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COMPARISON OF HARD MACHINING PROCEDURES ON THE BASIS OF THE AMOUNT OF THE USED UP COOLANT AND LUBRICANT

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ПОРІВНЯННЯ ПРОЦЕСІВ ЧИСТОВОЇ ОБРОБКИ, ЩО БАЗУЕТЬСЯ НА КІЛЬКОСТІ ВИКОРИСТОВАНОЇ МАСТИЛЬНО-ОХОЛОДЖУВАЛЬНОЇ СЕРЕДИ

Застосування холодоагентів і змащень вносить значний вклад у збільшення ефективності видалення металу при механічній обробці. Охолодження й мастильний ефект зменшують навантаження на інструмент, у такий спосіб полегшуючи відділення матеріалу й формування поверхневого шару кращої якості. Ця робота спрямована на рішення даного завдання виробництва - а саме, механічної обробки поверхні - і чи може вона бути виконана з тією ж точністю й економічною ефективністю з використанням меншої кількості змащення.

Ключові слова: обробка матеріалів високої твердості, холодоагент і змащення

Применение хладагентов и смазок вносит значительный вклад в увеличение эффективности удаления металла при механической обработке. Охлаждение и смазочный эффект уменьшают нагрузку на инструмент, таким образом облегчая отделение материала и формирование поверхностно гослоя лучшего качества. Эта работа направлена на решение данной задачи производства – а именно, механической обработки поверхности – и может ли она быть выполнена с той же точностью и экономической эффективностью с использованием меньшего количества смазки.

Ключевые слова: *обработка материалов высокой твердости, хладагент и смазка*

The application of coolants and lubricants (CL) considerably contributed to the increase of the efficiency of material removal in metal machining procedures. Both the cooling and the lubricating effect reduces the load on the tools, thus facilitates the partition of the material and the formation of a better surface quality.This article seeks to ascertain whether given production task – namely the machining of a hard surface – can be fulfilled with the same accuracy and economic efficiency if using less CL.

Keywords: hard machining procedures, coolant and lubricant

INTRODUCTION

In production engineering, when choosing the machining procedures and operations, the aspects applied so far (accuracy, surface quality, economy etc.) are more and more frequently completed by environmental expectations.

A technologist has to consider what possibilities there are to reduce the significant amount of CL. The functions of CL are: chip disposal with washing and scavenging is 70%, cooling is 20%, and lubrication is 10% [1]. Besides their advantageous features, however, their application have a significant environment polluting effect. Because of this the CL became the most important environment damaging factor in the field of cutting.

Depending on the workpiece, the manufacturing structure, and the place of the production, the costs related to the use of CL average 7-17% of the total manufacturing cost of the workpiece [2]. In the field of cutting, the environment friendly methods of the application of coolant [3] are the following:

1. Modification of the coolant's and lubricant's composition
2. Reducing the amount of CL
3. Minimizing the amount of liquid (minimal cooling) (using less then 50 ml/h amount of liquid)
4. Application of coolant not in liquid state
5. Dry machining

The finish machining of hard, hardened materials traditionally was done by abrasive grinding, using large amount of CL in most cases. The environmental load can be reduced by the enlisted methods, to the largest extent by dry machining of course. Experts in the industry generally accept new technologies, – in this case the application of dry cutting technology –, if the task to be solved is fulfilled at least at the previous technical level, having approximately the same economic benefits.

This paper focuses on the usage of CL in hard machining. It compares hard turning and grinding of hardened steels, and examines the possibility, whether the significant amount of CL used up in grinding is possible to be reduced, and to what extent in another version of machining.

1. USING CL IN HARD MACHINING

Using of CL in grinding and hard turning, the two procedures most frequently applied in finish hard machining of hardened steels is examined as well as the polluting effect of these procedures.

1.1. Grinding

For a long time the most often used operation of hard machining was grinding. With the tools having superhard cutting edges, constructed in a way that their application is possible in industrial scale as well, hard turning has become widely spread for today.

Grinding, due to the large amount of lubricant, pollutes the environment in large measure, damages the workers' health and even the process costs are higher. In Figure 1 the relations of the grinding process are indicated taking auxiliary materials and the after process remains into calculation [4, 6].

Mud consists of abrasive and binding material grains broken off the wheel, flakes of microscopic size and lubricant. To separate them is impossible, the mud is harmful to the environment and health, to eliminate it requires special circumstances. In grinding one must account on liquid mist, too, in which tiny under 1 μm solid particles, aerosols float. Breathing aerosols in may lead to serious damage to one's health.

