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Full Length Research Paper

The effect of water absorbtion in cast PA6G material on processing parameters

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In this study, parameters that effect metal cutting process of cast PA6G (Castamide) material whose usage area in machine design and production has been increasing is investigated. Castamide is an engineering plastic whose mechanic strength values are high, durable towards corrosion and suitable for metal cutting. However due to the physical feature of the material; it has the feature of water absorbing in about 7% rate. The amount of water in castamide materials influences the processability of the material and average surface roughness. The average surface roughness values of dry and humid castamides that is under same conditions wants to be observed, the best cutting conditions were detected. Therefore, the parameters of cutting speed, feed rate and depth chip changed in defined for conditions. Experiment showed that the amount of humidity in castamide materials is an important factor for average surface roughness.

Key words: Metal cutting processes, water absorbing, average surface roughness.

INTRODUCTION

In the process of engineering the surface quality is one of the indicators of the material quality. Surface quality which is aimed to attain in metal cutting processes is controlled by the measurement of surface roughness. There are many factors that effect the formation of surface roughness. Factors such as the type of used cutting tool, the type of material, cutting conditions influence the formation of surface roughness. Surface roughness also influences the features of materials such as fatigue resistance, corrosion, friction, heat conduction (Özel and Karpat, 2005; Tonshoff et al., 2000; Wang and Chang, 2004).

Usage of engineering plastics has been constantly increasing together with technological innovations. Today it has a wide range of usage from aerospace industries to construction industry. There are different types and characteristics of engineering plastics. Polyamides are one of these most widespread plastic types (Davim et al., 2009). The type which is obtained as casting and whose mechanical features are improved with additives is called cast polyamide or Castamide with its specific industrial name. Castamide takes place of many metals being a cheap, easily processed, light, high-resistant, abrasion resistant and quiet working engineering material. It is more preferred because of being cheaper than metals such as aluminium, copper and brass.

Many studies have been carried out for different characteristics of polyamides since 1960's when they are got to be used as an engineering material to this day. Some of these studies are based on their friction condition (Adams, 1963). Friction force of dry castamides which do not contain any lubricant are lower than other metals. In order to decrease this friction force even more; different lubricant are added in castamide materials (Samyna et al., 2007; Palabiyik and Bahadur, 2000; Samyn and Tuzolana, 2007; Liu et al., 2006).

With the feature of adding lubricant in the castamide materials; operating life of machine elements such as frictional bearings, shafts, slides and cams are extended. Castamide materials are processed with metal cutting. Workability of different polyamide types, cutting force and average surface roughness observations are other area of experiment. A lot of parameters such as cutting types, cutting speed, cut of depth; material used etc., can be effective on cutting force and surface quality (Davim et al., 2009; Mata et al., 2006). Studies carried out upon surface roughness are studied on a wide range from micro cutting conditions to the effect of cutting

Table 1. Physical features of PA6G (Castamide).

		Test method		
Properties	**Unit**	**DN**	**ISO**	**Value**
Specific gravity	gr/cm^3	53479	1183	1.15
Service temperature	0°C	53461	75	100
Melting point	0°C	-	-	1900
Thermal elongation	$1K^{*}10^{5}$	53752	-	8-9
Pulling resistance	N/mm^2	53455	527	55-85
Pulling elongation	%	53455	527	-
Breaking resistance	N/mm^2	53455	527	88-90
Breaking elongation	%	53455	527	10-40
Stoke resistance	Kj/m^2	53453	179	-
Elastic module	N/mm^2	53452	178	39000-4200
Water absorption	%	53495	62	6-7
Resistance as per vol.	Ω X cm	53482	167	>10^{15}
Resistance as per surf.	Ω	53482	167	>10^{12}

Figure 1. The pictures of experiment setting. (a) CNC machining (b) Surface roughness measurement.

parameters upon surface roughness (Wang et al., 2005). Generally; cutting conditions, cutting tool geometry, cutting tool type, usage of coolant, rigidity of machine tool, cutting method and the type of material used have effects on average surface roughness in metal cutting process. Cutting parameters feed rate, depth of cut, cutting speed, cutting edge number of cutting tool have effects on cutting process (Ertakin et al., 2003 ; Dabade et al., 2003).

