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Analysis of Effect of Different Process Parameters on the Properties of the Component Manufacture Using FDM Machine

Pawan V Mulkarwar[1], Abhijit D. Munishwar[2], Prof. Ashish M Wankhade[3], Prof. Mansur N Syed[4]
Department –Mechanical Engineering[1,2,3,4]
Affliation Name-Student of Jawaharlal Darda Institute Of Engineering &Technology ,Yavatmal[1]
Affliation Name-Student of Jawaharlal Darda Institute Of Engineering &Technology ,Yavatmal[2]
Affliation Name-Asst.Prof Of Jawaharlal Darda Institute Of Engineering &Technology ,Yavatmal[3]
Affliation Name-Asst.Prof Of Jawaharlal Darda Institute Of Engineering &Technology ,Yavatmal[4]
Email Address -mulkarwarpawan4@gmail.com[1]

Abstract- The rapid prototyping is an emerging technology in developing the physical prototypes from the 3D cad models by using the additive process with layers. FDM is one such RP technique which can build parts using layer by layer deposition technique using thermoplastic building material according to numerically defined cross sectional geometry. The quality of FDM produced parts is significantly affected by various parameters like build orientation, road width, air gap etc. This dissertation work aims to study the effect of three process parameters such as Road width, Air gap and sample orientation on properties. To achieve this the sample machine part were manufactured at different orientation (0^o,45^o,90^o) at min, med, max road width and air gap. Specimens is further analyzed for accuracy, surface finish and build time. Results are tabulated and are shown graphically representation.

Index Terms-Minimum, Medium, Maximum

1. INTRODUCTION:

Measures to improve the efficiency of production processes always include the application of new and innovative manufacturing methods. Therefore, in recent years, applications of the rapid technology turned out to be potentials of the modern product development process [1].compared with traditional material removing method, rp technology is an additive material method based on layer manufacturing (lm) technique. Rp's additive nature allows it to create objects with complicated internal features that cannot be manufactured by other means. In all commercial rp processes, the part is fabricated by deposition of layers contoured in a (x-y) plane two dimensionally. The third dimension (z) results from single layers being stacked up on top of each other, but not as a continuous z-coordinate. Therefore, the prototypes are very exact on the x-y plane but have stair-stepping effect in z-direction. In recent decades, rp technologies have been widely developed and used in different applications, and even being applied as a direct manufacturing route to applications in automobile and aerospace [2]. Since1986, more than ten main technics of rpm technology were developed such as stereolithography (SL), laminated object manufacturing (LOM),selective laser sin-tering (SLS), selective laser melting (SLM), fused deposition modeling (FDM), ink jet printing (IJP), 3-d printing (3DP), patternless casting manufacturing(PCM), and electron beam selective melting (EBSM). Of course, rapid prototyping is not perfect. Part volume is generally limited to 0.125 cubic meters or less, depending on the rp machine. Metal prototypes are difficult to make, though this should change in the near future. For metal parts, large production runs, or simple objects, conventional manufacturing techniques are usually more economical. These limitations aside, rapid prototyping is a remarkable technology that is revolutionizing the manufacturing process. This paper includes the manufacturing of specimen i.e connecting rod model at three different build orientations i.e.at three different angles (0^o,45^o,90^o) along with different road width and air gap(Min, Med, Max) separately by the rapid prototyping technique(FDM).Then we will get the readings of different parameters like build time, support material required, model material required for above orientation. Also we will test the above prototypes for surface roughness, accuracy and tabulate the readings. After analyzing the readings we will conclude the effect of process parameters on properties of model and will compromises at better orientation.

2. LITERATURE REVIEW:-

Alexander et al. developed an accuracy calculation model and the methodology for creating the cost model. Cusp height is used to measure the accuracy of a part. The part orientation that minimizes part accuracy, build time and the amount of support material selected. The accuracy is calculated using the cusp height that considers the area of each part in the stereo lithography. The best orientation is chosen in terms of the user from the results calculated.

