Design of Automated Moving Fixture for Conveyorised Special Purpose Machine

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Abstract

It is required to fix typical shape engine components on conveyor while performing cleaning operation. In conveyorised multistage washing machine, to fix these typical shape components is very difficult. Hence these components need dedicated fixturing with poke-yoke to avoid accidents inside the zone on conveyor. This project gives feasible solution on conventional roller chain conveyorised arrangement with dedicated moving fixture with conveyor for the tractor components like rear axle career, bull gear and shaft of a tractor model. This arrangement will be widely used for numerous cleaning purposes owing to its effectiveness for high production volume, reliable and durable performance.

1. Introduction

1.1 Project background

For an automobile industry it's very difficult job to clean the engine component in the assembly line before assembly of the engine to obtain the required Millipore value. Hence in automotive, aviation, auto ancillaries and other industries automated washing machines are highly demanded to save the time, man power and to improve washing and drying quality.

The conventionally using conveyor in production line is worldwide known, but in special purpose machine conveyors are needed with special design and parameter for its operational feasibility. In this automated moving fixture arrangement fixturing parameters like V pads, vertical rods, mounting pads, etc. moves along with chain roller conveyor and reach at multiple station with stop and go operation with given speed by gear box.

1.2 Problem statement

In an industry, it is required to clean engine component rear axle career, bull gear, and shaft of tractor engine in assembly line. It is very difficult to fix and clean these components on conveyor. Hence automated washing machine with fixture on conveyor is highly needed. Hence dedicated fixture for these components and chain conveyor to reach these components at various workstations is designed.

1.3 System legends

The travelling of components from one station to another should be operation oriented. Following important legends are considered to design planning the system as objectives.

i) To design fixture for auto moving components (Rear axle career, Bull gear and shaft).
ii) To design chain and sprocket arrangement with proper guiding rollers.
iii) To design driving and driven shaft.
iv) To calculate required torque, pulling load, speed
v) To mount fixture on conveyor by considering movability on forward and return side of conveyor.
vi) To select the sensors.
vii) To select the material

1.4 Scope of the project

i) The fixture to fix the typical shape components will be designed.
ii) Chain conveyor to move automotive components will be designed.
iii) Design feasibility will be based on theories of chain drive and fixture design fundamentals

2. Literature Review

2.1 Conveyor

Different types of conveyors are available viz., slat type conveyor, powerised roller belt type conveyor, etc., as shown in figure.

Slat type Conveyor

Powerised roller belt type conveyor

All these type of conveyor are not feasible for the require purpose because of no scope for Fixture arrangement, no scope for return arrangement, since the return of pallets is must.

A SPM Manufacturer has designed the same purpose machine by return roller conveyor. But it needs lifter and pusher arrangement which was pneumatically operated. Fixture on pallets was not fixed on the conveyor, it needs the manually separation.

Procedures for Selecting Roller Chain

The following factors must be considered when selecting roller chain.

a. Source of power
b. Driven machine
c. Horsepower to be transmitted
d. RPM of driving and driven shafts
e. Diameter of driving and driven shafts
f. Canter distance of the shafts

2.2 Fixture

Fixtures are important in both traditional manufacturing and modern flexible manufacturing system (FMS), which directly affect machining quality, productivity and cost of products. The time spent on designing and fabrication fixtures significantly contributes to the production cycle in improving current product and developing new products.

Therefore, great attention has been paid to study of fixturing in manufacturing (Thomas and Ghadhi, 1986). A fixture design used in machining, assembly, welding and other manufacturing operation to locate and hold a work piece firmly in position so that the required manufacturing process can be carried out corresponding to design specifications (Nee and Senthil kumar,1991).

