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AUTOMATED GUIDED MECHANISM FOR PICK AND PLACE APPLICATION AT OPPOSITELY PLACED VERTICAL MACHINING CENTRES

Sumit Chaudhari, Kedar Khule, Pradeep Deshmukh, Onkar Nagarkar, Prof. N. B. Patil.

Mechanical Engineering Department, PES Modern College of Engineering, Savitribai Phule Pune University, Maharashtra, India.

sumit17.chaudhari@gmail.com

kedar.khule10@gmail.com

deshmukhpradeep704@gmail.com

onkar1612@gmail.com

ABSTRACT-Earlier the purpose of automation was to increase productivity (since automated systems can work 24 hours a day) and to reduce the cost associated with human operators (i.e. wages & benefits). However, today, the focus of automation has shifted to increasing quality and flexibility in the manufacturing process.
At Precimac Solutions, we had an amazing opportunity to work on an industrial automation project for Sandwick Asia under the guidance of highly qualified engineers. The aim was to increase quality, productivity, and most importantly safety at a Vertical Machining Centres. Optimized production processes are essential to achieve a good competitive position. This means flexible production systems with the right level of IT and automation. Automation gives faster, safer production processes that are more efficient, flexible, reliable, sustainable, and cost- effective.

We have designed an automated pick and place machine using a best in class Universal robot 10 (UR10 kg) paired with a linear guide mechanism allowing for efficient work management on two Vertical Machining Centres. Thus saving time, increasing productivity, and ensuring safety at all times.

Keywords- Universal Robot(UR10), Vertical Machining Centres(VMC).

1. INTRODUCTION

The importance of automation in industrial processes. To speak of automation of manufacturing processes. We must first understand what it is and what it does. The auto industry is a benchmark when we are talking about the automation of manufacturing processes. Fordism brought to the industry the concept of serializing manufacturing processes and,

therefore, the standardization of products. With the evolution of the industry, other concepts were created involving automation and the automotive industry, such as the Toyota system, also known as Ohnoismo, which brought many other changes, such as the JIT (Just in Time) system, the Statistical Process Control and incorporated other systems such as Taylorism and Fordism itself. Automating the process is to bring numerous benefits to its production. An automated manufacturing process in the industry today, means a final product with higher quality and more competitive due to factors such as standardization of process and product, speed of production, production schedule and continuous, reduction of waste, and fewer chances to commit mistakes. We aimed to automate pick and place operation for two oppositely placed Vertical Machining centres with a job processing capacity of 5 jobs per hour per machine and 80 jobs in total.

2. METHODOLOGY

1. We used Catia software to design the structural C Frame considering all the forces and constraints into account.

2. Selection of linear guide was done according to the positional accuracy requirement. Rack and helical pinion is used for it's better feedback and less backlash.

3. We used Catia software to design the job mounting table in accordance with the job carrying capacity of 40 jobs per table.

4. Manufacturing of structural C frame was carried out by first cutting square tubes with required dimensions and welding the tubes in the shape of 'C' with the opening of 'C' in downward direction.

5. The complete process of automation was achieved by interfacing Universal Robot with PLC controlled servomotor.

3. SELECTION OF COMPONENTS

3.1 Selection of LM Guide

From Manufactures Catalogue we Selected following LM guide-

- LM Guide Selected - **HGH25CA**

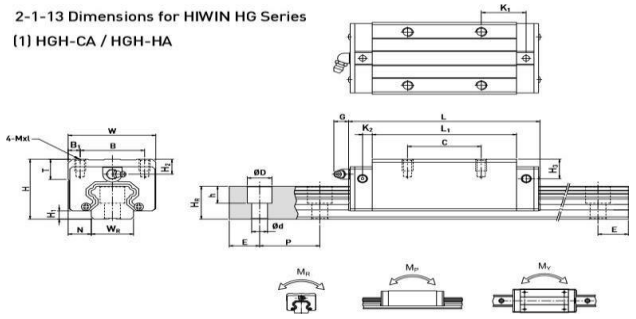


Fig. 3.1.1 Diagram of selected LM Guide.

Model No.	Dimensions of Assembly (mm)						Dimensions of Block (mm)										Dimensions of Rail (mm)						Mounting Bolt for Rail	Basic Dynamic Load Rating	Basic Static Load Rating	Static Rated Moment			Weight	
	H	H_1	N	W	B	B_1	C	L_1	L	K_1	K_2	G	Mxl	T	H_1	H_2	W_2	H_3	D	h	d	P	E	(mm)	C(kN)	C_0(kN)	M_R kN-m	M_P kN-m	M_Y kN-m	Block kg	Rail kg/m
HGH25CA	40	5.5	12.5	48	35	6.5	35	58	84	15.7	6	12	M6x8	8	10	9	23	22	11	9	7	60	20	M6x20	34.9	52.82	0.42	0.33	0.33	0.51	3.21
HGH25HA							50	78.6	104.6	18.5															42.2	69.07	0.56	0.57	0.57	0.69	

