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Design & development of multi orientation drilling special purpose machine subsystem

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Abstract:- The growth of Indian manufacturing sector depends largely on its productivity & quality. Productivity depends upon many factors, one of the major factors being manufacturing efficiency with which the operation /activities are carried out in the organization. Productivity can be improved by reducing the total machining time, combining the operations etc. In case of mass production where variety of jobs is less and quantity to be produced is huge, it is very essential to produce the job at a faster rate. This is not possible if we carry out the production by using general purpose machines. The best way to improve the production rate (productivity) along with quality is by use of special purpose machine. Usefulness and performance of the existing radial drilling machine will be increased by designing and development of multispindle drilling head attachment. This paper deals with such development undertaken for similar job under consideration along with industrial case study. Keywords- Various methods, Design, Manufacturing, Statistical process control (Process capability)

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I. INTRODUCTION

In today's market the customer demands the product of right quality, right quantity, right cost, & at right time. Therefore it is necessary to improve productivity as well as quality [1]. One way to achieve this is by using multi spindle drilling head [2]. On the other hand, in order to meet quality requirements of final product, quality should be achieved at every stage of production [3]. Another way of achieving good quality during production is to use the statistical period techniques at every stage of production. If the production is statistically under control the process can continue and there is no need for a change in the process[4]. However, if it is not statistically under control, the assignable causes should be discovered and removed from the process. The most noteworthy aspect when using multi-spindle machines is the cycle time, due to parallel machining the total operating time is dramatically decreased[5]. Added benefits include less chance for error, less accumulated tolerance error, and eliminate tools changes. This paper gives guidelines regarding design and development of multispindle system

II. VARIOUS METHODS OF MULTISPINDLE

Various Methods of multispindle drilling head are,

Adjustable multispindle drilling head- Can be used in many components, where change centre distance to some range It will increase drilling capacity in single special purpose machine. These are the gear adjustable centre drilling head, in which drill spindle is fitted on slotted plate (slotted plate is fixed in position in the gear box) and the gear mounted on the drill spindle. By changing the gears as per required pitch circle diameter the drill spindle is adjusted in the slotted plate

A. Changeable multispindle head-For flexible production system used for small series production production as shown in fig1

Fig.1Changeable multispindle head

B.Fixed Multispindle drilling head-In this type of Multispindle head one cannot change the centre distance to some range. This type of Multispindle drilling head are used for higher productivity
Features of both the type multispindle drilling head are,
1) By using these multispindle drilling head, increase the productivity is substantial.
2) Multispindle drilling ensures the potential accuracy.
Multispindle head can be fixed centre construction for mass and large batch production and for batch production, adjustable centre type design offered.

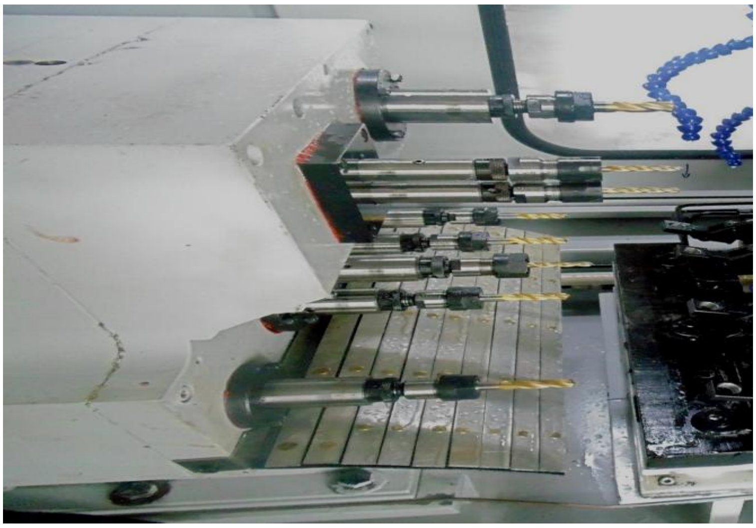


Fig.2Fixed multispindle drilling head

As requirement of Component is fixed C.D. (centre distance) as explain in component description fixed multispindle head is selected. As this head used only for specific components. It is easy to design and manufacture, quit efficient gearing**.**