Fixtures were develop for job, batch and mass productions, which are widely used in manufacturing operations locate and hold a part firmly in position so that the required manufacturing process can be carried out according to design specifications (Hoftman,1991)

In machining processes geometry accuracy of manufactured part mainly depend on the relative position of work piece (silicon chip) to the machining tool (Rong, 1988).Fixture are needed to locate the workpiece relative to the machining tool in order to ensure the manufacturing quality. It is clear that the primarily requirement s for a fixture are located and secured the workpiece in a given position and orientation on a worktable of a machining tool. To secure the workpiece on a fixture, clamps are often utilized to keep a stable location against the machining force. Clamping method can be classified into top and side clamping, which may provide normal and friction force, but in this case polishing due on top surfaces and top clamping is not encouraged. The fixture must be rigid enough to resist the harmful deformation and vibrating during machining. Clamping method and clamping position should be carefully selected to firmly hold the workpice. In addition to the primary requirements in fixture design, many other demands also found, such as ensuring productivity like easy load and unload of the workpiece, utilization of automated or clamping semi automated devices. Special design for reducing formation of weak rigidly parts, simple and safe operation and effective cost reduction. Hence the fixture design is complicated process. The application of these fundamental principles to individual fixture design depends on primarily designer’s experience in manual fixture design.

2.2.1 Dedicated Fixture

Since dedicated fixtures are commonly used in mass production, dedicated fixtures design are usually applied the fixture construction is perfectly designed for specific operation. As part of machining tooling, the application of dedicated fixture has greatly contributed to the development of automated manufacturing system. Therefore dedicated fixture designs are specially designed for each specific operation, with special consideration of fixture structure, auxiliary support, and other operational properties. Moreover, the operations can be conducted quickly and the tolerance requirement can easily assured in the operation. The problem involving in dedicated fixture application includes the flexibility and long lead time required to designed and fabricate the fixture. When product design change like the shape and the size changes he dedicated fixture are usually not longer useful and scrapped. Today a flexible fixture is desired to a certain extent in order to design variations of the products.

2.2.2 Fixture design principle

Fixtures are one of operational equipment in manufacturing which are used to ensure the product quality and operational efficiency. Fixture design is desired to be rapid or on time, effective and economic.

3. Design of Fixture

3.1 Fixture Design Fundamentals

Fixture design consists of a number of distinct activities: fixture planning, fixture layout design, fixture element design, tool body design, etc. They are listed in Figure 3.1 in their natural sequence, although they may be developed in parallel and not necessarily as a series of isolated activities in actual execution. Fixture design deals with the establishment of the basic fixture concepts: Fixture layout is an embodiment of the concepts in the form of a spatial configuration of the fixture, Fixture element design is concerned with the concrete details of the locators, clamps and supports, Tool body design produces a structure combining the fixture elements in the desired spatial relationship with the machine tool.

3.1.1 Fixture Design

Fixture planning is to conceptualize a basic fixture configuration through analyzing all the available information regarding the material and geometry of the workpiece, operations required, processing equipment for the operations, and the operator. The following outputs are included in the fixture plan:

- Fixture type and
- complexity Number of workpieces per fixture
- Orientation of workpiece within fixture
- Locating datum faces
- Clamping surfaces
- Support surfaces, if any

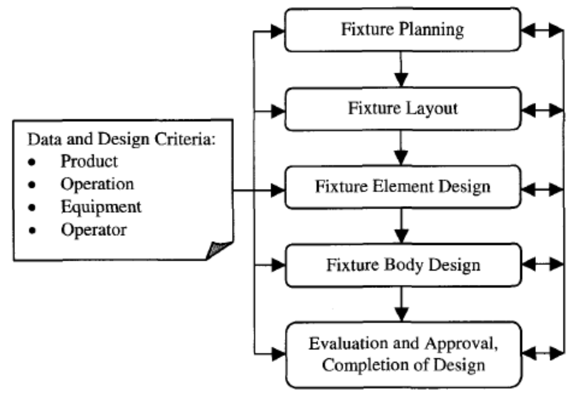

Fig. 3.1 Various aspects of fixture design

4. Design and Selection of Chain and Sprocket

4.1 Selection of chain

ISO Roller Chain no. 64B
Pitch = 4" = 101.6mm
Minimum bearing load = 67000 N
Weight of chain = 6.5 Kg/m

Table 4.1 Weight of the components

SN	Name of Comp.	Wt./ Component (kg)	No. of Component	Total Wt. of Component (kg)
1	Rear Axle Career	26.4	2	52.8
2	Shaft	22.6	2	45.2
3	Bull Gear	7.8	2	15.6
	TOTAL		**6**	**113.6**

Weight of components on one fixture tray = 113.6 kg
Maximum number of fixture tray on conveyor at a time = 06
Total weight of component at a time on conveyor = 113.6 x 6 = 681.6 kg ~ 700 kg.

