Design of Special Purpose Machine

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Abstract— Automation is the technology by which process or procedure is performed with minimum human assistance automation. Automatic control is the use of various control system for operating equipment such as machinery processes in factories boilers and heat treating ovens, switching on telephone networks, steering and stabilization of ships, aircraft and other applications and vehicles with minimal or reduce human intervention. Some processes have been completely automated.

Keywords: Design of Special Purpose Machine, CAD, SPM

I. Introduction

A. *Special Purpose Machine*

Basically the name itself indicates the characteristics of it. Special purpose machines (SPM) is the machine which is not available off the shelf. These are not covered in standard manufacturing programs. Special purpose machines are designed to perform some specific applications which cannot be carried out using conventional machines.

B. *Need of Special Purpose Machine*

The need of Special Purpose Machine (SPM) is that it gives very high productivity. The use of special purpose machine (SPM) and automation minimises possibility of human errors and also reduces human fatigue in carrying out repetitive operations again and again.

II. Aim of the Project

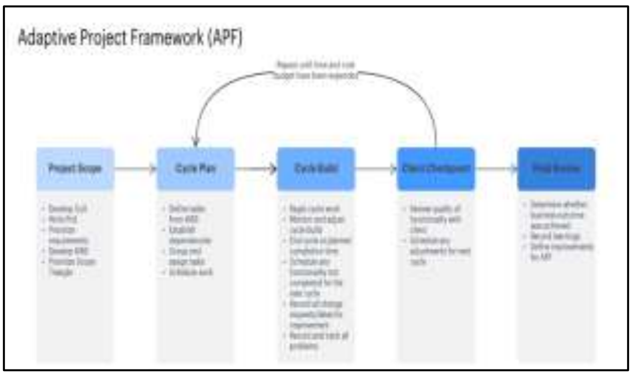
To design a mechanism for special purpose of loosening bolts of intermediate plate of clutch housing.

The operation of loosening bolt is performed to remove intermediate plate, thereby enabling worker to clean and perform other operation on the surface below the intermediate plate.

III. Methodology

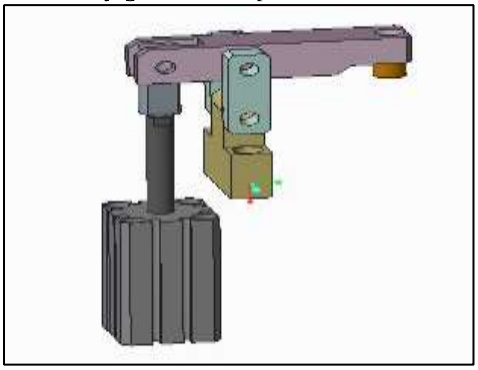
- Adaptive project Framework.
- CAD based development.
- Feature driven development.
- DMAIC.
- Poka-yoke.

A. *Adaptive Project Framework*



B. *CAD based Development*

Computer-aided design CAD involves creating computer models Defined by geometrical parameters.



C. *Feature driven Development*

The feature driven development methodology is aligned to agile development methodology.

D. *DMAIC*

- Define, Measure, Analyse, Improve, Control. Incremental process improvement using Six Sigma methodology.
- DMAIC refers to a data-driven quality strategy for improving processes, and is an integral part of the company's Six Sigma Quality Initiative. DMAIC is an acronym for five interconnected phases: Define, Measure, Analyse, Improve, and Control.
- Each step in the cyclical DMAIC Process is required to ensure the best possible results. The process steps:
- Define the Customer, their Critical to Quality (CTQ) issues, and the Core Business Process involved.
- Define who customers are, what their requirements are for products and services, and what their expectations are,
- Define project boundaries the stop and start of the process.
- Define the processes to be improved by mapping the process flow.
- Measure the performance of the core business process involved.
- Developer data collection plan for the process.

E. *Poka – Yoke*

Poka-yoke is Japanese term that means "mistake proofing" or "inadvertent error prevention". Poka-yoke is any mechanism in any process that helps an equipment operator avoids mistake. Its purpose is to eliminate product defects by preventing, correcting or drawing attention to human errors as they occur. The concept was formulised and the term adopted by Shingeo Shingo as part of the Toyota Production System. It was originally described as Poka-yoke, but as this means "fool-proofing" the name was changed to my milder poka-yoke.

