INVESTIGATION OF CUTTING PARAMETERS IN MILLING OF DIN 1.2379 AND SLEIPNER MATERIALS

by

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In today's machining conditions, the goal is to produce the most suitable quality with the lowest cost. In order to minimize the problems of mouth spillage, especially those used in cutting molds, we have studied Sleipner material as an alternative material and examined the machinability parameters between DIN 1.2379 material used in the application. In this study, with the aid of a force gauge, the forces generated on the material during machining, the surface roughness values after machining with the help of surface roughness device and the temperature values of the materials during machining were measured with the temperature gauge. A total of twelve experiments were carried out for each material at three different chip depths at constant cutting speed and four different progressions for each chip depth. These experiments have been understood from the results obtained from the data that Sleipner material has shown a more stable structure and better results than DIN 1.2379. Thus, the negative manufacturing conditions that may occur during mold production and during mold operation are minimized. In this case, it is necessary to take into consideration the number of the parks produced in the mold and the frequency of mold usage in the material selection of the cutting steel of the cutting molds.

Key words: *Sleipner material, DIN 1.2379, cutting parameter, frequency, cutting steel, cutting mold*

Introduction

The researchers, continues for reducing the time and the cost required for manufacturing. Automated production and minimal processing are one of the most important goals of modern manufacturing [1]. To achieve this goal, it is highly prioritized to develop techniques to minimize the needs for intermediate processes in production [2, 3]. The technology is currently available to researchers and engineers in the manufacturing process. The control system developed with the combination of existing technologies reduces both production time and cost. One of the minor processes is the controlling the surface quality of the produced part. Determining the surface quality of each part is both costly and a time consuming job. Therefore, it is possible to reduce the time and cost allocated to quality control by improving prediction models and systems.

According to the *World Machine-Tool Output & Consumption Survey*, the global machine tool consumption in 2014 was $75.3 billion. Based on this report, the machine tool purchasing trends evidently show that the strongest manufacturing countries invest more on the latest machine tool technology. This is due to the fact that machine tools have a hand in

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manufacturing of every products in a wide range of industries such as biomedical engineering, nanotechnology, aerospace, automotive, home appliances, and so forth.

On computer numerical control (CNC) machines, the correct sizing and surface quality can be achieved by the correct selection of machining parameters [1]. The machining parameters are parameters such as cutting, feed, spindle speeds, depth of cut [3]. The selection of these parameters is usually made either according to the experience of the operator, the manual of the machine or the tool catalogues [4]. Nevertheless, it is difficult to determine the feed and cutting speeds that can provide the surface roughness and tolerance values specified in the manufacturing drawings [5].

The tribological properties of machined part surfaces are primarily affected by the surface shape [6]. Surface roughness is an important factor not only in traditional tribology fields such as wear, friction, and lubrication, but also in sealing, hydrodynamics, electricity and heat transfer [7, 8]. The most important factor in the industry is surface roughness. Surface treatments are affected by many variables. Reduced surface roughness depends on factors such as reduced depth of cut, proper feed and use of appropriate cutting speeds, increased coolant flow, cutting tool tip radius and large rake angle values.

Ozel *et al.* [9] emphasized what kind of results can be encountered in the working conditions of tempered AISI 1060 and AISI 4140 steels which are frequently used in practice and in the workings on the change of surface roughness as a result of random selection of machining parameters. In their work, low surface roughness values have been found to be achieved when using high radius cutting tools for both steels.

Their pilot tests with aluminum alloy samples showed that the surface roughness of the work piece, the micro hardness of the work piece, the permanent surface stresses and the dislocation densities changed depending on the tool tip radius. The surfaces treated with the blunt tool were found to be stiffer than those machined with a sharp tool.