Chain – Sprocket Parameters

Chain pitch (P) = 101.6 mm

Chain speed (v) = 4 m/min
Number of teeth on sprocket (z) = 13

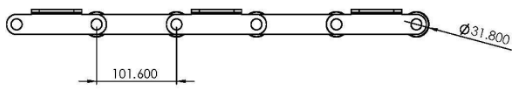

Fig. 4.1 ISO Chain 64B

Pitch circle diameter of sprocket

$$\mathrm{PCD} = \frac{P}{\sin\left(\frac{\pi}{z}\right)}$$

PCD = 424.5 m
~ 425 mm

PCD of sprocket (D_p) = 425 mm = 0.425 m.
Sprocket outside diameter (D_o) = D_p + 0.8 d
Where, d = Roller diameter

$d = \frac{5}{8} \times \text{Pitch} = \frac{5}{8} \times 101.6 = 63.5$ mm

Do = 425 + (0.8 × 63.5) = 475.8 mm

Inner width i.e. minimum distance between roller link plate = $\frac{5}{8} \times \text{Pitch} = \frac{5}{8} \times 101.6 = 63.5$ mm

Pin diameter = $\frac{5}{16} \times \text{Pitch} = 31.75$ mm

Thickness of link plate = $\frac{1}{8} \times \text{Pitctch}$ = 12.7 mm

Centre distance ≤ 80 × pitch
Hence,
Maximum centre distance = 80 × 101.6
= 8128 mm
= 8.128 m
But due to the space availability, let us consider centre distance (C) = 5000 mm = 5 m.

Length of chain

$$L = 2C + \frac{N1 + N2}{2} + \left(\frac{N1 - N2}{4\pi^2 C}\right)^2$$

Where,
C = Centre distance = 5000 mm
N1 = Number of teeth on driven sprocket = 13
N2 = Number of teeth on driving sprocket = 13
Hence,
Length of chain = 23 m.

Weight of the chain
For the selected chain number C100, weight of the chain is 6.5 kg/m
Hence, Weight of the chain = 6.5 × 23
= 149.5 kg
~ 150 kg.

Total pulling weight = Weight of chain + Weight of components
= 150 + 700
= 850 kg
Maximum pulling weight = Total pulling weight × Coefficient of friction
In general, for rolling application, the coefficient of friction is considered to be 0.2.
Hence,
Maximum pulling weight = 850 × 0.2
= 170 kg.
Let, g = 10 m/s^2
Hence,
Maximum pulling weight = 1700 N.

Pulling Torque

$$\text{Required torque} = \text{Maximum pulling weight} \times \frac{\mathrm{PCD}}{2}$$

= 361.25 Nm
Final output torque = Required torque × Service factor
Let, Service factor = 1.5
Hence,
Final output torque (T) = 361.25 × 1.5
= 541.9 Nm
~ 550 Nm
Hence,
Pulling Torque = 550 Nm.

$$\text{Pitch between components} = \frac{\text{Centre distance}}{\text{Number of fixture tray}}$$

$$\text{Pitch between components (Pc)} = \frac{5000}{6}$$

Pitch between components (Pc) = 833.33 mm
Time to travel pitch Pc = 13 sec.

$$\text{Required RPM} = \mathrm{Pc} \times \left(\frac{60}{13}\right) \times \left(\frac{\text{Pitch}}{z}\right)$$

Where, z = number of teeth = 13
Hence,
Require RPM = 2.97 rpm
~ 3 RPM

$$\text{Horse Power (hp)} = \frac{2\pi n T}{45000}$$

Horse Power (hp) = 0.22 HP

$$\text{Required Power (kW)} = \frac{\pi \times \text{Torque} \times \text{RPM}}{30000}$$

Required Power (kW) = 0.17 kW

Hence,
Final output Torque (T) = 550 Nm
Final output RPM (n) = 3 rpm
Final output Horsepower (hp) = 0.22 HP

Required kilowatt (kW) = 0.17 kW.

