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Research paper

Comparison of Manufacturing Data Analysis For 5 & 3-Axis Vertical Machining Center for the Time and Tool Benefits of Industries

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Abstract

The dawn of globalization of business and competitiveness in manufacturing has forced firms to enhance their manufacturing facilities to reply to plug necessities. One of the crucial factors for this is often machine evaluation that involves a crucial decision using general and obscure information. The Primarily mass production aims high productivity so as to reduce cost and interchangeability to facilitate simple assembly which necessitates the production devices to increase the speed of manufacture. Across the business, the assembly challenges pivot around cutting lead times, increasing throughout and obtaining products to market as quickly as possible alongside some less challenging problems like shorter runs, higher product combine, tighter tolerances, a lot of complicated geometries in harder materials, and complete machining during a single handling. Advancements in technology have resulted in a creation of a lot of responsive tools referred to as MTM systems that are computer numerical Control (CNC) systems capable of acting a variety of operations with multiple tools and spindles in a single setup. The following project aims at reduction of manufacturing cost by modifying the process layout and operational parameters by novel approach for an identical element for 3 and 5- Axis Vertical Machining center. Nowadays, machining layout and operational sequence plays a significant role in automotive business to produce products at competitive price in market which consists of Machines, Tools, fixtures, computer interface, trained professionals and form of products. MAKINO PS60 is a Multi axis CNC machine (BRIDGE PORT), that helps to perform the machining operations on the roles at 5 totally different axes to create the required profiles whose implementation can pave means for a few terribly important benefits like, seven machines are replaced by Single machine, Man power are reduced from 9 to 3 per day, Tools usage reduced from 40 to 30 per day & production cost can reduce up to 60%.

Keywords: *Machining Operations, 3 & 5 Axis vertical machining Center, Operation Parameters, Time & Tool industrial Benefits.*

1. Introduction

This 5-axis machining gives vast possibilities on the part sizes and shapes will have the capacity to successfully technique. The expression "5-axis" states to the quantity of bearings inside which the cutter will move. On a 5- axis machining focus, the cutter moves over the X, Y and Z straight tomahawks correspondingly as turns on the A and B axis to approach the work piece from any direction. In various words, you'll process 5 sides of an area in an exceedingly single setup. In synchronic 5- axis machining, the machine device's 3 straight tomahawks (X, Y and Z) and 2 movement motion axes (A and B) all have cooperation at a comparable time to perform propelled process on components. With 3 + 2, the machine executes a 3- axis milling program with the cutting instrument hooked amid a tilted position utilizing its 2 motion axes. The procedure, also known as 5- axis positional machining, relies upon the fourth and fifth tomahawks to arrange the cutter in an exceedingly settled position rather than control it constantly all through the machining strategy. The small cutting by exactness machine instruments is a proficient technique for delivering 3D little components. Subsequently, investigation related with little cutting is being performed. Amid this man of science made a precision 5- axis milling machine of smaller size (around 300 mm in stature) and with ease (around 1/10 of the cost of exactness processing machines available), that is accessible for machining little components. This machine is made out of 3 exactness direct stages (X, Y and Z-hub) and 2 accuracy revolving stages (A and C-pivot). The concerning 5-pivot machine with PC supported outline (CAD) programming frameworks give us the possibility to demonstrate extremely complex shapes. The developing nature of item has been pushing the improvement of most recent delivering innovations [1]. The progressed or natural geometries present extraordinary and more mind boggling producing issues. Kicks the bucket and form are normally machined misuse 5- axis ball finish edge. Due to the expanding interest for higher precision, bring down machining time, and better surface honesty, numerous specialists have researched the effect of cutter introduction on surface harshness and rigging life [2]. A similar investigation of processing at various slant edges, they inferred that descending/invert processing with an apparatus slant inside the scope of 10-20 degrees speaks to the ideal machining technique. Creation of a processing machine is given a considerably vertical help on which a machine head is mounted. The machine head incorporates a

