Experimental Investigation of Surface roughness of Polypropylene Polymer using TNMG Insert

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Abstract-This paper investigate the effect of cutting insert Radius and feed rate on Ra value of surface roughness of the Polypropylene Polymer-PP. According to previous study it is observed, Surface roughness significantly influenced by insert nose radius and feed while turning operation. Hence, this experimental investigation focuses on the on the effect on the nose radius and feed on Ra value roughness, vibration and cutting temperature. Lathe machine used to conduct the experiment with varying spindle speed, Feed rate and Depth of cut. Turning operation has been done by three types of TNMG inserts such as TNMG 160404, 160408 and 160412. While machining Polypropylene Polymer-PP. The Ra value of the surface roughness usually decreases with increases in nose radius. The relationship between cutting speed and nose radius to Ra value is inversely proportion. Feed and depth of cut directly promotional to Ra value. There is less influenced between vibration to temperature and vibration directly influenced on surface roughness.

Keywords: Polypropylene Polymer-PP, Surface roughness, TNMG 160404, 160408, 160412

1. Introduction

In 1951 P. Petrolem, J. Hogan and R. Bnks first time introduced the Polypropylene. In the manufacturing industry; Polypropylene known as a PP. [1] Polyoxymethylene is thermoplastic engineering material extensively used because it has better mechanical properties. [2] Aim of this paper is to investigate machining parameter optimization for Polypropylene Polymer-PP. To obtained lower cutting temperature, lower vibration amplitude, lower Ra value and higher MRR (Material removal rate). The Vc (cutting speed), (f) feed, (ap) depth of cut were analyzed. Experiment has been conducted on Lathe machine. Turning operation performed on PP material by the TNMG insert. [3] In these recent days of globalization the customer demand increased personalized. Customer demands, desired quality product with minimum cost. It is forced modern manufacturing to manufacture quality product in less manufacturing time and time and cost. Hence, to achieve desired results; industries adopting the new technology which change the Manufacturing scenario, it exploring innovation quality, and provide freedom for manufacturing process. It would help to improve quality, economical, reliable, and sustainable of product.[4] In the industry 4.0 technology the use of polymer drastically increased in the various industries and manufacturing field. It is happened, due to polymer's unique properties such as low density, better corrosion resistance, good specific strength and modulus, better damping properties, low friction; with highest thermal and electrical insulation properties etc. [5] metal machining requires the external lubrication whereas polymer material gives same quality of result even without external lubrication. Therefore polymer material are used mostly all applications such gear, bearing, rolling elements, medical, structural, and chemical instruments. [5] Also, the cost and weight of the polymer material is low as compared to metal. Use of plastic is rapidly increasing because; plastic material gives high accuracy with better surface. Mostly desired output achieved by machining process such as Milling, Turning, Drilling etc.

