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STUDY OF TEMPERATURE DEPENDENCE IN THE CUTTING ZONE ON COOLING CONDITIONS AND MACHINING TIME DURING MILLING WITH TWO-ANGLE ASYMMETRICAL HSS MILLING CUTTER

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Keywords: milling cutter, coolant, heat process, heat capacity, convection air, cooling mode, finite element method.
Abstract. The SolidWorks Simulation program employs the finite element method to model the process of groove machining by two-angle asymmetrical milling cutter under two different cooling conditions. The dependence of the temperature in the cutting zone on the machining time and the place of its measurement on the cutter tooth is considered. The results obtained on high-speed steel do not contradict the data obtained on hard alloy.

ИССЛЕДОВАНИЕ ЗАВИСИМОСТИ ТЕМПЕРАТУРЫ В ЗОНЕ РЕЗАНИЯ ОТ УСЛОВИЙ ОХЛАЖДЕНИЯ И ВРЕМЕНИ ОБРАБОТКИ ПРИ ФРЕЗЕРОВАНИИ ДВУХУГЛОВОЙ НЕСИММЕТРИЧНОЙ ФРЕЗОЙ ИЗ БЫСТРОРЕЖУЩЕЙ СТАЛИ

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Ключевые слова: фреза, СОЖ, тепловой процесс, тепловая мощность, конвекция воздуха, режим охлаждения, метод конечных элементов.
Аннотация. В программе SolidWorks Simulation методом конечных элементов смоделирован процесс обработки канавки двухугловой несимметричной фрезой при двух разных условиях охлаждения. Рассмотрена зависимость температуры в зоне резания от времени обработки и места ее измерения на зубе фрезы. Полученные результаты на быстрорежущей стали не противоречат данным, полученным на твердом сплаве.

In the presented work, the influence of cooling on the temperature in the cutting zone and the dependence of temperature on machining time at given cutting modes are considered. As a machining process, we considered milling of a groove with a two-angle asymmetrical milling cutter with a diameter of 63 mm [1]. The cutter material is P18, the workpiece material is steel 3. Using reference literature [2-4], we determine the cutting mode – depth $t = 6$ mm, feed per tooth Sz = 0,015 mm/tooth, cutting speed 10 m/min, rotational speed 50 rpm.

It is necessary to determine an appropriate cooling mode. In order to model the thermal process of cooling with air only at an ambient temperature of 20°C, it is necessary to use known methods [5]. The distribution of thermal power on the contact surfaces follows a combined law, with uniform distribution at the apex and linear distribution as we move away from the edge. The same approach was used in [6] to model the milling process in relation to the coolant feed rate. The entire surface of the milling cutter, with the exception of the edges engaged in the cutting zone and the hole for the holder, is assigned to air convection (Fig. 1).

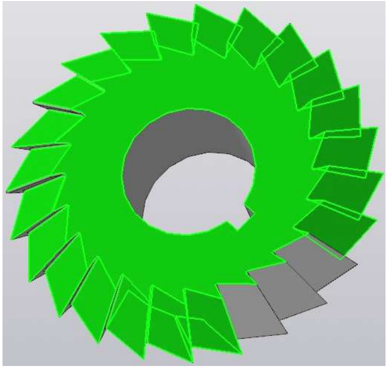

Fig. 1. Surfaces cooled by air convection

Figure 2 illustrates the outcome of this study. During the initial seconds of operation, the temperature reaches 1012°C. The red-resistance temperature of P18 is 700°C. It is not feasible to perform machining under the specified conditions without the use of coolant, as the temperature in the cutting zone exceeds the red-resistance temperature of the material P18.

