Design of 2-Axis Cartesian Gantry Robot for Connecting Rod Handling in Final Gauging and Grading Application

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ABSTRACT

The purpose of this project is to understand factory automation for certain applications for inspection and grading of connecting rods. Grading of connecting rods is done using automated in-process verification. Automation is necessary for fool-proofing of checking quality parameters and to eliminate human intervention to avoid errors and subsequent degradation of quality. Connecting rods are graded and similar grades are used in an application to ensure uniformity. The parameters on the basis of which connecting rods are graded are center-distance, diameters of big-end and small-end, thickness at big-end and small-end and weight.

Gantry robot is designed on the basis of various parameters such as number of axes in which motion is permitted, motion profile, stroke length of set-up in those directions, type of gripper used, cycle time defined by customer, guiding system, selection of transmission elements, motor, sensors, encoders, gear box, input-output systems, safety interlocks, geometrical dimensioning and tolerance.

Making use of the above elements, grading of a connecting rod is carried out within the prescribed time given by the customer.

Keywords: ***Automation, Connecting rods, Gauging, Grading, IPV, Gantry robot***

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1. INTRODUCTION

Automation can be perceived as an intended, collaborative and efficient use of machines, control system and information technology to achieve productivity, repeatable quality and reliable performance in various manufacturing processes. It also takes out operator from the tasks and hence eliminates the dependency on skill of an operator. Categories of automation on the basis of quantity and variation:

1. Fixed (Hard)
2. Flexible
3. Programmable (Soft)

Category of this project- flexible automation

Classification on the basis of function:

1. Continuous process
2. Manufacturing
3. Factory

Some elements of the firm's production system are likely to be automated, whereas others will be operated manually or clerically.[1] For our purposes here, automation can be defined as a technology concerned with the application of mechanical, electronic, and computer-based systems to operate and control production.[1] The automated elements of the production system can be separated into two categories: (1) automation of the manufacturing systems in the factory and (2) computerization of the manufacturing support systems.[1] In modern production systems, the two categories overlap to some extent, because the automated manufacturing systems operating on the factory floor are themselves often implemented by computer systems and connected to the computerized manufacturing support systems and management information system operating at the plant and enterprise levels.[1] The term computer-integrated manufacturing is used to indicate this extensive use of computers in production systems.[1]

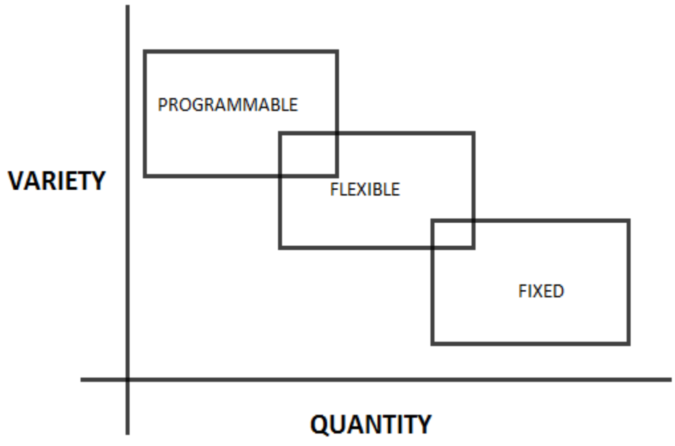

Fig-1: Types of Automation

Types of factory automation- Handling and assembly automation

Category of this project- handling automation with in-process verification or inspection in production line.

Material Handling and Storage. A means of moving and storing materials between processing and/or assembly operations is usually required.[1] In most manufacturing plants, materials spend more time being moved and stored than being processed.[1] In some cases, the majority of the labor cost in the factory is consumed in handling, moving, and storing materials.[1] Inspection and Test. Inspection and test are quality control activities.[1] The purpose of inspection is to determine whether the manufactured product meets the established design standards and specifications.[1]

1.1 Problem Statement

"Design of 2 axis cartesian gantry robot for connecting rod handling in final gauging and grading application."

1.2 Need

Need of this project is to understand factory automation for certain applications for inspection and grading of connecting rods. In-process verification (IPV) of quality of connecting rods is to be done in order to reduce the number of rejects. Automation ensures full-proofing of checking quality parameters, it also helps to eliminate human intervention. Grading of connecting rods on the basis of parameters like centre-distance and mass so that those having similar specifications can be grouped together and used in the applications. Automation induces a safe working environment.

