Design and Modification of Laser Marking Machine to Increase Efficiency

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Abstract - *In the conventional laser marking machine, operators need to do various jobs manually and that can cause various mistakes. In this paper, we change the design of the system so that we can get accurate markings by reducing human interference in one marking cycle. Due to this system, we can reduce the reworking, checking the configuration on the demo workpiece, save manpower at the time of adjusting all settings and also increase the rate of production. It is used in all production lines to make accurate markings (Barcode, ID, etc.) on various metal parts.*

Key Words: Marking Machine, Rotating Fixture, Modification, Efficiency Increment

1. INTRODUCTION

The laser marking machine is used to make company logos, barcode, QR codes component specifications, etc. on the metal surface of components. This is very important as it is crucial for part replacement and tracing. Laser marking makes a permanent mark on the component which is important in industrial applications, it is a good solution to the possibility of heated temperature or vigorous rubbing of other parts and erasing the conventional marking. It is also better than Dot-peening scribing, manual stamping, impact machines, chemical etching, ink-jet printing because it causes no damage to components. To fulfil the basic need of fast manufacturing a laser marking machine should possess the following properties:

• Fast completion of the machine cycle.

• Low human interference.

• Efficient and precise marking.

Some design changes can make this possible to achieve the desire rate of production.

2. Problem Definition

In a laser marking machine precise focal adjustment of laser is very important. In a conventional laser marking machine, the operator had to remove the component after every cycle and replace it with the next component. This makes the process extremely hectic & time-consuming. Moreover, when the size of the component is changed, the operator needs to manually adjust the height of the laser which is a crucial task. There is a risk of error in setting the exact focal length of the laser. Also, as the gases are stuck in the machine, the back door of the machine always needs to be open after a few machine cycles. These are the common problems of conventional laser marking machine. Hence, there is a need for a proper design modification to overcome the above problems to increase the accuracy and efficiency of the laser marking machine with a minimum increase of price.

3. Methodology

1. Literature Review
2. Problem Definition
3. Approach to Solve the Problem
4. System Design
5. 2D/3D Drawing
6. Part & Material Selection
7. Fabrication
8. Test the Model
9. Conclusion

4. Comparison

Comparison of laser marking machine on the following points which can contribute to the high production rate: -

1. Fixture arrangement
2. focal length adjustment (height adjustment)
3. Hot gases removal
4. verification of work done by machine

4.1. Conventional laser marking machine

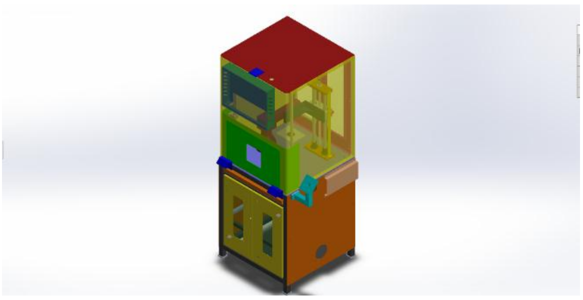

Fig-1: Conventional Machine

4.1.1. Normal fixture arrangement:

Fig-2: Normal Fixture

In the conventional laser marking machine, the component needs to be removed after every cycle and replaced by a new component even if they are small in size. This is time-consuming for large scale production.

4.1.2. Manual height adjustment Screw:

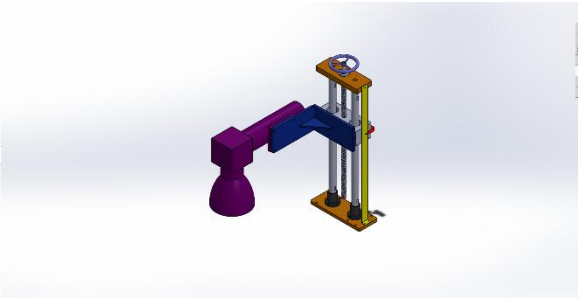

Fig-3:. Laser Mount Column

The height adjustment of the conventional laser marking machine is time-consuming and not very accurate. The worker has to manually adjust the height of the laser by moving the handwheel. This can have an error of 1-2mm which can affect its performance.