More broadly, the term can refer to any behaviour-shaping constraint designed into a process to prevent incorrect operation by the user.

Simple poka-yoke example is demonstrated when a driver of the car equipped with a manual gearbox just press on clutch pedal prior to starting an automobile. The interlock service to prevent unintended moment of the car.

1) Benefits of poka-yoke implementation,

- A Typical feature of poka yoke solution is that they don't let an error in a process happened. But that is just one of their advantages others include,
- Less time spent on training workers.
- Elimination of many operations related to quality control.

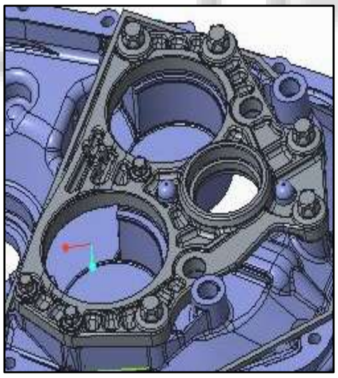
IV. Components

A. The Work Piece - Clutching House

Clutch Housing is a critical part of housing system which holds clutch plates, pressure plates and conducts complete clutch function in combination with clutch centre and hub. A cast iron or aluminium housing that sounds the clutch mechanism.

B. Intermediate Plate

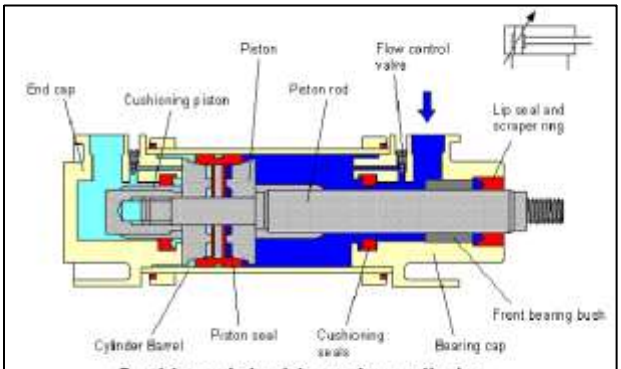
The gearbox has a cast intermediate plate which support all the main bearings in this gearbox. This intermediate plate is casted from aluminium and are not as solid as they should be.



C. Pneumatic Cylinder

Pneumatic cylinders are mechanical devices which use the power of compressed gas to produce of force in a reciprocating linear motion. Hydraulic cylinder something forces piston to move in the desired directions.

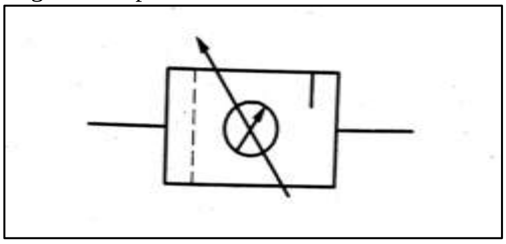
Double-acting cylinders (DAC) use the force of air to move in both extends and retract strokes. They have two ports to allow air in, one for outstroke and one for in stroke. Stroke length for this design is not limited, however, the piston rod is more vulnerable to buckling and bending. Additional calculations should be performed as well.



Cushioned double acting cylinder

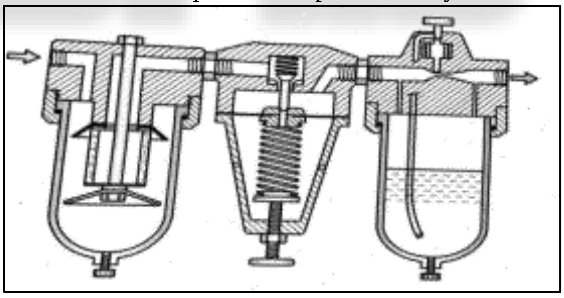
D. FRL

FRL unit is a device consisting of air filter, air regulator and air lubricator. It is also called as air servicing unit, because it does the functions of cleaning, pressure adjustment and lubricating the compressed air.



E. Functions of FRL Unit

- Air filter: It separates solid contaminants from compressed air and provides clean air to pneumatic system.
- Air regulator: It is a pressure reducing valve. It maintains constant reduced pressure in pneumatic system.