The essence and nature of the polymer and polymer composite are different. Hence, different polymer machining parameters need to study separately. According to literature many research work carried out regarding the metal as compared to polymer material, therefore it is required to study the polymer machining variables. [2] Economical machining is the hard task along with productivity and effectiveness in the manufacturing process. According to the industrial scenario the metal parts are replaced with polymer material due to their high elastic property. Here it is important to manufacture such parts which are suitable for assembly product, polymer material has limitation such low melting point and high Ductility of machining process and parameters are very difficult task. [6] In the manufacturing industries such as civil, aircraft, automobile; polypropylene material is widely used now a day because of its superior properties. Mostly matrix based fiber glass polypropylene used to enhance the quality of the product. It is machining process because of anisotropy, limited plastic deformation and inhomogeneity. Surface finish is the essential characteristic in many assembly products due to requirement of accurate fits. Contact lens is the best example of this [7] In optical industry; requirement of better surface finish and dimensional accuracy are essential. Hence selections of optimal machining parameter and selection of measuring techniques and experimental design are important in contact lens machining. Final surface quality depends upon tool charterer such Cutting angle rake angle nose radius etc. along with input parameter such as cutting speed (Vc), Feed (f) and depth of cut (ap). Polypropylene along with polymer material such as nylon, Polymide, CFRP AND GFRP studied to enhance the knowledge about the polymer material regarding their use, machining performance and to investigate the optimum machining parameters. [8] Nylon and polypropylene are mostly used for industrial product such as precision equipment, electronics and optics. These two materials have the better surface finish and accuracy. It fulfill requirements of industry [9] Cast nylon is polymer, its properties are different than metal according to physical and chemical properties. Also it has different dimension properties such as size, shapes, internal structure and surface texture. Hence Nylon is difficult to machining even for surface roughness evaluations. [10] Various parts of machine are made of lightweight material by using the different polymer material. In the polymer material category, Nylon is the special polymer material. Nylon has lower density with higher tensile strength as compare with steel. Hence it is difficult for selection of machining parameter while machining the Nylon polymer. Because the quality of the product is directly affected by the machining process, process parameters and cutting tool geometry. [11] Polymide composites material widely used in manufacturing, Automobile and Aerospace, robots, mechatronics and processing industries due to their mechanical and chemical properties. Polymide manufactured by the injection molding and extrusion methods hence it is require post process. Mostly machining is used to convert this raw product in to finish product. This product aims acceptable surface quality, high dimensional accuracy. Mostly Polymide product manufactured by the injection molding process because, injection molding is low manufacturing process. Generally gears cams and bearing parts are manufactured with it. Polymide has good wear resistance properties as compare to other polymer material. [12] Due to nanocomposite explored the new class of material and hence the use of polymeric nanocomposites is rapidly growing in the various manufacturing industries. It has good physical, mechanical, thermal, and chemical properties. Mostly this product is manufacturing with extrusion method, but recently the trend is changed. Now many industries using machining process to obtain the desired parts by the polymeric nanocomposites. Calcium carbonate becomes the most widely used filler in the polymeric industries. [13] Glass fiber reinforced polymers (GFRP) composite is the best option to alter the different material hence; it is used in various applications. It is suitable at oil, gas and corrosion environment. There is large demand of such composite polymer in industries to manufacturing different product. It is ability to fabricate near-net shape components. But it needs more efforts to find out the machining parameter. As known that, metal cutting developed mainly for the continuous solid material. Fiber materials are different from the metal. Which are mostly consists of fiber layers or separate fiber arrangement hence discontinuity creates in the fiber products while machining it. [14] Glass fiber reinforced polymer enhances reinforcement with adding the glass fibers. It alters the properties of GFRP and makes it more suitable for engineering products. Even plays crucial role in the various engineering field as an alternative for different heavy materials.[15] CFRP Composite has better mechanical properties such as stiffness, corrosion resistance, with high strength to weight ratio. Hence, it is used in the aircraft and manufacturing industries. It is also performed satisfactory under extreme environment. For example, currently military aircraft products are under study due to weight and cost saving that may carbon fiber reinforced polymer provide. It is difficult to understand their micro structure along with uneven or non-uniform fiber layers make it difficult to predicate the machining process parameters. This introductory part gives overview of the different Polymer and composite material mostly the work is done regarding the Ra value and MRR. With observed results regarding surface roughness and MRR mentioned, It is experimentally observed [1] PP has good tensile strength and stiffness. It is widely used in engineering products with huge satisfaction of customers. Stated Polypropylene given better surface roughness Ra value 0.5 micron observed at the combination of cutting speed RPM 4100, f 1200 mm/min. and ap 0.5. [3] Worked on polypropylene (pp) material, surface roughness measured while machining of PP with milling machine. It was noticed that, the higher Speed, Feed and Depth of cut, results in higher surface roughness.[8] With experimentally it is observed that in the both Nylon and polypropylene; Feed influenced Surface roughness of the product. MRR directly affects the flatness because these are the softer polymer materials. The surface quality also affected with insert clearance angle the smaller insert clearance angle results in better surface finish then the larger insert clearance angle. It was happened because friction between tool and work piece interface which will affects the machining quality. [6] While turning PP the Ra value increased; when feed increases and decreases with cutting speed but, tool material has less tool material has less influenced. [9] Experimental work is done on Nylon with cutting speed range was between 58m/min to 110m/min, Feed 0.05 to 0.20mm/rev and depth of cut 1.25mm to 4.25mm. Obtained results were observed, for forces and Ra value was 7N - 55N and Rz 22 - 60 microns respectively. [10] The results indicated the forces increased with higher Spindle speed and Depth of cut. Surface roughness Ra value is mostly affected by the Feed rate. While machining Nylon material. [16] From the experimental work it is identified that Ra value decrease with increases Vc and feed decreases. Minimum Feed gives the better Surface finish. Better surface finish can be achieved by high Vc, ap and minimum f (Vc 1400m/min, f 0.1 and Doc 0.3mm) while machining Nylon6/6. [11] Polymide composite material machined with PCD tool and found that lowest cutting forces while machined with uncoated carbide tool; best surface finish achieved. [13] Surface roughness, f was mainly influenced the Ra value for glass fiber reinforced polymer followed ap. Depth of cut (ap) and tool nose affect the MRR. The interaction effect of Vc and tool nose radius influenced Ra value as well as for material removal rate. [12] While turning the PA6/NCC composite material; less cutting forces generated than pure PA 6. Even the surface roughnesses for both composites were similar. [7] Stated Vc is most effective parameter while machining ONSI-56 Contact eye lens. Best Ra value 6micron observed at 2000 rpm, 7micron feed and 25micron depth of cut. [14] Glass fiber reinforced polymer. Noted that, Vc is significant input factor for Ra value of GFRP. [15] Experiment has been done on CFRP under the dry and MQL machining. Highest Cutting forces were observed while dry turning of CFRP at lowest feed rate. Using MQL these cutting forces observed less along with quite small better finish. [4] With several levels of experiments, it is observed that ap is more significant for minimum Ra value of HDPE and Vc influenced on both PA6 and HDPE material. MRR is influenced by Feed both materials. [3] There were little research has been done on machining of the polypropylene, according to optimal machining parameters. [16] Surface roughness is an important parameter and plays important role in product manufacturing. For better surface finish, machining process require high cost because it is undesirable but unavoidable at same time. Therefore proper selections of input parameters are necessary while machining the polymer material to achieve the good surface finish product in low cost and low time. [9] Whatever, the developed model focused on the metal such as cast iron, steel etc. but, less research has been done on the nonmetal such as polymer material. Even it has be found that till no one has done any research work on cutting temperature or vibration generated during Polypropylene polymer machining. Considering TNMG inserts of different nose radius has not been used for machining various polymer materials. Some literature review mentioned here regarding metal machining with TNMG inserts. [17] Worked on 1045 steel material with TNMG 160404PFand 160408PF. observed that increased Tool nose radius affecting cutting power. For better surface combination suggested as higher Vc, f, and tool nose radius. [18] Experiment conducted on EN24. Turning operation has been done by the TNMG 160404,160408 and 160412. Cutting insert along with ISO Coded ETJNL2525M16 cutting tool holder used. Tool nose radius, Feed, Doc. and affected the surface roughness 65%, 25%, 3.06%, 1.4%, 0.09% respectively. [19] Stated that, low feed and high tool nose radius with higher cutting speed, influenced for minimum surface roughness while machining AISI 1040steel. Contour and 3D surface plot helpful to identify the optimum variable parameter for minimum Ra value [20] Used Responses Surface Methodology (RSM) for optimization of surface roughness variable for Co28Cr6Mo medical alloy. Found results that insert tip radius and feed rate contribute more than other variables. Insert tip radius 38% and feed rate 33%. Minimum Ra value recorded at Vc 318rpm, f 0.1, ap 0.7 and 0.8mm nose radius. [20] Stated that, Ra value increases as the nose radius decreases. For surface roughness Vc and nose radius have an inversely proportion. Feed rate and depth of cut directly promotional to surface roughness. [21] Different three TNMG insert were used to machining Al.7075 and circularity, cyliendricity, Ra value and MRR. Optimum parameter found were Vc 283m/min, f 0.17mm/rev, doc 0.68mm and tool nose radius 1.2mm. [22] Stated that, nose radius was influenced to Ra value followed ap and feed rate while worked on Ti-6Al-4V material with different nose radius of TNMG inserts. [23] Used SS304 as experimental material. Stated surface roughness mostly affected by ap followed by f and nose radius with combination 69.81% while using TNMG insert. Better surface finish obtained at f 0.15mm/rev, ap 0.2 and nose radius 0.8mm.