4.1.3. No Exhaust System in the working area:

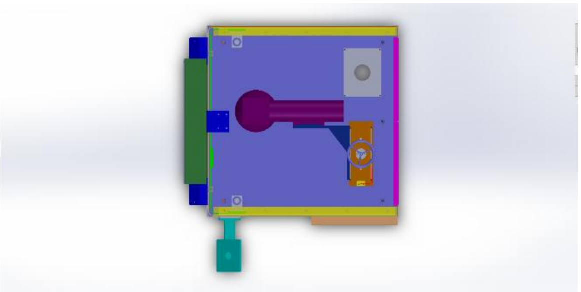

Fig-4: Top View (Workspace planning)

In any machine, the safety of the operator is very important. In conventional laser marking machines, the gases get stuck in the working area, and the temperature increases. The conventional laser marking machine does not have any place for exhaust system. This can be harmful to the operator and also lead to an inappropriate working environment.

4.1.4. Verification of QR code:

In the conventional laser marking machine, verification of QR code is done after the component is taken out of the machine. It is time-consuming as the component is first taken out, then checked and if marking is not done properly, the component gets rejected.

4.2. Modified laser marking machine:

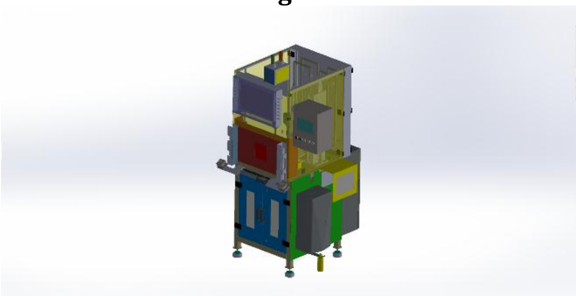

Fig-5: Modified Machine

4.2.1. Circular fixture plate:

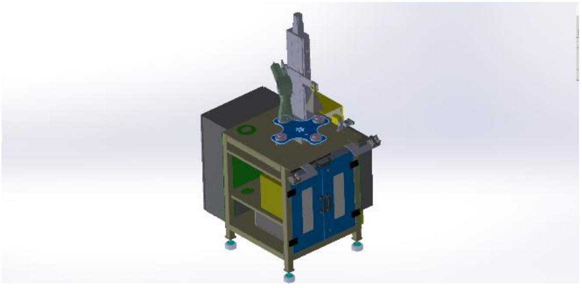

Fig-6: Rotating Fixture

In a modified laser marking machine, there is a rotating fixture assembly in which four components can be mounted at one time. When the operator loads the components and starts the machine cycle, the fixture rotates and automatically adjusts so that one component comes under the laser head. At this position, the sensor senses the component surface and adjusts the focal length of the laser. Then marking is performed on the first component. After that fixture rotates through 90 degrees. At this position, the first component is under the verifying sensor and the second component is under the laser for marking. After this marking on the second component fixture again rotate by 90 degrees to mark and verify the next components. After the last component gets marked laser stops but fixture rotates to verify marking on the last component then the machine sends the signal of completion to the operator. In one machine cycle, the fixture rotates through 360 degrees. This fixture can be used when the components are smaller than or equal to 210*210*70mm. The circular fixture is removable so that when a large component is to be marked the fixture can be changed accordingly.

4.2.2. Automatic height adjustment shaft:

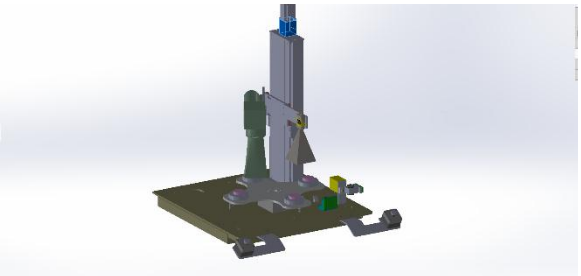

Fig-7: Servo motor position

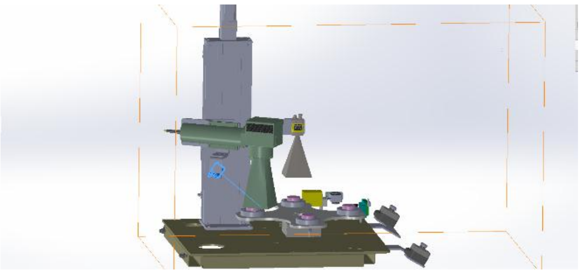

Fig-8: High-performance laser distance sensors position

In a modified laser marking machine, the vertical movement of the shaft is controlled by the servo motor. When the size of the component changes the focal length needs to be adjusted. In this case, the laser head which is mounted on the vertical column goes to the home(top) position. Then High-performance laser distance sensors – OM70 gets activated which is shown in fig.8 and it tries to detect the top surface of the component at the focal length of the laser as laser head starts to move in a downward direction until the exact height is achieved. This process is very fast and it is accurate in micrometres (0.7 μm).