In this study, one of the most important criteria in determining the surface quality in machining is the roughness value on the surface of the produced part. In the research, modern production is one of the most important targets of production, while also minimizing cost, increasing automation and minimizing processing for optimal efficiency [10]. To achieve this goal, it is highly prioritized to develop techniques to minimize the needs for intermediate processes in production. Technology therefore, leads researchers and engineers in the production process [11]. The control system developed with the combination of existing technologies reduces both production time and cost. One of the minor processes is the controlling the surface quality of the produced part. Controlling the surface quality of each part is both costly and a time consuming job. Therefore, it is possible to reduce the time and cost allocated to quality control by improving estimation models and systems.

Ebner *et al.* [11] measured the acoustic sound at high cutting speeds in the milling machine. Mishra *et al*. [12] attempted to estimate the CNC milling tool wear from the sound changes measured by the sensors in their work. Heng *et al.* [15] concluded that. It has been shown that the cutting tool changes the sound pressure under various cutting conditions and gives effective results. Mannan *et al.* [14] studied the relationship between surface quality and the analysis of the noise produced when the cutting tool during chip removal resulting from tool wear.

The aim of this study is to determine the advantages and disadvantages of each other by examining the cutting parameters of DIN 1.2379 and Sleipner materials used in cutting steels cut in sheet metal moulds.

Materials and methods

Working machines, appliances, and tools used in experimental work

Existing CNC machines have less heat rise and vibration than high speed CNC machines. Therefore, there is no need to be mechanically different according to the other machines. The difference in diameter and step determines the axial thrust and the progression in the desired advance values of the machine table through the rotational speed, the torque and the power of the axis motor and all of them.

The CNC machine used in experimental set-up is a milling machine which is a series of O-M series with FANUC control which can perform three axis linear and circular interpolation and it can perform ISO format programming in metric and imperial units. In this study, DIN 1.2379 and Sleipner steel has been chosen as it is widely used, fig. 1.

Figure 1. Johnford VMC-550 model CNC milling machine

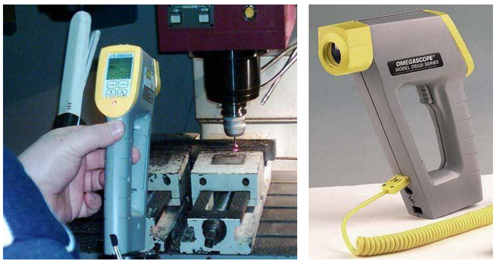


Figure 2. Non-contact temperature meter using infrared technology

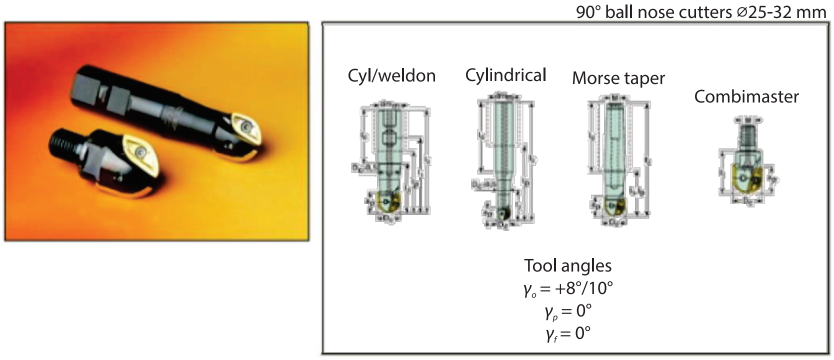
In production, quality control and maintenance processes, temperature is an important parameter that must be checked. By keeping the temperature under control, it is possible to improve product quality, increase production and avoid sudden stops in unexpected times. Which in turn makes it possible for enterprises to operate in the most favorable conditions. Especially in places where access is not possible, it is possible to measure the temperatures of the objects in motion without contact, fig. 2. The main features that are effective in non-contact temperature measurements are. The environmental conditions of the part are lens and optical system, IR detector, indicator and output.

Advantages of non-contact temperature measurement device include: increased production, reduced maintenance costs, developing quality, removing sudden stops, preventing energy losses.

