Design and Analysis of Loading and Unloading Station for Auto Pallet Changer of Horizontal Machine Center

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Abstract- *A Machining center is computer controlled machine tool with automatic tool changing capability. The machining center is designed to perform a variety of cutting operation on different surfaces of the work-piece. Any machining center is capable of carrying out milling, drilling, reaming, tapping, boring, facing, turning and other operation without operator intervention for changing tools In a machining center, after a particular operation, say turning has been completed, the work-piece does not have to be moved to another machine for additional operation, say drilling, boring etc. In other words, the tool and the machine are brought to the work-piece. Most of the machining centers are provided with two work tables called as pallets. While the work-piece on one pallet is being machined, the operator set-up the next work-piece on the free pallet at loading station. When the work-piece is machined, the automatic pallet changer(APC) moves the pallet with the finished work-piece away from the working area and moves the other pallet with the new work-piece to the working area. The operator can then unload the finished work-piece from the first pallet and set-up a new work-piece on it while the operatration on second pallet is being carried out. Machining centers with several pallets are also available where machine can be programmed to accept new pallet when the work on the previous pallet is completed. Thus on machining center non-productive time is reduced to great extent.*

Machining centers are mainly used to increase production rate ,productivity and cost per piece. Productivity depends on input to machining center in form of raw material, electric supply etc. and output in form of finished product. Either decreasing input or increasing output to the machining center, we can improve productivity. To decrease input, optimize use of all resources is of great interest. Output can be increased by reducing cycle time of a product & it can also possible with minimizing idle time of machine between loading and unloading of product. We have one option to use pallet changer which reduces idle time of machining center considerably by enabling operator to load the raw material while machining center performing task on previously loaded material or part. Thus pallet changer plays vital role in case of improving productivity which is the main objective of using machining center. Machining centers are mainly used to increase production rate and productivity. Productivity depends on input to machining center in form of raw material, electric supply etc. and output in form of finished product. Either decreasing input or increasing output to the machining center, we can improve productivity.

I. INTRODUCTION TO AUTO PALLET CHANGER

It is mechanism used to move pallet with finished work-piece in case of linear pallets or to rotate work-piece in case of rotary pallets and another pallet takes position of it. Rotary pallets require less floor space compared to linear hence widely used in industries. Linear pallet changer rarely used where rotary pallets are not suitable due to some technical reasons. H-plate is integral part of rotary pallet changer. When machining is completed and already loaded unfinished part has to move inside to perform series of operations on it to obtain final finished product then H-plate lifts rotary table upward on which two pallets are mounted exactly opposite to each other and rotate with 180o. Here,Locking Pin arrangement plays an important role to confirm the fool proofed movement of rotary table hence two pallets will move with exact 180o.

Automatic pallet changer provides fast work-piece changing to reduce loading time and increases spindle utilization. APC is a value added accessory for productivity enhancement of small machining centers and CNC drill tap centers. These pallet changers can be installed onto the existing machines. By installing the APC, the productivity of the machining center can be increased by cutting the down time to the extent of component loading and unloading.

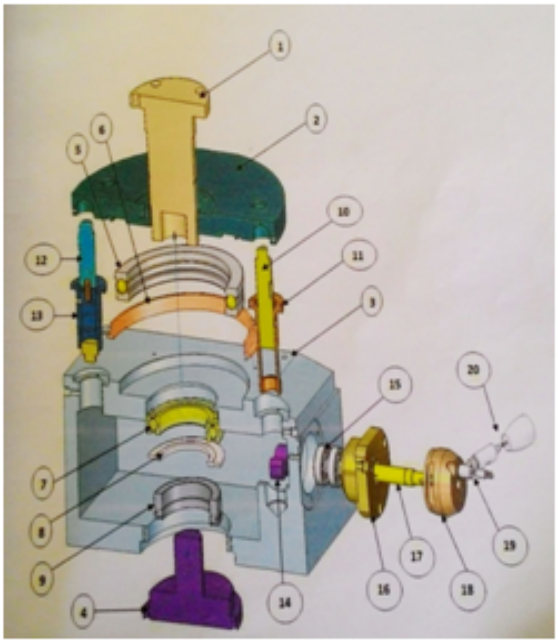
- Features
  - Compact in design
  - Smooth, guided movement on loaded pallet
  - Side loading of the pallet onto the machine
  - Servo operated for fast pallet change
  - Pallet change time: 8-14sec