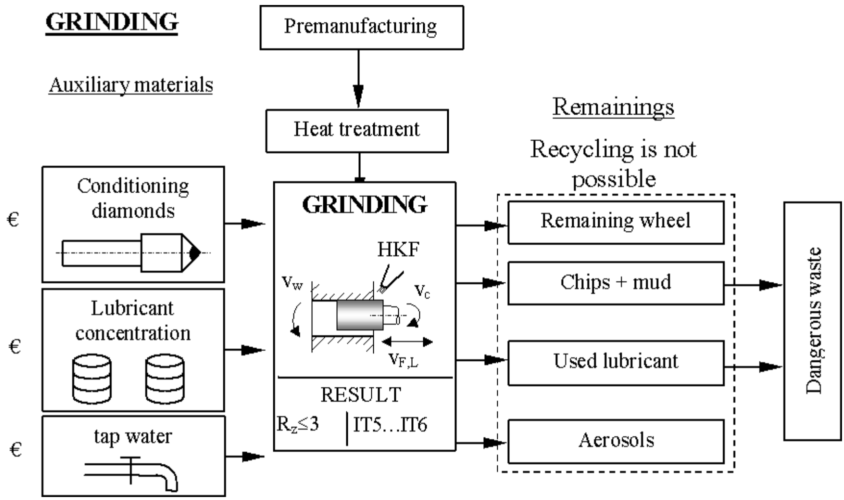


Figure 1 – Processes, auxiliary materials and remains in grinding

1.2. Hard turning

Hard turning is dry machining. From ecological aspects dry machining is much more beneficial than grinding, because the disadvantageous effects enlisted before do not emerge [5, 7, 8, 9, 10].

The chips are the same as the workpiece material, thus they can be recycled. The worn tool is either put away or after being resharpened it is reused, but it is not mixed with other materials. The ecological block-figure is in Figure 2. The dry procedure is fully environment friendly.

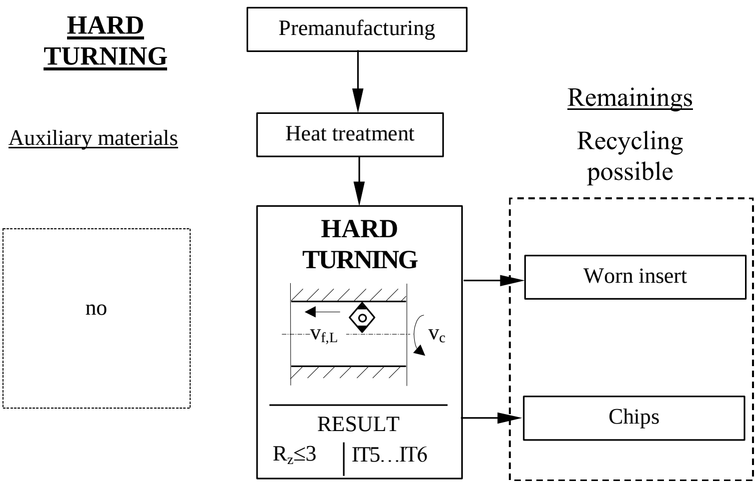


Figure 2 – Process remains in hard turning

2. *EXPERIMENTS TO COMPARE THE HARD MACHINING PROCEDURES*

We have done comparative examinations for the machining of two bore holes with the same lengths, having different diameters, with given accuracy and roughness, to examine the used up CL.

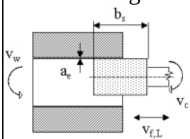
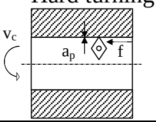
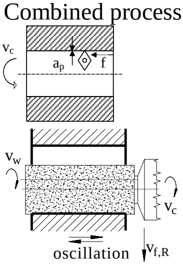
2.1. Experiments

The experiments were made for gear's bore-holes of IT5 accuracy when surface roughness Rz=5 µm was to be provided. Table 1 summarizes the sign and description of the applied procedures.