III. METHODOLOGY

The Multispindle drilling head requires various components, the major components are gear box, drilling spindle, gear shafts, main spindle gear, drive gears, idler gears etc. It requires various machines to manufacture them like band saw machine for cutting operation, lathe machine for rough machining, drilling machine, surface grinding machine, cylindrical grinding machine, internal grinding machine, slotting machine, milling machine, hobbing machine.
Following steps give followed to design multiorientation subsystem

- Study the component drawing and find position of holes
- Construct embodiment diagram
- Calculate speed ratio, gear design and bearing design using standard CMTI handbook
- Generate table of gear and bearing
- Create detail two dimensional drawing

IV. DESIGN

A. Component description

The component is a Side pillion of Bajaj Pulsar 220NS:- Side Pillion right hand side has three holes having diameter Ø5.5 position from ref. hole Ø 8.5 is 34.5mm horizontally&35.3 vertically ,100.2mm horizontally&117.6mmvertically,116.2mm horizontally &137.7mm vertically. Two holes of diameter Ø 8.5mm at position 93.1mm horizontally & 48.5mm vertically. Side Pillion left hand side has two holes of diameter Ø 8.5having centre distance from ref. hole Ø 12 is 178 mm & offset by 17mm from ref. hole axis &another Ø 8.5 hole position from previous hole is105mm horizontally &48mm vertically. Total holes for left hand side pillion is 3 no’s. Total no of holes are 8 to be drilled.
B.The Component drawing for which multispindle drilling head is designed is as shown in fig3.and fig.4