II. AIM AND OBJECTIVES

- To make easy assembly of various part.
- To reduce manufacturing as well as assembly time for some complicated components.
- To design main casing and top plate according to requirement.
- Design of new top plate arrangement for balancing the load.
- Design new component for suitable movement of the plate.
- Study of drawings and assembly of currently used APC.
- Calculations for selections of various components.
- Fail safe check calculations for respective components.
- Part modelling and assembly using Solid Edge software
- Optimization of some of parts used in APC.

III. LOADING AND UNLOADING STATION

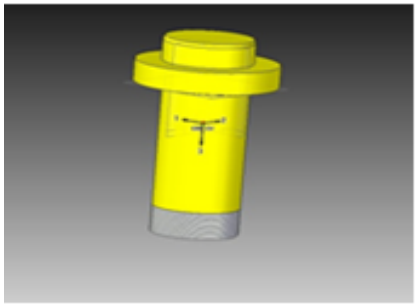
1) EXISTING ASSEMBLY



- List of various components used in station assembly -
  1. Axel
  2. Top piece
  3. Loading station
  4. Shaft
  5. Thrust roller bearing
  6. Ring
  7. Bearing 90x140x24
  8. Cover
  9. Lock nut M 90x2
  10. Diamond pin
  11. Bush
  12. Pin
  13. Bush
  14. Dog
  15. Bearing 65x47x14
  16. Sleeve
  17. Shaft
  18. Knob
  19. Spring plunger assembly
  20. Handle

2) ANALYSIS

2.1 SHAFT



1. Material properties

Material name	Steel, structural
Mass density (kg/m^3)	7833
Young's modulus(GPa)	199.947
Poisson's ratio	0.29
Thermal conductivity(kW/m-C)	0.032
Yield strength(MPa)	262
Ultimate strength(MPa)	358.527

2. Load and constraint information:

- **Load set:**

Load set name	Load 1
Load type	Force
No. of load elements	1
Load value (N)	15000

❖ **Constraints:**

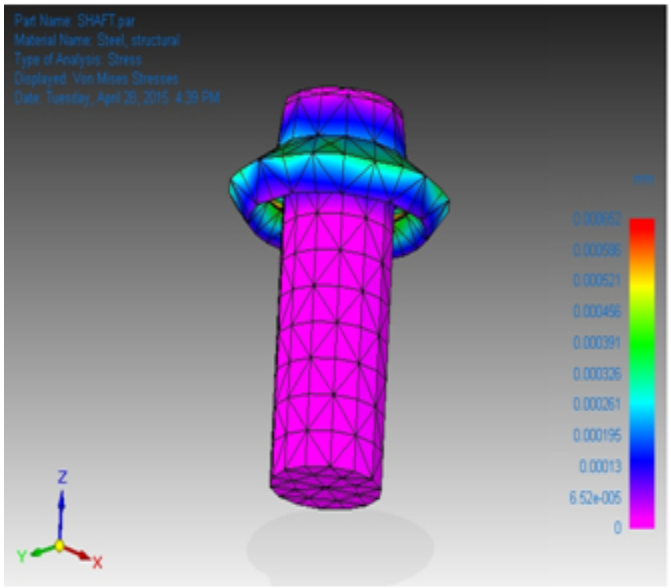
No. of constrained faces	1

3. Study properties:

Mesh type	Tetrahedral mesh
No. of elements	759
No. of nodes	1,610
Solver type	Nastran

