5. CONCLUSIONS

The present work provides an understanding about the effect of mild steel chill (MSC) and addition of inoculants like chromium and nickel to cast iron. Casting of the cast iron has been carried out by varying the chill condition, increasing the chill thickness and changing the position of the chill. Hence, the cast iron produced in the present investigation is identified as chill condition, chill thickness and chill position alloys. Chill condition is varied from room temperature to cryogenic temperature (sub-zero temperature) by using mild steel (MS) as the chill surface. MS chill thickness was varied from 15 mm to 30 mm during casting. Chill position was changed by keeping the MS chill side, either bottom or both places during casting. In chill conditioned alloys, chromium is added (up to 0.3% wt) as inoculant for un-chilled, room temperature MS chilled and cryogenic MS chilled alloys. After casting, the microstructural analysis has been carried out using optical and SEM images. Mechanical properties like hardness, compressive strength and impact strength were performed on selected samples. Sliding wear behavior was also studied for a few samples. Based on the above experiments, the following conclusions are drawn.

1. The rate of solidification is faster in subzero chilled zone and chilling effect decreases away from the chill surface. Chill thickness also affects the chill effected zone during casting. An effective chill length is also varied by changing the chill position. It was observed that effective chill region increases by increasing the chill thickness and further increases by keeping the chill position at both bottom and sides.

2. Microstructural studies reveal the presence of high volume fraction of carbide in chilled region than graphite concentration. Carbide formation is clear in SEM images for the chilled zones. MS chilled room temperature samples exhibits carbide in the form of plates/or needles. MS chill with cryogenic condition samples demonstrates complete carbide formation instead of plates/or needles. Chilled zone exhibits the formation of graphite of type D, E and smaller length size of 7 and 8. Smaller size graphite concentration of 12-15 % by area or volume fraction is observed in the chilled zone. MS chilling with ~ 1% chromium resulted in the formation of carbides in plates/or needles form. However, thin graphite flake of ~8% volume fraction is observed through the image J software. An addition of nickel (~2%) with chilling effect leads to promote pearlite formation. Un-chilled casting and zones away from the chills resulted in the formation of graphite of type-A and longer length size of 4
and 5. Pearlite matrix with longer graphite flakes is observed. Graphite formation in this region is found in the range of 14-17%.

3. High hardness is noticed at the chill face. Cryogenic effect of ~ -60 °C produces high hardness in the vicinity of chill end face. An addition of 0.3% Cr has little effect on hardness of the material. Increase in MS chill thickness has shown proportionate increase in hardness. However, addition of ~1% chromium with MS chilling increases the hardness of the material. Ni addition decreases the hardness of the material as compared to chromium added cast iron alloys. The combination of Cr and Ni (1.5% each) increases the hardness to a level, which is intermediate between the presence of Cr or Ni alone in the composition. Un-chilled zone (away from the chill) and the samples prepared without using chill exhibited low and uniform hardness. Un-chilled chromium and /or nickel based alloys has not shown any significant variation in hardness. Location of chill at both side and bottom resulted in exuberant increase in hardness. It is observed that formation of carbides (Fe₃C) due to chilling and chromium carbide presence promotes hardness. Microstructural studies are in confirmation with hardness results.

4. High compression strength is observed at the chilled zone (F) than the zones away from the chill (B). Cryogenic chilling effect has not shown any appreciable increase in compression strength as compared to room temperature MS chilled samples. Increase in chill thickness demonstrates proportional increase in compression strength. However, an addition of 1% chromium with MS chilling exhibited significant increase in compression strength.

5. Cast iron produced at room temperature and cryogenic temperature chilling effect resulted in absorbing ~ 3 Joules of energy was observed. An increase in energy absorption of ~4 J is resulted at the back face (away from chilled face) of both RT and CT chilled samples. Cast iron produced without chilling exhibited an absorption of 4 J. Chilling leads to the formation of carbides, which are very hard and resulted in low impact strength. An increase in impact energy in un-chilled or normal alloys is due to graphite and pearlitic matrix formation, where longer flakes assist in energy absorption due to cushioning effect.
6. Sliding wear rate is high for the normal cast iron samples. RT and CT castings at the chilled face exhibited high wear resistance. Increase in wear is found for the surfaces away from chilled face. A small percentage of chromium has not shown any significant change in wear resistance. As the MS chill thickness increases, wear resistance is also increased. However, increase in chromium percentage ~1% with MS chilling assisted in increasing wear resistance of the material. An addition of nickel with MS chilling depicts reduction in wear resistance as compared to chromium added cast iron samples. It is clearly observed that, longer and type A graphite flakes with pearlite matrix samples exhibits high wear. Graphite acts as lubricant and hence high wear is found in GCI and un-chilled zones. Presence of carbides and reduction is graphite length to have high wear resistance results. Chromium based chilled castings exhibited high wear resistance due to formation of chromium and iron carbides. Nickel based chilled samples resulted in reduction in wear as compared to chromium based chilled alloys and this is due to the presence of longer graphite and pearlite matrix.