DESIGN AND IMPLEMENTATION OF TRANSFER ASSEMBLY LINE OF BLDC MOTOR TO BE USED IN AN ELECTRIC VEHICLE.

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ABSTRACT
In today's manufacturing industry there is an increased focus to produce the right product at right time and in the automotive sector the pressure on suppliers in order to deliver is high. In this matter the organization has to have clear and reachable goals together with a production system that can meet these goals. The designing of such a plant layout to accomplish these goals is necessary. This paper gives possible outcome of the project that is designing of the plant layout. The transfer assembly line of components of a new product has to be designed. Data collection or recording techniques such as Flow processes charts are used. Experiments like manually assembling the product are done to become aware of the processes to be followed. Intermediate designs of the layout are done which are then corrected to come at a final conclusion of layout. The problem of assembling the components are focussed on and certain tools, fixtures for the same have to be designed. Also the material selection of the tools, fixtures, etc. is to be done.
Keywords: *BLDC, Layout, fixtures, Tools, Flow process chart, Gluing assembly.*

I. INTRODUCTION TO THE PRODUCT:

1.1 Construction of BLDC Motor:

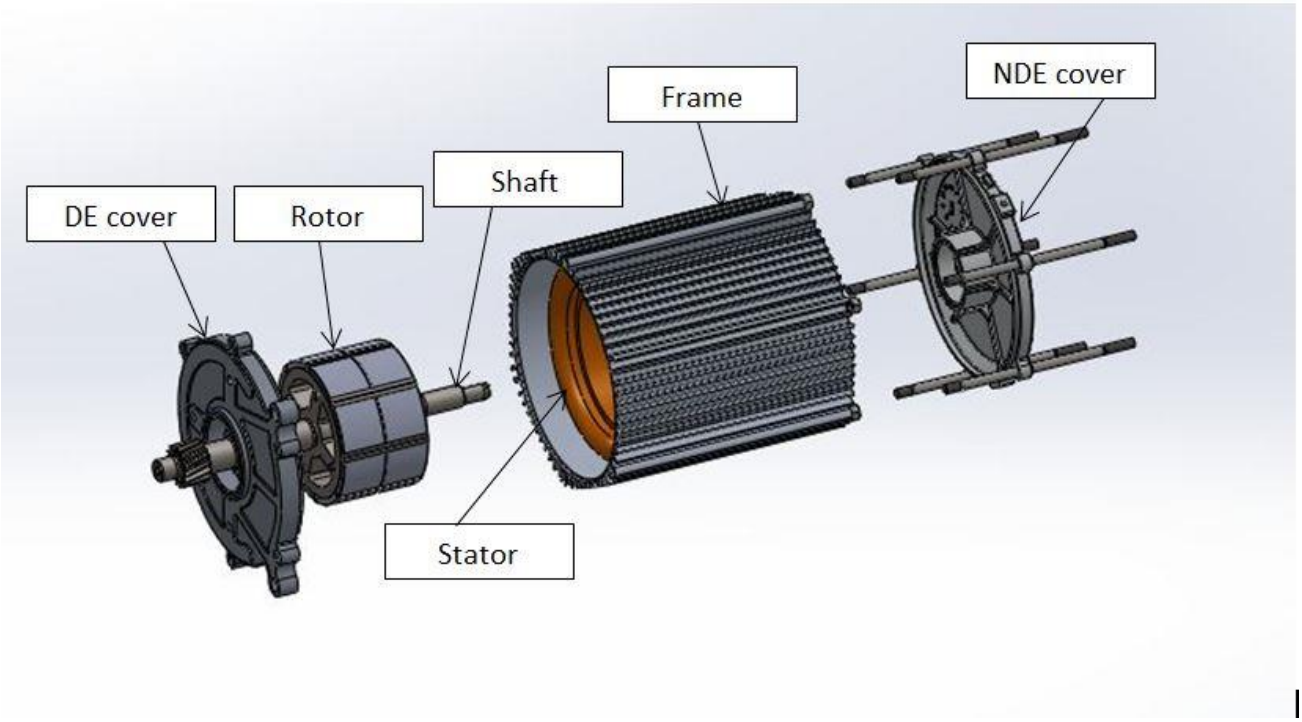

Figure 1

Stator: Stator of a BLDC motor made up of stacked steel laminations to carry the windings. These windings are placed in slots which are axially cut along the inner periphery of the stator.
Rotor: BLDC motor incorporates a permanent magnet in the rotor. The number of poles in the rotor can vary from 2 to 8 pole pairs with alternate south and north poles depending on the application requirement.
Shaft: Shaft is connected to the drivers end to provide the output. The driving end of the shaft contains a helical pinion profile to drive the gearbox.

Covers: The DE and NDE covers are mounted on each side of the motor.
Frame body: The frame or housing is the body which covers the components of the motor. Provisions for mounting the DE and NDE covers are provided on the frame housing of the motor.

1.2 Other applications of BLDC Motor:

BLDC are used for a wide variety of application requirements such as varying loads, constant loads and positioning applications in the fields of industrial control, automotive, aviation, automation systems, health care equipment's, etc. Some specific applications of BLDC motors are.