Apart from excellent mechanical features, castamide materials have the characteristic of dehumidification up to 7%. Although process conditions have not changed for dehumidified castamide material, expected average surface roughness value change. Experiments carried out confirm this result as well (Bozdemir, 2010; Bozdemir and Aykut, 2010).

EXPERIMENTAL

Castamide material in 46 mm. plates that is used in the experiments is supplied from Polimersan firm. It is named as POLIKES® PA6G firm product catalogue. PA6G obtained in plates are cut in dimensions of 112x82x46 mm and are kept in humid and dry place. Physical features of castamide are given in Table 1.

Humid and dry samples are processed in TMC500 CNC vertical machining centre. Cycle of bench can be adjusted between 60-6000 cycle/min. Carbide cutting tools that is used is 14 mm. This cutter is produced in the standards of DIN, has four cutting edge, has the features of 30° helix angle, 87.7% WC rate, 12.3% cobalt rate, TRS 4200 MPa, 92.5 HRA Rockwell rigidity, 0.5 µm particle size, high abrasion and effect ability. Cutting tools are bound to spindle with the help of pincers. By making use of cutting parameters; cutting speed, feed rate, depth of cut and humid/dry castamide material in milling process; average surface roughness are detected. The picture of experiment setting can be seen in Figure 1.

Experiment samples that are kept as humid and dry in keeping conditions are processed in cutting conditions specially designed for CNC environment. Coolant is not used while carrying out experiment in CNC. Cutting conditions can be observed from Table 2.

Average surface roughness values detected are recorded on computer. For the measurement of roughness, MarSurf PS1 portable surface roughness measurement equipment is used.

Table 2. Cutting conditions.

Cutting factor	Symbol	Levels				
Material	M	humid			Dry	
Feed rate (mm/min)	f	100	120	140	160	
Depth of cut (mm)	a_p	1	1.5	2	2.5	3
Cutting speeds (m/mm)	V_c	90	110	130		

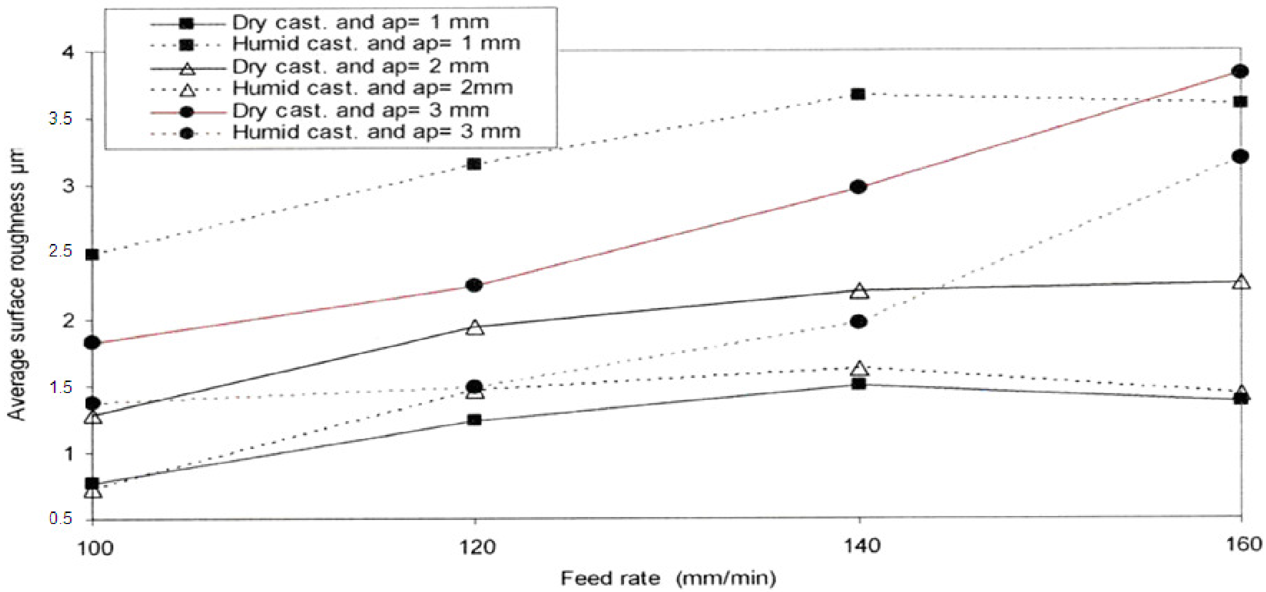


Figure 2. The relationships between feed rate and depth of cuts.