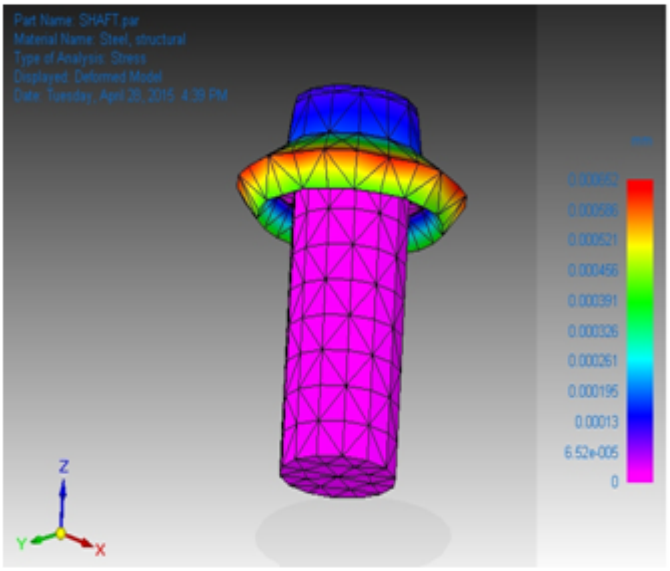
4. Stress results:

Type	Extent	Value (kPa)	X(mm)	Y(mm)	Z(mm)
Von misses stress	Minimum	2.183e-003	-40.54	-19.52	-180
	Maximum	4.639e+003	-10.42	59.09	0



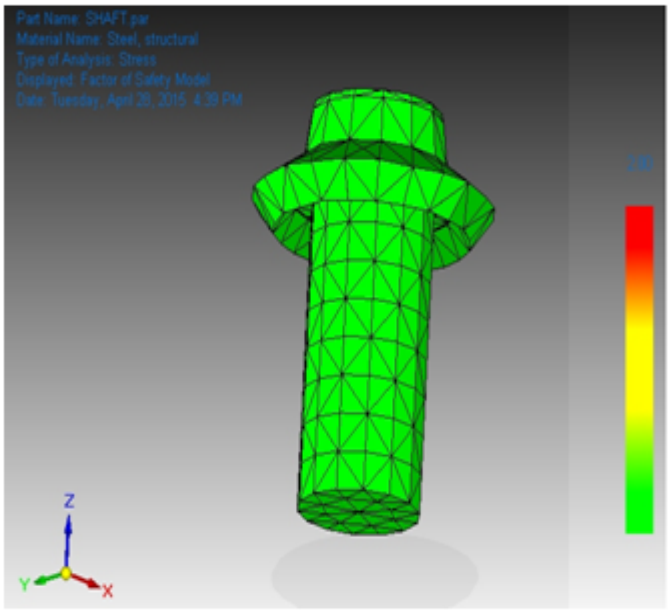
5. Displacement results:

Type	Extent	Value(kPa)	X(mm)	Y(mm)	Z(mm)
Resultant displacement	Minimum	0	10.01	43.87	0
	Maximum	6.52e-004	31.16	68.22	30

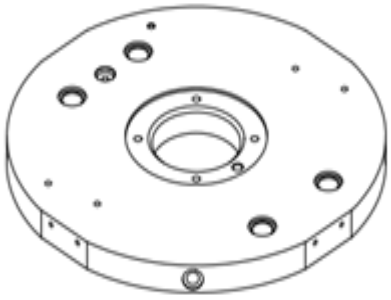


6. Factor of safety:

Factor of safety	41.958



2.2 TOP PIECE



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Poisson's ratio	0.29
Thermal conductivity(kW/m-C)	0.032
Yield strength(MPa)	262
Ultimate strength(MPa)	358.527