4.2.3. Vacuum in the working area:

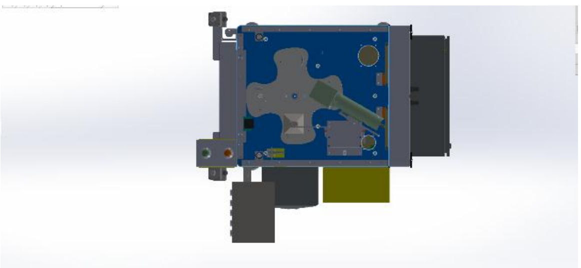

Fig-9: Top View (New Workspace planning)

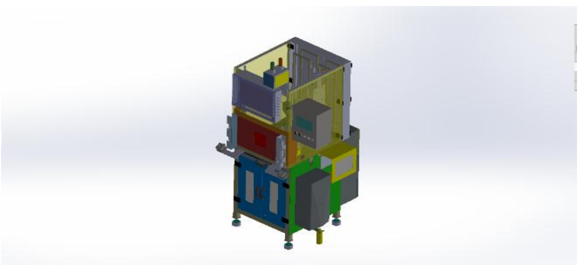

Fig-10: Side Box for Vacuum Setup

In a modified laser marking machine, with the help of a vacuum pipe vacuum is generated in the working area. Due to this, all the gases and heat are sucked out of the machine and are released in the environment. Hence, the safety of the worker and a proper working environment is ensured.

4.2.4. Verification of QR code:

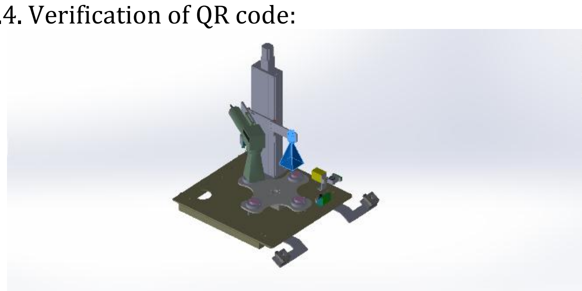

Fig-11: Verification Sensor

In a modified laser marking machine, the verification of QR code is done simultaneously with the marking process in one rotation of the rotating fixture. It saves time and also increases the efficiency of the machine. It saves too much time of manual verification.

5. Calculation

PART-1

All Calculations are done by considering, for every cycle operator needs to set the height of the laser head (Unit production).

CASE 1: -

Consideration

Component dimension are less than or equal to 210*210*70mm, so that 4 components can be placed on rotational fixture.

For calculation we are assuming actual marking time i.e. **cycle time** is 10 sec. It depends on what we are marking and it may change according to complexity of logos, barcode, QR codes component specifications, etc.

Allowances and rating: -

Assuming relaxation allowance as 12%, contingency allowance as 3% and policy allowance as 10 %.

Total allowance = relaxation allowance+ contingency allowance + policy allowance = 12+3+10=25

Assumed rating is 90% as standard rating.

A. Calculation for conventional design

Process chart:

Process no.	**Description**	**Observed time(sec)**
1	Place component on fixture	3
2	Adjust the height of laser head	15
3	Close the door	2
4	Start the cycle	2
5	Cycle time	10
6	Opening of front door	2
7	Removal of component	3
8	Check the component for proper marking	2
Total		39

Table no.1

Total observed time required is 39 sec for one component.

Considering the allowances and rating,

39*0.9=35.1sec……rating

Normal time/cycle = 35.1sec

Standard time with allowances = 35.1+(35.1*25/100) =43.9sec …. allowances

Calculation for number of components for 8 hours shift.

8 hr. = 28800sec

Number of component = time / Standard time with allowances

Number of components = 28800/40.5

Number of components = 656

B. Calculation for modified design

Process chart:

Process no.	**Description**	**Observed time(sec)**
1	Place component on fixture	12
2	Adjust the height of laser head	4
3	Close the door	2
4	Start the cycle	2
5	Cycle time	10+10+10+10= 40
6	Fixture rotation time	4
7	Opening of front door	2
8	Removal of component	12
9	Check the component for proper marking	0
Total		78

Table no.2

Total observed time required is 78 sec for four components.

Here we used rotating fixture for placing four components at a time.

