MATERIALS AND MACHINING TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT

Cristian PISARCIUC¹, Flavius A. SARBU¹
Transilvania University of Brasov, Romania, ¹pisarciuc.c@unitbv.ro, ²sflavius@unitbv.ro

Abstract: Technologies developing in the world are requiring the application of new achievements of science and technology, with direct implications on increasing of productivity, quality and reliability in order to reduce production costs for products. All these are evident in those goals but have also beneficial effects in light of new regulations concerning environmental protection contributing as well to sustainable development. Currently, the industry benefits from a large number of processing methods and unconventional technologies. Among technologies used today and which are applied on an increasingly large scale, are unconventional technologies, because they offer opportunities for manufacturing industry to use hard and superhard materials under conditions of maximum technical and economic efficiency. These technologies are able to produce parts with complex shapes and types of surfaces, hard or impossible to obtain using conventional processing technologies.

Keywords: unconventional technologies, environmental protection, sustainable development

1. INTRODUCTION

Products development with an accelerated rate of production led, largely, to an increased demand for materials and products with special physicochemical properties (hard, refractory, corrosion resistant, etc.). Using classical methods in processing these materials with high features, is, if not impossible, at least very complicated. The productivity of cutting processing of such materials decreases with their hardness, while it remains almost constant for erosion (electrical, electrochemical, water jet machining, etc.). Up to 400 - 500 HB hardness, machining speeds through conventional means are more productive; over those values unconventional processing technologies are far more beneficial (figure 1) [1].

Taking into account the great diversity of materials used, geometric shapes and surfaces dimensions made today, processing productivity through various means, in relation to the machinability of materials, can be appreciated from the graph in figure 2.

Fig. 1. Productivity versus hardness evaluation

Fig. 2. Productivity versus machinability evaluation

It can be seen easily that, even taking into account processing costs, for simple features conventional machining processes are recommended, while for the most difficult most unconventional machining are more appropriate.

2. MATERIALS AND PROCESSING METHODS IN TERMS OF SUSTAINABLE DEVELOPMENT

Current development of industrial activities shall be subject to reduction in consumption of raw materials (steel - in particular) and energy consumption. In addition, in view of sustainable development,
harmonizing human activities with the environment the implications over nature must be taken into account.

Although metal losses were significantly reduced, the material consumption is still high. Nowadays, iron and steel, both widespread in the engineering industry, are forming 83% of metal production and the weight of one tenth of world production of materials [2].

Taking into account the negative effects that high consumption of metals has on the environment will result in a new factor to be taken into account when designing the product and its processing technology.

Thus, from material deployed throughout a large part is discarded in the form of waste. Furthermore, to separate metal from ore are used, most often, toxic substances such as cyanide, mercury, sulphuric acid and others. The remaining material left after separation - waste - is stored in various areas that, in this way, become extremely dangerous.

As the concentration of ore deposits currently used for metal production falls, it is expected that for every useful tonne to generate more and more waste. If in 1990, the copper is extracted from ores containing only the metal at a rate greater than 3% today, following the application of effective methods of enrichment, becomes economic the use of minerals, even at a concentration of only 0.5%. Mining in these conditions is done with the price of a large quantity of rock displaced and excessive energy consumption, with obvious negative impact on the environment [3].

In order to reduce the consumption of metallic materials, several solutions are available:

- Use of metal materials with superior physicochemical properties that are involving less specific weight, over whole the product;
- Reducing, were is possible, the safety factor by appropriate redesign;
- Improving physical and mechanical qualities of metallic materials by appropriate treatment;
- Use of new technologies or other processing methods to ensure a high index of the material utilization;
- Election of other materials capable to ensure the same quality or better;

To summarize, in authors opinion, to reduce both consumption of materials and energy researches can turn in two directions:

1. Researches on the development of new materials or to improve properties of existing ones;
2. Researches in development of conventional processing technologies and / or using unconventional technology in manufacturing.

Considering the first aspect, the materials, more exactly their properties, should provide resistance to the stresses, they will be subject as finished parts. It can therefore be said that products must meet both operational and technological requirements.

One of the most important properties of metal materials is tensile strength σ. Researches has shown that with its increasing occurs intensification of cutting tools wear, a decrease of cutting speed (figure 3), an increase of specific cutting energy (figure 4), a temperature rise in the cutting area (with possible effect of changes of material properties during processing), etc.

![Fig. 3. The influence of tensile strength over cutting speed](image)

![Fig. 4. The influence of tensile strength over specific cutting energy](image)

The increase in hardness leads to a decrease in machinability of steels and an increase of cutting forces. Taking into account the characteristics of steel toughness is found that if this raises then specific mechanical cutting energy increase as well.
Steels, and generally homogeneous materials, have a good thermal conductivity. However, there are cases, especially when processing special varieties of steel, that this property has small values. For example, thermal conductivity at 20 °C is 0.140 for normal carbon steel, compared to only 0.035 to 0.065 for stainless steels. A low value of thermal conductivity is reflected in the difficult evacuation of heat from the cutting area, a high concentration of heat at the cutting tool level, all those having negative impact over tool wear.