F. PLC

A programmable logic controller PLC for programmable controller is an industrial digital computer which has been ruggedized an adopted for the control of manufacturing processes, such as assembly lines, for robotics devices, or any activity that requires highly reliability control and is of programming and process fault diagnosis.

G. HMI

A Human-machine interface HMI is a user interface or dashboard that connects a person to a machine, system or device. While the team can technically be applied to any screen that allows a user to interact with the device HMI is most commonly used in the context of an industrial process.

H. Base Plate

A flat supporting plate on frame at the base of a column designed to distribute the columns wait over a great area and provide increased stability.

1) Function:

When you provide a base plate beneath a column the load gets dispersed to larger area and after that if is transferred to concrete Foundation hence the system is safe.

I. Gear Box

Gearbox is a transmission device which is used between engines output shaft and the final drive in order to transfer required torque and power to the wheels of vehicle.

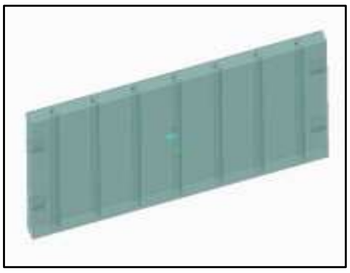
1) Functions:

1) Reduction in speed produces a mechanical advantage.
2) Increasing torque.

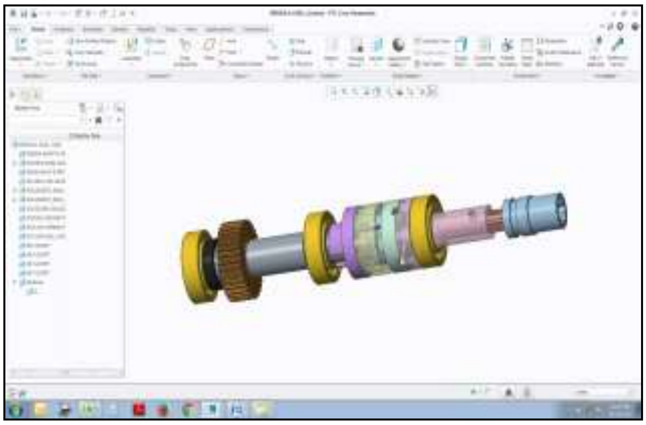
J. SPACER ROD & SPACER PLATE

The spacer rod is designed for stabilizing rods when using two rods on a single picture.

Spacer plates are used to provide space between two or more components.



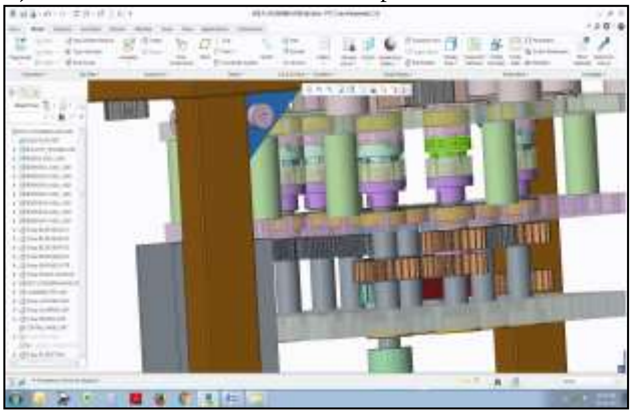
K. Drive Assembly



V. WORKING

Bolt Loosening Unit

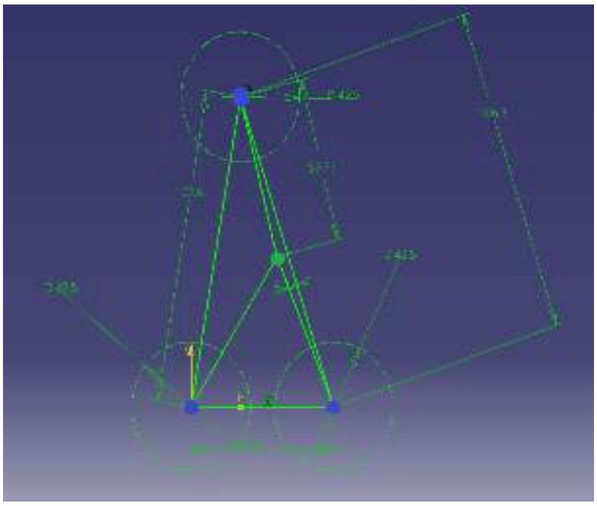
1) Operator pushes the START button.
2) All 8 Sockets will rotate clockwise direction at rpm.
3) Operator will load the component and press the Cycle Start.
4) All bolts will engaged with socket and insure by Sensors (in Auto Inching Mode). To stop after all Sensors off.
5) Component will rest on rest pad indicated by air seat check.
6) Component will clamp by Pneumatic clamp system, after seat check confirmation.
7) Bolt socket will start Anticlockwise direction.
8) Bolt will be loose settable count of rotation (Base on down side proxy sensor and value to keep settable).
9) Motor will stop after reaching set value:- Component to declamp
10) Operator unload the component.
11) Machine should be LMMS compatable.