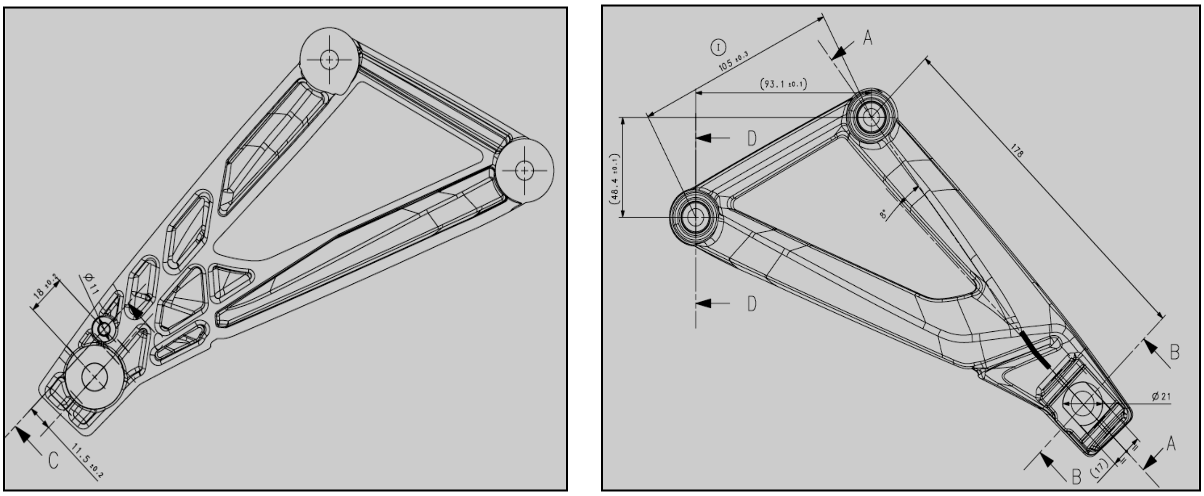


Fig.3 right side Component drawing

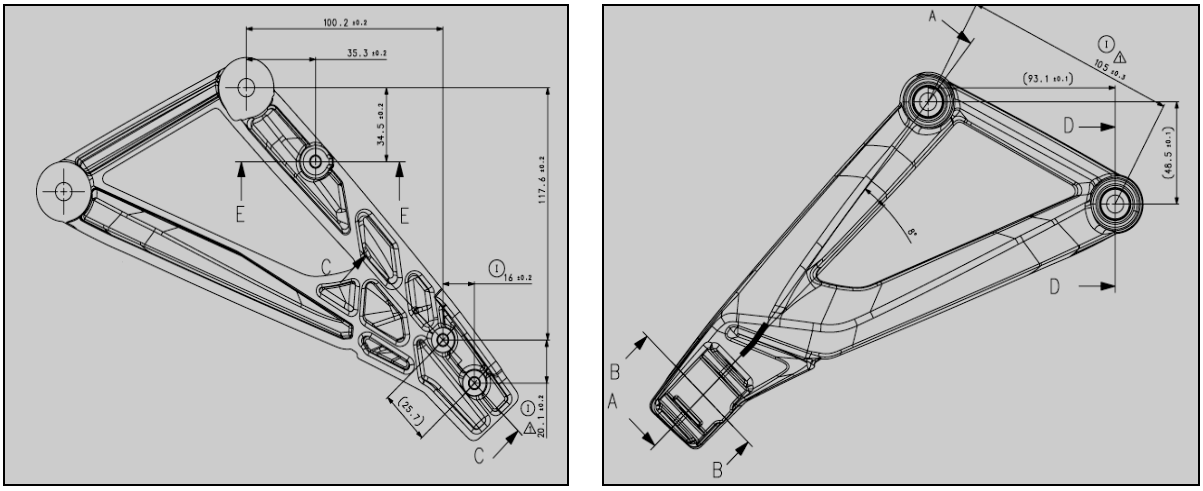


Fig.4 left side Component drawing

Conceptual three dimensional drawing of multispindle drilling head is as shown in fig.5