2. Findings and Gap

Founding were that, Ra value decreases with increases tool nose radius. For the Ra value Vc and nose radius having inversely proportion relationship. F and ap directly promotional for Ra value. It has been observed with above introductory along with literature review that, there is gap indicating that less research has been done on polymer cutting temperature; vibration. Also less effort has been done to find relation between insert tip radiuses to surface roughness in polymer material. For this Polypropylene polymer used as experimental metal due to its ideal polymer properties hence, the objective of the study is as below,

1. Investigate the variable input parameter for minimize cutting temperature, spindle vibration and surface roughness while turning Polypropylene (pp).
2. Investigate the relation among cutting temperature, vibration and surface roughness to insert nose radius for Polypropylene (pp).

Table no. 1 showed Mechanical Properties of Polypropylene and Table no. 2 TNMG Insert nomenclature and Table no. 3 mentioned the experimental three levels of input parameters.

Table no.1 Properties of Polypropylene

Tensile strength (N/mm^2)	Elastic modulus (MPa)	Density (g/cm^3)	Hardness (Shore D)	Melting point (˚C)
1.30	0.93	0.93	60	171

Table no. 2 TNMG Insert Nomenclature

T	N	M	G	16	04	04
Shape	Rake angle	Tolerance	Insert type	width	thickness	Radius

Table no. 2 showed example of TNMG inserts nomenclature. Actually in this research paper, different three TNMG inserts were used. **Fig. no. 1** shown, TNMG insert which is triangular in shape, sides are 16mm, thickness is 4.76mm, angle of insert is 60˚ and according to nose radius there are different types of inserts such as, TNMG 160404 has radius 0.4mm, TNMG 160408 has radius 0.8mm and TNMG 160412 has 1.2mm insert nose radius.

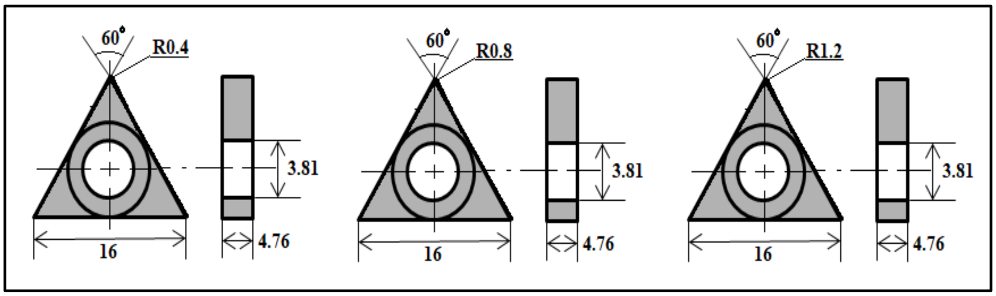


Fig. no. 1 TNMG Insert: TNMG 160404, TNMG 160408 and TNMG 160412

Table no. 3 level of input parameter

Level	1	2	3
Vc (m/min)	70	120	170
f (mm/min)	0.10	0.20	0.30
ap (mm)	1	2	3
Insert nose radius (mm)	0.4	0.8	1.2

3. Experimental Apparatus

Fig. no. 1 shown the Experimental set up (a) schematic view and (b) photograph, this experimental apparatus set up developed for machining Polypropylene Polymer-PP on conventional 4.5ft Lathe machine. Experimental set up shown in fig. no.1.The experiment conducted on Polypropylene Polymer-PP round bar Dia. 40mm X 50mm long. For turning operation the TNMG insert used. It was triangular in shape and has 6 cutting edges with 8mm insert cutting nose radius. Along with this set up infrared temperature gun, vibration analyzer and Mitutoyo surface tester used to measure the temperature, vibration frequency and surface roughness Ra value respectively.