- Computer hard drives and DVD/CD players.
- Electric vehicles, hybrid vehicles, and electric bicycles.
- Industrial robots, CNC machine tools, and simple belt driven systems.
- Washing machines, compressors and dryers.
- Fans, pumps and blowers.

II. DATA RECORDING

The BLDC motor was assembled and disassembled a couple of times manually to understand the flow process. By assembling the motor manually we would know the flow of material and hence design the layout of the product. We also understood some of the tasks such as magnet gluing for which the fixture and tooling was to be designed. After the assembling of the BLDC motor manually we made a flow process chart making some assumptions. The flow process chart would then be helpful to design the layout.

Table 1

Flow process chart							
Material : BLDC Motor							
Date : 31/12/2018							
Sr. No.	Description	Symbols					Remarks(JFT & IMT)
1	Retrieval of rotor and magnet from storage					■	
2	Magnet Gluing	■					Fixture
3	Hand press of magnet on rotor	■					Press machine
4	Heating rotor	■					Oven
5	Cooling (Air quenching)	■					N2 gas
6	Inserting locking pin	■					
7	Moves to next operation		■				
8	Retrieval of output shaft from storage					■	
9	Fitting of DE side bearing	■					
10	Fitting of DE cover	■					
11	Fitting of magnetic rotor stack	■					press machine
12	Fitting of NDE bearing using circlip	■					
13	Moves to next operation		■				
14	Retrieval of frame and winding from storage					■	
15	Assembly of frame and winding	■					Oven, fixtures
16	Frame-winding assembly moves to next station		■				
17	Assembly of rotor and body	■					Hydraulic, pneumatic press
18	Moves to next operation		■				
19	PCB connection	■					
20	Fitting of NDE cover	■					Pneumatic gun, bolts
21	Circlip mounting	■					Plier
22	Fan mounting	■					
23	Circlip mounting	■					Plier
24	Fitting of fan cover	■					Screws
25	Moves for testing		■				
26	Testing				■		

III. DESIGN OF LAYOUT:

As the product will be produced in mass, an inline layout design was selected initially. The problem that could be faced with that layout is that the labour at initial stations could not work at other stations during available idle time. Also they were not facing at each other so communication required would become tough at times.

After changing the inline layout to U-line layout problems such as labours not facing each other and labours working on multiple stations during available idle time could be solved. Hence the final layout after 4 intermediate layouts designed is shown below.