Sprocket parameter

Pitch circle diameter of sprocket

$$PCD = \frac{P}{\sin\left(\frac{\pi}{z}\right)}$$

$$PCD = 424.5 \text{ m}$$
$$\sim 425 \text{ mm}$$

PCD of sprocket (D_p) = 425 mm = 0.425 m.

Top diameter, $(D_o)_{max} = D + 1.25p - d_1$
$= 488.5$ mm
$(D_o)_{min} = D + p(1\text{-}1.6/z)\text{-}\ d_1$
$= 450.59$ mm

Hence, let us take top Diameter = 475 mm

Root diameter, $D_f = D - 2r_i$

Where, r_i = roller seating arrangement
$(r_i)_{max} = 0.505d_1 + 0.069(d_1)^{1/3}$
$= 32.34$ mm
$(r_i)_{min} = 0.505d_1$
$= 32.06$ mm
Take $r_i = 32.3$ mm

Hence root diameter = 410.8 mm

Tooth flank radius
$(r_e)_{max} = 0.008d_1\ (z^2+180) = 117.3$ mm
$(r_e)_{min} = 0.12d_1 + (z+2) = 114.3$ mm

Take tooth flank radius = 115 mm

Roller seating angle (α)
$(\alpha)_{max} = [120 - (90^0/z)] = 113.08^0$
$(\alpha)_{min} = [140 - (90^0/z)] = 133.08^0$
Hence take
$\alpha = 125^0$

Tooth height above the pitch polygon
$(h_a)_{max} = 0.625p - 0.5d_1 + (0.8p/z) = 38$ mm
$(h_a)_{min} = 0.5(p - d_1) = 19.05$ mm
Hence
$h_a = 25.4$mm