Measurement needle has the measurement diameter of 2 µm and pressure force is averagely 0.7 mN. Measurement scanning length is adjusted as 5.6 mm. There is an air conditioning in CNC laboratory where the measurements are carried out and average room temperature is 21±1˚C. The processes are carried out in CNC laboratory in 45% relative humidity condition. After 30 days of keeping in water for humid castamide materials, 7% dehumidification is carried out on average.

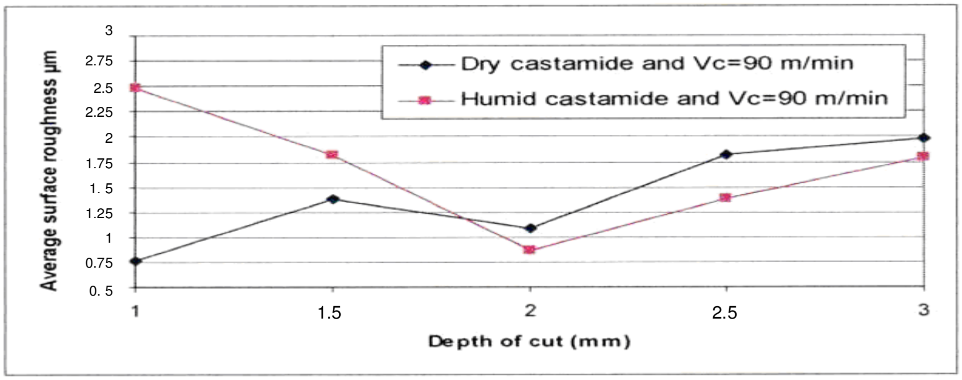
RESULTS AND DISCUSSIONS

In this study, workability of humid and dry castamide materials on CNC vertical machining centre and the surface quality after the process are studied. Humid and dry castamide materials are processed by sing same cutting conditions: (1, 1.5, 2, 2.5, 3 mm) chip thickness, (90, 110, 130 m/min) cutting speed and (100, 120, 140,160 mm/min.) feed rate. Average surface roughness values are measured and recorded.

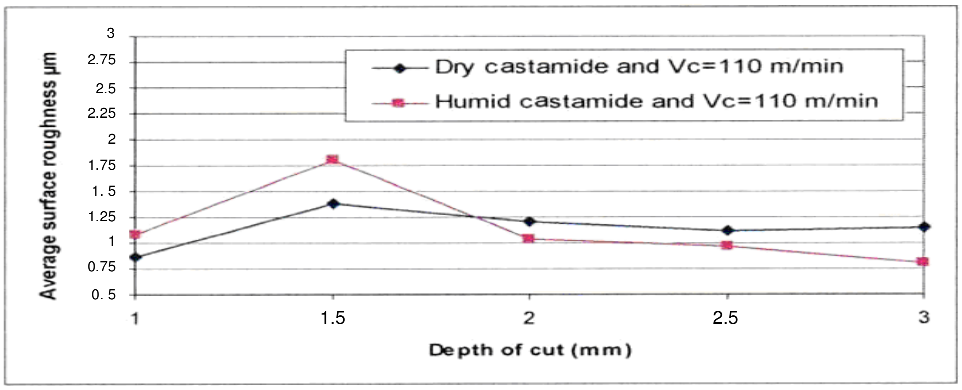
The effects of cutting speed, feed rate and depth of cut of dry and humid castamide materials are observed in the sense of average surface roughness. In Figure 2, the effect of feed rate which is applied in different cutting depth rates on average surface roughness is shown. Same cutting conditions are applied on dry and humid castamide materials and they are same figure. It is generally seen that increasing feed rate brings negative effect on the surface roughness. The point that paid attention in Figure 2 is that, as the depth of cut increases the value of average surface roughness that occurs gives better results in humid material. In the event of depth of cut being low, surface roughness of dry castamides are low.