The ability to select the optimal orientation of buildup is one of the critical factors since it affects the part surface quality, accuracy, build time and part cost. Various factors to be considered in optimization of build orientation for FDM are build material, support material; build up time, surface roughness and total cost. Experiments were carried out and results are analyses for varying build orientation for primitive geometries like cylinder. A mathematical model was developed after validating the theoretical values of surface roughness with measured values. This helps in reducing experimental work and improves possibilities of virtual simulation of rapid prototyping parts (chenget. al.1995)

This paper presents a generic system that performs a computer-aided optimization of part orientation in consideration of the mentioned factors of influence as well as related effects. The proprietary development of the implementation of the presented approach is based on the paradigm of object-oriented and generic programming and therefore versatile. A vertical orientation would result in good part quality except the holes but also in a high number of layers and therefore in longbuild time. A horizontal orientation would lead to a cost-effective build time but also to insufficient dimensional accuracy.(S. Danjou 1, P. Koehler et. al.2009).

Paper represent characterize some of the properties of Stratasys. Fused Deposition Modeling (FDM) process, as well as the effects of varying some of the build parameters. Series of Samples were manufactured at FDM m/c and tested for load using inston load frame. In the tension tests, the predicted behavior does not correlate very well with the measured behavior when the correct material properties are used. However, when the tensile strength in the transverse direction with a negative airgap is substituted into the no airgap material properties, the predictive model is quite accurate (John Michael Brock et. al.2000).

2.1 FDM:- FDM is one of the RP technology developed by Stratasys, USA. But unlike other RP systems which involve an array of lasers, powders, resins, this process uses heated thermoplastic filaments which are extruded from the tip of nozzle in a temperature controlled environment. For this there is a material deposition subsystem known as head (Figure 3.2) which consist of two liquefier tips. One tip for model material and other tip for support material deposition both of which works alternatively. The article forming material is supplied to the head in the form of a flexible strand of solid material from a supply source (reel). One pair of pulleys or rollers having a nip in between are utilized as material advance mechanism to grip a flexible strand of modeling material and advance it into a heated dispensing or liquefier head. The material is heated above its solidification temperature by a heater on the dispensing head and extruded in a semi molten state on a previously deposited material onto the build platform following the designed tool path. The head is attached to the carriage that moves along the X-Y plane. The build platform moves along the Z direction. The drive motion are provided to selectively move the build platform and dispensing head relative to each other in a predetermined pattern through drive signals input to the drive motors from CAD/CAM system. The fabricated part takes the form of a laminate composite with vertically stacked layers, each of which consists of contiguous material fibres or rasters with interstitial voids. Fibre-to-fibre bonding within and between layers occurs by a thermally-driven diffusion bonding process during solidification of the semi-liquid extruded fibre.

2.2 Advantages:-

(1)Quick and cheap generation of models

(2)There is no worry of exposure to toxic chemicals, lasers or a liquid chemical bath.

2.3Disadvantages:-

(1)Restricted accuracy due to the shape of material used, wire is 1.27 mm diameter.

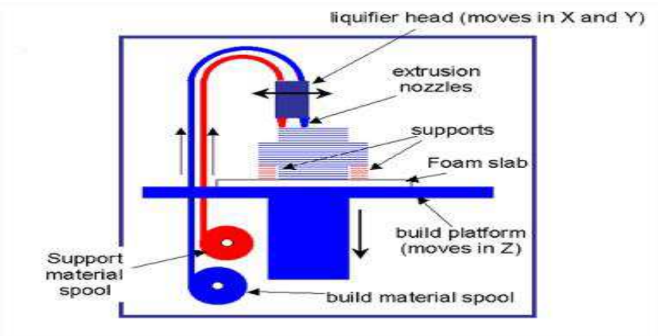


Fig. 1:- FDM Process

3. MATERIAL:- ABS is an ideal material for conceptual modeling, functional prototyping and direct digital manufacturing. Acrylonitrile - Butadiene - Styrene (ABS) identifies a family of engineering thermoplastics with a broad range of performance characteristics. The copolymeric system is alloyed to yield the optimum balance of properties suited to the selected end use.