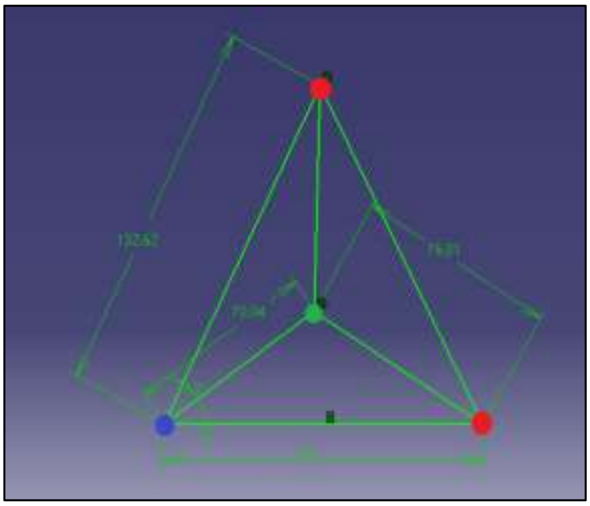


VI. CALCULATIONS

A. Gear Box for M8 Bolt

Sum of gears = (2*cd)/m
= (2*54)/2.5
= 43.2 = 43
Considering Z1 =17
$Z_1 - Z_{I1} = 48-17 = 26$
$Z_{I1} = 26$





Now, Reference diameter or PCD = Z*m
$(PCD)_{I1}$ =ZI1*m
$(PCD)_{I1}$= 26*2.5
$(PCD)_{I1}$= 65
Standardizing $(PCD)_{I1}$= 65.36
Since,
Centre distance between gears and idlers is 54,
Therefore, 54 = (65.36/2) + $(Radius)_{G1}$
$(Radius)_{G1}$ = 54- (65.36/2)
$(Radius)_{G1}$ = 21.3
$(PCD)_{G1}$ = 42.6
Standardizing $(PCD)_{G1}$= 42.5

B. *Gear Box for M12 Bolt*

Sum of gear teeth = $(Z)_{G1}$ + $(Z)_{I2}$
But,
Sum of gear teeth= (2*cd/m) = (2*70/2.5) = 56
Therefore,
$(Z)_{G1}$ + $(Z)_{I2}$ = 56
$(Z)_{I2}$ =56-17
Since, $(Z)_{G1}$ =17
$(Z)_{I2}$ = 39
Since,
$(Z)_{I2}$ = 39
$(PCD)_{I2}$ = $(Z)_{I4}$*m
$(PCD)_{I2}$= 39*2.5
$(PCD)_{I2}$ = 97.5
Standardizing $(PCD)_{I2}$ =97.98
Again,
Sum of gear teeth = $(Z)_{G2}$ + $(Z)_{I2}$
Sum of gear teeth= (2*cd/m) = (2*76.3/2.5)
= 61.04
$(Z)_{G2}$ + $(Z)_{I2}$ = 61
$(Z)_{G2}$ = 61-39 =22
Now,
$(Z)_{G2}$ =22
$(PCD)_{G2}$ = $(Z)_{G2}$*m
= 22*2.5
=55

