



# Development of the High-speed Half Nut Tightening Mechanism in the Clamping Unit of the Injection Molding Machine

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# Agenda

1. Introduction of LS Mtron Company
  - ; History of LS Group and LS Mtron
  - ; LS Mtron Products
2. Understanding of Injection Molding Machine
  - ; Injection Molding Process of Plastic Materials
  - ; Classification of Injection Molding Machine
3. Motivation of this development
  - ; Half nut Tightening Time (HTT)
  - ; Main Patents related to HTM
4. Generate Ideas
  - ; Function Analysis
  - ; Generate Ideas by using TRIZ inventive principles
  - ; Evaluate the main ideas
  - ; Performance test at the same hydraulic condition
5. Results and Discussion

# 1. Introduction of LS Mtron Company

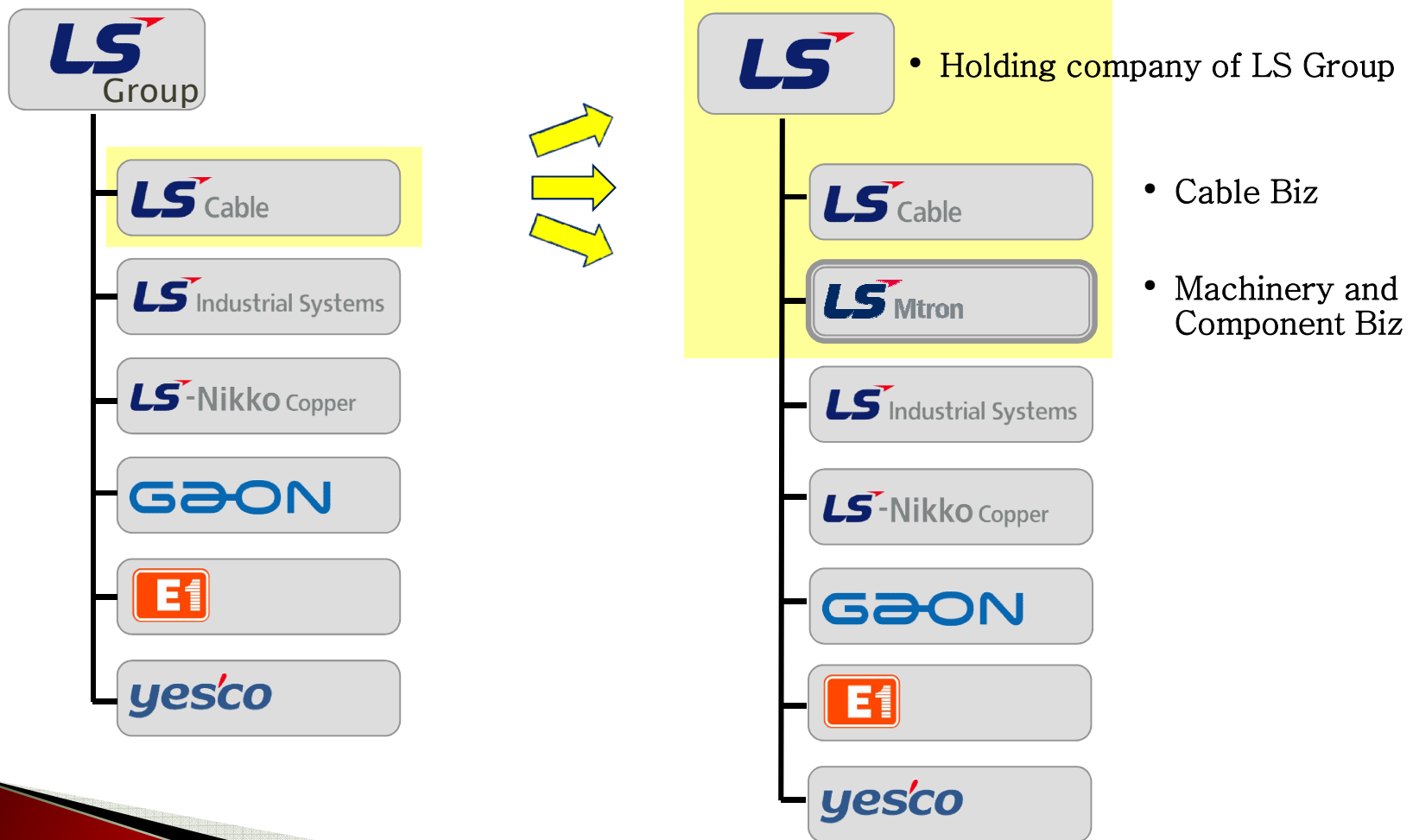
At 2003

LG group splitted into three (LG, LS, GS ) groups for improving the global competitiveness that can strengthen the business competence and specialty.