3.1 ACRYLONITRILE - Imparts chemical resistance and rigidity.

3.2 BUTADIENE - Endows the product with impact strength, toughness and abrasion resistance.

3.3 STYRENE – Contributes to the lustre, ease of processing and rigidity.

The outstanding properties of ABS are:

1.High impact ,strength and ductility, which combine to give exceptional toughness.

2. Good chemical resistance.

3. Abrasion resistance.

4 High strength solvent weld jointing which allows efficient system assembly and modification.

5. Rubber Ring joint methods, allowing compatible systems jointing techniques.

6. Nontoxic and non-taint properties.

7. Withstands aggressive ground waters.

8. High strain tolerance for buried applications.

9. Good resistance to ultraviolet light.

10. Lower celerity and extreme tolerance to water hammer.

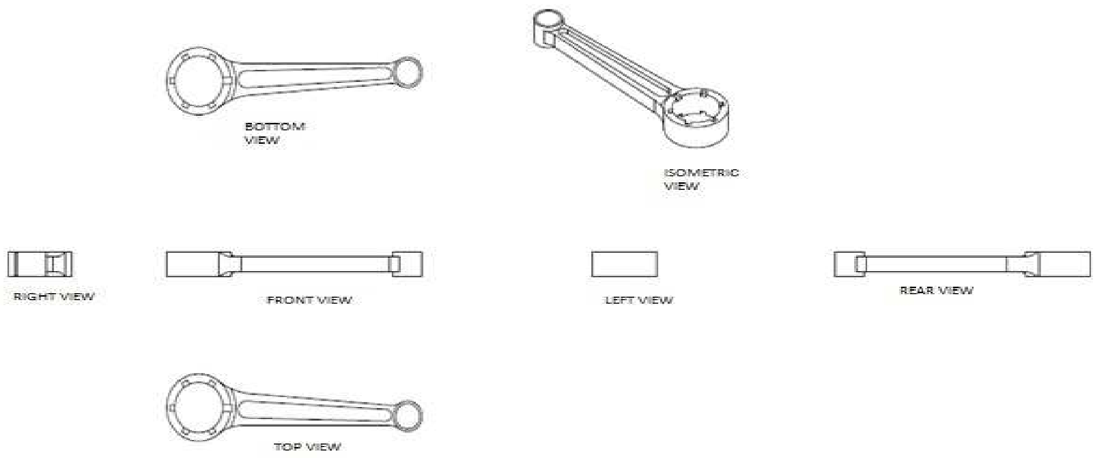


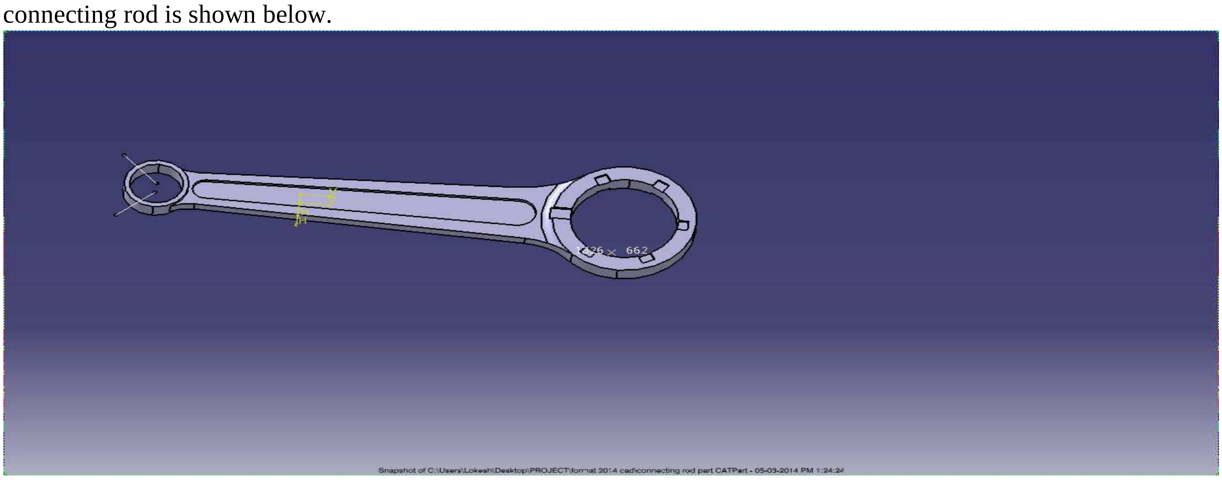
Fig 2: General view connecting rod

4. METHODOLOGY:- The methodology of the project is described in following steps:-

4.1 Selection of specimen:- We selected the simple m/c part i.e connecting rod of two stroke engine as specimen.

4.2 Design of specimen:-After selecting the specimen, we measured out the actual dimensions of specimen. Optimized Connecting Rod has been modeled with the help of CATIA, in general we had perform the reverse engg. The Orthographic and Solid Model of optimized connecting rod is shown below.

4.3 FABRICATION OF MODEL:- Actual fabricated prototypes of specimen at different build orientation i.e 0^o,45^o,90 along with different process parameters i.e roadwidth and air gap Min(0^0,45^0,90^0), Med(0^0,45^0,90^0), Max(0^0,45^0,90^0) on FDM TITAN T1 machine. ABS was used as Raw material for fabrication of model. We fabricated nine models i.e for each angle, Min(0^0,45^0,90^0),Med(0^0,45^0,90^0),Max(0^0,45^0,90^0) road width and air gap was varied.



5. OBSERVATION AND ANALYSIS:- Fabricated model at 0^0,45^0,90^0 with Min,Med,Max, roadwidth and airgap and the reading for orientation at an interval of 45^0each an taken from system software. Fabricated models were tested for surface roughness at parth metallurgical services. Instrument named SRT(Times-TR 110) was used for same. Accuracy of models was determined with the help of digital vernier calliper. Readings are tabulated as below,