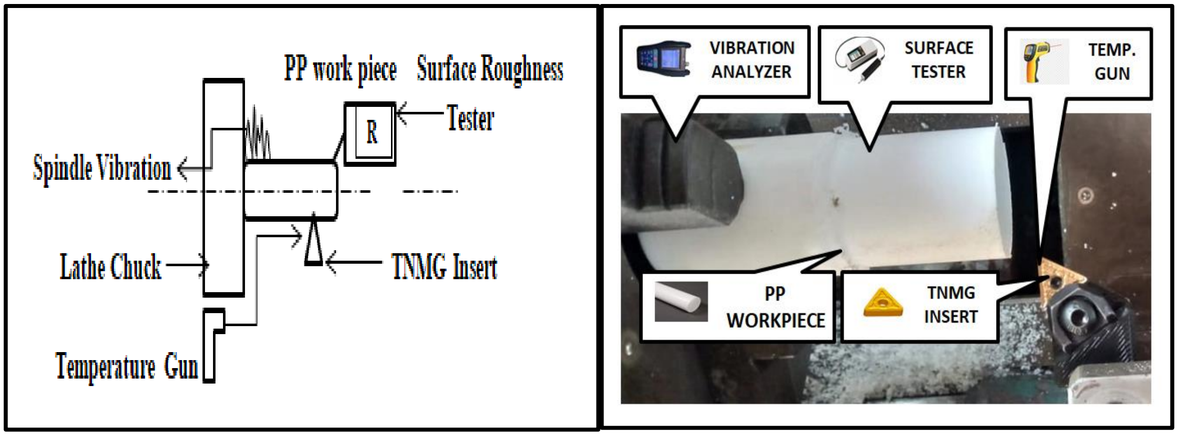


Fig. no. 2 Experimental set up (a) schematic view and (b) photograph

4. Characterization and Measurement

Experimental set up is developed for the Polypropylene Polymer-PP on the conventional Lathe machine. Turning operation performed with the standard TNMG with 8mm radius insert. Experiment conducted on PP round bar Dia. 40 mm X 50mm length. Specimen turned 30mm length with proper turning process as per levels of Design of experiment. Infrared temperature gun was used to record the cutting temperature. Vibration frequency recorded according to ISO10816 by vibration analyzer while surface roughness Ra value measured with Mitutoyo surface roughness tester according to ISO 25178-2 standard process.

Table no. 4 Output Response along with corresponding variable input parameter

Sr. No.	**Input Parameter**				**Output Parameter**			
	m/min	**mm**	**mm**	**Mm/min**	**µm**	**µm**	**˚C**	**mm/sec²**
	Speed	**DOC**	**TR**	**Feed**	**Ra**	**Rmax**	**Temp**	**Vibration**
1	70	0.50	1.2	0.10	1.40	1.04	35.33	6.46
2	70	1.00	0.8	0.10	1.11	1.56	36.53	6.19
3	70	1.50	0.4	0.10	1.06	3.13	40.33	5.55
4	70	0.50	1.2	0.20	1.80	4.17	33.23	7.79
5	70	1.00	0.8	0.20	1.55	6.25	35.93	7.41
6	70	1.50	0.4	0.20	1.36	12.50	38.63	6.99
7	70	0.50	1.2	0.30	2.18	9.38	30.93	8.98
8	70	1.00	0.8	0.30	2.11	14.06	31.83	8.6
9	70	1.50	0.4	0.30	2.04	28.13	32.93	8.21
10	120	0.50	1.2	0.10	1.34	1.04	44.73	6.71
11	120	1.00	0.8	0.10	1.09	1.56	48.43	6.07
12	120	1.50	0.4	0.10	1.04	3.13	51.23	5.69
13	120	0.50	1.2	0.20	1.70	4.17	41.63	7.67

14	120	1.00	0.8	0.20	1.41	6.25	44.23	7.26
15	120	1.50	0.4	0.20	1.26	12.50	48.33	6.58
16	120	0.50	1.2	0.30	2.06	9.38	38.73	8.47
17	120	1.00	0.8	0.30	2.01	14.06	43.33	8.07
18	120	1.50	0.4	0.30	1.97	28.13	46.83	7.93
19	170	0.50	1.2	0.10	1.21	1.04	51.23	6.46
20	170	1.00	0.8	0.10	1.07	1.56	51.83	5.94
21	170	1.50	0.4	0.10	1.02	3.13	52.23	5.55
22	170	0.50	1.2	0.20	1.68	4.17	49.43	7.53
23	170	1.00	0.8	0.20	1.35	6.25	49.63	6.87
24	170	1.50	0.4	0.20	1.15	12.50	50.73	6.32
25	170	0.50	1.2	0.30	2.18	9.38	46.63	9.19
26	170	1.00	0.8	0.30	2.11	14.06	47.83	8.73
27	170	1.50	0.4	0.30	2.04	28.13	48.13	8.33

5. Result and discussion

Table no. 5 Influence of (TNMG 160404) insert nose radius 0.4 mm on surface roughness.