Total observed time for one component = 78/4= 19.5 sec

Considering the allowances and rating,

19.5*0.9=17.55sec……rating

Normal time/cycle = 17.55sec

Standard time with allowances = 17.55+(17.55*25/100) = 21.9 sec ……. allowances

Calculation for number of components for 8 hours shift.

8 hr. = 28800sec

Number of component = time / Standard time with allowances

Number of components = 28800/21.9

Number of components = 1315

Efficiency increased in modified machine:

No. of product in case 1-part B/ No. of product in case 1-part A = 1315/656 = 2

CASE 2: -

Consideration

Component dimension are greater than 210*210*70mm, so that 4 components cannot be placed on rotational fixture as case 1. We have to place one component at a time in modified machine also.

For calculation we are assuming actual marking time i.e. **cycle time** is 10 sec. It depends on what we are marking and it may change according to complexity of logos, barcode, QR codes component specifications, etc.

Allowances and rating: -

Assuming relaxation allowance as 12%, contingency allowance as 3% and policy allowance as 10 %.

Total allowance = relaxation allowance+ contingency allowance+ policy allowance = 12+3+10=25

Assumed rating is 90% as standard rating.

A. Calculation for conventional design

Process chart:

Process no.	Description	Observed time(sec)
1	Place component on fixture	3
2	Adjust the height of laser head	15
3	Close the door	2
4	Start the cycle	2
5	Cycle time	10
6	Opening of front door	2
7	Removal of component	3
8	Check the component for proper marking	2
Total		39

Table no.3

Total observed time required is 39 sec for one component.

Considering the allowances and rating,

39*0.9=35.1sec……rating

Normal time/cycle = 35.1sec

Standard time with allowances = 35.1+(35.1*25/100) =43.9sec …. allowances

Calculation for number of components for 8 hours shift.

8 hr. = 28800sec

Number of component = time / Standard time with allowances

Number of components = 28800/40.5

Number of components = 656

B. Calculation for modified design

Process chart:

Process no.	Description	Observed time(sec)
1	Place component on fixture	3
2	Adjust the height of laser head	4
3	Close the door	2
4	Start the cycle	2
5	Cycle time	10
6	Opening of front door	2
7	Removal of component	3
8	Check the component for proper marking	0
Total		26

Table no.4

Total observed time required is 26 sec for one component.

Considering the allowances and rating,

26*0.9=23.4sec……rating

Normal time/cycle = 23.4sec

Standard time with allowances = 23.4+(23.4*25/100) = 29.25 sec ……. allowances

Calculation for number of components for 8 hours shift.

8 hr. = 28800sec

Number of component = time / Standard time with allowances

Number of components = 28800/29.25

Number of components = 984

Efficiency increased in modified machine:

No. of product in case 2-part B/ No. of product in case 2-part A = 984/656 = 1.5

PART-2

All Calculations are done by considering, the machine is operated for a similar component (batch production or mass production) where we set the height of laser only at the start of the process so for every cycle operator does not need to set the height of the laser head. So, we are not considering that time for batch or mass production.

CASE 1: -

Consideration

Component dimension are less than or equal to 210*210*70mm, so that 4 components can be placed on rotational fixture.

For calculation we are assuming actual marking time i.e. **cycle time** is 10 sec. It depends on what we are marking and it may change according to complexity of logos, barcode, QR codes component specifications, etc.

Allowances and rating: -

Assuming relaxation allowance as 12%, contingency allowance as 3% and policy allowance as 10 %.

Total allowance = relaxation allowance+ contingency allowance + policy allowance = 12+3+10=25

Assumed rating is 90% as standard rating.

A. Calculation for conventional design

Process chart:

Process no.	Description	Observed time(sec)
1	Place component on fixture	3
2	Close the door	2
3	Start the cycle	2
4	Cycle time	10
5	Opening of front door	2
6	Removal of component	3
7	Check the component for proper marking	2
Total		24

Table no.1

Total observed time required is 24 sec for one component.

Considering the allowances and rating,

24*0.9=21.6sec……rating

Normal time/cycle = 21.6sec

Standard time with allowances = 21.6+(21.6*25/100) =27sec …. allowances

Calculation for number of components for 8 hours shift.

