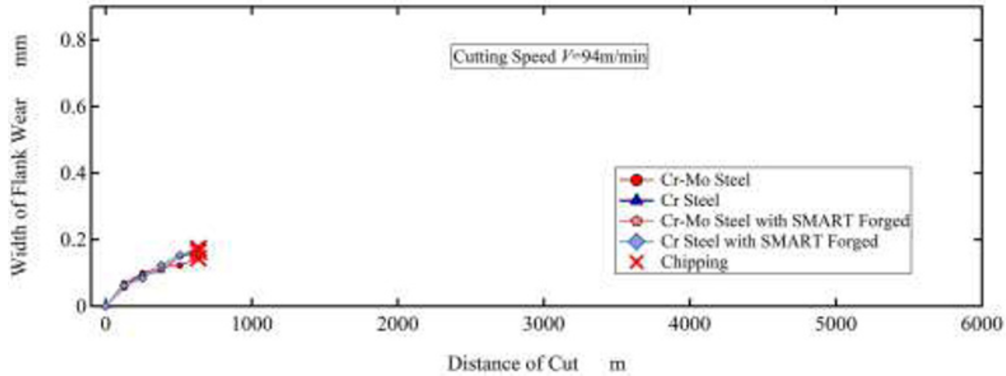
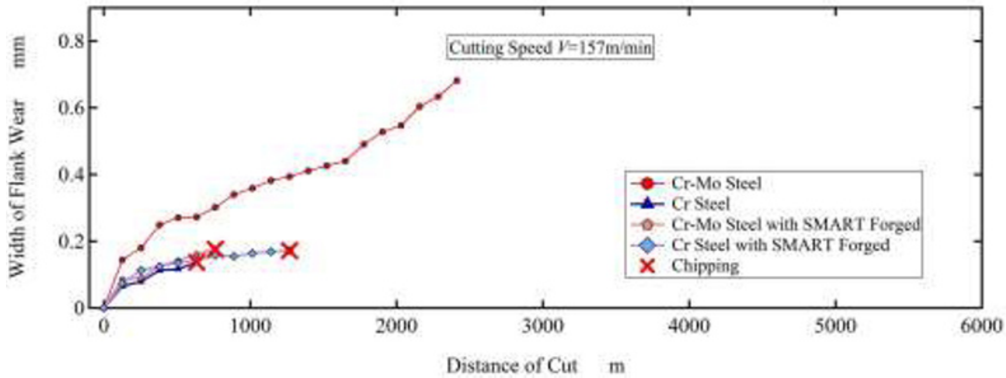
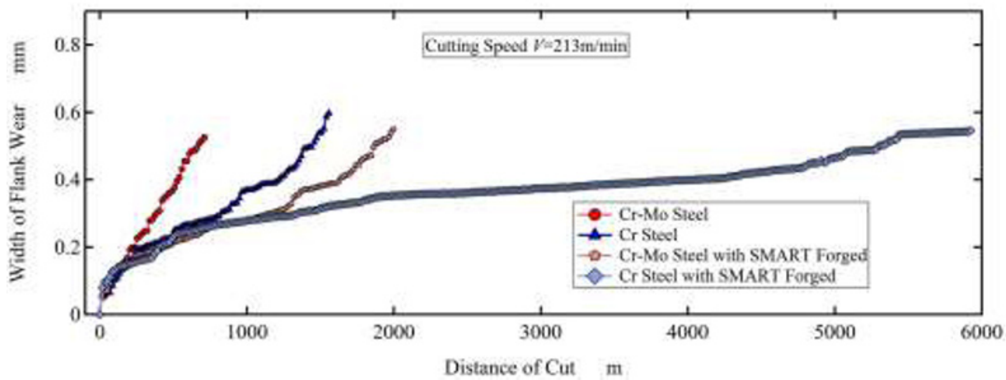


(a) Cutting speed *V*=94.2m/min



(b) Cutting speed *V*=157m/min



(c) Cutting speed *V*=213m/min

(d) Cutting speed *V*=308m/min

Fig. 7. Relationship between distance of cut and width of flank wear

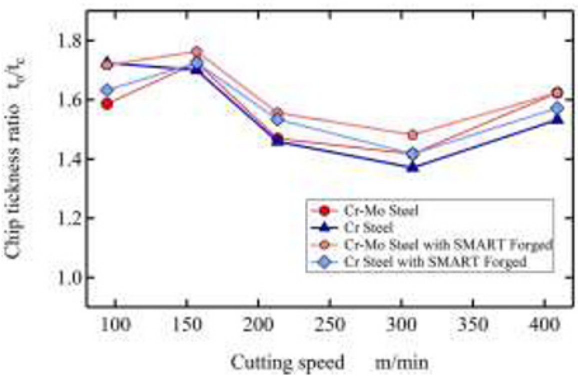


Fig. 8. Relationship between cutting speed and chip thickness ratio

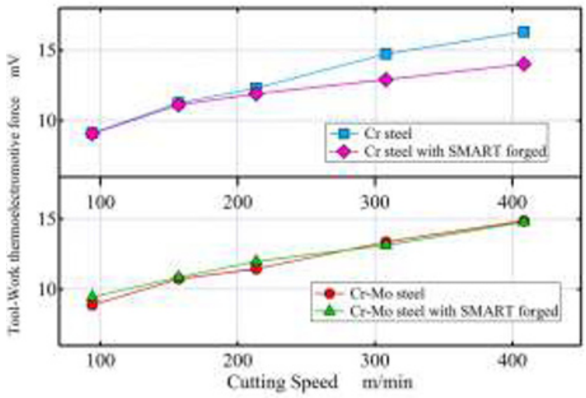


Fig. 10. Relationship between cutting speed and Tool-work thermoelectromotive force

