# CUTTING TOOL COMPLEX COOL SYSTEM BASED ON PHASE CHANGED MATERIALS FOR DRY MACHINING

Cand. of Eng. Sciences Dubrov D.Y.[1], Cand. Of Eng. Sciences, Prof. Dubrov Y.S.[2], Cand. Of Ph.-Math. Sciences Prihodko G.I.[3]
Research Center «Diapazone-1»[1], Don State Technical University[2], Southern Federal University[3] – Rostov-on-Don, Russia

**Abstract**: *the paper presents a cutting tool complex cooling system (CCS) based on the use of the first-order phase transitions for cutting process thermal stabilization by prolongation of the fusible material melting (e.g., Rose's metal) with the help of the heat pipes.Combined cutting tools and mills with indexable inserts are designed and manufactured. The time of temperature stabilization, depending on the amount of consumable substance is calculated. It is shown that the size of the container with fusible substance can provide a melting time equal to or multiple of the execution time of technological operations.*
***KEYWORDS***: *HEAT PIPE, COMBINED CUTTING TOOL, PHASE TRANSITION, FUSIBLE MATERIAL*

## 1. Introduction

One of the trends of modern engineering is a growing interest in the "dry" cutting. In the dry processing we can receive a number of advantages, which include improving working conditions and increasing its efficiency by reducing costs due to the lubricant-cooling agents and their recycling. It is obvious that "dry" cutting is the most appropriate technology in the interrupted cutting especially in the milling process. In this case, the temperature in the cutting zone continuously varies within a wide range and can reach 1000°C . In this case there is a sharp change of temperature at the moments of entry and exit of the cutting edge from cutting zone. The cutting edge is thus subjected to thermal shock and cyclic stresses that can contribute to thermal cracking [1].

Scope of "dry" cutting applications is constantly expanding due to the fact that the treatment of a number of structural materials, particularly in machining of titanium alloys the use of coolants may affect their technological heredity.

## 2.Results and discussion

One of the ways of temperature stabilization (inhibition of the temperature increasing ) is the heat absorption with the help of changing the physical state of matter (evaporative cooling of open and closed types, the use of low-melting substances).

The application experience of the cooling with the help of phase-changed processes in other technical fields allows to make a conclusion about the validity of the same approach in the case of modular cutting tools. The results of the comprehensive study of the evaporate cooling system for combined cutting tools in the dry cutting were published [2] . The complex cooling system (CCS) was analyzed. CCS is based on the heat sink due to the absorption of latent heat of fusion of the working substance (Rose metal) with a melting point 96 $^0$C located in the container inside the holder and implanted heat pipe (HP). HP using allows to delay the melting process. The design of a modular cutting tool based on the standard cutter as well as the design of the combined mill are presented (Fig.1,2).

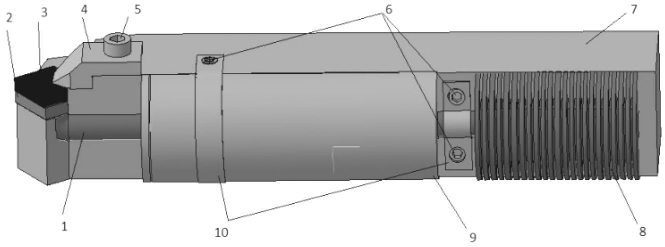


Fig.1 – cutter design with a container (Rose metal inside) and HP (1-HP;2-support plate;3-cutting insert; 4-clamp;5...6-screws;7-holder;8-HP radiator;9-container with fusible substance;10 -retaining clips)

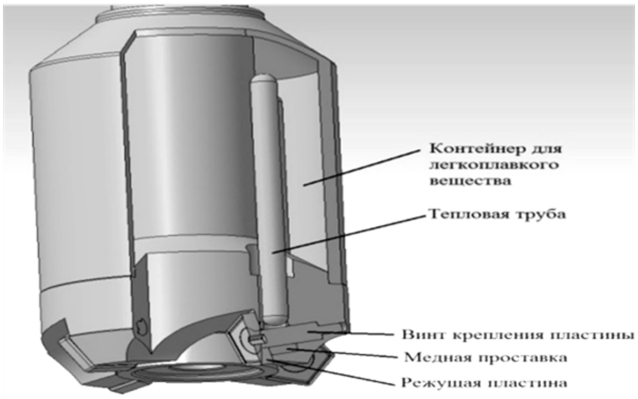


Fig.2 –Combined mill with integrated cooling system

The main problem is the phase transition state keeping for the working medium (Rose metal) for a long time as possible.

The ideal process during melting and solidification, can be represented as follows. During the cutting process the heat energy releases and the temperature of the low-melting working substance is growing up. Upon reaching the melting point the fusible substance begins to melt, turning into liquid phase. During this process a quantity of heat corresponding to a heat of fusion of the working substance is absorbing. The temperature on the border, "holder - working substance" would not be larger than temperature melting point of the substance, while there are liquid and solid phase. Thus, it is possible to speak about the possibility of a long temperature stabilization, which should lead to increased efficiency of the cutting tool.

On the basis of the solution of the Stefan problem, we have obtained the expression (1) to determine the time of complete melting of the working medium, τ,min [2...3].

$$\tau = \frac{L^2}{6a_ж\left[1 - \frac{\lambda_т qL}{\lambda_ж (T_{фп} - T_{держ})}\right]}, \qquad (1)$$

where

$L$-linear size of the container with a substance

$a_{ж}$ –thermal diffusivity

$\lambda_т$ – heat conductivity factor for solid phase

$\lambda_ж$ – heat conductivity factor for liquid phase

$T_{фп}$ – phase transition temperature

$T_{держ}$ – holder's temperature

$q$ – a constant value, caused by heat dissipating characteristics of the heat pipe.

The regulatory resistance determinism for «one tool» machining Tn = 30...60 min and for CNC machining Tn = 12...20 min [4] allows to estimate the linear dimension of the container with a working substance L.

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## 3.Conclusions

1. An alternative method of temperature stabilization under dry cutting is the absorption of heat by changing the state of aggregation of a substance, based on the use of phase transitions of the first kind.

2. Determination of the of the container with fusible substance parameters gives the opportunity to stabilize the optimal temperature of the cutting process and thus reduce the rate of wear of the tool cutting edge.

3. The temperature stabilization method for dry cutting can be applied in other types of the technological systems (deep hole boring, reaming, etc.).

## 4. Bibliography

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