Connecting rod is often in high speed movement as one of the main parts of automobile engine.[2] It's shape error and accuracy of the hole or the plane will directly influence the working performance and the service life of engine.[2] So the production has very strict requirements on the shape error.[2] Connecting rod standard gauge block, as a standard part of manufacturing connecting rod, it's manufacturing accuracy is higher, and the measurement and calibration of error directly affects the machining efficiency and the precision of the connecting rod.[2]

1.3 Objective

- To design a gantry robot for handling connecting rod
- To design work stations to:
  1. Measure parameters like mass and centre distance between big end and small end of connecting rod
  2. Set up a traceability system by using 2-D matrix to be marked by dot marking machine
  3. Sorting of OK and NOT OK components as well as grading of the same

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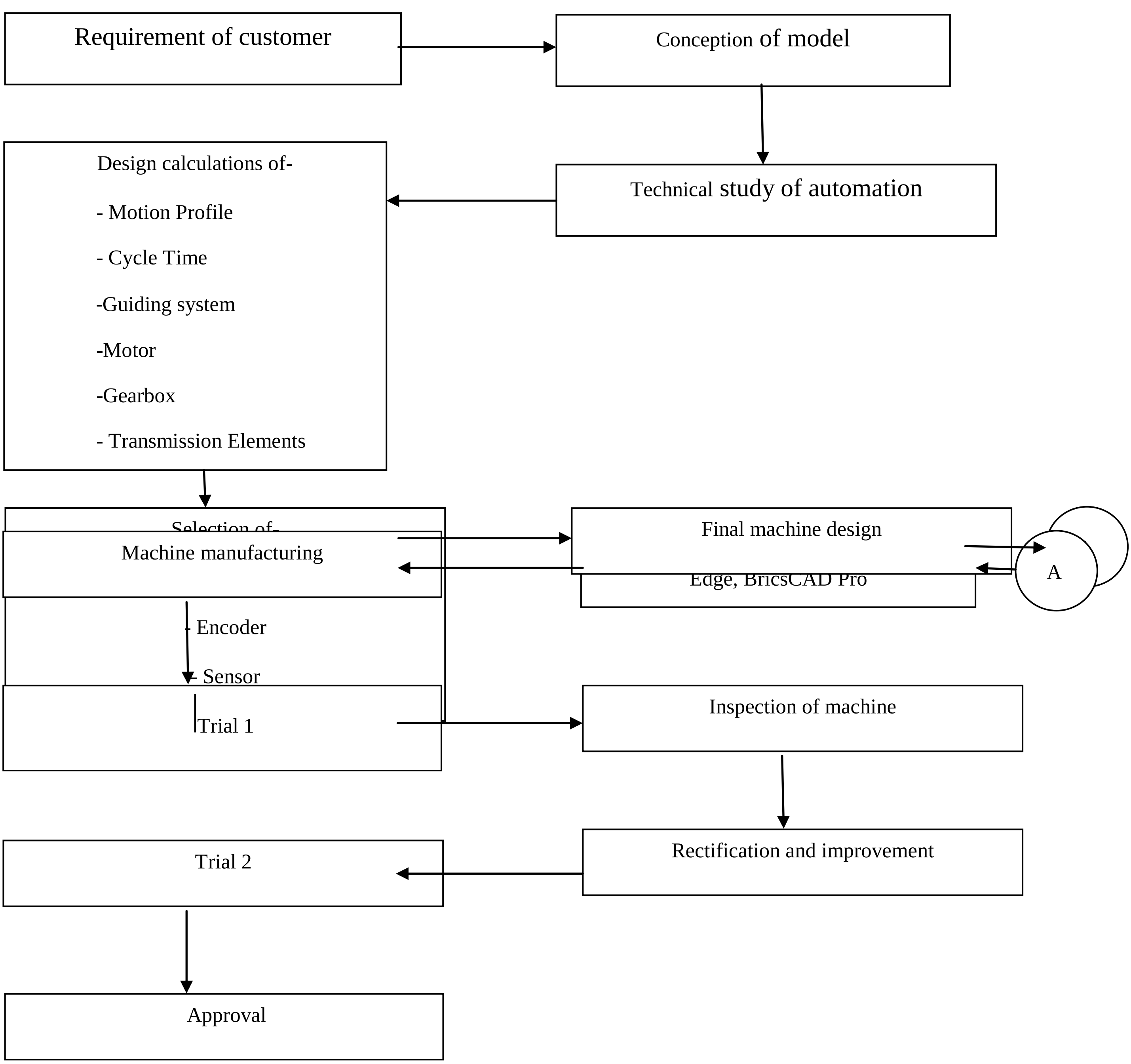
2. LITERATURE REVIEW