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mounting segment that is portable appended to the vertical help for rotational development a couple of generously vertical pivot. The machine head is furnishing with instrument shaft in which a processing apparatus is likewise mounted for processing a piece upheld on bed of the machine [3-9]. The various sorts of reasonable outline of backings of machine device for multi hub machine instruments. In this investigation the creator attempted to build up another style device to help higher intellectual process at the reasonable style phase of machine devices. The proposed style investigation procedure in view of strong style strategy was valuable in deciding reasonable structure of machine apparatuses [4-16].The thorough review of multi-useful machine instruments utilized for metal cutting, and their kinematic setups, control and programming advances. Plan standards and evaluation of multi-practical machine devices are talked about for the most part taking cases of 5-pivot machining focuses [5-13]. The innovation issues a processing head for machine apparatus, which has lodging and in it a working shaft put so it will move pivotally, and the work head, which may move even on the face, is mounted so it will turn on a level hub of revolution [6-22]. The assurance of this examination is to deliver an understanding to various choices and arrangements of 3 axis and 5 - axis Machining focus to create however the axis Machining focus can works proficiently looks at to 3 axis that demonstrates machining design, operational grouping, and creating cost and no of devices. The real favourable position of five-pivot machining is that the capacity to machine complex shapes in an exceedingly single set-up. This offers greater machining profitability contrasted with playing out the assignment in a progression of set ups, in like manner as significantly lessening the time and cost of planning apparatuses. Moreover, with numerous set-ups, there's ceaselessly a prospect of off base arrangement each time the part is enchanted. Another critical preferred standpoint of five-hub machining is that it enables shorter slicing apparatuses to be utilized since the head is brought down towards the assignment and the cutter situated towards the surface. Subsequently, a higher cutting rate is accomplished without swing over the top load on the cutter, in this way expanding device life and lessening breakages. Once executing 3 Axis to 5 Axis, To Avoid money out Flow, Reduced assembling cost by 500th. Also, part lead time for that it would be benefit for ventures.

2. Experimental Procedure

The cutting tests were carried on a 3 axis Machining focus and 3-axis vertical Machining center focus with the turning table of B and C Axis, furnished with the Sinumerik numerical control unit is appeared in figure 1. The trials were performed under dry and wet cutting conditions. The material of the work-piece is a solidified steel sort SP300 as of late created for Super Plast SP 300 broadly utilized for infusion molds. The hardness of this material is 300 HB.

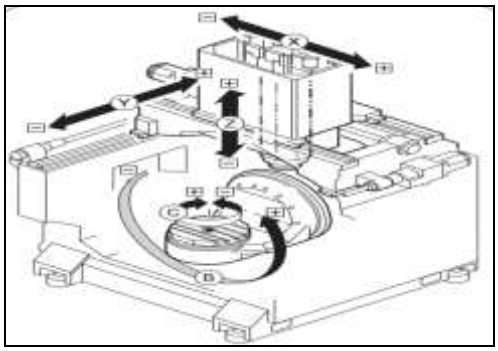

Fig. 1: Five - Axis Machining Center setup.

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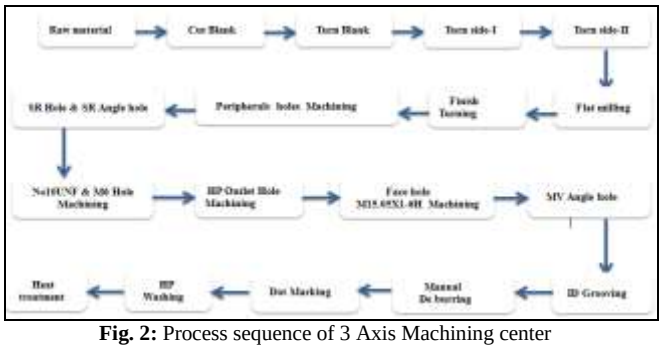

Fig. 2: Process sequence of 3 Axis Machining center

Figure 2, shows the Process sequence of 3 Axis Machining center here 7 Fixtures needed to complete all the operations shown in Figure 2, it starts with initial raw material to some milling, turning, hole operation and Grooving.

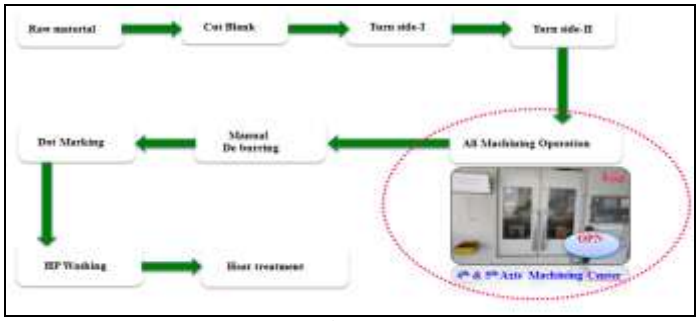

Fig. 3: Process sequence of 5 Axis Machining center

Figure 3, shows the Process sequence of 5 Axis Machining center here 7 Fixtures are replaced with rotary table to complete all the operations in single setup.