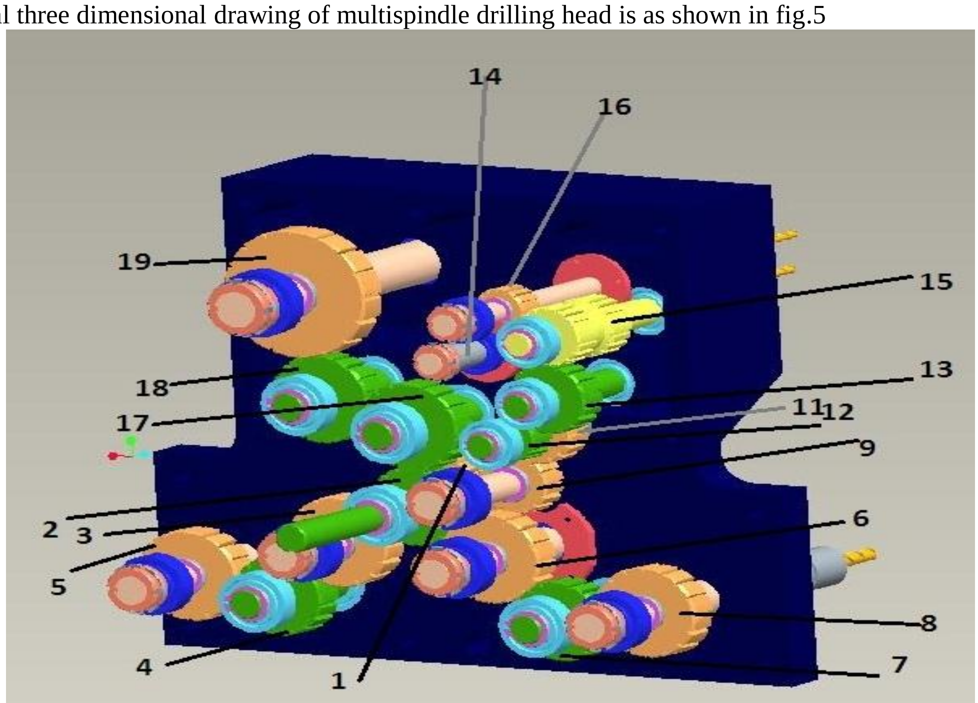


Fig.5 Three Dimensional configuration diagram of Gearbox

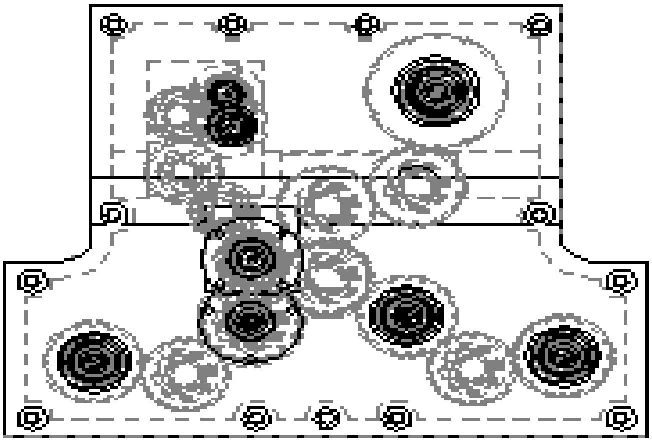


Fig.6 Two Dimensional configuration diagram of Gearbox

Table I All gear are summarized and tabulated

Gear No	PCD mm	Teeth	Hole mm	Speed rpm	Direction	Outer Diameter mm
1	Ø54	36	Idler	1582	CC	Ø57
2	Ø58.78	39	Idler	1582	CC	Ø61.5
3	Ø64.5	43	Ø8.5	1324	C	Ø67.5
4	Ø57	38	Idler	1499	CC	Ø60/ Ø57
5	Ø64.5	43	Ø8.5	1324	C	Ø67.5
6	Ø64.5	43	Ø8.5	1324	C	Ø67.5
7	Ø57	38	Idler	1499	CC	Ø60/ Ø57
8	Ø64.5	43	Ø8.5	1324	C	Ø67.5
9	Ø42	28	Ø5.5	2504	C	Ø45
10	Ø45	30	Idler	2204	C	Ø67.5
11	Ø42	28	Idler	2204	CC	Ø45
12	Ø30	30	Idler	2204	CC	Ø32
13	Ø50	50	Idler	1327	C	Ø52
14	Ø30	30	Ø5.5	2504	C	Ø32
15	Ø36	36	Idler	1843	CC	Ø38
16	Ø30	30	Ø5.5	2504	C	Ø32
17	Ø60	40	Idler	1424	C	Ø63
18	Ø60	40	Idler	1424	CC	Ø63
19	**Ø91.5**	**61**	**Ø12.0**	**934**	**C**	**Ø94.5**

TableII. All bearing are summarized and tabulated

Shaft no	Bearing designation		Bearing dimensions				
			Inner diameter (d) mm		Outer diameter (D) mm		Bearing width (B) mm
	A	B	A	B	A	B	
1	30204	30204	20	47	20	47	15.25
2	30204	30204	20	47	20	47	15.25
3	7005	7004	25	20	42	47	12
4	6004	6004	20	20	42	42	12
5	7005	7004	25	20	47	42	12
6	7005	7004	25	20	47	42	12
7	6004	6004	20	20	42	42	12
8	7005	7004	25	20	47	42	12
9	7005	7004	25	20	47	42	12
10	7005	7004	25	20	47	42	12
11	6003	6003	17	17	35	35	12
12	6003	6003	17	17	35	35	12
13	6003	6003	17	17	35	35	12
14	7002	7002	15	15	32	32	9
15	6003	6003	17	17	35	35	12
16	7002	7002	15	15	32	32	9
17	6004	6004	20	20	42	42	12
18	6004	6004	20	20	42	42	12
19	7005	7006	25	30	47	55	12,13

Where:-30204: Taper roller bearing; 6003&6004:-Deep groove ball bearing; 7002&7004&7005:-Single row Angular contact bearing