Feed	0.10	0.10	0.10	0.20	0.20	0.20	0.30	0.30	0.30
Ra	1.06	1.04	1.02	1.36	1.26	1.15	2.04	1.97	2.04
Depth of cut	0.5	0.5	0.5	1.0	1.0	1.0	1.5	1.5	1.5

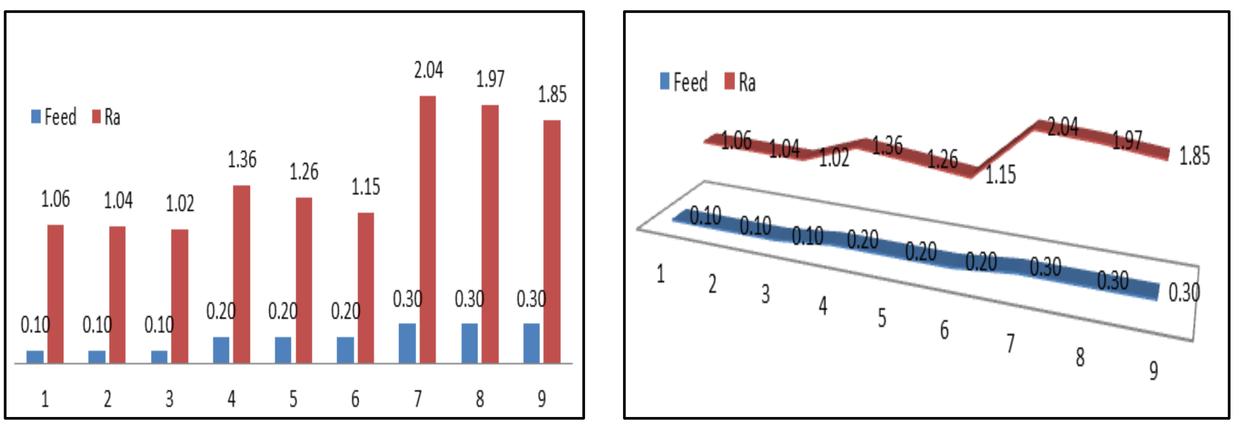
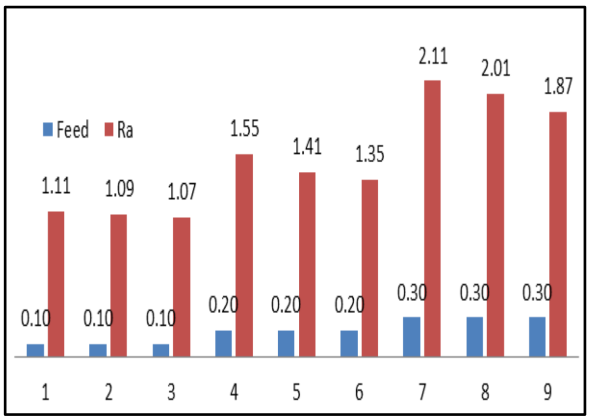


Fig. no. 3 (a) Column and 3 (b) Line graph for (TNMG 160404) insert nose radius 0.4 mm on surface roughness.

This is the analysis of insert nose radius to surface roughness. Considering constant tool radius and cutting speed max. 170m/min and depth of cut vary with three levels 0.5, 1.0 and 1.5mm along with varying Feed level 0.1 to 0.3mm/min. Table no. 5 shows the recorded Ra value with respect to f and ap levels according to TNMG 160404, which has 0.4 insert nose Radius. Fig no. 3 (a) and (b) shows the Column and Line graph for (TNMG 160404) insert nose radius 0.4 mm for surface roughness. As per the Fig. no. 3 (a) Column graph, it is indicated that, at the level of f 0.10mm/min, ap 0.5mm, the Ra value was 1.06 µm. at same f and 1mm ap the Ra value recorded .04 µm. and at third level f is 0.30mm/min the lowest Ra value recorded 1.02 µm, at level second the f changed 0.1mm/min to 0.2mm/min Ra value increased at f 0.2mm/min and ap is 0.5mm it was 1.36 µm, at 1mm depth of cut it was 1.26 µm and at 1.5mm depth of cut it was 1.15 µm. while at third level surface roughness increasing according to feed. When f was 0.30mm/min and depth of cut vary from 0.5mm to 1.5mm the Ra value changed 2.04 µm, 1.97 µm and 1.85 µm. as per the Fig. no. 3 (b) Line graph there is particular definite trend is observed. [22] Stated that, nose radius was influenced on surface roughness followed f and ap. Ra value continuously increases as increasing f and decreasing ap. Hence it could be concluded Ra value means surface roughness directly proportional to feed and inversely proportional to ap when cutting speed is constant at higher speed.

Table no. 6 Influence of (TNMG 160408) insert nose radius 0.8 mm on surface roughness.

Feed	0.10	0.10	0.10	0.20	0.20	0.20	0.30	0.30	0.30
Ra	1.11	1.09	1.07	1.55	1.41	1.35	2.11	2.01	1.87
Depth of cut	0.5	0.5	0.5	1.0	1.0	1.0	1.5	1.5	1.5



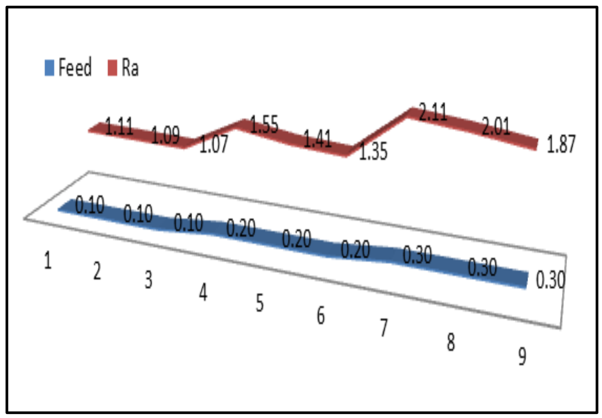


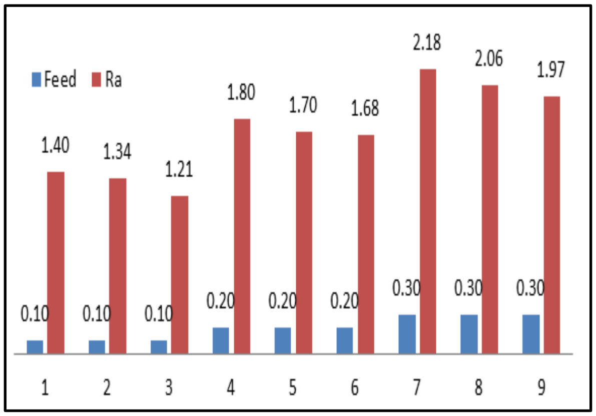
Fig. no. 4 Column and Line graph for (TNMG 160408) insert nose radius 0.8 mm on Surface Roughness