Infrared thermometers. Since the temperature does not come into contact with the measured object, other production losses are considerably reduced. Infrared thermometers used in isolation-lines also play an important role in educing energy losses. The device used in this study is Omega’s OS532 infrared touch-type thermometer. They have many advantages over other types of thermometers.

Surface roughness measurement tool. Instruments measuring surface roughness with a penetrating tip measure or control surface roughness at the appropriate lengths and circumferences. In these tools, the drill bit penetrates into the recesses and protrusions which are moved over the surface. This movement is converted into electric current in a magnetic coil or crystal. This electric current is also magnified in the respective units and displayed with the help of a pointer or digitally, and if desired, the printer can be plotted in paper strips as a tip graphic. The cradle attached to the head of this device’s arm-shaped piece supports both the arm and the yoke during movement in certain directions. The movement of the probe tip looks better in the perspective view of the profile measurement geometry.

Team information used in experiment. The R218 obtained from experiment SECO carriers. The 20-2525. 3-22. 218. 20-125ER-ME07 F25M code insert insert used with 060A milling cutter is used. The R218. 20-2525. 3-22. The 060A code gives the mill scale, coupling type, kg values, maximum speed and torque values, fig. 3.



	Dimensions [mm]												Insert () = No. of inserts	
Part No.	D_c	dm_m	l_1	l_2	l_p	l_3	M	a_p	z'_p	kg		Type of mounting	218.20	SPM
Short cutting edge														
R218.20-2525.3-22.080A (DXF)	25	25	104	136	80	76	–	22	2	0.4	16900	Cyl/Weldon	–125 [2]	–
R218.20-2525.3-22.060A (DXF)	25	25	84	116	60	56	–	22	2	0.3	16900	Cyl/Weldon	–125 [2]	–

Figure 3. End catalogue information used

Experimental results and evaluation

The 1.2379 and Sleipner materials and SECO brand 218.20 copy milling set. The constant cutting speed of the milling tool is 130 m per minute. The materials were processed at three different chip depths (2.5 mm, 5 mm, and 7.5 mm) and the materials: f_x forces, surface roughness, and temperatures were investigated. It was measured according to the ideal cutting conditions of SECO brand tool tips, fig. 4.

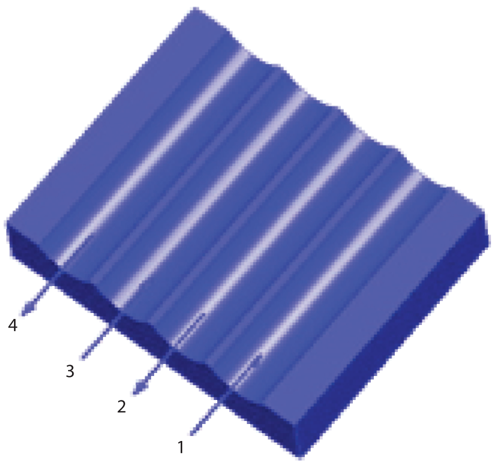


Figure 4. Cutting direction

In the experimental set-up. A force gauge is attached to the table of the CNC Milling Bench. The Sleipner and DIN 1.2379 materials prepared in the appropriate size are connected to the table of the force gauge with the order. At constant cutting speed at three different chip depths and feed values. A total of 30 experiments were performed. In these experiments, the vibrations generated in the x-, y-, and z-directions at the end of the cutting tool were detected by the force gauge while the force values in the f_x, f_y, and f_z directions were taken graphically by the force gauge. When machining is carried out, four rows of tracks are observed at each chip depth and in progress.

During the experiment. The 3 or 4 surface roughness values for each cutting direction were measured and averaged. At the beginning and middle of the experiment, the temperature was measured with a temperature gauge. As a result of the experiment. The 2nd and 4TH path data are used.

According to the determined experimental conditions and calculations. The obtained values are given in tab. 1.