V. STATISTICAL PROCESS CONTROL (PROCESS CAPABILITY)

Case study analogue:- The process capability (or machine accuracy study) of a machine or manufacturing process can be defined as the minimum tolerance to which machine can possibly be expected to work and produce no defectives under the specified conditions. If the product is approximately 100% in tolerance limits, it can be said that the system is ‘‘capable’’. The tolerance limits are determined by customers, engineers and management and they are classified as requirements, aims, specifications and standards. There should be lower and upper limits of specification. Machine tool capability (Cp) and process capability (Cpk) are used to determine the efficiency. Cp is used to determine the system’s location in tolerance limits. If the system is not at the centre of specification values, the trend of Cp is progressing faulty. Cpk is used to determine the average so that the system will work better in the specification limits. If the value of Cpk is 1 it shows that the manufacturing is going on in the system specification limits staying at 99.73% level (±3 sigma limits). When the value of Cp and Cpk is 1, this is considered, as the minimum requirement of the system for some companies. Alongside this, larger Cp and Cpk values, for instance 2, are accepted by many companies. One approach is given below for procedure of calculating process capability. Same process will be applied to calculate multispindle drilling head accuracy, for the measuring operations carried out

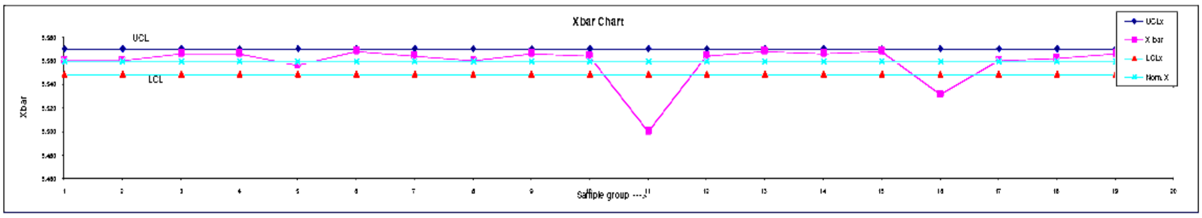
Approach

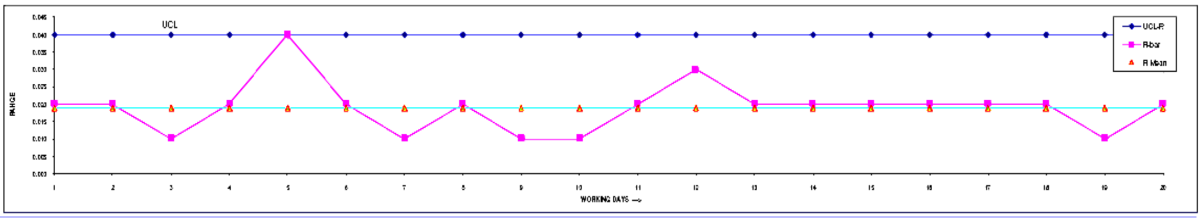
Consider a component as shown below, checking process capability of hole diameter 5.5, 8.5,12 for drilling operations.

<u>For Diameter 5.5</u>

TableIII. Process capability result for drill diameter5.5

Time																				
Sample group / Sample no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
X1	5.560	5.550	5.570	5.560	5.570	5.550	5.560	5.560	5.570	5.560	5.570	5.560	5.560	5.560	5.560	5.540	5.550	5.560	5.560	5.570
X2	5.580	5.560	5.560	5.580	5.560	5.570	5.560	5.550	5.560	5.570	5.580	5.560	5.580	5.570	5.570	5.540	5.560	5.550	5.570	5.560
X3	5.570	5.560	5.570	5.560	5.570	5.580	5.570	5.560	5.560	5.560	5.560	5.550	5.570	5.580	5.580	5.530	5.530	5.570	5.570	5.580
X4	5.570	5.560	5.570	5.570	5.560	5.560	5.570	5.570	5.570	5.560	5.580	5.560	5.560	5.560	5.570	5.520	5.570	5.570	5.560	5.560
X5	5.560	5.570	5.560	5.560	5.570	5.560	5.560	5.560	5.580	5.570	5.580	5.570	5.570	5.560	5.560	5.530	5.570	5.560	5.570	5.580
X bar	5.568	5.560	5.566	5.566	5.566	5.564	5.564	5.560	5.568	5.564	5.500	5.560	5.568	5.566	5.568	5.532	5.556	5.562	5.566	5.560
R	0.020	0.020	0.010	0.020	0.010	0.030	0.010	0.020	0.020	0.010	0.020	0.020	0.020	0.020	0.020	0.020	0.040	0.020	0.010	0.020