This is the analysis of insert nose radius to surface roughness. Considering constant tool radius and cutting speed max. 170m/min and depth of cut vary with three levels 0.5, 1.0 and 1.5mm along with varying f level is between 0.1 to 0.3mm/min. Table no. 6 shows the recorded Ra value with respect to f and ap levels according to TNMG 160408, which has 0.8 insert nose Radius. Fig no. 3 (a) and (b) shows the Column and Line graph for (TNMG 160408) insert nose radius 0.8 mm for surface roughness. As per the Fig. no. 4 (a) Column graph, it is indicated that, at the level of f 0.1mm/min, ap 0.5mm the Ra value was 1.11 µm. at same f and ap 1mm the Ra value was 1.09 µm. and at the last level of feed 0.30mm/min the lowest Ra value recorded 1.07 µm, at level second the feed rate changed 0.1mm/min to 0.2mm/min., Ra value also increased at f 0.2 and ap 0.5, it was 1.55 µm, at 1mm depth of cut it was 1.41 µm and at 1.5mm depth of cut it was 1.35 µm. while at third level surface roughness increasing according to feed. When f was 0.30mm/min and depth of cut vary 05, 1.0 and 1.5mm Ra value changed 2.11 µm, 2.01 µm and 1.87 µm. [17] Anselmo Eduardo worked on 1045 steel material with TNMG160404PF AND 160408PF. That increases tool radius, tool life and cutting power. For better surface combination suggested as higher feed, nose radius and lower Vc. As per Fig. no. 4 (b) Line graph there is particular definite trend is noted.

Ra value continuously increases with feed increasing and ap decreasing. Hence it could be concluded that, Ra value directly proportional to feed rate and inversely proportional to ap when cutting speed is constant at higher speed.

Table no. 7 Influence of (TNMG 160412) insert nose radius 1.2 mm on surface roughness.

Feed	0.10	0.10	0.10	0.20	0.20	0.20	0.30	0.30	0.30
Ra	1.40	1.34	1.21	1.80	1.70	1.68	2.18	2.06	2.18
Depth of cut	0.5	0.5	0.5	1.0	1.0	1.0	1.5	1.5	1.5



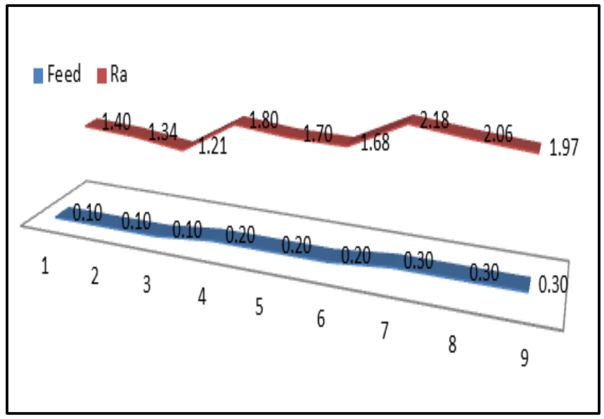


Fig. no. 5 Column and Line graph for (TNMG 160412) insert nose radius 1.2 mm on

It is the analysis of insert nose radius to surface roughness for TNMG 160412. Considering constant tool radius and cutting speed max. 170m/min and depth of cut vary with three level 0.5, 1.0 and 1.5mm along with varying Feed rate 0.1 to 0.3mm/min. Table no. 7 shows the recorded Ra value respect to f and ap levels according to DOE, which has 1.2 insert nose Radius. Fig no. 5 (a) and (b) shows the Column and Line graph for (TNMG 160404) insert nose radius 0.4 mm for surface roughness. As per the Fig. no. 5 (a) Column graph, it is indicated that, at the level of f 0.10mm/min, ap 0.5mm and recorded Ra value was 1.40 µm. at same feed and 1mm ap the Ra value recorded 1.34µm. and when f 0.30mm/min the lowest Ra value recorded 1.21 µm, at level second the changed f 0.1mm/min to 0.2mm/min Ra also increased at f 0.2mm/min along with ap 0.5mm, the Ra value noted 1.80 µm, at 1mm depth of cut it was 1.70 µm and at 1.5mm depth of cut it was 1.68 µm. while at third level surface roughness increasing according to feed. When f is 0.30mm/min and ap is vary 0.5 to 1.5mm , the Ra value changed 2.18 µm to 1.97 µm. [24] stated that, Ra value decrease when tool nose radius increases. Observed correlation between Vc and nose radius to Ra value is inversely proportion. Feed rate and depth of cut directly promotional to Ra value. As per Fig. no. 5 (b) Line graph there is particular definite trend is recorded. Ra value continuously is increased with feed and decreasing with depth of cut. Hence it could be concluded that, surface roughness Ra value is directly proportional to feed and inversely proportional to depth of cut, when cutting speed is constant at higher speed.