## At 2008

LS Cable of LS group split into three companies (LS, LS Cable, LS Mtron ) again and the new holding company (LS) of LS Group was established in 2008.



Now, 2013

LS Mtron has specialized in the division of Machinery and Component products like these items

Consolidated Statement Of Operations \* Unit : in millions of Korean won

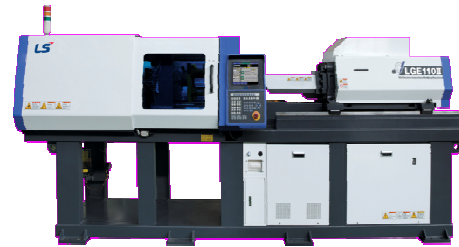
Category	2011	2010
<b>Continuing operations</b>		
Revenue	1,500,727	809,234
Cost of sales	1,245,355	646,310
Gross profit	255,372	162,924
Operating profit	57,390	38,836
<b>Discontinued operations</b>		
Profit for the year from discontinued operations	62,114	15,159
Profit for the year	82,424	31,936



· Machinery Biz



Tractor

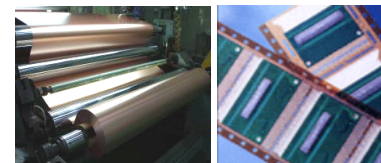
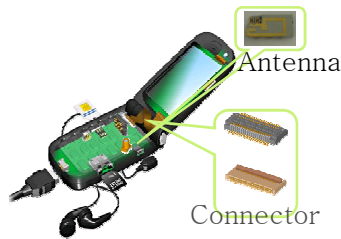


Injection Molding Machine



Track shoes  
(Defense division)

· Component Biz



Copper Foil

FCCL



Rubber Hose

## 2. Understanding of Injection Mold Machine

Injection Molding Machine manufactures a plastic product by repeating injection molding cyclic process ( 1 cycle: ① → ② → ③ → ④ → ⑤ → ⑥ → ⑦ → )

- Injection molding process (1 cycle)