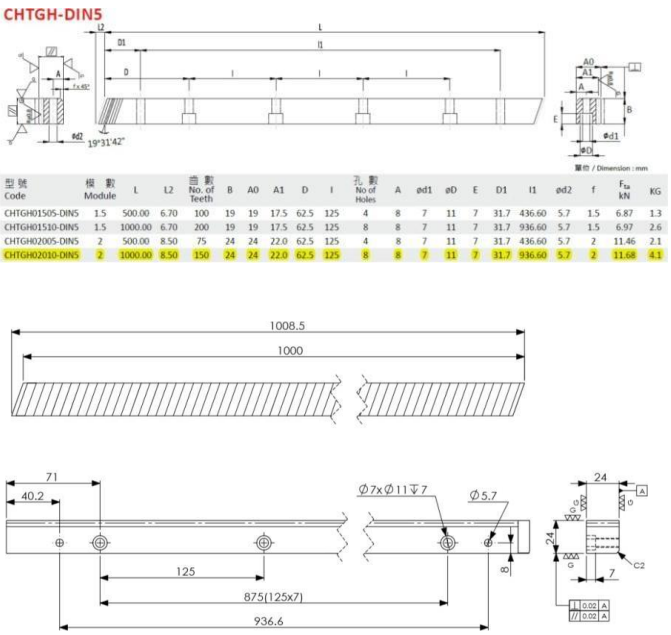
Fig. 3.1.2 Dimensions of LM Guide.

3.2 Selection of Rack and Pinion Gear:

- ❖ Pinion Gear Design
- Pinion material : S45C (Mild steel)
- No. of Pinion teeth (Z) : 20
- Ultimate tensile strength (S_{ut}) : 686 N/mm^2 (Hardening)

- Maximum Torque : 14.3 (servomotor PDF company P.g. No. 17)
- Pressure Angle (Ø) : 19 Degree

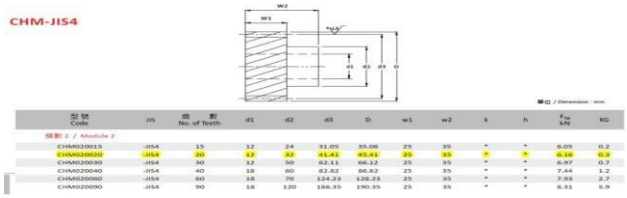
For module = 2, N=2, Grade DIN6,(As recommended by Company)
From above Calculation we selected the following Rack CHTGH-DIN5 from YYC company catalogue.



型號 Code	模數 Module	L	L2	齒數 No. of Teeth	B	A0	A1	D	I	孔數 No of Holes	A	ød1	øD	E	D1	l1	ød2	f	F_{ka} kN	KG
CHTGH01505-DIN5	1.5	500.00	6.70	100	19	19	17.5	62.5	125	4	8	7	11	7	31.7	436.60	5.7	1.5	6.87	1.3
CHTGH01510-DIN5	1.5	1000.00	6.70	200	19	19	17.5	62.5	125	8	8	7	11	7	31.7	936.60	5.7	1.5	6.97	2.6
CHTGH02005-DIN5	2	500.00	8.50	75	24	24	22.0	62.5	125	4	8	7	11	7	31.7	436.60	5.7	2	11.46	2.1
CHTGH02010-DIN5	2	1000.00	8.50	150	24	24	22.0	62.5	125	8	8	7	11	7	31.7	936.60	5.7	2	11.68	4.1

fig. 3.2.1 Design of Rack.

From above calculation we selected following Pinion,
Selected- CHM-JIS4 from YYC company catalogue.



型號 Code	JIS	齒數 No. of Teeth	d1	d2	d3	D	w1	w2	k	h	F_{ka} kN	KG
模數 2 / Module 2												
CHM020015	-JIS4	15	12	24	31.05	35.08	25	35	*	*	6.05	0.2
CHM020020	-JIS4	20	12	32	41.41	45.41	25	35	*	*	6.16	0.3
CHM020030	-JIS4	30	12	50	62.11	66.12	25	35	*	*	6.97	0.7
CHM020040	-JIS4	40	18	60	82.82	86.82	25	35	*	*	7.44	1.2
CHM020060	-JIS4	60	18	70	124.23	128.23	25	35	*	*	7.93	2.7
CHM020090	-JIS4	90	18	120	186.35	190.35	25	35	*	*	8.31	5.9

Fig. 3.2.2 Dimensions of Pinion

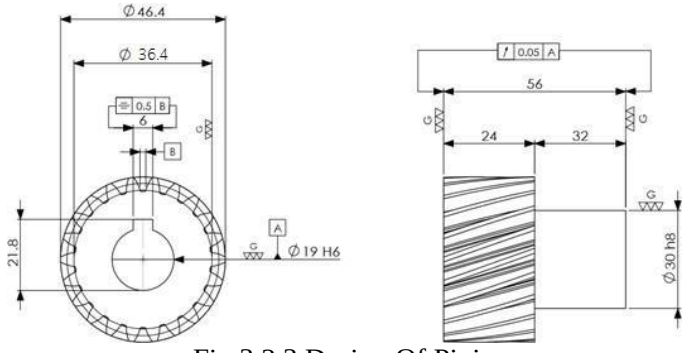


Fig.3.2.3 Design Of Pinion

3.3 Selection of Servomotor

- Overall Efficiency(η_0)= 0.95
- Force(F)= 3000 N.
- Speed(V)= 15 m/min. (For No shock and vibration V≤15 m/min.)
- Power-From standard table of Siemen's ,we assume that higher rating of Motor is P= 1KW, N= 2000rpm , Shaft Height = 65mm.