Table 1:- Surface Roughness Values of Connecting rod

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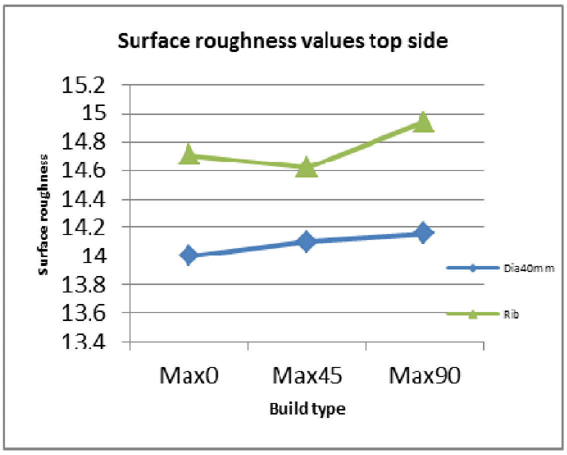
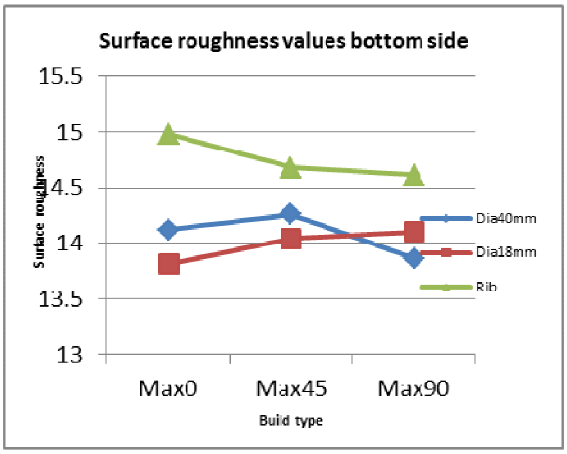
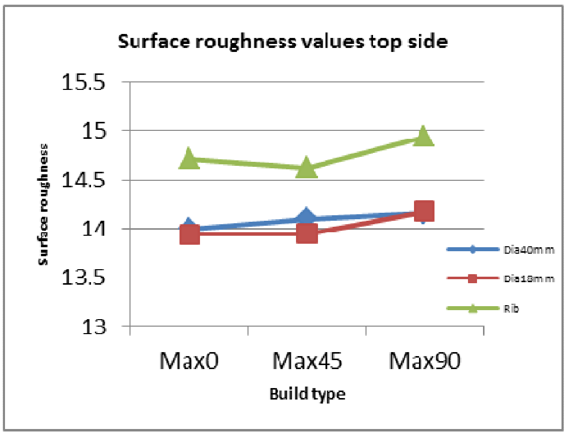
Sample no.	**Location**	**Ra Values(um)**							
		Top				**Bottom**			
		R1	R2	R3	Avg	R1	R2	R3	Avg
Min 45°	Dia 40 mm	13.69	14.76	14.47	14.31	15.28	14.9	14.52	14.90
	Dia 18 mm	13.7	13.39	14.44	13.84	13.98	14.14	13.56	13.86
	Rib	15.04	15.31	15.22	15.19	14.78	15.03	15.14	14.98
Med 45°	Dia 40 mm	15.26	15.4	14.92	15.19	14.92	15.16	14.77	14.95
	Dia 18 mm	15.06	14.68	15.06	14.93	14.86	14.88	15.08	14.94
	Rib	15.69	15.35	15.9	15.65	15.18	14.98	15.39	15.18
Max 45°	Dia 40 mm	14.44	13.83	14.03	14.10	14.2	14.57	14	14.26
	Dia 18 mm	14.43	13.83	13.59	13.95	13.9	14.34	13.88	14.04
	Rib	14.74	14.47	14.66	14.62	14.88	14.63	14.52	14.68
Max 0°	Dia 40 mm	13.76	14.22	14.02	14	14.2	14.32	13.84	14.12
	Dia 18 mm	14.17	14.18	13.48	13.94	14.04	13.46	13.92	13.81
	Rib	15	14.46	14.66	14.71	14.72	15.16	15.06	14.98
Max 90°	Dia 40 mm	14.12	14.52	13.84	14.16	14.29	13.96	13.32	13.86
	Dia 18 mm	14.05	14	14.5	14.18	14.48	13.55	14.27	14.10
	Rib	14.78	15.09	14.96	14.94	14.52	14.7	14.62	14.61