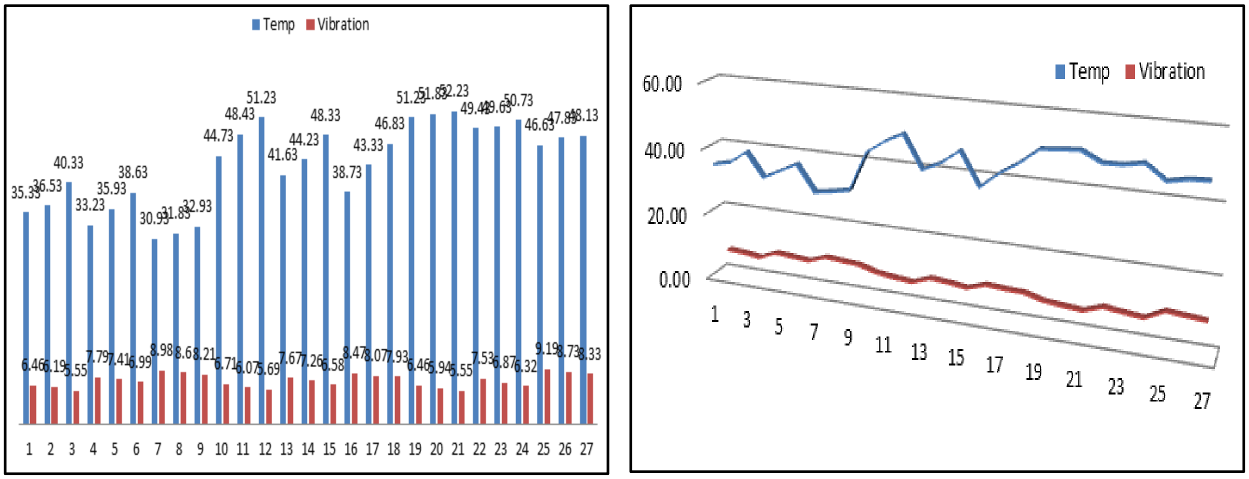


Fig no. 6 (a) (b) Column and Line graph for Temperatures to vibration

Cutting Temperature and vibration influenced on the surface roughness of the product quality. These are the variables related to each other with definite relation. Here in this research paper this co relation between vibrations to temperature analyzed fig no. 6 (a) and (b) are the graphs plotted to understand the relation between them. Fig. no. 6(a) represents the column graph and fig.no. 6(b) representing the line graph. With help of these two graphs indicating that there is very less influenced between them while turning the Polypropylene polymer material. Three levels of input variables taken for the experiment, showed in table no. 3. During machining of the Polypropylene polymer the temperature increased with minimum temperature 30.93˚ to maximum 52.23˚. As ap and Vc increased with lower level of the feed the cutting temperature increase. When feed rate is minimum the work piece take more time to travel forward and due to high depth of large portion of the workpiece interface with cutting tool portion hence at higher Vc and ap and low f rate more shear stress occurred between the workpiece and tool insert interface due that more heat is generated at cutting zone while the machining of the Polypropylene. Same effect of cutting condition the vibration also occurred.

Fig no. 6 (b) shows the Line graph for Temperatures to vibration here it is indicated that, there is very less relation between cutting temperature and Vibration during machining of Polypropylene the vibration range is between 6.55 mm/sec^2 to 9.19 mm/sec^2. The line graph trend of cutting temperature and vibration are totally different because vibration mostly occurred at high Vc and ap. Less temperature and vibration occurs at 0.4mm the low tool radius with TNMG 160404 inserts because less contact between work piece and tool insert results less frication. Hence the less vibration generated as well as less heat is generated at cutting zone. As per the vibration trend which were shown in the Fig no. 6 (b) vibration frequency increasing according to the increasing the cutting speed. And temperature range is not varying too much it is observed steady with minor fluctuating.