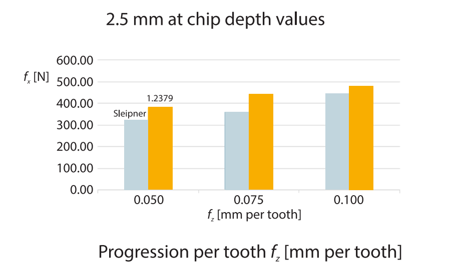
Table 1. Substrate roughness and temperature values at varying chip depths and in progress at Sleipner and DIN 1.2379 materials

Material	No.	a_p	V_c	N	f_z	v_f	Surface roughness [Ra]				Temperature 1	Temperature 2
	1	2.5	130	2758.686	0.05	275.869	1.18	0.99	1.7	1.3	44 °C	54 °C
	2	2.5	130	2758.686	0.075	413.803	0.86	1.27	1.4	1.1	46 °C	59 °C
	3	2.5	130	2758.686	0.10	551.737	1.37	1.95	2.8	2.3	48 °C	55 °C
	6	5	130	2069.014	0.05	206.901	1.11	2.98	1.3	1.6	55 °C	81 °C
Sleipner	7	5	130	2069.014	0.075	310.352	1.65	1.5	1.6	1.4	58 °C	85 °C
	8	5	130	2069.014	0.10	413.803	3.96	4.94	3.4	4.4	64 °C	86 °C
	11	7.5	130	1805.984	0.05	180.598	1.31	3.72	3.5	3.8	67 °C	88 °C
	12	7.5	130	1805.984	0.075	270.898	2.86	4.71	4.7	3.3	74 °C	98 °C
	13	7.5	130	1805.984	0.10	361.197	1.83	4.41	4.4	5.5	67 °C	99 °C
Material	No.	a_p	V_c	N	f_z	v_f	Surface roughness [Ra]				Sicaklik 1	Sicaklik 2
	1	2.5	130	2758.686	0.05	275.869	1.79	2.34	1.7	1.5	67 °C	86 °C
	2	2.5	130	2758.686	0.075	413.803	1.84	1.75	1.3	1.8	75 °C	80 °C
	3	2.5	130	2758.686	0.10	551.737	2.10	2.74	2.8	2.6	70 °C	86 °C
	6	5	130	2069.014	0.05	206.901	1.75	2.85	1.8	2.5	106 °C	126 °C
Sleipner	7	5	130	2069.014	0.075	310.352	2.62	2.81	2.6	2.9	93 °C	110 °C
	8	5	130	2069.014	0.10	413.803	2.29	3.7	2.5	2.5	85 °C	118 °C
	11	7.5	130	1805.984	0.05	180.598	1.75	2.44	3.2	1.0	115 °C	154 °C
	12	7.5	130	1805.984	0.075	270.898	1.93	2.54	3.0	2.6	116 °C	135 °C
	13	7.5	130	1805.984	0.10	361.197	2.92	2.29	3.2	1.2	115 °C	135 °C

Changing chamber depth, f_x force value, surface roughness, and temperature experiment

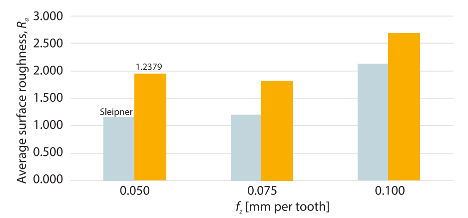
The 130 m per minute fixed cutting speed, 2.5 mm. in chip depth, and three different feed quantities (0.050, 0.075, and 0.100) were applied. Looking at the cutting forces, 1.2379 material was found to be more difficult than Sleipner material, fig. 5(a). Surface roughness value at 1.2379 was higher than Sleipner material, fig. 5(b). The temperature value has changed as the amount of progression increases. Sleipner material was slightly warmer than material 1.2379, fig. 5(c).