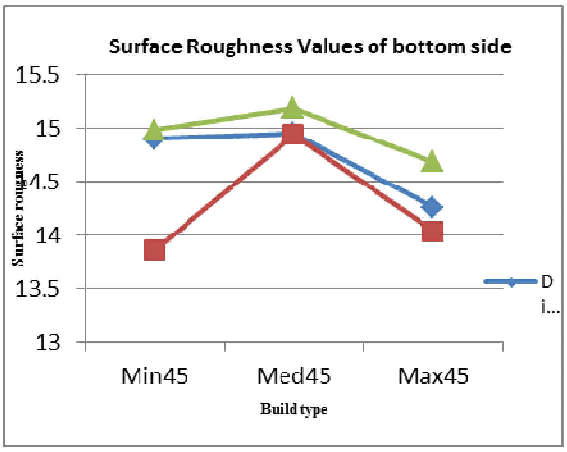


Table 2:- Dimension of prototypes for accuracy

Sr.no	Build Type	Wt. (gm)	Dia 40 mm		Dia 80 mm		Dia 40mm	Dia 18mm	Rim	Notches
			Inner	Outter	Inner	Outter				
1	Max 0°	15	29.73	39.90	14.81	18.03	15.27	15.25	9.42	3.68
2	Max 45°	16	29.60	39.77	14.77	17.90	15.25	15.24	9.35	3.74
3	Max 90°	18	29.81	39.90	14.83	17.88	15.43	15.33	9.54	3.62
4	Med 0°	18	29.78	39.92	14.84	18.06	15.30	15.30	9.43	3.50
5	Med 45°	20	29.88	39.83	14.81	17.94	15.50	15.28	9.38	3.56
6	Med 90°	15	29.90	39.94	14.95	17.92	15.45	15.34	9.57	3.36
7	Min 0°	19	29.95	39.94	14.90	18.11	15.48	15.33	9.60	3.14
8	Min 45°	19	29.96	39.03	14.98	18.05	15.69	15.35	9.45	3.23
9	Min 90°	10	29.93	39.97	15.08	18.03	15.51	15.42	9.59	3.27

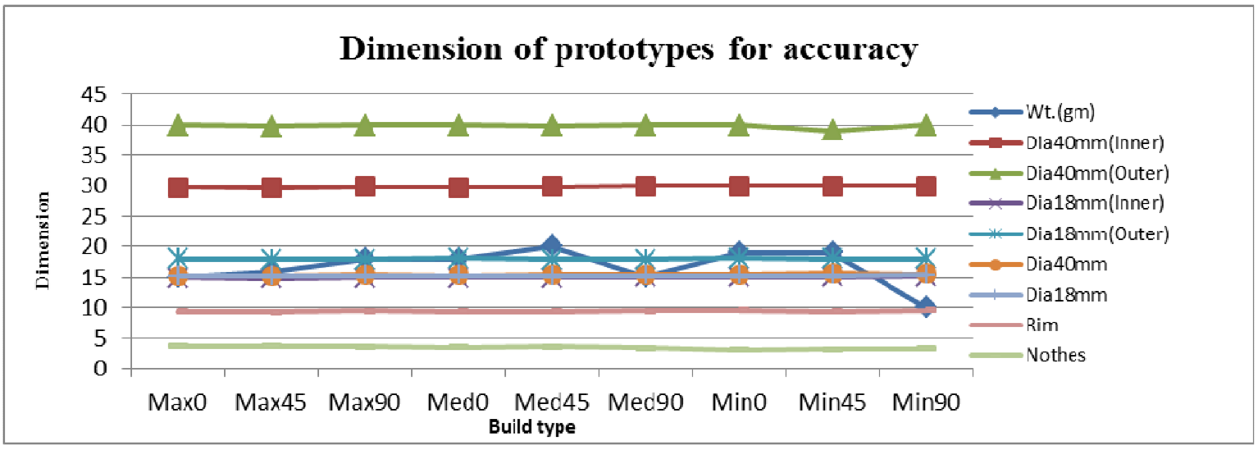
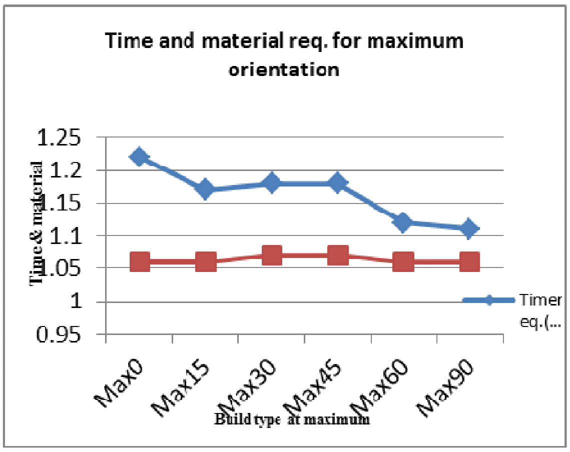
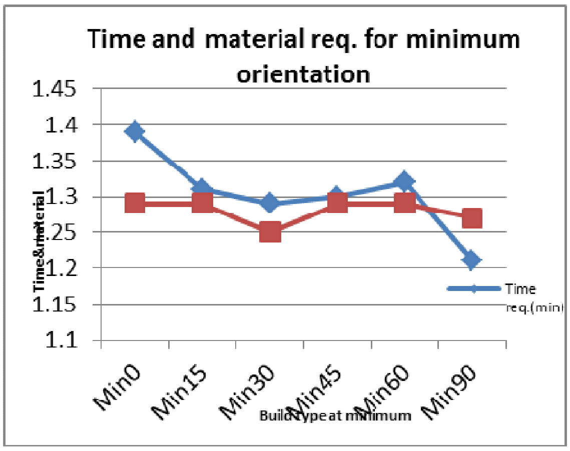