From Siemens Catalogue (Page No. 23)

Motor	Screw	Flange Size	Flange Material
FL606	4*M8	350*350*20 mm^3	Aluminium Alloy

As from above calculation we selected a motor from catalogue (Siemens company), following are Specification Of selected Servomotor:

TABLE 1

Parameters	Values from Catalogue Of Siemens Servomotor
Shaft height	67
Rated power	2.00 Kw
Rated torque	9.55 Nm
Rated speed	2000 rpm
Maximum torque 1)	28.7 Nm
Maximum speed	3000 Rpm

Rated current	5.9 A
Maximum current	17.7 A
Torque constant	1.7 Nm/A
Moment of inertia • without brake • with brake	 29.9 * 10^-4 Kgm2 31.0* 10^-4 Kgm2

3.4 Job mounting table

The job mounting table plays an important role in this project as the minimum requirement of the jobs was 40 job/ per shift. As the area was restricted between two VMC, we have to consider the following factors like the desired height of the table so that the worker can have easy access to mount the jobs on the table. Also, we have to keep free ample space for free movements of the workers at the center of the frame i.e.(1.5 meters apart). In this case, three categories where analyzed were 36, 38, and 40 jobs where mount on the table design. As per the services of company project approval of 40 jobs finalized. The material selected is mild steel with a yield strength of 310 N/mm^2.

TABLE 2

Description	
Job Mounting	**40**
Material selected	**Mild steel**
Yeild strength	**370MPa**
Hardness (Brinell hardness)	**131**
Ultimate strenght	**440 MPa**
Table height	**875mm**

3.5 Universal Robot (UR10)

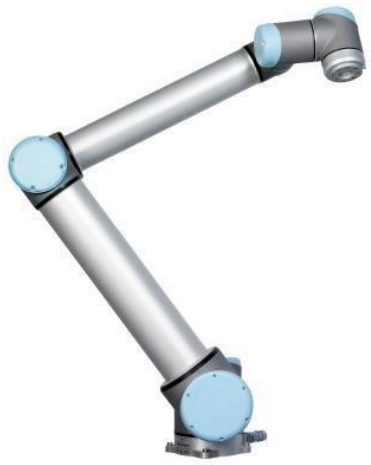


Fig. 3.5.1 UR10 Cobot

The robot can be programmed to move a tool, and communicate with other machines using electrical signals here in this case UR10 communicates with VMC with the help of PLC programmed servomotor. It is an arm composed of extruded aluminum tubes and joints .Using UR Programming interface, PolyScope, it is easy to program the robot to move the tool along a desired trajectory.

TABLE 3

Robot type	UR10
Weight	28.9 kg / 63.7 lb
Payload	10 kg / 22 lb
Reach	1300 mm / 51.2 in
Joint ranges	± 360 ◦ for all joints
Speed	Base and Shoulder joints: Max 120 ◦ /s. All other joints: Max 180 ◦ /s. Tool: Approx. 1 m/s / Approx. 39.4 in/s.
Repeatability	± 0.1 mm / ± 0.0039 in (4 mils)
Degrees of freedom	6 rotating joints

Programming	PolyScope graphical user interface on 12" touchscreen with mounting
Noise	Comparatively noiseless
Power consumption	Approx. 350 W using a typical program
Temperature	The robot can work in a temperature range of 0-50 ◦C
Power supply	100-240 VAC, 50-60 Hz
Calculated operating life	35,000 hours

4. CONCLUSION

The automated guided machine is fully capable of performing pick and place operation for both the vertical machining centres with a positional accuracy of ±0.05mm within the time constraint of 12 minutes. The job table is well within the space constraints and fulfils the requirement of holding 40 jobs. The Universal Robot 10 is a reliable and highly efficient six axis robot. It is capable of carrying a weight of 10kg without affecting it's performance. With a reach of 1300mm, the robot easily performs pick and place operation on all jobs at the table. The selected linear guide and PLC controlled servomotor give the required motion and maintain the required positional accuracy of 0.1mm.The machine includes a fail safe circuit if there is a failure. The UR10 robot comes equipped with collaborative safety technology that immediately stops the robot if there is human interference in the working range. The collaborative machine is fully equipped and automated and is ready to work in an industrial environment.

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