	2. ve 4. Kanal f_x Degeri	a_p	N	f_z	V_f
SLIPNER EXPERIMENT 01	320,00	2,5	2.758,686	0,050	275,869
SLIPNER EXPERIMENT 02	360,00	2,5	2.758,686	0,075	413,603
SLIPNER EXPERIMENT 03	445,00	2,5	2.758,686	0,100	551,737
1.2379 EXPERIMENT 01	380,00	2,5	2.758,686	0,050	275,869
1.2379 EXPERIMENT 02	440,00	2,5	2.758,686	0,075	413,603
1.2379 EXPERIMENT 03	480,00	2,5	2.758,686	0,100	551,737



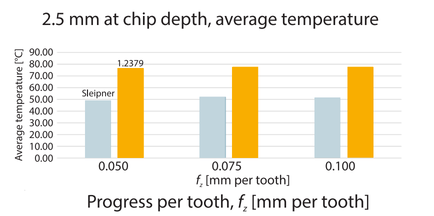
(a)

Material	a_p	N	f_z	V_f	Surface roughness, R_a		Average surface roughness, R_a
SLIPNER	2,50	2.758,69	0,050	275,869	0,990	1,30	1,145
	2,50	2.758,69	0,075	275,869	1,270	1,13	1,200
	2,50	2.758,69	0,100	275,869	1,950	2,30	2,125
Material	a_p	N	f_z	V_f	Surface roughness, R_a		Average surface roughness, R_a
1.2379	2,50	2.758,69	0,050	275,869	2,340	1,56	1,950
	2,50	2.758,69	0,075	275,869	1,750	1,87	1,810
	2,50	2.758,69	0,100	275,869	2,740	2,64	2,690



(b)

Material	a_p	N	f_z	V_f	Temperature [°C]		Average temperature [°C]
SLIPNER	2,50	2758,69	0,050	275,869	44	54	49,00
	2,50	2758,69	0,075	275,869	46	59	52,50
	2,50	2758,69	0,100	275,869	48	55	51,50
Material	a_p	N	f_z	V_f	Temperature [°C]		Average temperature [°C]
1.2379	2,50	2758,69	0,050	275,869	67	86	76,50
	2,50	2758,69	0,075	275,869	75	80	77,50
	2,50	2758,69	0,100	275,869	70	86	78,00



(c)

Figure 5. Cutting speed 2.5 mm at 130 m per minute, cutting depth; (a) average f_x value, (b) average surface roughness, and (c) average temperature

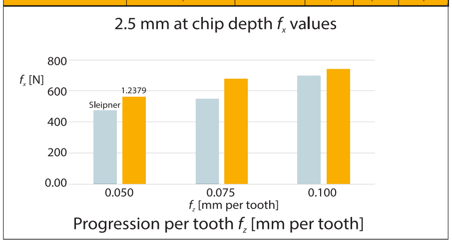
The 130 m per minute, at constant cutting speed, 5 mm in depth of cut, and three different feed rates (0.050, 0.075, and 0.100) were applied. When the shear forces were examined, it was seen that 1.2379 material had more difficulty compared to Sleipner material, fig. 6(a). Surface roughness value in 1.2379 material was higher than Sleipner material, fig. 6(b). The temperature value changed as the amount of feed increased. Sleipner material warmed less than material 1.2379, fig. 6(c).

Considering the f_x cutting force taken from the four different feeds (0.050, 0.075, and 0.100) made at a fixed cutting speed of 130 m per minute at 7.5 mm depth, the 1.2379 material is at 2.5 and 5 mm machining depth. It has been observed that it has more difficulty. Accordingly, the surface roughness value has increased more. Sleipner material was roughened more and 1.2379 showed a more stable structure, figs. 7(a) and 7(b). The temperature value increased with increasing progress. Sleipner material is less heated than 1.2379, fig. 7(c).