More and more higher-quality steels are required in relation to their resistance to corrosion, which end in chemical composition of stainless steel where are placed special alloying elements as: Ni, Cr, Mo, V. etc. Some of these, however, adversely affect the cutting machining, contributing, as well, to an increase in tool wear and cutting forces.

In terms of technological properties of materials, particularly of the metal, the most important is machinability through cutting processes. Because a number of factors (manufacturing process, material and tool geometry, cutting regime, cooling conditions, etc.) influences the chip formation, removal material behaviour can be characterised based on a global criterion with a character of generality. Figure 5 shows, in comparison, machinability through cutting processes of some most used materials [4]. As reference, standard martensitic stainless steel is used whose machinability through cutting processes was assessed at 100%.

![Fig.5. Machinability through cutting processes](image)

As can be seen, most of metallic materials do not present favourable characteristics in terms of cutting. In fact, applying cutting processes - in the authors’ opinion - is more related to a convenience in using conventional methods and technologies. Thus, we prefer to invest time, energy and money in developing new cutting tools, made of performing materials instead in “investing” in more efficient methods and technologies.

Most of the times, because of the competitive economy, the first criterion taken into account in the choice of material and processing technology is economical one.

Although it is an easy observation to be noted, depending on the nature of production (mass production, large or in small number), ratio between material price and processing cost varies:

- In mass production, due to automation and mechanization of the production, processing cost is lower than that for material;
- In opposition, in small series production, the share of the cost of the material in the finished piece is small compared with the processing costs.

Because of the way material is removed, through unconventional technologies, from workpiece, i.e. by erosion, the production character has no influence over the production costs.

In these conditions is less expensive to use, when appropriate, more expensive but quality materials, coupled with a technology operation to ensure required economic efficiency.

Alongside metallic materials, industry increasingly uses, more and more, non-metallic materials. Their use, for example in the category of composite materials, has a greater interest as the overall energy costs are higher.

In machine building industry, coefficient of metal utilisation (the ratio between the weight of the finished piece and blank) is averaging 50 ... 60%, but in some cases, this percentage drops to 15%. The total weight of metal processing chips is, for example, one third in bars and laminates. Even when produced in large series, the waste can reach up to 30 ... 40% of the metal blank [5]. Being more accurate and precise, acting only were is necessary, unconventional technologies dramatically reduce the amount of material wasted contributing this way to environmental protection.

It can be stated, as an overall conclusion, that the operating properties, technological and
economic matters are closely interdependent. Thus, no matter how high it would be some operating properties of a material, if it cannot be processed, i.e. has no technological machinability, it cannot be used in the production of industrial products. Moreover, even if processing is possible, this should be done in economic terms, in order to be a profitable operation. Therefore, part designer and technologist must take into account also the properties of materials set out above.

Cutting technologies (conventional technologies) are based on the phenomenon of chip formation. Whatever the cutting process is analysed, under the cutting tool action over workpiece material, a force is developed, acting on the cutting layer. In case of unconventional technologies forces emerged are negligible, meaning that is now load over the machine or workpiece.

Of those mentioned so far, it appears that the cutting tool must have, in terms of its form, a relatively complex geometric design. It also presents specificity due to both machine - tool (where processing is done), and from the processing itself. Tools used in unconventional machining, at most, are having a negative form compared to machined surface (electro discharge machining, electro chemical machining) or not having a form at all (laser, water jet machining, electron beam machining etc.).

3. CONCLUSIONS

Although a known process, cutting is characterised by phenomena that prevent its use in all situations.

Regardless of the processed material, cutting forces are developed during machining and, in most cases, present important values. This aspect involves both performance materials for cutting edges of cutting tools and machine tools capable to ensure cutting conditions. Dynamic issues emerged during cutting, related to both tool - workpiece interaction and machine operation, are not so obvious and further complicate the process.

Cutting, as machining process, cannot be applied in all situations arising in engineering.

Limitations of the procedure are mostly related to the technological concept (which really refers to the technological aspects and constructive). Materials with special properties, as well increasingly complex machined parts, reveal the process limits.

In conclusion, technologist will have to consider alternative methods of processing, respectively, unconventional, at least in one of the following cases:

- When machinability (using conventional cutting processes) is very low, making difficult, inefficient and / or impossible the use of a conventional technology. The less effort is implied in this activity, the more positive aspects arise in terms of sustainable development and, as well, in environmental protection.

- When the surfaces to be obtained present such forms, sizes or locations that either applying of a classical processing method is uneconomic, or that in fact there no practical method for obtaining the desired surface.

REFERENCES