Short Term process capability Results			
Grand X bar	=	*5.559*	Average of all sample readings
R bar	=	*0.019*	Average of indivisual ranges
Sigma	=	*0.011*	R bar/d2 = Rbar/2.33
UCLx	=	*5.570*	Grand X bar + (A2xR bar)
LCLx	=	*5.548*	Grand X bar - (A2xR bar) (where A2 = 0.58 for 5 samples)
UCLr	=	*0.040*	R bar x D4 (where D4 = 2.11)
LCLr	=	*0.00*	--
CP	=	***1.85***	(USL-LSL) / (6xSigma)
Cpk-1		1.71	(USL-Xbar) / (3x Sigma)
Cpk-2		1.97	(Xbar-LSL) / (3x Sigma)

<u>For Diameter 8.5 Process Capability result</u>

Short Term process capability Results			
Grand X bar	=	*8.569*	Average of all sample readings
R bar	=	*0.018*	Average of indivisual ranges
Sigma	=	*0.008*	R bar/d2 = Rbar/2.33
UCLx	=	*8.579*	Grand X bar + (A2xR bar)
LCLx	=	*8.558*	Grand X bar - (A2xR bar) (where A2 = 0.58 for 5 samples)
UCLr	=	*0.039*	R bar x D4 (where D4 = 2.11)
LCLr	=	*0.00*	--
CP	=	***1.86***	(USL-LSL) / (6xSigma)
Cpk-1		1.75	(USL-Xbar) / (3x Sigma)
Cpk-2		1.97	(Xbar-LSL) / (3x Sigma)

<u>For Diameter 12 Process Capability result</u>

Short Term process capability Results			
Grand X bar	-	12.097	Average of all sample readings
R bar	-	0.002	Average of indivisual ranges
Sigma	-	0.001	R bar/d2 = Rbar/2.33
UCLx	-	12.098	Grand X bar + (A2xR bar)
LCLx	-	12.096	Grand X bar - (A2xR bar) (where A2 = 0.58 for 5 samples)
UCLr	-	0.005	R bar x D4 (where D4 = 2.11)
LCLr	-	0.00	--
CP	-	1.87	(USL-LSL) / (6xSigma)
Cpk-1		1.77	(USL-Xbar) / (3xSigma)
Cpk-2		1.98	(Xbar-LSL) / (3xSigma)
CPK	-	1.77	(The lower one from Cpk-1 & Cpk-2)

Table IV. Machining Time Comparison

Older machining time per component	New machining time per component	% Time saved
4.38 MINUTES	1 MINUTES	77.2

VI. CONCLUSIONS

- By using multispindle drilling head productivity will increase as shown in tableIV. Because with the present process one hole produces at a time requires 4 minutes for each component (because tool change takes place for drilling 5mm hole (for M6x1 tap)). i.e. 12-15 parts are produced during one hour, but by using multispindle drilling head cycle time approximately takes place 2 minutes. i.e. 25-30 parts may produce during one hour.
- Table III shows process is under control for drilling hole 5.5,8.5,12.
- Possibility of hole missing is eliminated, because six holes drilled at a time
- The cost per piece is reduced. As we see in conclusion no.1 the production rate is approximately double by using multispindle drilling head. The machine used for multispindle drilling head is same (Radial drilling machine) which present uses to produce the part, so machine hour rate remains unchanged.

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