C. *Bolt Lossening Gear – Driver M8 Gear*

Module – 2.5
where, module=PCD/No of teeth
Also, module= OD/N+2. where, N=No of teeth
PCD=42.5
No of teeth (t_1)= 17
1) *Addendum (h_a)= module(m)*
h_a = 2.5mm
2) *Dedendum (h_f) = 1.25*m*
h_f = 3.125mm
3) *Tooth thickness (circular thickness) = 1.5708*m*
= 1.5708*2.5
= 3.927mm
4) *Fillet radius = 0.4*m*
= 0.4*2.5
= 1mm
5) *Addendum circle dia = pitch + 2(h_a)*
= 42.5+2(2.5)
= 47.5mm
6) *Dedendum circle dia = pitch circle-2(h_f)*
= 42.5+2(3.125)
= 36.25mm
7) *Circular thickness angle= (360^0/no of teeth)*0.5*
= (360^0/17)*0.5
=10.58^0
8) *Circular thickness angle for teeth = 10.58/2*
= 5.29^0
9) *Circle (A) diameter = PCD/8*
= 42.5/8
= 5.3125 (radius)
= 10.625 (diameter)

D. *Idealer 1*

Module = 2.5
PCD = 65.36
No. of teeth = 26
1) *Addendum (h_a)= module(m)*
h_a = 2.5mm
2) *Dedendum (h_f) = 1.25*m*
h_f = 3.125mm
3) *Tooth thickness (circular thickness) = 1.5708*m*
= 3.927mm
4) *Fillet radius = 0.4*m = 0.4*2.5 = 1mm*
Addendum circle dia = PCD + 2(h_a)

= 70.36mm

5) *Dedendum circle dia = PCD - 2(h_f)*

= 59.11mm

6) *Circular thickness angle= (360^0/no of teeth)*0.5*

=6.92^0

7) *Circular thickness angle for teeth = 6.92/2*

= 3.46^0

8) *Circle (A) diameter = PCD/8*

= 8.17 (radius)

= 16.34 (diameter)

E. Idealer 2

Module = 2.5

PCD = 97.58

No of teeth = 39

1) *Addendum (h_a)= module(m)*

h_a = 2.5mm

2) *Dedendum (h_f) = 1.25*m*

h_f = 3.125mm

3) *Tooth thickness (circular thickness) = 1.5708*m*

= 3.927mm

4) *Fillet radius = 0.4*m*

= 1mm

5) *Addendum circle diameter = PCD + 2(h_a)*

= 102.5mm

6) *Dedendum circle diameter = PCD - 2(h_f)*

= 91.33mm

7) *Circular thickness angle= (360^0/no of teeth)*0.5*

= 4.615^0

8) *Circular thickness angle for teeth = 4.615/2*

= 2.3075^0

9) *Circle (A) diameter = PCD/8*

= 12.1975 (radius)

= 24.395 (diameter)

F. Idealer 3

Module = 2.5

PCD = 60

No of teeth =24

1) *Addendum (h_a)= module(m)*

h_a = 2.5mm

2) *Dedendum (h_f) = 1.25*m*

h_f = 3.125mm

3) *Tooth thickness (circular thickness) = 1.5708*m*

= 3.927mm

4) *Fillet radius = 0.4*m*

= 1mm

5) *Addendum circle diameter = PCD + 2(h_a)*

= 65mm

6) *Dedendum circle diameter = PCD - 2(h_f)*

= 53.75mm

7) *Circular thickness angle= (360^0/no of teeth)*0.5*

= 7.5^0

8) *Circular thickness angle for teeth = 7.5/2*

= 3.75^0

9) *Circle (A) diameter = PCD/8*

= 7.5 (radius)

= 15 (diameter)

G. For Gear Box Monitor

8bolts

5 bolts - m12 – pitch – 1.75

3 bolts – m8 – pitch – 1.25

– M12 – 80N-m Torque required - 80*5 = 400N-m

– M8 – 25N-m Torque required – 25*3 = 75N-m

8 bolts = 475-m

F.O.S. = 1.8

Pitch = 1.4

Total torque = 475*1.8

= 855 N-m

For torque of 950 N-m

Rpm= 14

Wattage = 1392.0667

HP = 1.8641

Motor conf. = 2HP

Gear bar ratio = 98.514 = 1380/14

Driver torque = torque*(rpm/power)

= 950* (14/1380)

= 9.63

VII. Conclusion

Machine capable of performing special purpose of loosening 8 bolts of different sizes using appropriate mechanism to attain the mentioned objectives is designed and manufactured successfully.

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