similarly the ZrN coating is also studied using SEM, XRD and EDAX. Those studies confirm the presence of Zr$_3$N$_4$ and Zr$_3$AlN. It has been found these compounds improve the mechanical properties of the coatings.

Based on the hardness tests results, ZrN coated AZ91D Mg alloy is much harder when compared to ZrO$_2$ coated and uncoated AZ91D Mg alloy. The calculated values of hardness are as follows:

- Uncoated Mg alloy - 68.12 HV,
- ZrO$_2$ coated Mg alloy - 80.53 HV
- ZrN coated Mg alloy - 91.7 HV

The tensile test performed on the samples gives the following results. The tensile strength values are as given below:

- Uncoated heat treated Mg alloy is 179 N/mm$^2$
- ZrO$_2$ coated Mg alloy is 223 N/mm$^2$
- ZrN coated Mg alloy is 233 N/mm$^2$

Following are the conclusions derived from the wear test.

- Some of the wear mechanisms observed are abrasive, delamination, thermal softening and oxidation. The PVD coating improved the wear resistance of the AZ91D Mg alloy.
- ZrN coating has less wear rate when compared with ZrO$_2$ coating and uncoated AZ91D.
- It has been confirmed that for different load conditions, coefficient of friction is more in ZrN coating than ZrO$_2$ coating and uncoated AZ91D Mg alloy.

The following conclusions are summarized from the corrosion study of heat treated, ZrO$_2$ coated and ZrN coated AZ91D Mg Alloy:

- The immersion test showed that corrosion rate of heat treated sample was higher than ZrN and ZrO$_2$ coated samples. The Tafel curve articulated that ZrN coating has improved the corrosion resistance of AZ91D Mg alloy.

The ZrN coated AZ91D Mg alloy showed higher micro hardness and tensile strength than ZrO$_2$ coating and uncoated AZ91D Mg alloy. Further, ZrN coated AZ91D Mg alloy
have high corrosion and wear resistance behaviour than ZrO₂ coating and uncoated AZ91D Mg alloy.

Hence it can be concluded that ZrN PVD coating on AZ91D Mg alloy has the better improved properties when compared to ZrO₂ coated and uncoated AZ91D Mg alloy. The careful examination of the results shows that optimization of the process parameters have helped in selecting the best combination of parameters. It helped me to develop the best coating in the given conditions. So results obtained are more reliable and accurate. As far as the results are concerned, it is major breakthrough in the research of AZ91D ceramic coating by PVD process. It has proved that AZ91D acquires better wear resistance and corrosion resistance when coated with ZrN using PVD process. It will be of interest to the manufacturing industries which is looking for lightweight materials with better mechanical properties for different applications.