clamping unit: ① Mold Clamping

injection unit: ② Nozzle touch

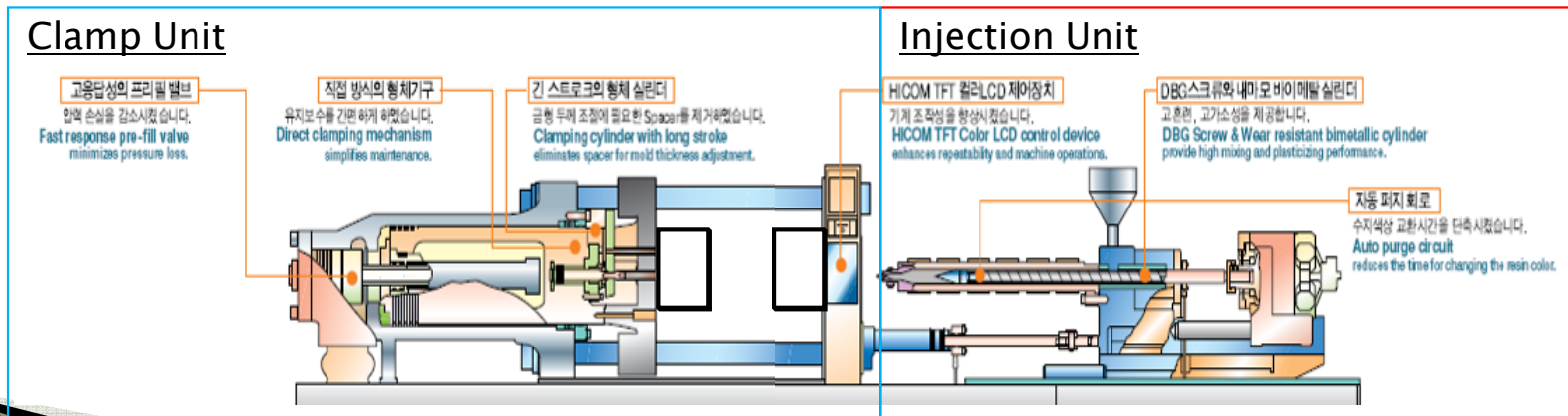
③ Filling Process

④ Packing Process

⑤ Plasticatizing process

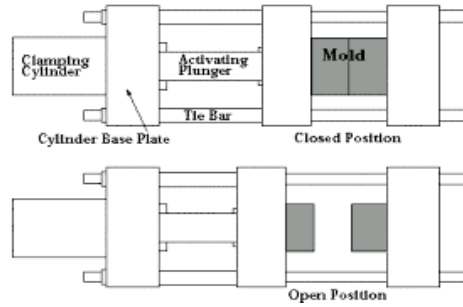
⑥ Cooling Process

⑦ Mold Opening (+ Ejecting)

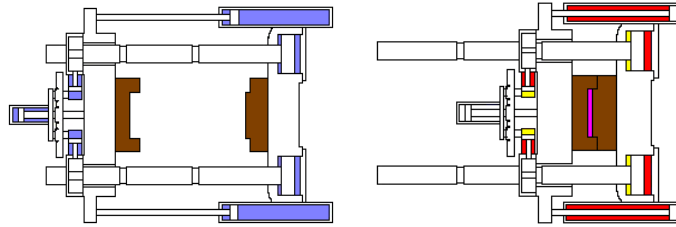


• Classification of Injection Molding Machine

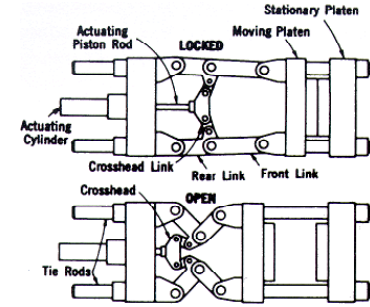
1) Clamping Unit Type



① Direct



② Two Platen



③ Toggle

2) Actuator Type

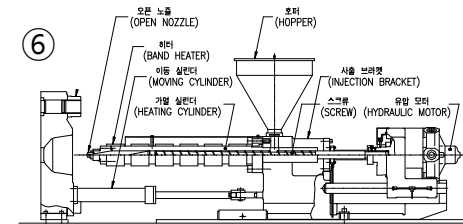
④ Hydraulic (Cylinder)

⑤ Electric (Motor)

3) Injection Unit Type

⑥ Inline

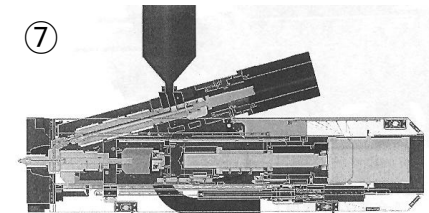
⑦ Plunger



4) Layout Type

⑧ Horizontal

⑨ Vertical





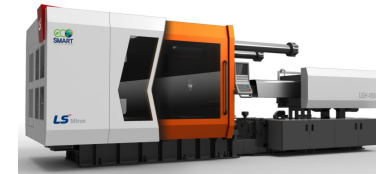
• Injection Mold Machine Line up (LS Mtron Ltd)

Series	Actuator Type	Clamping Mechanism	Tonnage
Small Class : LGH – D	Hydraulic	Direct	80~350 ton
Middle Class : LGH – M	Hydraulic	Two Platen	450~4000 ton
Large Class : LGH – S	Hydraulic	Two Platen	1300~3000 ton
All Electric : LGE	All Electric	Toggle	30~550 ton

✓ **LGD-Series**  
- Direct Hydraulic



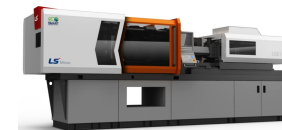
✓ **LGH-M Series**  
- Two Platen



✓ **LGH-S Series**  
- Two Platen  
( Variable Pump)