Table 1 – Summary of the investigated procedures

Sign	Description	Procedure	
		Roughing	Smoothing
A	internal traverse grinding	corundum wheel	corundum wheel
B	hard turning	standard insert	standard insert
C		wiper insert	
D	combined procedure	standard insert	corundum wheel
E		wiper insert	

Table 2 – Technological data of cutting bore-holes

Process	Machine tool / Tool	Condition data	
		Roughing	Smoothing
Grinding 	SI-4/A 40x40x16-9A80-K7V22	v_c=25…29 m/s v_w=14…19 m/min $v_{f,L}$=2.2 m/min	v_c=25…29 m/s v_w=14…19 m/min $v_{f,L}$=2 m/min
Hard turning 	PITTLER PVSL-2 CNGA 120408S-LO CBN CNGA 120408 7020	v_c=180 m/min f=0.12 mm/rev. a_p=0.10 mm	v_c=180 m/min f=0.24 mm/rev. a_p=0.05 mm
Combined process 	EMAG VSC 400 DS CNGA 120408S-LO CBN 40x40x16-9A80-K7V22	v_c=180 m/min f=0.24 mm/rev. a_p=0.1 mm $v_{f,R}$=0.0033 m/min	v_c=25…29 m/s v_w=14…19 m/min $v_{f,R}$=0.0016 m/min

The data of the workpiece were as follows: material: 16MnCr5; hardness: 61÷63 HRC; diameter: d=38 and 66 mm; accuracy: IT 5; length of bore: 29 mm; allowance: 0.3 mm; sequence size: n=200.

From 0.15 mm allowance 0.1 mm were removed by roughing, 0.05 mm by smoothing.

The operation times and the ratio of the used up CL were defined for five possible machining variations. In grinding CL were used throughout the whole machining process, hard turning was done dry, however, in the combined procedure roughing was done dry, in smoothing CL was applied.

The characteristic technological parameters are summarized in Table 2.

3. RESULTS AND EVALUATION OF EXPERIMENT

In the first part of the experiment it was investigated whether in different machining variations done with the cutting data ensuring the same accuracy and roughness how much CL was used up.

If the amount of the liquid used up in grinding is considered 100%, the ratios indicated in Figures 3 and 4 are obtained.

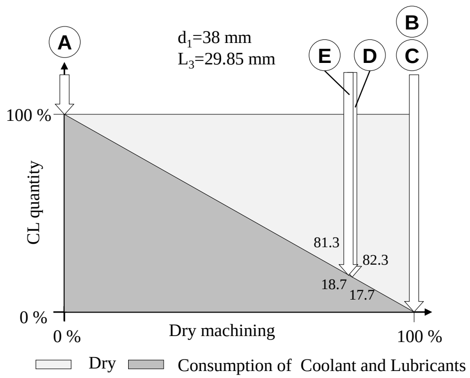


Figure 3 – The proportion of environmental load in different procedures related to grinding

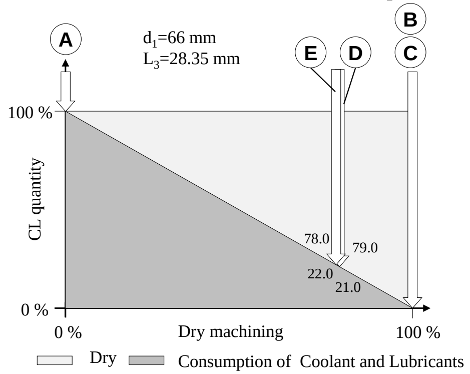


Figure 4 – The proportion of environmental load in different procedures related to grinding

It can be stated that in the case of both diameters, applying the combined procedure, the usage of CL can be reduced to its one fifth, while in hard turning CL is not needed. The operation times of the processes were also investigated.

Grinding takes the longest operation time. In hard turning the operation time of a gear-wheel reduces to one fourth compared to grinding. It can be reduced even lower by the application of wiper inserts (Figure 5 and 6).