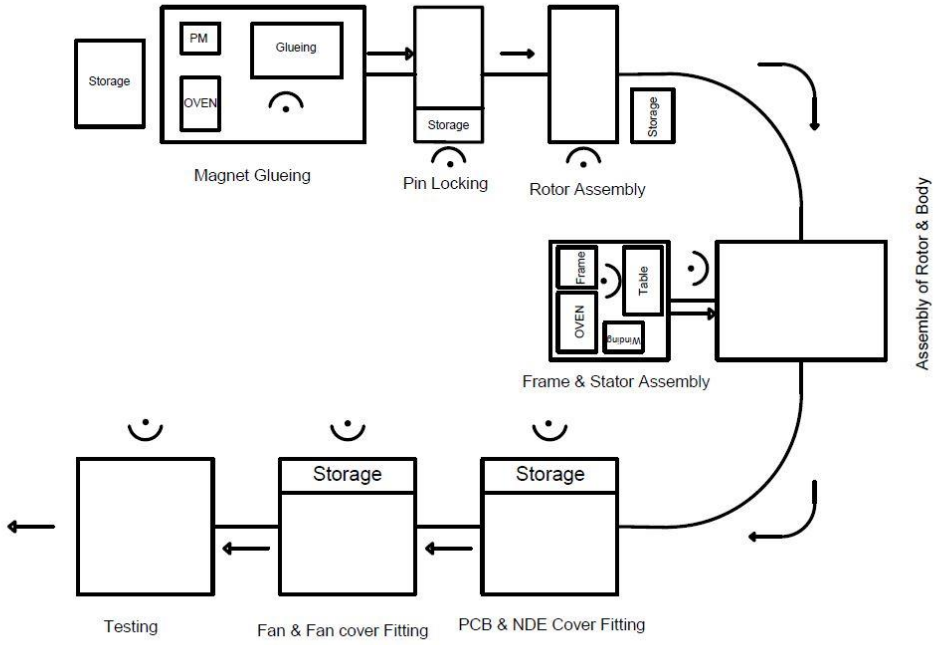

Figure 2

IV. DESIGN OF MAGNET ASSEMBLY STATION

The operation of gluing magnets on the rotor stack is currently done manually. Certain problems are being faced by gluing the magnets manually which are as follows:

- The magnets could not be guided accurately to their respective slots in rotor.
- Consumption of time.
- Attraction between two adjacent magnets.
- Repulsion force between magnets of same poles which are to be aligned linearly in the same slot.
- High force required to insert the second batch of magnets.
- Injury on fingers due to strong magnetic force.

This problem could be solved by using a pneumatic press machine. The components to be used in the press machine were to be designed.