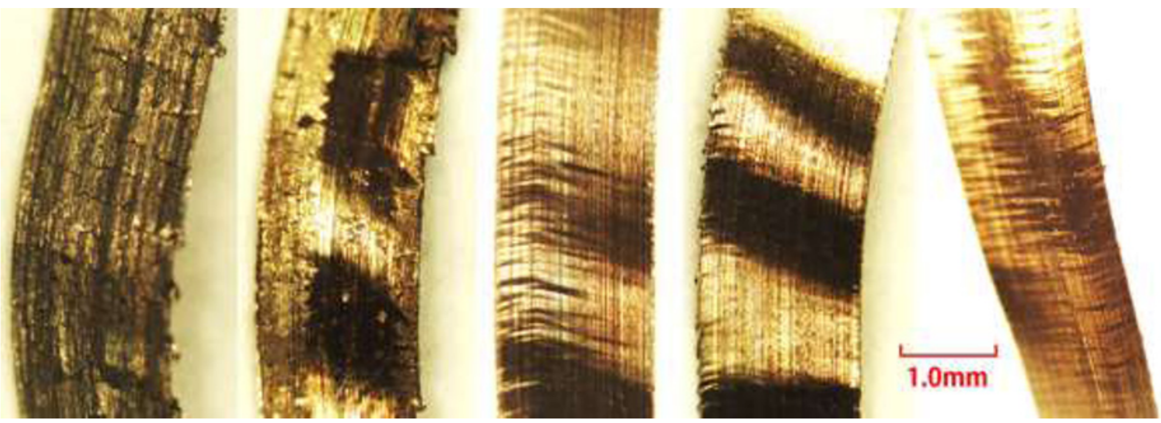
Next, the microscope observation of the chip surface to be discharged and the cutting temperature at that time were investigated. Figure 9 shows the photographs of the chips discharged from chromium molybdenum steel made by SMART forging process classified according to the cutting speed. From these photographs, it can be seen that the pluck type chip is discharged up to the cutting speed *V* of *V*=157 m/min, and it is changed to the flow type chip at the cutting speed *V* of *V*=213 m/min or more. That is, it can be seen that the chip thickness ratio shown in fig. 8 and the chip configuration show a very good relationship. This tendency was almost the same for the other three materials.

The cutting temperature at that time is shown in fig.10. It can be seen that the cutting temperature increases in proportion to the rise in the cutting speed in both materials. From these results, it is considered that built-up edges are generated because the cutting temperature is close to the recrystallization temperature of the workpiece at a cutting speed *V* of *V*=157 m/min or less regardless of which material is cut. And the breakage of the cutting edge occurs due to the separation of the built-up edges. However, with respect to the cutting temperature, only relative comparison is made for each material. From now on, it is necessary to fabricate a thermocouple of cemented carbide and each forged material and investigate the absolute temperature during cutting while calibrating the temperature.

From the above, it can be considered that in the cutting of these forged materials, the occurrence of the built-up edges is remarkable near the recrystallization temperature of the material, which causes the tool to be frequently chipped. Therefore, when cutting these forged materials with cemented carbide, it is necessary to cut at a cutting speed *V* of *V*=213 m/min or more. However, when cutting at the cutting speed *V* of *V*=308 m/min, tool life becomes extremely short, so it is considered that the optimum cutting condition per cutting speed *V* of *V*=213 m/min.

4 Conclusion

In order to investigate the machinability of the material made by the new forging method, we examined the cutting speed region which could not be covered in the previous report. As the result, it was found that general cutting speeds such as cutting the steel with cemented carbide are not suitable for cutting conditions of these forged materials because the tool frequently chip. For this reason, the chip thickness ratio the microscope



V=94.2m/min *V*=157m/min *V*=213m/min *V*=308m/min *V*=409m/min

Fig. 9. Photograph of the chips surface at each cutting speed.

observation of the chip surface and the cutting temperature were measured. As a result, at the cutting speed *V* of *V*=157 m/min or less, it reached the conclusion that the built-up edges frequently occurred and the tool was chipped due to it. From the previous report and the results of this experiment, it was found that the cutting speed *V* of about *V*=213 m/min is optimum for cutting these forged materials with cemented carbide.

The materials used in this experiment are finally gear cutting processed. Therefore, from now on, it is necessary to study machinability including tool life by using fly tool made by coated high speed steel. In addition, we will also clarify the cause of the difference in tool life observed by the difference in the heat treatment after forging which was reported in the previous report.

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