Tooth width, $(b_f)_{max} = 0.95b_1 = 60.325$
~ 60.5mm
Where, $b_1 = 63.5$mm

5. View of Dedicated Fixture Arrangement

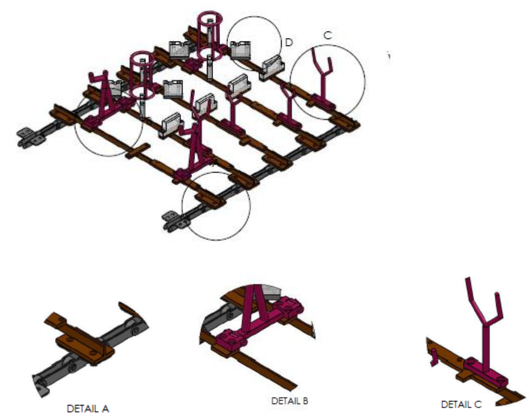

Fig. 5.1 Fixture arrangement on fixture tray

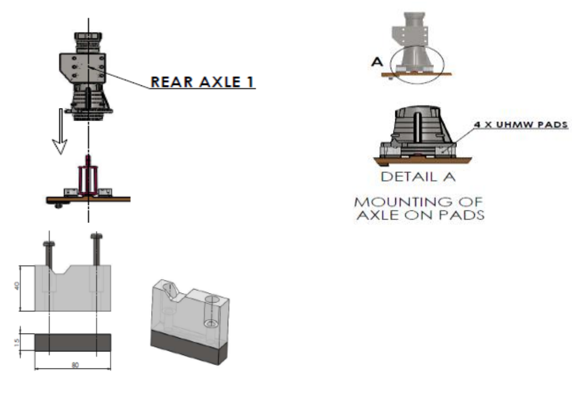

Fig. 5.2 Mounting of rear axle career on fixture

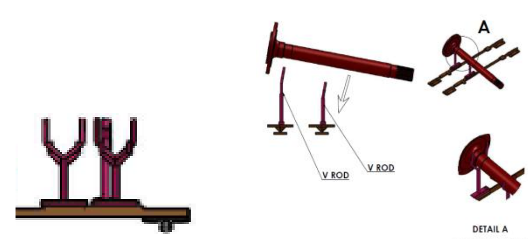

Fig. 5.3 Mounting of shaft on fixture

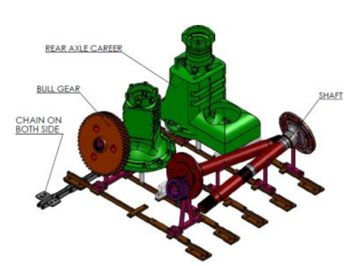

Fig. 5.4 View after mounting all components on fixture

6. Working Process of the System

As shown in fig.2.1, system will be of six stations where from one end component will get loaded and after going through the various stations it will get unloaded at last station.

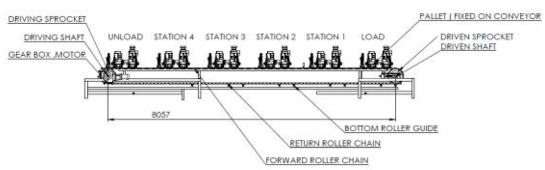

Fig. 6.1: Process Layout

1. On loading station, operator will load the multiple components on dedicated fixture with full proofing.
2. Operator will press the Cycle start Button. Proximity sensors will sense the existence of component on fixture then only conveyor will start moving otherwise it will show error.
3. Fixture will having the unique sensing Dogs for receiving the presence of proximity fixed at every station to stop at that station for processing on components. Station wise respected operation will be done one by one like washing, Degreasing, cold air blowing, hot air blowing. All operations separated zone wise.
4. Another operator exist at unload station will unload the components manually .here also if proximity get sense of availability of components on unload station it will not allow to move the conveyor unless and until the components are not unloaded from the fixture.

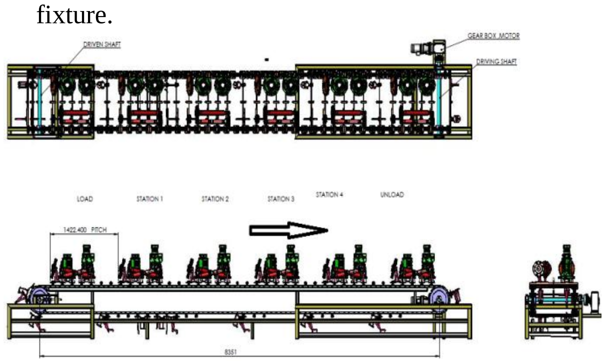

Fig. 6.2 Working view of the system

7. Result and conclusion

As discussed above, the dedicated fixtures are designed for the components rear axle career, bull gear and shaft. To carry these components to various workstations, a chain conveyor is designed by selecting ISO chain no. 64B.

The parameters of chain conveyor are as follows.

Chain No. : ISO Chain 64B
Pitch (p) = 101.6 mm
Roller Diameter = 63.5 mm
Width between inner plates = 63.5 mm
Pin diameter = 31.75 mm
Pin length = 130.00mm
Inner plate height = 90.17mm
Plate thickness = 15.00 mm

Sprocket parameters are as follows.

Pitch circle diameter = 425 mm
Top diameter = 475.8 mm
Root diameter = 410.8 mm
Roller seating radius = 32.2 mm
Tooth flank radius = 115 mm
Roller seating angle = 125^{o}
Tooth height above the pitch polygon = 25.4 mm
Tooth width = 60.5mm

This project gives the suitable solution on the other conveyors to carry the components like Rear Axle Carrier, Bull Gear, shafts of tractor before going to assembly line. Also this project suggests the dedicated fixturing arrangement for these components.

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