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- **Load set:**

Load set name	Load 1
Load type	Force
No. of load elements	1
Load value (N)	15000

- **Constraints:**

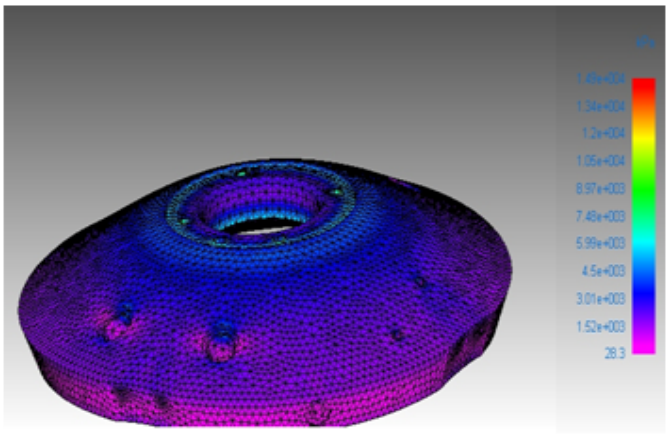
No. of constrained faces	1

3. Study properties:

Mesh type	Tetrahedral mesh
No. of elements	70,271
No. of nodes	117,168
Solver type	Nastran

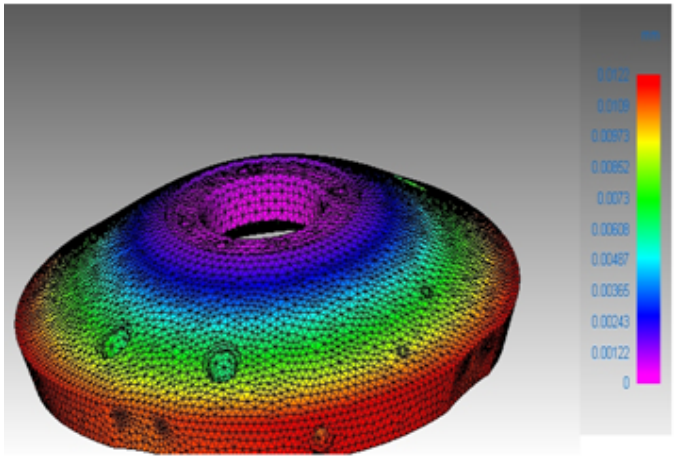
4. Stress results:

Type	Extent	Value (kPa)	X(mm)	Y(mm)	Z(mm)
Von misses stress	Minimum	2.829e+001	-57.79	194.60	13.38
	Maximum	1.494e+004	32.15	67.76	3



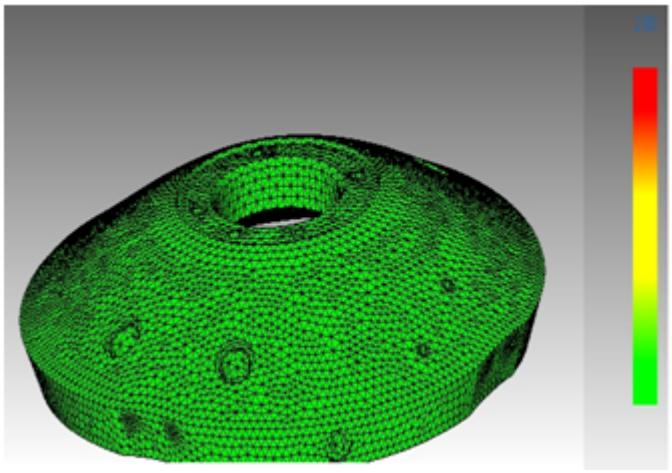
5. Displacement results:

Type	Extent	Value(kPa)	X(mm)	Y(mm)	Z(mm)
Resultant displacement	Minimum	0	-54.60	-19.94	3
	Maximum	1.22e-002	90.88	-181.52	31