Average surface roughness that occurs in 90, 110, 130 m/min cutting speeds and 100 mm/min feed rate are observed related to chip thickness and they are shown in Figure 3.

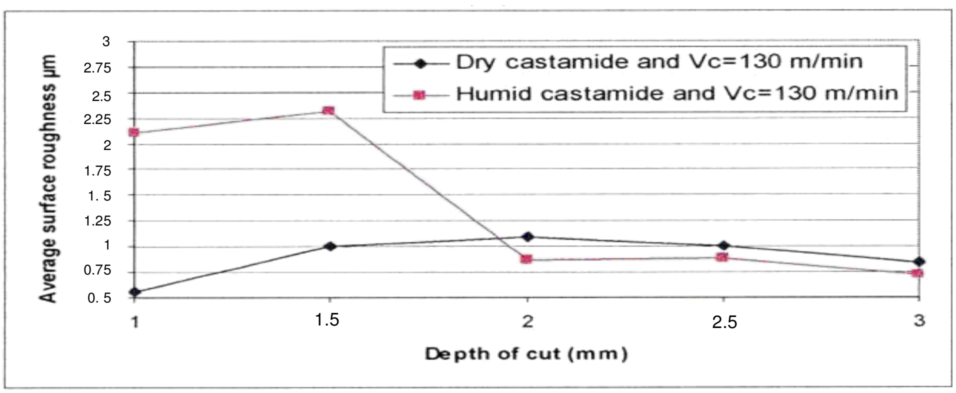
In Figure 3(a), it is seen that in the event of cutting speed being 90 m/min, as the depth of cut increase and average surface roughness deteriorates. In the other figures in which the cutting speed increase the effect of depth of cut decreases. However, average surface roughness value which is foul in low depth of cut for humid material begins to give better results in humid castamide after 1.8 mm depth of cut compared to dry castamide. Similar results can be seen in Figure 3(b) and (c). If the graphics of cutting speed in Figure 3(a), (b) and (c), are generally evaluated; it can be seen negatively



(a)



(b)



(c)

Figure 3. The relationships between cutting speeds and depth of cuts. (a)Cutting speed=90 m/min and feed rate =100 mm/min. (b)Cutting speed=110 m/min and feed rate =100 mm/min. (c) Cutting speed=130 m/min and feed rate =100 mm/min

that effects surface roughness for humid and dry castamide increases the cutting speed. In case of low cutting speed and low depth of cut for humid castamide; the value of average surface roughness increases.

A change in graphics of cutting speed, depth of cut and average surface roughness value for humid and dry castamide materials are given in Figures 4 and 5. While the increase of cutting depth is evaluated to be negative for dry castamide, increase of both depth of cut and cutting speed cause better formation of average surface roughness for humid castamide.

Conclusion

In this study, the observation of dehumidification feature of castamide materials which has a wide usage area in today's industry in the sense of processability and