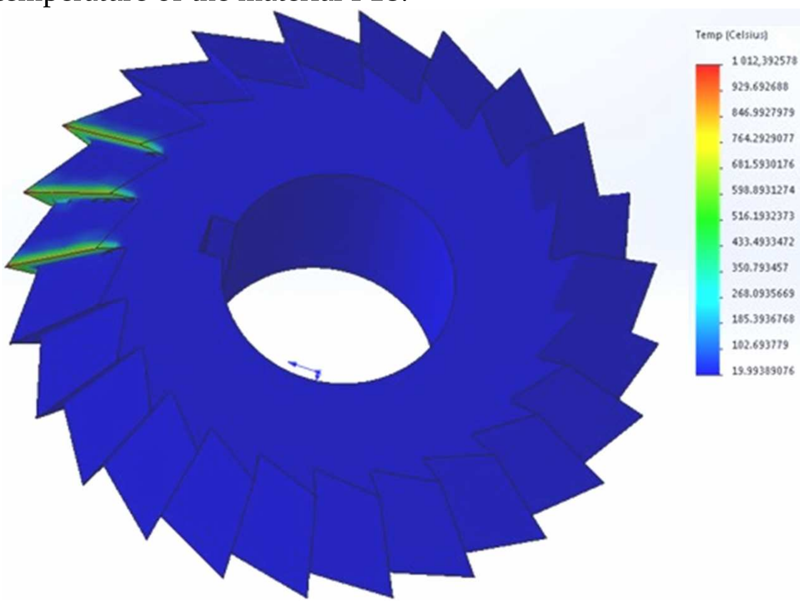

Fig. 2. Temperature in the cutting zone during air convection cooling

We now turn to the second variant of processing under the condition of natural convection by air and coolant supply. In order to model the unsteady thermal mode – transient process, we employ known methods [7].

Let us consider the total processing time within 360 seconds. We may preliminarily divide the time into intervals: 60, 120, 180, 240, 300, 330, 340, 350, and 360 seconds.

The value of the cutting part temperature, for all time intervals, is determined by three points, as illustrated in Figure 3.

The results of the thermal study at the controlled points of the cutter, over the entire time range, are presented in Figure 4.

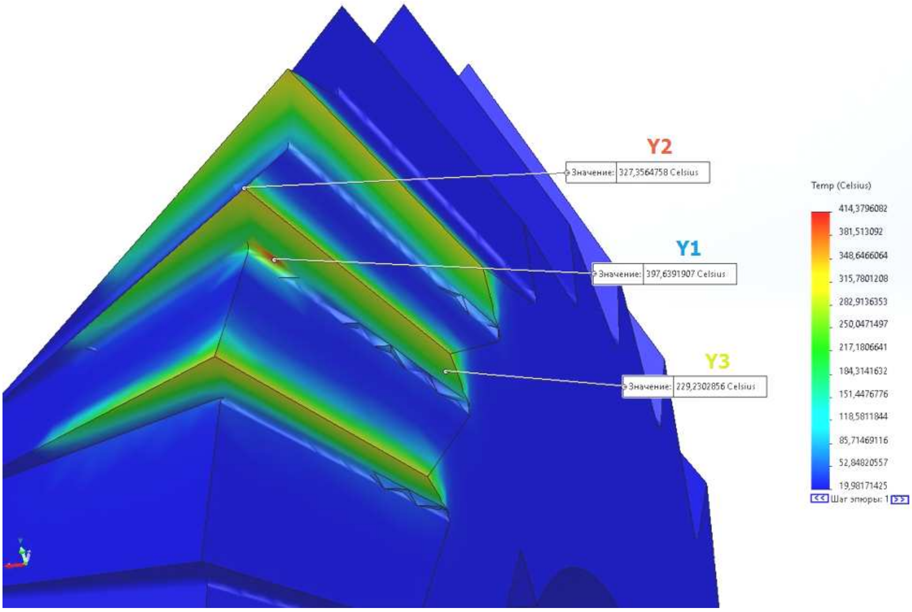

Fig. 3. Probing the temperature at point Y1 – at the base of the tooth, point Y2 – at the apex and point Y3 – at the periphery of the tooth

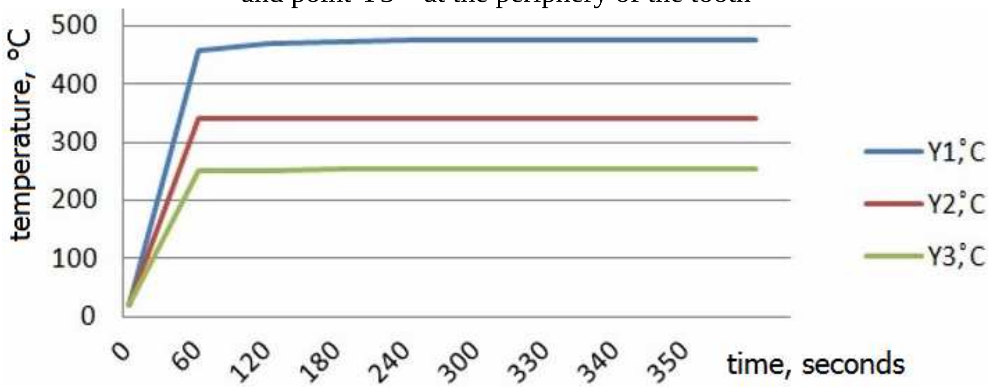

Fig. 4. Graph of temperature versus time

Conclusions

1. The initial study's findings indicate that, under the specified cutting modes, the absence of coolant renders machining impractical due to the elevated temperature within the cutting zone, which exceeds the red-resistance temperature of steel P18.