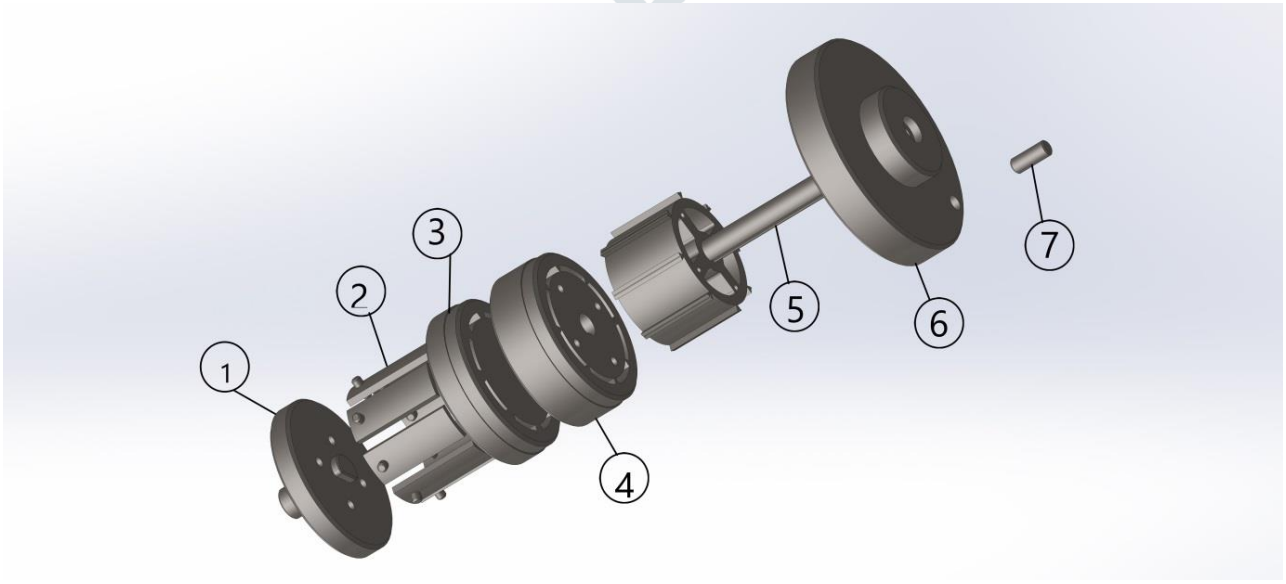

Figure 3

1. Top Ram support: This plate is mounted on press and provides support to Top ram.
2. Punch: Punch pushes the magnet on the rotor.
3. Top ram: Top ram houses the punch.
4. Guiding plate: It guides the magnet on the rotor and is mounted on top of rotor.
5. Shaft: It has a keyway and aligns the rotor and guiding plate.
6. Base plate: Mounted on the base of press.
7. Base dowell: Used for locking of base plate on the press.

Material selection for Magnet Assembly: For the selection of material of components we visited WI Met-Lab situated in V.U.Nagar, GIDC on 24th January. By consulting the expert from the industry we came to conclusions of selection of material and heat treatment processes to be carried out. The parts of which the material selection is done are mentioned in the below table. Also necessary heat treatment processes are mentioned. Standard materials are to be used for parts which are not mentioned in the below table.
The heat treatment processes to be done on the parts are shown under the column of remarks.

Table 2

Sr. No.	Part Name	Material	Remarks
1	Base Plate	SS 310	Nickel chrome plating (30 micron)
2	Shaft	EN-9	Through hardening (50-55 HRC)
3	Guiding plate	SS 310	Nickel chrome plating (30 micron)
4	Punch	SS 310	Nickel chrome plating (30 micron)
5	Top ram	EN-9	Nitriding
6	Support plate	EN-9	Through hardening (50-55 HRC)
7	Dowel (dia. 6mm)	EN-24	Through hardening (50-55 HRC)
8	Dowel (dia. 10mm)	EN-24	Through hardening (50-55 HRC)
9	Base key	EN-9	Through hardening (50-55 HRC)

V. DESIGN OF ROTOR BODY ASSEMBLY:

The operation of assembling the rotor sub-assembly with the sub-assembly of frame and stator is a tedious task. The reason being is the humongous attraction force due to magnets that act between the rotor and the stator. If this task is to be done manually there could be some serious injury issues to the labour. Hence some kind of automation was to be done to perform this task in the most efficient and safe manner and following design was finalised after 3 intermediate concepts.