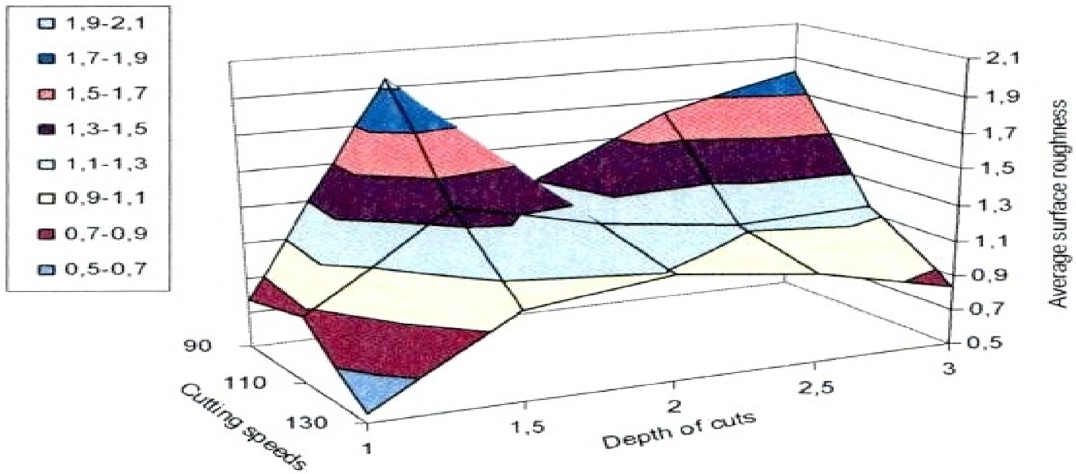


Figure 4. The average surface roughness values for dry castamides.

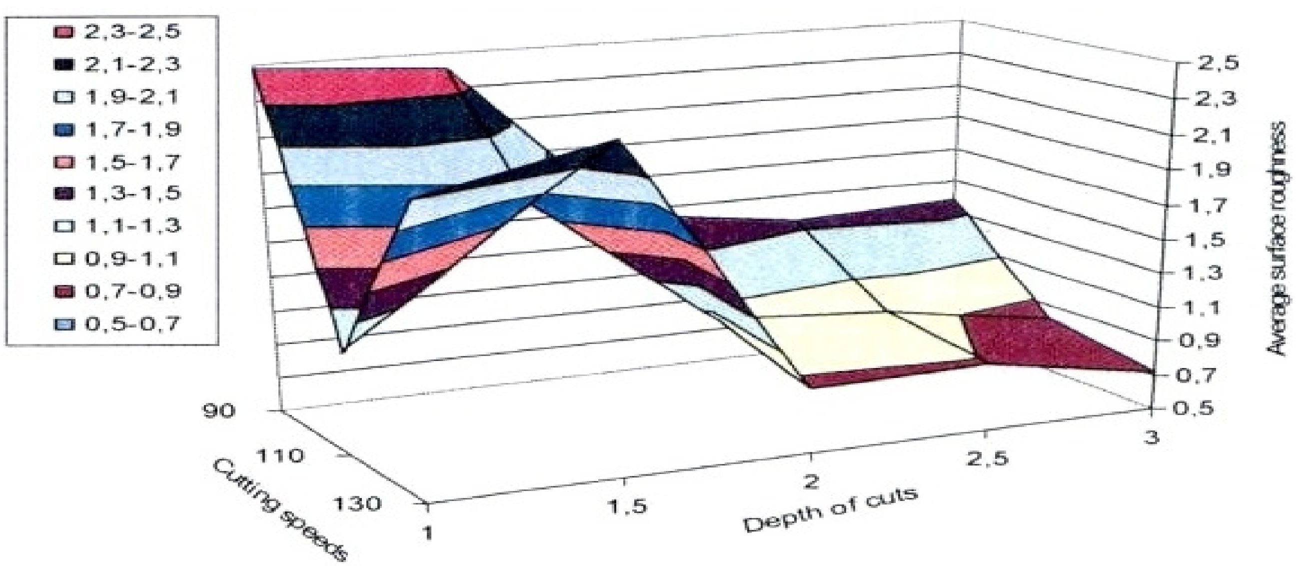


Figure 5. The average surface roughness values for humid castamides.

average surface roughness formation is carried out. Castamide materials that are prepared after kept in humid and dry environment are processed with same kind of cutting tool in (1, 1.5, 2, 2.5, 3 mm) chip thickness, (90, 110, 130 m/min) cutting speed and (100, 120, 140,160 mm/min) feed rate. The results below are obtained as the result of process and measurements carried out under the detected cutting conditions:

1) While the increase of cutting speed in humid and dry castamide materials influence average surface roughness positively, increase in feed rate may influence negatively.
2) While the increase in depth of cut for dry castamide causes negative average surface roughness, humid castamide materials show better average surface roughness value under same conditions.
3. High feed rate and low depth of cut influence average surface roughness value more negatively in humid materials.
4) The case of cutting depth being around 1.8 mm is the common surface roughness formation point for humid and dry castamide materials. After this point more chip thickness gives positive results in humid materials, negative results in dry castamide.

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