11th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2007, Hammamet, Tunisia, 05-09 September, 2007.

PERFORMANCE OF VARIOUS TOOL STEELS IN METAL SHEET FORMING COLD WORK TOOLS

Đurđica Goršćak[1], Damir Čačković[1], Lidija Ćurković[2]

[1]Končar-Alati d.d.
Fallerovo šetalište 22, 10000 Zagreb
Croatia

[2]Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb,
Ivana Lučića 1, 10000 Zagreb
Croatia

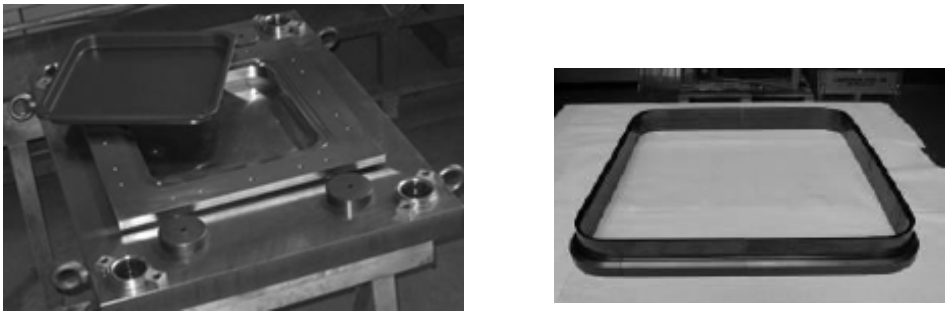
ABSTRACT
Performance of the sheet metal cutting and forming tools producing baking tray parts was monitored. The baking trays are produced from the carbon steel sheet and from the Teflon coated steel sheet, where resistance of the steel substrate of the tool forming inserts against galling is very important, as well as resistance of the cutting inserts to wearing out. The operating inserts were produced from various Uddeholm steels. For the first cutting inserts, Sverker 21 was used, followed by Sleipner steel, both of them uncoated. In order to improve performance, PVD coating (nano-structured TiAlN) was applied on Sleipner substrate. A step forward was using of the powder metallurgy steels, Vanadis 6. The initial forming inserts were made from Vanadis 10 steel, whereas further investigations involved the recently launched steel Vancron 40, a steel type produced specifically for the applications where resistance against galling is a predominant wearing mechanism.
The analysis shows that PVD coating provides cost savings due to less frequent tool resharpening. The currently obtained results indicate promising performance of the newly developed steel Vancron 40 for forming applications.
Keywords: tool steel, PVD coating, adhesive wearing

1. INTRODUCTION
In the tooling industry, the pressure on tool economy is ever increasing. Any interruption in tool exploitation generates costs and decreases efficacy. Therefore, the focus in toolbuilding industry is ensuring long and continuous tool operation time. Great attention is being paid to optimizing the tool design – the solutions must be easy for maintenance, the tool must be disassembled in the press in order to reduce the press waiting time. After dealing with the design concepts and solutions, further possibilities to reduce the maintenance time and costs were investigated. In sheet metal tooling, particular attention is paid to resharpening the cutting tool inserts and to cleaning the forming inserts. Frequency of resharpening directly influences the operating costs, as the tools are not able to operate during the resharpening time. In case of the aggressive blank material, where edge wearing out is extreme, the issue gets critical, as it often happens that the production must be discontinued in order to resharpen the tool. Therefore, the hereinabove mentioned requirements from the tooling industry have influenced the steelworks to develop new steels in order to prolong the tool operating time. Besides development of the tool steels, the toolbuilding supporting industries started development of various coatings whose purpose is maximizing the cutting edge lifetime, as well as the forming parts lifetime. One of the cutting-edge technologies was involvement of the PVD coatings. At the beginning, the wear resistant coatings were introduced, many PVD coatings were developed later on in order to

increase efficacy in various applications – the coatings resistant to galling as well as coatings suitable for both, cutting and forming applications.
The trend in stamping of sheet metal is to use automatic press lines with higher press speeds, fewer stations according to JIT, new steel sheet grades with higher strength levels, less harmful lubricants and as long as possible only use the antirust/prelube oil applied at the steel mill and thus no additional supply of press lubricant. This will inevitably allow boundary lubrication conditions and metal to metal contacts, which address different type of solutions to avoid galling. [1]
The steel manufacturers show tendency to develop new steel grades which would diminish a need to use the PVD coatings, which would decrease the toolbuilding costs as well as leading times (time needed for PVD coating would be saved, which is particularly important for the toolshops which are not in vicinity of the needed coating facilities.)
In terms of resistance to galling, for forming applications, a newly developed steel Vancron 40 should bring new improvements into the sheet metal forming field.