3.2. Title and author details

All title and author details must be in single-column format and must be centred.
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The Table 1, refers the Fixture Description and its functions for all the machining process of 3 Axis, in that for doing Peripheral Holes the Peripheral Holes fixture was designed the role for that fixture is Job is hold on the rotary head and doing Peripheral holes on the periphery of the job. The next operation was making hole in the Electro solenoid orifice Hole fixture was designed the functions in that fixture is Orifice hole fixture mounted on the VMC work table for undertaking orifice hole. The next Operation is Making Cross hole in that Metering Valve Cross hole fixture was designed the functions and setup for this fixture is Metering valve cross hole fixture mounted on the VMC work table for undertaking cross hole. The Next operation is cross hole of 2 different diameters in that prepared the cross-hole fixture and the functions and setup for the type of fixture is Pneumatically operated tilting type fixture mounted on the VMC work table for undertaking Ø2.3 and Ø3mm cross hole. The next operation is Flat Mill for that Flat Milling fixture was designed the setup and functions are

Milling fixture mounted on the VMC work table for performance flat milling operation.

Table 1: Axis Process Layout Fixtures for 3 Axis

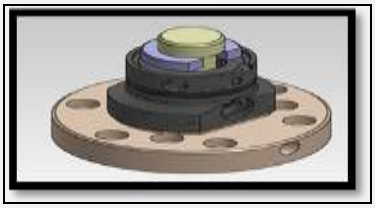
S.no	Fixture description	Fixture design	Fixture functions
1.	Peripheral Holes Fixture		Job is hold on the rotary head and doing Peripheral holes on the periphery of the job.
2.	Electro solenoid orifice Hole fixture		Orifice hole fixture mounted on the VMC work table for undertaking orifice hole.
3.	Metering Valve Cross hole fixture		Metering valve cross hole fixture mounted on the VMC work table for undertaking cross hole.
4.	2.3mm & 3.0mm cross hole fixture		Pneumatically operated tilting type fixture mounted on the VMC work table for undertaking Ø2.3 and Ø3mm cross hole.
5.	Flat milling fixture		Milling fixture mounted on the VMC work table for performance flat milling operation.
6.	Face hole fixture		Pneumatically operated face hole fixture mounted on the VMC work table for doing face holing operation.
7.	UNF Tapping Fixture		Pneumatically operated tap hole fixture mounted on the VMC work table for doing United Nation Fine thread(UNF) tapping operation.

The net operation is Hole for that prepared the face hole fixture the functions and constructions are Pneumatically operated face hole fixture mounted on the VMC work table for doing face holing operation. The last operation is Tapping for that UNF

Tapping Fixture was manufactured here the construction and functions are Pneumatically operated tap hole fixture mounted on the VMC work table for doing United Nation Fine thread(UNF) tapping operation.

The Table 2, refers the Fixture Description and its functions for all the machining process of 5 Axis, the fixture description is 5th Axis Rotary table is shown in the table middle column the function and setup for Rotary Table is Rotary table mounted on the VMC work table for doing different sides of operation in one set-up purpose. In the 1st Setup Fixture is shown in the table 2, 2nd columns the function and setups are 1stsetup fixture is mounted on the VMC work table for machining top side operation of the job profile. 2nd Setup Fixture is shown in the Table 2, here the functions and setup are After top side operation completed then the same job mounted on the second setup fixture for machining bottom side operation. The 2 Fixtures will do Metering Valve Hole, Light Load Advance Hole, Head Locating Fixture Hole, Electro Solenoid Orifice Hole, Dia2.3mm & 3mm Cross hole, Flat milling, Profile milling, Stress Relief Hole Drilling this operation within the single setup.

Table 2: Axis Process layout for 5 Axis.

S.no	Fixture description	Fixture	Fixture functions
1	5th Axis Rotary table		Rotary table mounted on the VMC work table for doing different sides of operation in one setup purpose.
2	1st Setup Fixture		First setup fixture is mounted on the VMC work table for machining top side operation of the job profile.
3	2nd Setup Fixture		After top side operation completed then the same job mounted on the second setup fixture for machining bottom side operation.