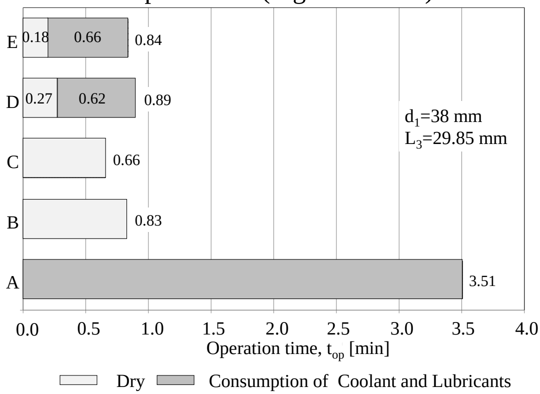


Figure 5 – Operation times in different procedures

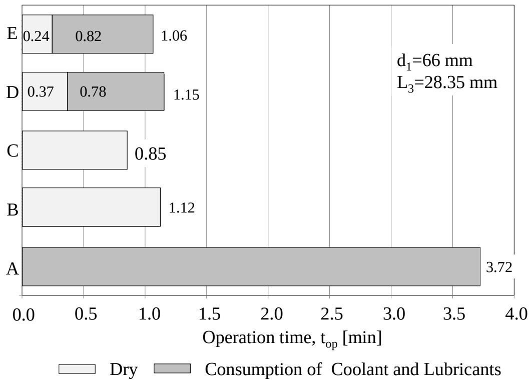


Figure 6 – Operation times in different procedures

This unambiguously proves the economic advantage of hard turning. Apart from those it ensures the accuracy, roughness and surface quality parameters at the same level as grinding. If the functional requirements for the part need ground topography, the proper joint application of the two procedures is suitable.

The condition for economy is that the bigger possible portion of the allowance should be removed by turning and only the allowance minimally needed for creating the topography should be ground. If it is done in a traditional way, because of the higher number of machine tools and clamping, the economic efficiency will not be, or will not be remarkably better than if applying only grinding.

This time the hybrid machining come to the front, which typically does not require another machine-tool, but together with hard turning grinding is done on the same machine-tool.

Figure 5 and 6 it can be seen that with the applied procedures in creating ground topography, economic efficiency can be reached similar to that of hard turning carried out by a standard insert. That is why for creating ground topography the combined version can be recommended because the operational time is hardly longer than in hard turning and the consumption of coolants and lubricants is one fifth of the grinding.

The consumption of the volume of coolants and lubricants is proportional to the time of grinding. Therefore it was also examined what the proportion of grinding is within the operational time in the different procedures, thus the consumption of CL. Hard turning, having the shortest operational time, can be done dry. If for the ground topography the total material removal is done by grinding, we get not only the longest operational time but the highest consumption of coolants and lubricants as well. In Figure 7 and 8 the portion of dry machining within the given procedure is also indicated. It is clearly indicated that in the combined procedure the consumption of CL can be reduced if the allowance to be removed by grinding is further reduced.

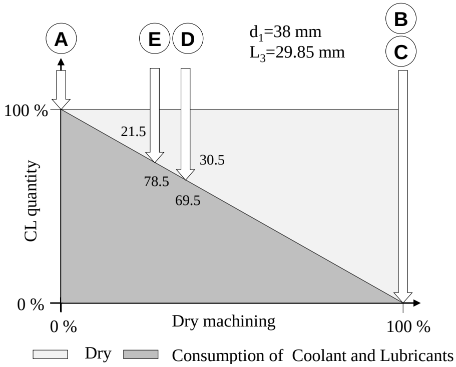


Figure 7 – The proportion of the use of coolants and lubricants in the different procedures

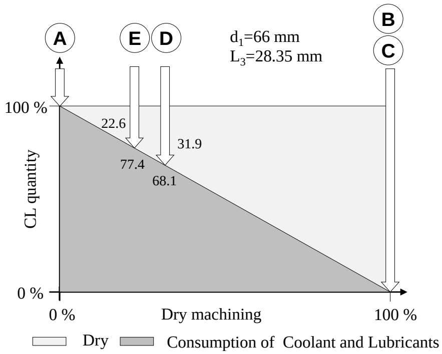


Figure 8 – The proportion of the use of coolants and lubricants in the different procedures

SUMMARY

A relatively wide range of hard machining procedures are available for the production of components. In this paper the different variations of grinding and turning applied in finish precision machining of hardened steels are presented on the basis of the used up amount of CL.

The results of the experiments have proved that there are significant differences in the consumption of CL in the procedures suitable to provide the given accuracy and surface quality.

At present, in most cases the technical and technological conditions for the application of hard turning are available, in which the machining can be done economically with no consumption of CL.

There are cases, however, when the functional conditions require ground topography. In such a case the so called combined (hybrid) machining is suggested.

Our investigations have proved that if the combined procedure includes a hard turning procedure besides grinding, the consumption of CL can be reduced to one fifth compared to grinding, having economic efficiency similar to hard turning, if the technological data are chosen properly.

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