Vision inspection plays an instrumental role in factory automation. In the past, manufacturers struggled between relying either on a team of operators to manually inspect parts for defects or on an expensive early generation automated vision system. On the one hand, manual inspection could never match the accuracy of an automated vision system. Inspection operators would get tired and inspection quality gradually suffered further into their shifts. On the other hand, an early vision system was expensive and did not have the hardware capabilities to handle the more complex algorithms that were required. The industry has changed a lot since then, as vision hardware and software capabilities have improved dramatically while equipment cost has lowered to the point where it now makes sense to automate visual inspection.[3]

Machine vision systems in factory automation seldom operate in a stand-alone mode. Instead, they send information to other parts of the factory enterprise for a variety of purposes. Quality traceability, for instance, requires the vision system either log or report inspection results to the enterprise.[3]

3. METHODOLOGY



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4. DESIGN

- Number of axes
- Stroke length
- Type of motion
- Motion Profile
- Cycle Time
- Selection of Transmission Elements
- Encoder
- Gripper
- Sensor

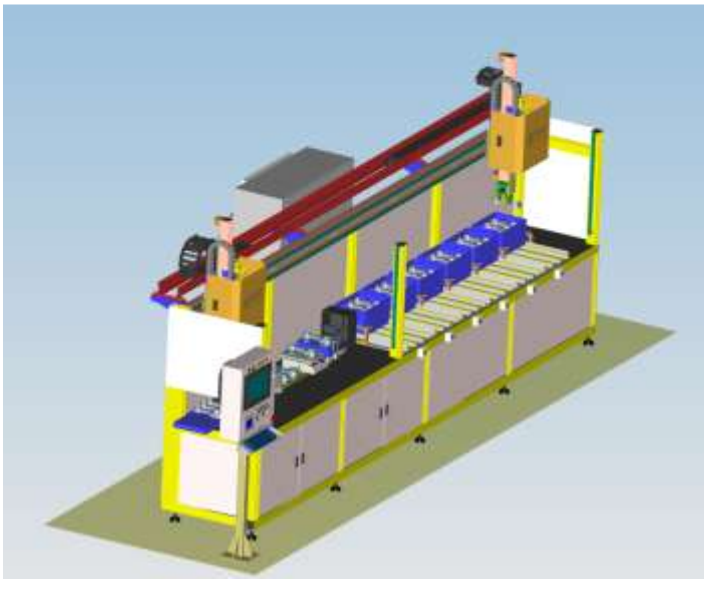

Fig-2: Proposed view of structure

- Cycle Time: calculated by
  1. Triangular motion planning
  2. Trapezoidal Motion Planning

PARAMETER	TRIANGULAR	TRAPEZOIDAL
s (DISTANCE)	$at^2/4$	$2(ta^3)$
t (TIME)	$(4s/a)$^(½)	$3(s/2a)$^(½)
a (ACCELERATION)	$4s/t^2$	$4.5s/t^2$
v (max VELOCITY)	2s/t	1.5s/t

Table-1: Formulae for cycle time calculation

As per our calculations, cycle time is found to be 30 seconds

- Transmission elements used: Transmission elements can be chosen as rope, chain, timer belt or rack and pinion.

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Choice of mechanism	Drive	Speed	Accuracy/ Precision	Backlash	Efficiency	Choice
Rope	Friction	Moderate	Low	No	High	×
Chain	Positive	Moderate	Low	Yes	High	×
Timer Belt	Positive	High	High	No	High	×
Rack & Pinion	Positive	High	High	Can be either	High	✓

Table-2: Selection of Transmission Elements

5. EXPERIMENTAL VALIDATION

- Stroke Length in X-direction: 4.14 m
- Stroke Length in Z-direction: 0.35 m
- Type of Motion: Linear in X and Z directions
- Motor manufactured by: MITSUBISHI ELECTRIC
  Series of the motor : HG-SN 102 J[5]
- Gripper manufactured by: FESTO
  Material of gripper :Brass
- Inductive Proximity: 15
  Capacitive Proximity: 7
  Area Sensors: 2
  Float Sensors: 2
  Sensors manufactured by: BALLUFF
- Drag Chain: It is used for cable management.
  Manufacturing company: IGUS
- Bins: Number of bins-7
  Number of connecting rods in each bin:10
  Outer dimension of bin: (0.4*0.3*0.22)m
  Inner dimension of bin: (0.375*0.274*0.195)m

6. CONCLUSION

Hence, we designed 2 axis cartesian gantry robot for connecting rod handling in final gauging and grading application. The cycle time was within the prescribed time by the customer.

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