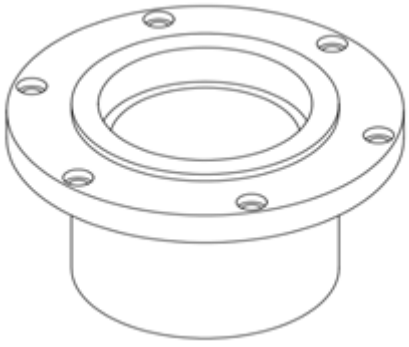


6. Factor of safety:

Factor of safety	17.542



2.3 CARTRIDGE



1. Material properties

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Young's modulus(GPa)	199.947
Poisson's ratio	0.29
Thermal conductivity(kW/m-C)	0.032
Yield strength(MPa)	262
Ultimate strength(MPa)	358.527

2. Load and constraint information:

- **Load set:**

Load set name	Load 1
Load type	Force
No. of load elements	1
Load value (N)	15000

- **Constraints:**

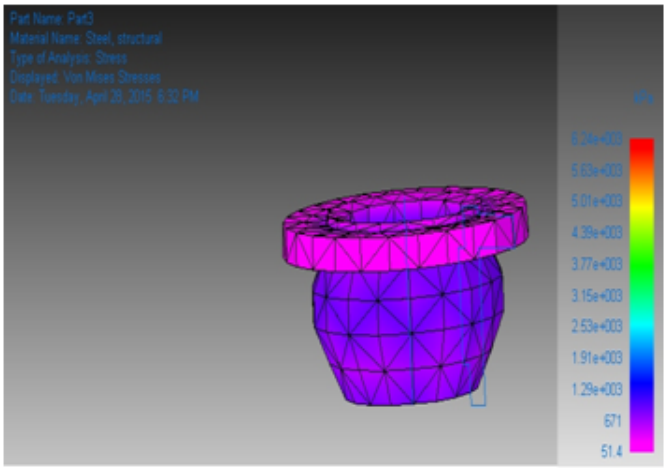
No. of constrained faces	1

3. Study properties:

Mesh type	Tetrahedral mesh
No. of elements	811
No. of nodes	1,741

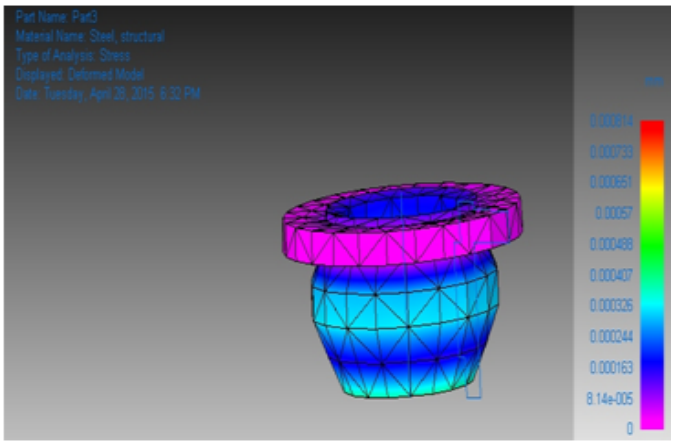
4. Stress results:

Type	Extent	Value (kPa)	X(mm)	Y(mm)	Z(mm)
Von misses stress	Minimum	5.138e+001	115.11	60.41	138
	Maximum	6.244e+003	54.13	-31.25	30



5. Displacement results:

Type	Extent	Value(kPa)	X(mm)	Y(mm)	Z(mm)
Resultant displacement	Minimum	0	46.10	121.55	114
	Maximum	8.14e-04	62.50	0	30