3. Results and Discussion

The following results obtained after introduction of "5 axis machining center, as stated earlier, 5 Axis machining center was prepared along with necessary modification to suite our project. The schematic diagram and necessary literature has been collected to understand the systems. This helps in giving an insight to working system and working principle which can be used further for development purposes. The table 3 refers the, the type of machine used, operations, and process parameter for each operation and it is cycle time. The total cycle time for all operations 4121 Sec.

Table 3: Operation Parameters Results for 3 Axis.

SI NO	MACHINE	OPERATIONS	TOOL DESCRIPTION	SPEED	FEED	DEPTH OF CUT	CYCLE TIME (Sec)
1	(MAKINO PS60 MACHINE)	MV Hole	Ø6mm Long Drill	2000	150	19	81
2			Dia10mm chamfer tool	1500	90	18.5	30
3			Ø6.296x8mm Reamer	600	80	25	64
4		XS, LLA	Ø11.48mm long drill	650	150	19.5	83
5			Dia16mm chamfer tool	2000	300	18.5	30
6			Ø12.435 Reamer	1200	80	12.14	63
7		HLF	Ø11.48mm long Drill	1500	75	21.9	92
8			14mm chamfer tool	850	90	18.5	47
9		XS, LLA, HLF	M12X1.25 Drill	400	500	23	72
10		3mmCross Hole	Ø3mm End mill	1000	40	23	67
11			Ø3mm Drill	1500	80	47.7	81
12		2.3mmCross Hole	Ø2.3mm End mill	1200	30	19	68
13			Ø2.3mm Drill	1250	95	42.25	83
				Cycle time			861 secs
				Loading & unloading time			20sec
				TOTAL CYCLE TIME			881 secs
14	(MAKINO PS60 MACHINE)	ESO & Face milling	Ø13.38mm long Drill	1000	80	5	67
15			16mm chamfer tool	900	90	27.3	64
16			Ø24mm End mill	950	85	17.8	79
17			20mm chamfer tool	1200	75	20.4	58
18			Ø14.78x16mm Reamer	750	62	34	99
19			Ø 4.1x6mm Drill	1200	83	6.65	87
20			Ø8mm End mill	1800	85	17.5	46
21			M14X1.5 Tap	1250	120	30.2	83
22			10.5mm chamfer tool	1220	180	17.5	79
23			6mm chamfer tool	1800	95	20.2	97
24			63mm face milling	400	400	2	84
				Cycle time			843
				Loading & unloading time			20
				TOTAL CYCLE TIME			**863 sec**
25	(MAKINO PS60	Face hole	8.82,13.18mm Drill	1000	80	39	88

26	MACHINE)		14.69x16mm hole	900	90	40	165
27			7.6 Flat bottom drill	950	85	45	97
28			13.48x14mm Hole	1200	75	46	143
29			M15X1.0 6H Tap	750	62	30	143
30			4.48 step drill	1200	83	22	82
31			No.10 UNF Tap	1800	85	43	154
				Cycle time			872Sec
				Loading & unloading time			20Sec
				TOTAL CYCLE TIME			**892Sec**
32	(MAKINO PS60 MACHINE)	Pocket hole & SR Hole	Ø3mm End mill	1200	100	13	102
33			Ø3mm S.C Drill	1500	60	25	148
34			8mmProfile mill	1425	420	19	207
				Cycle time			457Sec
				Loading & unloading time			20Sec
				TOTAL CYCLE TIME			**477Sec**
35	(MAKINO PS60 MACHINE)	MV Cross Hole	3.57mm HSS Drill	1200	50	13	172
36			Ø4mm End mill	1500	20	25	121
				Cycle time			293Sec
				Loading & unloading time			20Sec
				TOTAL CYCLE TIME			**313Sec**
37	(MAKINO PS60 MACHINE)	HP Cross Hole	2.7mm HSS Drill	1200	75	32	168
38			Ø4mm End mill	1000	80	15	104
				Cycle time			272Sec
				Loading & unloading time			20Sec
				TOTAL CYCLE TIME			**292Sec**
39	(MAKINO PS60 MACHINE)	SR Cross Hole	2.3mm HSS Drill	1500	95	28	181
40			Ø4mm End mill	1000	80	15	202
				Cycle time			383Sec
				Loading & unloading time			20Sec
				TOTAL CYCLE TIME			**403Sec**
TOTAL CYCLE TIME FOR ALL OPERATIONS							**4121 Sec**