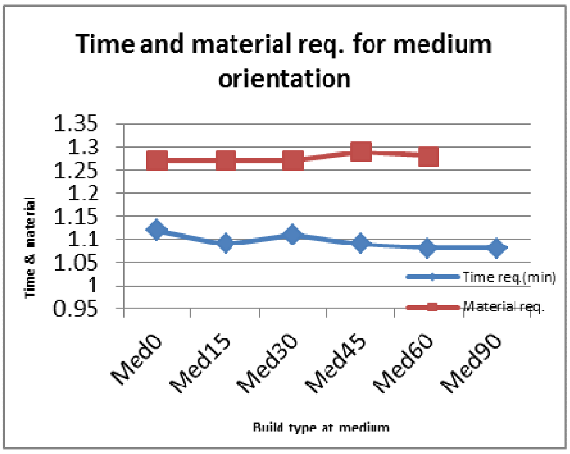
Table 3:- Material and time required for different orientation

Sr. no.	Build type	Time req.(min)	Material req.
	Maximum		
1.	Max0^0	1.22	1.06
2.	Max15^0	1.17	1.06
3.	Max30^0	1.18	1.07
4.	Max45^0	1.18	1.07
5.	Max60^0	1.12	1.06
6.	Max90^0	1.11	1.06
	Medium		
1.	Med0^0	1.12	1.27
2.	Med15^0	1.09	1.27
3.	Med30^0	1.11	1.27
4.	Med45^0	1.09	1.29
5.	Med60^0	1.08	1.28
6.	Med90^0	1.08	1.27
	Minimum		
1.	Min0^0	1.39	1.29
2.	Min15^0	1.31	1.29
3.	Min30^0	1.29	1.25
4.	Min45^0	1.30	1.29

5	Min60^0	1.32	1.29
6.	Min90^0	1.21	1.29







6. RESULT AND CONCLUSION:-

This Paper represent an approach that determines optimal build orientation for FDM, Also the effect of process parameters like Road width, Air gap, build material, support material on the properties of component i.e Accuracy, Surface roughness and build time. The minimization of Build material and support material is also implicitly included in work. The values of build time, Accuracy and surface roughness are determined for varying Road width and Air gap, Min(0^0,45^0,90^0),Med(0^0,45^0,90^0),Max(0^0,45^0,90^0) at each angle. From the computed Values of Build time, Model material, Accuracy, Surface roughness, Support material Required, its effect on build orientation and optimal orientation is determined.

For the Specimen taken i.e Connecting rod which is manufactured at varying raod width and air gap along with Different angles, It is found that for minimum road width and air gap build time and model material taken is more, followed by maximum and medium once. Also from the surface roughness values it is observed that surface finish of maximum road width and air gap prototypes is excellent and it decreases with increases in angles (0^0,45^0,90^0). Form the accuracy point of view better accuracy is obtained at minimum road width and air gap.

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