Conclusions

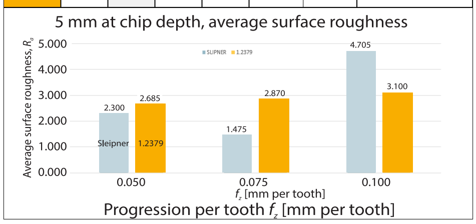
In this study, as a result of examining the cutting parameters between DIN 1.2379 and patented Sleipner materials in the cold work tool steel class. High abrasion resistance, high tempering resistance, high compressive strength, high dimensional stability in heat treatment, and high hardenability properties of the materials, as a result of the differences in the alloying

Sutunl	2. ve 4. channel f_x value	a_p	N	f_z	V_f
SLIPNER EXPERİMENT 01	475,00	5	2069,014	0,050	206,901
SLIPNER EXPERİMENT 02	550,00	5	2069,014	0,075	310,352
SLIPNER EXPERİMENT 03	700,00	5	2069,014	0,100	413,803
1.2379 EXPERİMENT 01	560,00	5	2069,014	0,050	206,901
1.2379 EXPERİMENT 02	680,00	5	2069,014	0,075	310,352
1.2379 EXPERİMENT 03	740,00	5	2069,014	0,100	413,803



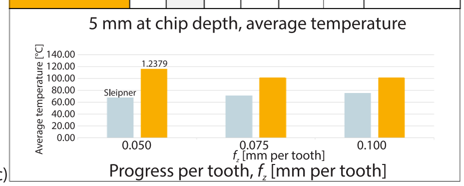
(a)

Material	a_p	N	f_z	V_f	Surface roughness, R_a		Average surface roughness, R_a
SLIPNER	5,00	2069,014	0,050	206,901	2,98	1,62	2,300
	5,00	2069,014	0,075	310,352	1,50	1,45	1,475
	5,00	2758,686	0,100	413,803	4,94	4,47	4,705
Material	**a_p**	**N**	**f_z**	**V_f**	**Surface roughness, R_a**		**Average surface roughness, R_a**
1.2379	5,00	2069,014	0,050	206,901	2,85	2,52	2,685
	5,00	2069,014	0,075	310,352	2,81	2,93	2,870
	5,00	2758,686	0,100	413,803	3,70	2,50	3,100



(b)

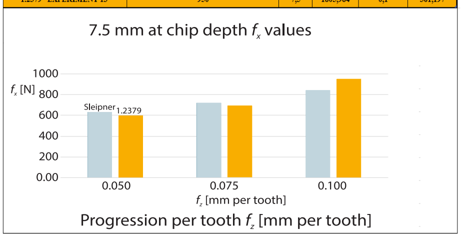
Material	a_p	N	f_z	V_f	Temperature [°C]		Average temperature [°C]
SLIPNER	5,00	2069,014	0,050	206,901	55	81	68,00
	5,00	2069,014	0,075	310,352	58	85	71,50
	5,00	2758,686	0,100	413,803	64	86	75,00
Material	**a_p**	**N**	**f_z**	**V_f**	**Temperature [°C]**		**Average temperature [°C]**
1.2379	5,00	2069,014	0,050	206,901	106	126	116,00
	5,00	2069,014	0,075	310,352	93	110	101,50
	5,00	2758,686	0,100	413,803	85	118	101,50



(c)

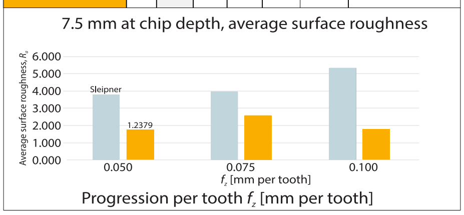
Figure 6. Cutting speed 5 mm at 130 m per minute, cutting depth; (a) average f_x value, (b) average surface roughness, and (c) average temperature

Sutunl	2. ve 4. channel f_x value	a_p	N	f_z	V_f
SLIPNER EXPERİMENT 11	630	7,5	1805,984	0,05	180,598
SLIPNER EXPERİMENT 12	720	7,5	1805,984	0,075	270,898
SLIPNER EXPERİMENT 13	840	7,5	1805,984	0,1	361,197
1.2379 EXPERİMENT 11	600	7,5	1805,984	0,05	180,598
1.2379 EXPERİMENT 12	690	7,5	1805,984	0,075	270,898
1.2379 EXPERİMENT 13	950	7,5	1805,984	0,1	361,197