Table 4: Operation Parameters Results for 5 Axis

SI.NO	OPERATION	TOOL DESCRIPTION	SPEED	FEED	DEPTH OF CUT	CYCLE TIME
FIXTURE-1						
1	MV Hole	Ø6x10mm Drill	3715	743	19	24
2		Ø6.296x8mm Reamer	1200	180	25	20
3	LLA Hole	Ø11.48x16mm drill	1500	300	19.5	24
4		Ø12.435 Reamer	1200	180	12.14	25
5	HLF Hole	Ø11.48x14mm Drill	1500	300	21.9	17
6		M12X1.25 Drill	400	500	23	42
7	3mm Cross hole	Ø3mm End mill	1800	40	23	44
8		Ø3mm Drill	3000	150	47.7	37
9	2.3mm Cross hole	Ø2.3mm End mill	1800	30	19	102
10		Ø2.3mm Drill	2600	100	42.25	107
11	Face milling	50mm Milling cutter	1200	360	5	153
12	ESO Hole	Ø13.38/16mm Drill	1400	220	27.3	20
13		Ø24x20mm End mill	900	150	17.8	14
14		Ø14.78x16mm Reamer	1200	180	20.4	14
15		Ø 4.1x6mm Drill	5400	800	34	12
16		Ø8mm End mill	1200	100	6.65	34
17		M14X1.5 Tap	400	600	26	17
18	SR Hole	Ø3mm End mill	1800	100	4.3	13
19		Centre Drill	1800	60	9.1	25
20		Ø3mm S.C Drill	4200	420	32	19
21	Profile milling	Ø24mm End mill	1100	110	4	15
22		Profile mill	2100	420	34.1	25
		LOADING & UNLOADING TIME				20 **Sec**
FIXTURE-2						
23	MV Cross Hole	3.57mm HSS Drill	250	15	90	97
24		2.3 HSS Drill	2000	60	83.25	54
25	SR Cross Hole	4mm Flat End mill	1800	110	0.7	38
26		Centre Drill	1800	120	1.8	28
27		2.7 S.C Drill	3500	300	32	92
28	Face Hole	8.82,13.18,14.63mm Drill	1100	240	21.3	39
29		7.6,13.48mm F.B Drill	800	100	23.5	45
30		M15X1.0 6H Tap	650	650	10.38	30
31	UNF Tapping	4.48 step drill	5437	800	20.3	22
32		UNF Tap	600	476	16	43
LOADING & UNLOADING TIME						20
TOTAL CYCLE TIME FOR 1ST & 2ND SETUP FIXTURE						1331 **Sec**

First Fixture Cycle time = 823sec (with loading & unloading time)
Second Fixture Cycel time = 508sec (with loading & unloading time)
Total Cycle time per component = 1331sec

The table 4, refers the, the type of machine used, operations, and process parameter for each operation and it
is cycle time for 5 Axis machining Center. The total cycle time for all operations 1331 Sec.

4. Conclusion

In the conferred study a trial has been created to compare of 3 and 5 Axis Vertical Machining Center for the time and tool benefits in Industries for cost reduction. For that capacity to machine complicated shapes in a single setup, that saves time, cost and operator allows. It permits the machining enables shorter cutting tools to be utilized since the head can be brought down towards the employment and the cutter arranged towards the surface. Therefore, higher cutting speed can be accomplished, and the vibration of the tool is lessened. Throughout this study would be a decision creating method it ought to be kept in mind that this is an example that is to help set the framework for a company to make a similar decision. a company that uses 3-axis machines for very simple components may not even need to address this decision, however there are firms would that require the new technology to help satiate the growing need for their product. For these firms it's necessary to appear at each possibility on the market. 5-axis machines are just one of the many alternatives that might probably facilitate increase productivity for industries. Ultimately, this is a method that may hopefully guide companies to the right decision to use the facilities of 5- Axis Vertical Machining center. From the results Total cycle time per part, tool usage and man power Utilization may reduce for 5 Axis, it would be helpful for getting profit in industries to use 5 Axis i.e. Multi Task Vertical Machining center. Comparing the 3 & 5 Axis, the Tool Fixtures may reduce for 5 Axis 60%,the total cycle time per component may reduce for 5 Axis 32.3%.3 ,Tool Usage may reduce for 30 to 40 per day, Man Power may reduce for 9 to 3 Per Day.

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