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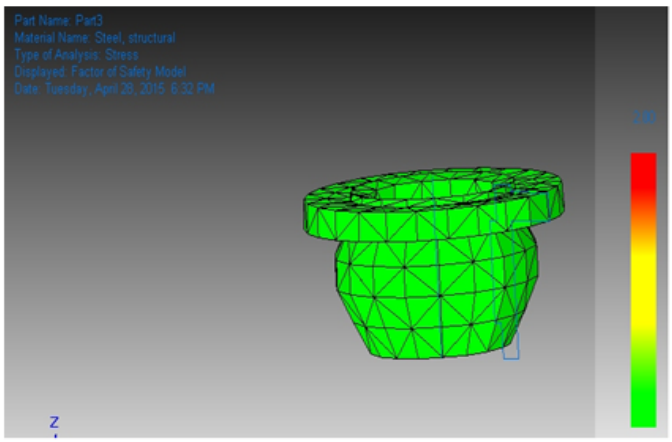
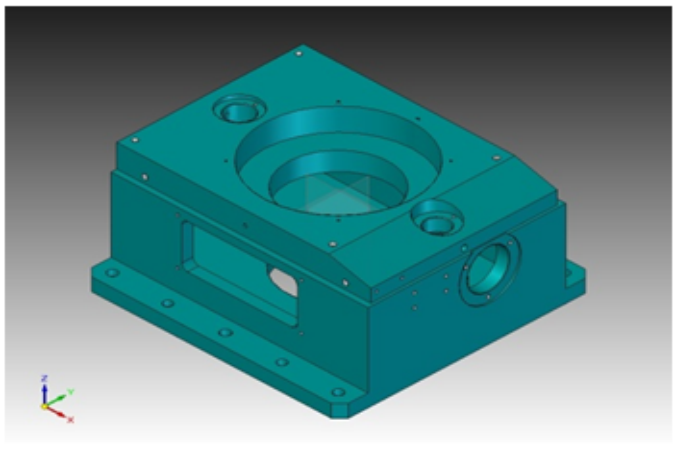
Factor of safety	41.958



2.4 HOUSING



1. Material properties:

Material name	Iron, grey cast type 60
Mass density (kg/m³)	6920
Young's modulus(GPa)	158.579
Poisson's ratio	0.29
Thermal conductivity(kW/m-C)	0.048
Yield strength(MPa)	1296.214
Ultimate strength(MPa)	413.685

2. Load and constraint information:

- **Load set:**

Load set name	Load 1
Load type	Force
No. of load elements	1
Load value (N)	15000

- **Constraints:**

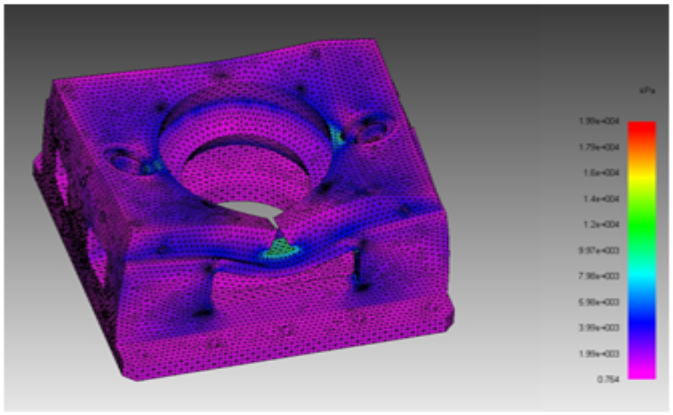
No. of constrained faces	1

3. Study properties:

Mesh type	Tetrahedral mesh
No. of elements	147,020
No. of nodes	246,153
Solver type	Nastran

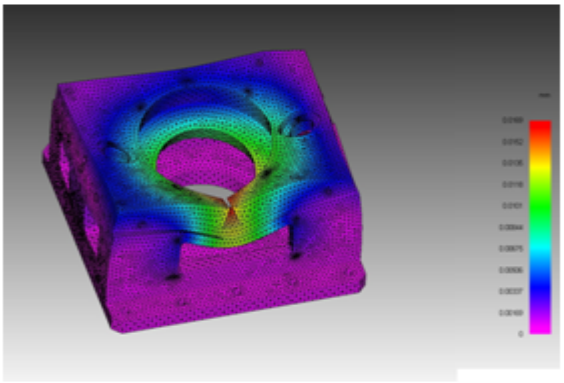
4. Stress results:

Type	Extent	Value (kPa)	X(mm)	Y(mm)	Z(mm)
Von misses stress	Minimum	7.643e-001	4.34	-105.36	-71.50
	Maximum	1.994e+004	99.57	-155.00	43.57



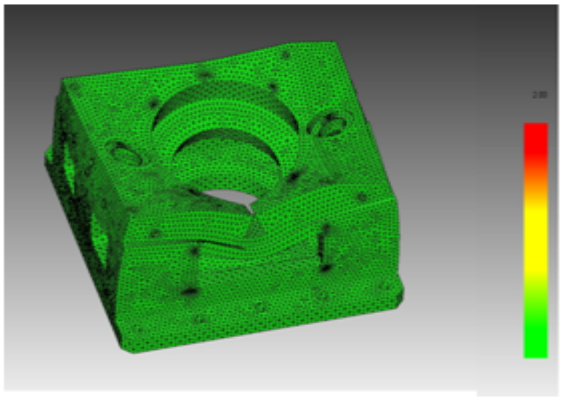
5. Displacement results:

Type	Extent	Value (kPa)	X(mm)	Y(mm)	Z(mm)
Resultant displacement	Minimum	0	124.36	42.52	-106.50
	Maximum	1.69e-002	0	-87.50	62.50

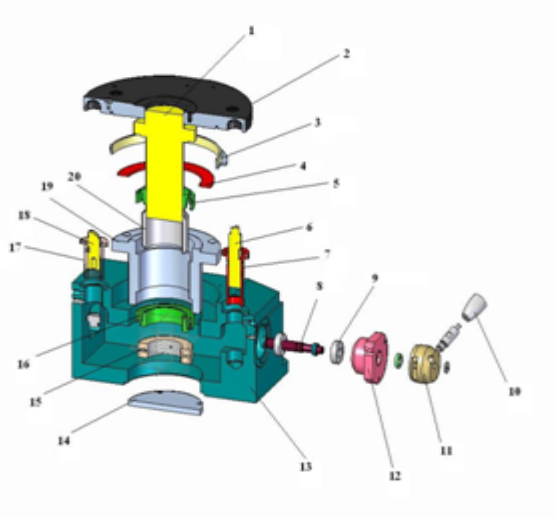


6. Factor of safety:

Factor of safety	65.009



3. EXISTING ASSEMBLY



❖ **List of various components used in station assembly –**

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16. Sleeve
17. Shaft
18. Knob
19. Spring plunger assembly
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IV. CONCLUSION

❖ The following objectives are achieved by meeting the functional requirements.

1. Easy assembly and dismantling of top piece and shaft with the help of cartridge.
2. New standard bearings are used to take required load.
3. Modification of casing produces less deflection value and less weight.
4. Elimination of bottom shaft by using cartridge assembly.
5. Time required for maintenance is significantly reduced.

❖ The learning objectives also achieved as follows:

1. Basic structure of horizontal machining center (HMC).
2. Design development procedure.
3. Modelling and drafting in solid edge.
4. Structural analysis in solid edge.
5. Way of finding solution of problem.
6. Application of technical knowledge.

V. RECOMMENDATION

For most of the components the factor of safety has crossed over 50. In some cases it is 56 up to 60. Though the range is small but this is not desirable as it increases component material as well as cost. So our aim is to reduce its value within the range of 5 to 8.

Thus, we can select one the undesirable parameter, mostly cost, for optimization.

Here we have following methods for reducing the factor of safety without violating the constraints:

1. Change the component material.
2. Increase the load factor by 5 point scale.
3. Reduce the dimension keeping same material properties for each component.

REFERENCES

❖ Catalogue and Books:

[1] TAL Product Manual.

[2] SKF Bearing Catalogue.

[3] Drawings and Documents of HMC.

[4] Design of Machine Elements, V.B.Bhandari, Tata McGraw Hill, Edition 2010.

[5] Technical Catalogue, NBC Bearings, National Bearing Industries, July 2005.

❖ Websites:

[1] www.tal.co.in

[2] www.solidedge.com