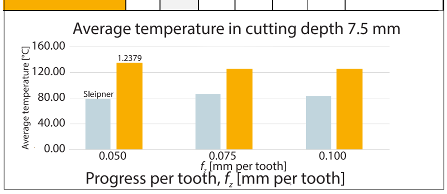
(a)

Material	a_p	N	f_z	V_f	Surface roughness, R_a		Average surface roughness, R_a
SLIPNER	7,5	1805,964	0,050	180,598	3,72	3,81	3,765
	7,5	1805,984	0,075	270,898	4,58	3,32	3,950
	7,5	1805,984	0,100	361,197	5,16	5,51	5,335
Material	**a_p**	**N**	**f_z**	**V_f**	**Surface roughness, R_a**		**Average surface roughness, R_a**
1.2379	7,5	1805,964	0,050	180,598	2,44	1,05	1,745
	7,5	1805,984	0,075	270,898	2,54	2,65	2,595
	7,5	1805,984	0,100	361,197	2,29	1,26	1,775



(b)

Material	a_p	N	f_z	V_f	Temperature [°C]		Average temperature [°C]
SLIPNER	7,5	1805,964	0,050	180,598	67	88	77,5
	7,5	1805,984	0,075	270,898	74	98	86,0
	7,5	1805,984	0,100	361,197	67	99	83,0
Material	**a_p**	**N**	**f_z**	**V_f**	**Temperature [°C]**		**Average temperature [°C]**
1.2379	7,5	1805,964	0,050	180,598	115	154	134,5
	7,5	1805,984	0,075	270,898	116	135	125,5
	7,5	1805,984	0,100	361,197	116	135	125,5



(c)

Figure 7. Cutting speed 7.5 mm at 130 m per minute, cutting depth; (a) average f_x value, (b) average surface roughness, and (c) average temperature

elements of the materials, their superiority to each other was observed. In order to observe the differences between materials, on the CNC milling machine, with the copy milling, constant cutting speed, changing depth of cut and feed per tooth are determined by considering the tool catalogue information and shown in tab. 1, the force f_x coming to the material in the x-direction, the surface roughness value measured as a result of the machining and the temperature values measured during processing were obtained as a result of the experiment. During the experiment, the f_x, Ra, and °C values found for the feed per tooth of 0.050, 0.075, 0.100, and 0.125 mm at cutting depths of 2.5 mm, 5 mm, and 7.5 mm and each cutting depth were compared with the graphs for the two materials. As a result of this. Looking at fig. 6 for 2.5 mm depth of cut, it was seen that 1.2379 material had more difficulties during processing. Accordingly, the surface roughness value is higher than the Sleipner material. The temperature value increased with increasing progress. Sleipner material is less heated than 1.2379. Looking at fig. 7 for 5 mm depth of cut, it is seen that 1.2379 material is forced more than 2.5 mm machining depth. Accordingly, the surface roughness value has increased more. At 0.100 and 0.125 mm feed, it was roughened 1.2379 more and Sleipner showed a more stable structure. The temperature value increased with increasing progress. Sleipner material is less heated than 1.2379. Looking at fig. 8 for 7.5 mm depth of cut, it is seen that 1.2379 material is more difficult than 2.5 mm and 5 mm machining depth. Accordingly, the surface roughness value has increased more. Sleipner material is roughened more and 1.2379 showed a more stable structure. The temperature value increased with increasing progress. Sleipner material is less heated than 1.2379. As a result, Sleipner material, which is shown as an alternative material in order to minimize the spout problems in cutting dies, has a more stable structure than DIN 1.2379 material. Considering the unit prices of the materials, the quality of the mold and the number of sheet materials to be printed in the mould, Sleipner can be accepted as an alternative and it has been observed that better results are obtained.

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