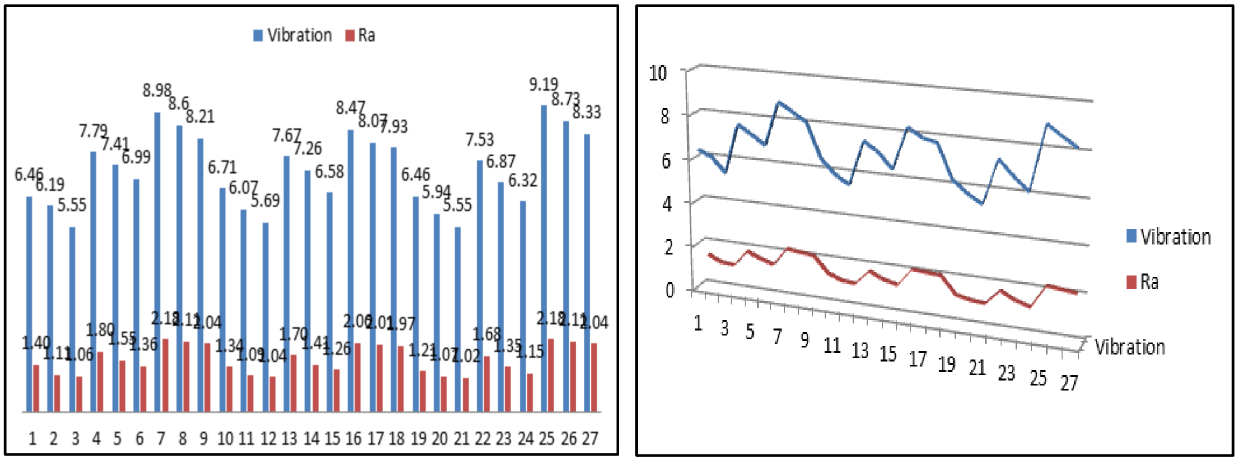


Fig no. 6 (a) (b) Column and Line graph for vibration to surface roughness

It's been observed with literature review, the Ra value mostly influenced by the feed rate and insert nose radius. Here also in this reseach work it is noted, feed is most dominating parameter followed by tool nose radius the insert nose radius. As it is alrady results were observed with various TNMG inserts which having different nose radius. It is been mentioned that as the feed decreases and tool radius increases, the Ra value is decreases and get better surface finish. It is happped because while madhining the soft material turning when cutting spped at higher level hence work piece ratating fastly and it willtake less tine to complete one revolution. At same condtion if the feed rate is low and insert radius is high. The contact area is high, tool traval time is less and roation of workpice high, it give sufficent time to remove the soft polymer material and gives btter surface finish. While turning the Polypropylene with TNMG insert the vibration range is vary between 6.55 mm/sec2 to 9.19 mm/sec2 according with vibration aslo varying between 1.06 µm to 2.18µm and it clearly obseved that as vibration increses the surface roughness also increses. This trend is more effetely indicated the Fig no. 6 (b) Line graph for vibration to surface roughness Ra value.

It has been observed with experimental work that, with the range of the vibration frequencies and Ra value that, the Ra value definitely influenced by the vibration. In the Fig no. 6 (a) showed the Line graph for vibration to surface roughness, the vibration frequencies varying with spindle speed mostly and the vibration frequencies line indicated that change, while the same change is indicated with surface roughness Ra value line also. With same trend the both line observed at 170m/min, maximum spindle speed both vibration and Ra value line show the higher peak range vibration range max 9.19mm/sec^2 . While, surface roughness Ra value 2.18µm and at lower spindle speed 70m/min vibration and Ra value was 8.90 mm/sec^2 and 1.80 µm respectively, at the moderate cutting speed 120m/min the both lines showed moderate vibration 8.47 mm/sec^2 and result moderate surface roughness value 2.02 µm.

6. Conclusion

The experimental work has been done on Polypropylene with varying different level of cutting speed, feed rate and depth of cut. Turning operation has been done by three types of TNMG inserts such TNMG 160404,160408 AND 160412. According to experimental results, it can be concluded that,

- Using TNMG 160404, when the f is 0.10mm/min, ap is 0.5mm the Ra value was 1.06 µm. at same f and ap is 1mm the Ra value was 1.04 µm. and when f 0.30mm/min the lowest Ra value recorded 1.02 µm, at level second the feed changed 0.1mm/min to 0.2mm/min, the Ra value also increased at f 0.2mm/min and ap 1.1, Ra value 1.15µm recorded. When f is varies between 0.1mm/min to 0.2mm/min, the surface roughness Ra value increased and it was 1.36µm and, at 1mm depth of cut it was 1.26 µm and at 1.5mm depth of cut it was. While at third level surface roughness increasing according to feed when feed 0.30mm/min and depth of cut vary 05, 1.0 and 1.5 mm the surface roughness Ra value changed 2.04 µm, 1.97 µm and 1.85 µm. Hence, it is conclude that with feed rate and decreased (ap) depth of cut (ap), increased the surface roughness.

- Using TNMG 160408, at the level of f 0.1mm/min, ap 0.5mm the recorded Ra value was 1.11 µm. at same f and ap is 1mm Ra value was 1.09 µm. and at the last level of feed rate 0.30mm/min the lowest Ra value recorded 1.07 µm, at second level the feed changed 0.1mm/min to 0.2mm/min, the Ra also increased at feed 0.2mm/min, increased at f 0.2mm/min and ap is 0.5 it was 1.55 µm, at 1mm depth of cut it was 1.41 µm and at 1.5mm depth of cut it was 1.35 µm. while at third level surface roughness increasing according to feed rate. When was 0.30mm/min and depth of cut vary 05, 1 and 1.5mm the Ra value changed 2.11 µm, 2.01 µm and 1.87 µm. It is concluded that, decreasing feed rate and increasing depth of cut obtained better surface finish.
- Using TNMG 160412 at the level of f 0.1mm/min, ap 0.5mm the Ra value was 1.40 µm. at a same f and ap is 1mm the recorded Ra value was 1.34 µm. and at the final level f is 0.30mm/min the lowest Ra value recorded 1.21 µm, at level second the f is changed 0.1mm/min to 1.5mm/min and 2mm/min, the Ra values also changed 1.80 µm at 1mm depth of cut, and 1.70 µm and at 1.5mm depth of cut it was 1.68 µm at 2mm. while at third level surface roughness increasing according to feed. Now feed was 0.30mm/min and depth of cut vary 05, 1 and 1.5mm the recorded Ra value changed 2.18 µm, 2.06 µm and 1.97 µm. same results were noted, at higher cutting speed, depth of cut and low feed with 1.2mm insert nose radius, obtained higher surface finish. Surface roughness Ra value decreases when insert nose radius increases.
- The correlation between Vc and nose radius to Ra value of surface roughness is inversely proportion. Feed rate and depth of cut directly promotional to surface roughness. Along with Higher insert nose radius 1.2mm; TNMG 160412 noted higher surface finish.
- The Temperatures to vibration relation here it is conclude that, there is very less relation between the cutting temperature and vibration during the machining of Polypropylene.
- It is clearly concluded, with relation between vibration to surface roughness value range of the vibration frequencies and surface roughness Ra values varies simultaneously that, the surface roughness definitely influenced by the vibration.

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