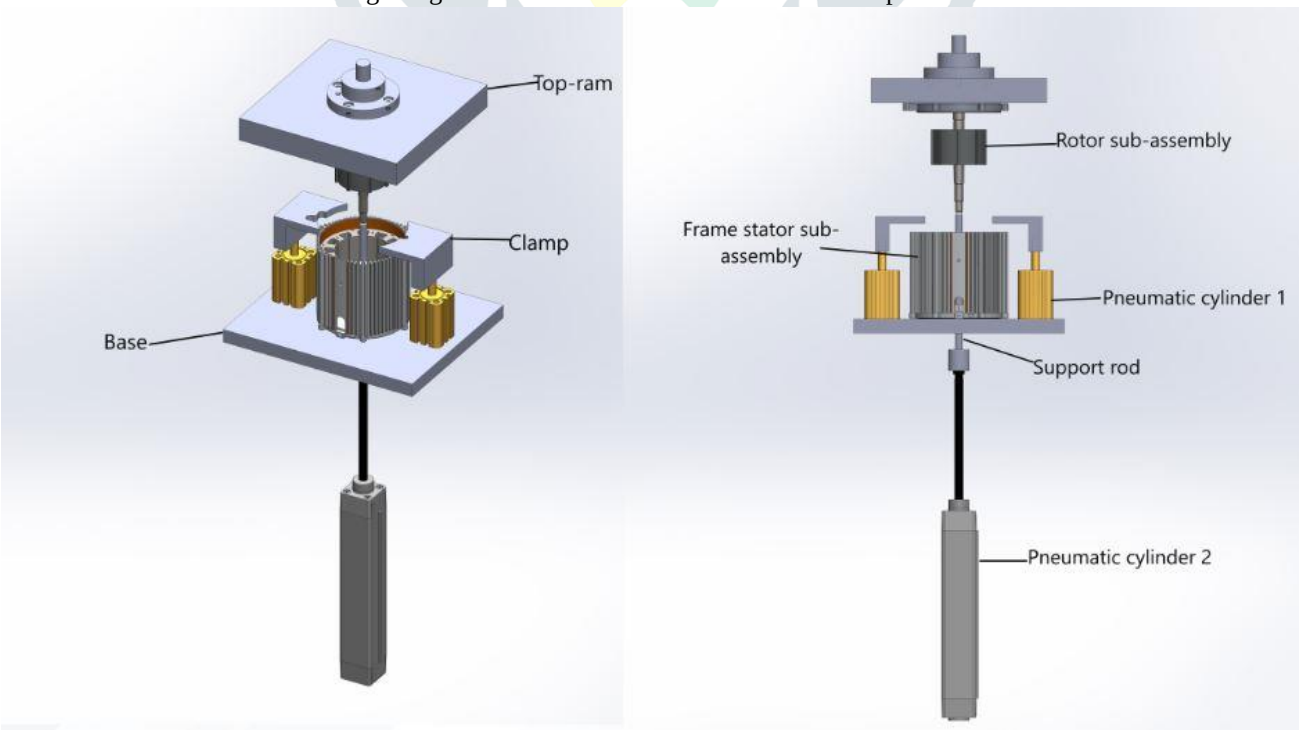

Figure 4

WORKING: The clamps are mounted on a pneumatic cylinder. With the actuation of the pneumatic cylinder the clamps are given movement and the body is locked. The sub-assembly of the rotor is located in the top plate using certain pins to locate the holes in the DE cover provided for connecting the gearbox and the holes for bolts to lock the covers. After the DE cover locates the sub-assembly of the rotor, the worker holds that sub-assembly through shaft and a support rod is brought upwards using pneumatic cylinder 2 to give support to the rotor sub-assembly. Once the support rod connects in the shaft of the motor, the sub-assembly will be brought down in a controlled manner and the assembly will be done. Once the assembly is completed, the pneumatic cylinders will push the clamp upwards and the top ram of the press will also be pushed upwards. Then the assembly can be easily removed by the labour.

VI. CONCLUSION:

After studying the existing product and assembling the product to be manufactured, the design of layout was begun. Four intermediate layouts were designed in which problems were discussed and a final layout was concluded thereafter. The magnet assembly was designed after that. Press concept was used for assembling the magnets on rotor which solved all the problems that were occurring if the magnets were to be assembled manually. Material selection of the components was done by consulting WI Met-Lab Company situated in V U Nagar. The drafting of the components of the assembly were done and the drawings were released successively. Communications with few vendors were done for the fabrication of the components and the PO was released for a particular company in Ahmedabad. The components are manufactured. After the magnet assembly, the designing of rotor body assembly was initiated. Three intermediate concepts were developed fourth being the final one. All the problems that could have occurred while assembling the rotor sub-assembly and the body sub-assembly are successfully solved.

VII. FUTURE SCOPE:

For the rotor body assembly, as the concept is finalised, the dimensions of the assembly components are to be finalised after selecting the optimum pneumatic cylinders and presses.
The drafting of the rotor body assembly components are to be done. The process of manufacturing of the components is to be followed just like the magnet assembly. The testing of the rotor body assembly is to be done and see if further improvements can be done in the concept. Some kind of process is to be designed for the pin locking process. The pin locking is done in the rotor so that the magnets are tightly gripped. Due to higher rpm, there is high centrifugal force which can throw the magnets away. Hence, pin locking is to be done. But the process for pin locking is not identified yet. The pins are getting damaged or damaging the rotor stamping while they are being inserted. The conveyor design is to be done. A conveyor with some kind of automation is to be designed. The conveyor should be designed in such a way that there is minimum man movement. Also, single piece flow should be maintained. The non-value adding time of the product should be minimised.

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