8 hr. = 28800sec

Number of component = time / Standard time with allowances

Number of components = 28800/27

Number of components = 1066

B. Calculation for modified design

Process chart:

Process no.	Description	Observed time(sec)
1	Place component on fixture	12
2	Close the door	2
3	Start the cycle	2
4	Cycle time	10+10+10+10= 40
6	Fixture rotation time	4
7	Opening of front door	2
8	Removal of component	12
9	Check the component for proper marking	0
Total		74

Table no.2

Total observed time required is 74 sec for four components.

Here we used rotating fixture for placing four components at a time.

Total observed time for one component = 74/4= 18.5 sec

Considering the allowances and rating,

18.5*0.9=16.65sec……rating

Normal time/cycle = 16.65sec

Standard time with allowances = 16.65+(116.65*25/100) = 20.81 sec ……. allowances

Calculation for number of components for 8 hours shift.

8 hr. = 28800sec

Number of component = time / Standard time with allowances

Number of components = 28800/20.81

Number of components = 1383

Efficiency increased in modified machine:

No. of product in case 1-part B/ No. of product in case 1-part A = 1383/1066 = 1.297

CASE 2: -

Consideration

Component dimension are greater than 210*210*70mm, so that 4 components cannot be placed on rotational fixture as case 1. We have to place one component at a time in modified machine also.

For calculation we are assuming actual marking time i.e. **cycle time** is 10 sec. It depends on what we are marking and it may change according to complexity of logos, barcode, QR codes component specifications, etc.

Allowances and rating: -

Assuming relaxation allowance as 12%, contingency allowance as 3% and policy allowance as 10 %.

Total allowance = relaxation allowance+ contingency allowance+ policy allowance = 12+3+10=25

Assumed rating is 90% as standard rating.

A. Calculation for conventional design

Process chart:

Process no.	Description	Observed time(sec)
1	Place component on fixture	3
2	Close the door	2
3	Start the cycle	2
4	Cycle time	10
5	Opening of front door	2
6	Removal of component	3
7	Check the component for proper marking	2
Total		24

Table no.3

Total observed time required is 24 sec for one component.

Considering the allowances and rating,

24*0.9=21.6sec……rating

Normal time/cycle = 21.6sec

Standard time with allowances = 21.6+(21.6*25/100) =27sec …. allowances

Calculation for number of components for 8 hours shift.

8 hr. = 28800sec

Number of component = time / Standard time with allowances

Number of components = 28800/27

Number of components = 1066

B. Calculation for modified design

Process chart:

Process no.	Description	Observed time(sec)
1	Place component on fixture	3
2	Close the door	2
3	Start the cycle	2
4	Cycle time	10
5	Opening of front door	2
6	Removal of component	3
7	Check the component for proper marking	0
Total		22

Table no.4

Total observed time required is 22 sec for one component.

Considering the allowances and rating,

22*0.9=19.8sec……rating

Normal time/cycle = 19.8sec

Standard time with allowances = 19.8+(19.8*25/100) = 24.75 sec ……. allowances

Calculation for number of components for 8 hours shift.

8 hr. = 28800sec

Number of component = time / Standard time with allowances

Number of components = 28800/24.75

Number of components = 1163

Efficiency increased in modified machine:

No. of product in case 2-part B/ No. of product in case 2-part A = 1163/1066 = 1.09

Efficiency chart: -

Case description	Efficiency of conventional machine	Efficiency of modified machine	Increase in efficiency
Unit production case-1	656	1315	**2**
Unit production case-2	656	984	**1.5**
Batch or mass production case-1	1066	1384	**1.297**
Batch or mass production case-2	1066	1163	**1.09**

Table no.5

6. CONCLUSIONS

A. For all cases attempt to add automation increases the efficiency. In this particular case of Laser Marking Machine efficiency for unit production increases much greater than batch or mass production.

B. Due to the modifications (which are mentioned above) the cost of the machine was increased by Rs.20,000 which is 10% of initial price But, with the increased cost we are able to design an automatic machine with accurate results.

C. The efforts required by the operator are reduce as compared to the conventional laser marking machine. The total time required for marking of a component is reduced by 19.5 sec for unit production and 5.5 sec for mass production when the components are of small size and by 13 sec for unit production and 2 sec for mass production when the components are of larger than mentioned size.

D. As the time needed for marking of one component is reduced, a greater number of components can be marked within a certain period of time. Due to this the efficiency of the machine is increased by a factor of 2 for unit production and 1.29 for mass production when the size of the components is small and 1.5 for unit production and 1.09 for mass production when the size of components is larger than mentioned size. With the help of a vacuum pipe, greater safety of the worker and accuracy is ensured.

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