Design for Battery Loader

- Subject definition
- Concept plan
- UG model explanation
- Action explanation of designed device
- Expected efficiency of new device
Cooperation of battery loader

There are two batteries with different size and weight BM-70(14kg), BM-85(18kg) - for two kinds of vehicles.

1. It should take in a minute for assembling batteries
2. There should be no interference with the car body or anything during work.
3. Workers do not lift batteries during assembling process.
4. Batteries should not be fallen during assembling process.
5. An examination and a detailed model for every little thing including running gears for equipment should be processed.
Concept plan

Ideas and reason

① Use of joints
- Fluent working space
- Security for machines
- Elimination of interference

② Use air pressure for clamps parts (cuffs of tonometer)
- Plastic body protection

③ Use of rotation plate
- Elimination of interference when batteries are assembled

④ Safety device addition
- Prevention of falling risk

⑤ Soft movement of clamps
- Realization of cooperation based on same width of the batteries
1. Detailed plan step 1
   - Change detailed plan based on inspection of conception plan for PBL2

   **Reason**
   ① It can be transported safely with just holding capacity of clamps
      → elimination of additional safety device
   ② change use of air pressure (which was presented during conception plan)
      for vacuum pump device
      → improvement of both safety and transport capacity
   ③ **working space reduction** based
      on increase of radius of right and left rotation for robot's arm

2. Detailed plan step 2
   - Robot's detailed plan based on concept plan modification

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**Fig. 2**
3. Holding part design

① Two clamps tie the battery primarily on both sides. Vacuum plate should be arranged in consideration that battery's sides are not flat.

(unit : mm)

<table>
<thead>
<tr>
<th>Comparison</th>
<th>BM-70</th>
<th>BM-85</th>
<th>Gripper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>315.00</td>
<td>206.00</td>
<td>300.00</td>
</tr>
<tr>
<td>Length</td>
<td>175.50</td>
<td>172.00</td>
<td>280.00</td>
</tr>
<tr>
<td>Height</td>
<td>190.26</td>
<td>183.67</td>
<td>209.98</td>
</tr>
<tr>
<td>Catching space height</td>
<td>62.16</td>
<td>62.16</td>
<td>65.00</td>
</tr>
<tr>
<td>contact surface width</td>
<td>-</td>
<td>-</td>
<td>180.00</td>
</tr>
<tr>
<td>contact surface length</td>
<td>-</td>
<td>-</td>
<td>90.00</td>
</tr>
<tr>
<td>Weight</td>
<td>14kg</td>
<td>18kg</td>
<td>-</td>
</tr>
</tbody>
</table>
4. Use air pressure

① Verification of Using air pressure

<table>
<thead>
<tr>
<th>Classification of air pressure</th>
<th>Pressure (Pa)</th>
<th>Applied field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low air pressure</td>
<td>$10^5$ (atmospheric pressure) $\sim 10^2$</td>
<td>Mechanical engineering, Food engineering</td>
</tr>
<tr>
<td>Medium air pressure</td>
<td>$10^2 \sim 10^{-1}$</td>
<td>Electronics, Optical vacuum metallurgy</td>
</tr>
<tr>
<td>High air pressure</td>
<td>$10^{-1} \sim 10^{-5}$</td>
<td>Semiconductor, laser optics</td>
</tr>
<tr>
<td>Super high air pressure</td>
<td>$10^{-5} \sim 10^{-10}$</td>
<td>Semiconductor, Accelerator, Space science, Surface science</td>
</tr>
<tr>
<td>Extremely high air pressure</td>
<td>Below $10^{-10}$</td>
<td>Space science, Next generation element, Study of elementary particle</td>
</tr>
</tbody>
</table>

- $100000 \text{ N/m}^2 = 10204 \text{ kg/m}^2$
- Contact area is $0.18 \times 0.09 \times 2 = 0.0324 \text{ m}^2$, that is 330.6 kg.
- If vacuum plate is located at the side, contact area is fallen off to one fifth.
- So it can be 66.12 kg. Compute inversely, there is 54439 N/m$^2$
- difference between air pressure and vacuum pressure because of vacuum state in case of low vacuum state in front table, it can be 66.05 kg.
5. Distribution of power which works on the battery

This analyzed the power that the battery took when clamps held the battery and made vacuous by ABAQUS software.

The result of Using low air pressure

The result of Using high air pressure
6. We got rough plan measure using digital model analysis program with MSC_Software ADAMS and at the same time we verified safety and efficiency through simulation.

7. Detail plan – Fig. 6~8
8. Virtual model plan using UG

Feature of UG model

① Whole automation system
② Lane setting considered with production line movement of factory
③ Arrange a number of fine inhalation hole at contacting part of clamps parts so that keep stabler inhalation power compared with single inhalation plate
④ Increase degree of freedom of robot's working space using body rotation and multi joints
⑤ Accurate measure deduction using kinetic analysis program ADAMS
⑥ Battery transportation cooperation device realization based on inhalation plate movement
⑦ Design robot for simple skill performance
Important part capture and explanation with picture using VisMockup

1. Approach the battery and hold it.
2. After holing it using clamps, fix the battery by inhalation power of air.
3. After lift the battery vertically, and spin it. And locate it at upside, where the battery would be located in actual vehicle.
4. When a vehicle go into its process, robot moves at same speed with vehicle and robot's arm move to assembling part of battery.
Important part capture and explanation with picture using VisMockup

⑤ When robot's arm reaches assembling part, cancel vacuous condition and widen it's clamps. Vacuum plate should be angled diagonally for smooth separation of clamps.

⑥ The arm rise up to the upper part of vehicle and spin to the forward.

⑦ After the arm get removed from the transfer course of vehicle, robot moves to battery's position again.
1. Expected efficiency

① Give rotation motion speed 110º/sec to robot's rotation part, so it takes within 2 seconds for one rotation - increase productivity

② Use not just simple holding robot but also inhalation using vacuum so that it fulfills accurate functions and reduces the number of inferior products. 

→ 6-Sigma pursuit

③ Move robot and factory's current line at once so that we can eliminate possible repose of line.
2. Expectation effect and merits

**Without loss**

*Increase efficiency of human resource system through electric automatic system* (eliminate uncertainty of production by human's irregular work)

**Prevent Industrial disaster**

*Prevent industrial disaster by preventing muscle skeletal disease.* (according to the industrial safety corporation’s statistical data, lifting work resulted in most problems in muscle and skeletal disease, so eliminate lifting work)

**Increase safety**

*Use clamps using inhalation power so that increase safety.*

**Reduce Production cost**

*Simple design make workers can control and repair robots by themselves and reduce production cost.*
3. Demerits

① **Restriction** of working space because of rails on the floor.

② It is necessary to **use complex algorithm** for construction of automation system.

③ Increase **early investment cost** for using devices.

4. Conquest plan of demerits

① **Broaden working space** by make sufficient space at process.

② Make production process uniformly and eliminate variable possibility so you can **eliminate complexity of algorithm**.

③ **Saving the cost** of maintenance including personnel expenses and increase of productivity and efficiency make profit in a long run.