2. In combined cooling, the temperature reaches a value of 412 degrees Celsius in the initial phase, then gradually stabilizes at 477 degrees Celsius at 330 seconds, and subsequently ceases to grow significantly. A steady-state heat exchange is observed.

3. The temperature changes in the same points of the cutter were determined over the entire range of time. An increased temperature was observed at the base of the tooth, but not at the top of the cutting edge. This result is consistent with similar data obtained from experimental studies and modeling in the DeForm-3D program conducted at the Ufa State Aviation Technical University [8] on a coated carbide tool.

References

1. TU 2-035-526-76. HSS double-angle asymmetrical cutter.
2. Sakharov G.N., Arbuzov O.B., Borovoy Yu.L. et al. Metal-cutting tools: Textbook. – M.: Mechanical engineering, 1989. – 328 p.
3. Handbook of a machine-building technologist. In 2 vol. / Ed. Dalsky A.M., Suslov A.G., Kosilova A.G., Meshcheryakov R.K. – M.: Mechanical Engineering, 2001. – Vol. 1, 914 p. – Vol. 2, 944 p.
4. Kozhevnikov D.V., Grechishnikov V.A., Kirsanov S.V., Kokorev V.I., Skhirtladze A.G. Cutting tools: Textbook for universities. – M.: Mechanical Engineering, 2004. – 512 p.
5. Reznikov A.N., Reznikov L.A. Thermal processes in technological systems. – M.: Mechanical Engineering, 1990. – 288 c.
6. Baranov V.I.; Romashin, R.V. Influence of the lubricating-cooling liquid feed rate on the temperature in the cutting zone during the machine time, during milling of a titanium alloy // Computer-aided design in mechanical engineering. 2022, no. 12, pp. 45-48.
7. Engineering calculations in SolidWorks Simulation [Electronic resource]. – Access mode: http://www.iprbookshop.ru/7967.
8. Migranov M.Sh., Migranov A.M., Shehtman S.R. Cutting temperature at application of the tool with multilayer coating // Bulletin of Tver State Technical University. Series "Technical Sciences". 2021, no. 3(11), pp. 34-43.

Список литературы

1. ТУ 2-035-526-76. Фреза двухугловая несимметричная из быстрорежущей стали.
2. Сахаров Г.Н., Арбузов О.Б., Боровой Ю.Л. и др. Металлорежущие инструменты: Учебник. – М.: Машиностроение, 1989. – 328 с.
3. Справочник технолога-машиностроителя. В 2-х т. / Под ред. Дальского А.М., Суслова А.Г., Косиловой А.Г., Мещерякова Р.К. – М.: Машиностроение, 2001. – Т. 1, 914 с. – Т. 2, 944 с.
4. Кожевников Д.В., Гречишников В.А., Кирсанов С.В., Кокарев В.И., Схиртладзе А.Г. Режущий инструмент: Учебник для вузов. – М.: Машиностроение, 2004. – 512 с.
5. Резников А.Н., Резников Л.А. Тепловые процессы в технологических системах. – М.: Машиностроение, 1990. – 288 с.
6. Баранов В.И., Ромашин Р.В. Влияние скорости подачи смазочно-охлаждающей жидкости на температуру в зоне резания в течение машинного времени, при фрезеровании титанового сплава // Автоматизированное проектирование в машиностроении. – 2022. – № 12. – С. 45-48.
7. Инженерные расчеты в SolidWorks Simulation [Электронный ресурс]. – Режим доступа: http://www.iprbookshop.ru/7967.
8. Мигранов М.Ш., Мигранов А.М., Шехтман С.Р. Температура резания при применении инструмента с многослойным покрытием // Вестник Тверского государственного технического университета. Серия «Технические науки». – 2021. – № 3 (11). – С. 34-43.

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