2. EXPERIMENTAL

Production of baking trays (Fig. 1 a), in a highly productive company, in a high labour cost country, is an illustrative example of the hereinabove mentioned issues. The same cutting and forming tools were used for production of baking trays from both, carbon steel sheet and Teflon coated steel sheets. Teflon coating is quite aggressive for the tool operating parts, it can attach to the tool surface and, also, more frequent resharpening is required if the tool forms the Teflon coated blanks.
Hereinbelow, the development history is presented.



(a) (b)

Figure 1: (a) tool for Baking Tray (b) coated tool inserts [2]

First, Sverker 21 steel was used for production of the cutting parts of this tool (Fig. 2 b), where only 3000 pieces were produced before regrinding. The uncoated cutting inserts from Sleipner steel could produce 4500 pieces. This 50 % improvement was good, but the result with Lumena PVD coating (TiAlN, nanostructured) applied on Sleipner steel was 30 000 pieces before the tool had to be regrinded for the first time. After that, the tool produced 25 000 pieces before the next regrinding. Prolonged time between regrinding, as per Fig. 2, provided savings in tool maintenance of 27.000 EURO/year [2].

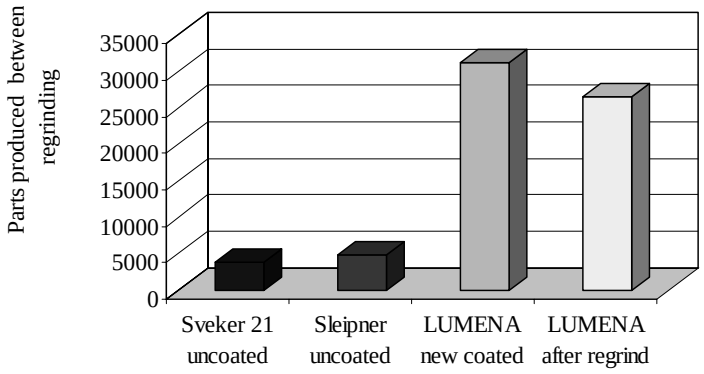


Figure 2. History of regrinding vs. tool materials and coatings

The above example shows a good performance of the PVD coated steel.
In order to further improve performance of the above tool, after reducing resharpening of the cutting inserts, the attention was paid to the forming (rolling) inserts which suffered galling.
Corners as shown on Fig. 1 b are particularly critical for forming – they suffer heavy galling, which actually destroys the form. Due to sensitive and hardly accessible profile, there is actually no possibility to refurbish the profile by cleaning the surface, but the initial profile must be milled again.
The good performance was reached with the steel Vanadis 10, where 20-30.000 parts were produced. However, application of the newly developed steel Vancron 40 more than doubled performance of these corner forming inserts – 70.000 parts were produced. As dimensions of the parts are small, economy of this steel upgrade is obvious.
Heikkila et al. [3] have found out that Vancron 40 considerably exceeds performance of Sverker 21 steel in galling.

3. CONCLUSION

The investigation was performed in highly efficient production, therefore the results are reliable for applications in production and can be applied in comparable cases, where attention must be paid to the part profile and forming conditions.
The results indicate importance of proper selection of steel type in toolbuilding, as well as of proper PVD coating for the specific purpose, which decreases the costs in part production.
In steels, powder metallurgy steels introduced many advantages in tool production, assuring better performance. Among them, Vancron 40 is the steel with a promising performance in forming applications.
Further investigations in critical tooling applications will be performed.

4. ACKNOWLEDGMENTS

The presented research results were achieved within the scientific project "Structure and properties of engineering ceramics and ceramic coatings" (Agreement No 120-1201833-1789) supported by the Croatian Ministry of Science, Education and Sport.

5. REFERENCES

[1] Sandberg O. : Advanced low friction tool steel for metal processing – properties and industrial experiences 7th International Tooling Conference, Torino, Italy, 2006
[2] Gorscak D., Panjan P., Curkovic L., Kapudija D. : Mechanical properties and application of various PVD hard coatings in cold work tools, 7th International Tooling Conference, Torino, Italy, 2006
[3] Heikkilä I., Lundberg M., Gunnarsson L, Feiler A., Rutland M. W. : The contribution of the surface properties of tool steels for galling behaviour in sheet metal forming, 7th International Tooling Conference, Torino, Italy, 2006