✓ **LGE-Series**  
- All Electric





### 3. Motivation of this development

#### • Abstract

Global TRIZ Conference 2013 in Korea

#### **Development of the High-speed Half Nut Tightening Mechanism in the Clamping Unit of the Injection Molding Machine**

J.W. Jung<sup>\*</sup>, J. W. Woo, H. J. Yu, K.H. Park, W.S. Kim, H.C. Shin and K.N. Woo

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#### Summary

We will introduce a development process for the new high-speed hydraulic half nut tightening mechanism (HTM) that can make the tightening process time shorter in half comparing with the previous HTM which is mostly used in the 2-Platen-type clamping unit of large class injection molding machine (IMM). We generated the several new ideas by using the TRIZ method for overcoming the previous technical limits and avoiding the patent networks of leading competitive companies in the division of IMM. We considered the pros and cons of those ideas in the view of stability, reliability, cost, productivity and so on. Then, the best one was chosen to make the proto type sample. As a result, we can complete our project successfully by obtaining the goal that the new HTM can reach the competitive level. We will expand this technology into our new IMM models in the near future.

*Keywords:* Half nut Tightening Mechanism (HTM) ; Injection Molding Machine (IMM)

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## Half nut Tightening Time (HTT) of Large Class Injection Molding Machine

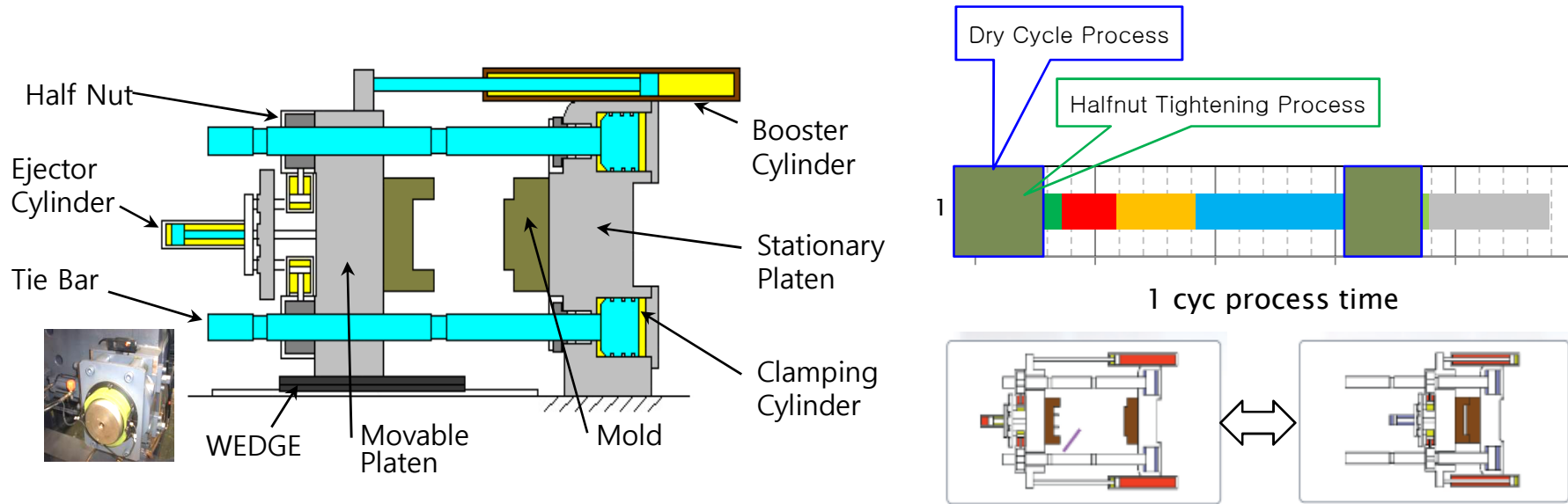


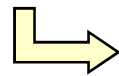
Fig.1 Clamping Unit and Injection Molding Process Time

; Halfnut Tightening Time (HTT) significantly affects a Dry Cycle Time (DCT) that shows the productivity of clamping unit.

cf. Dry Cycle Time (DCT) = Movable Platen Move Time + Pressurize Time + Halfnut Tighten Time (HTT)

; Our HTM takes more time for tightening process than the leading maker's HTM, which means that it is less competitive.

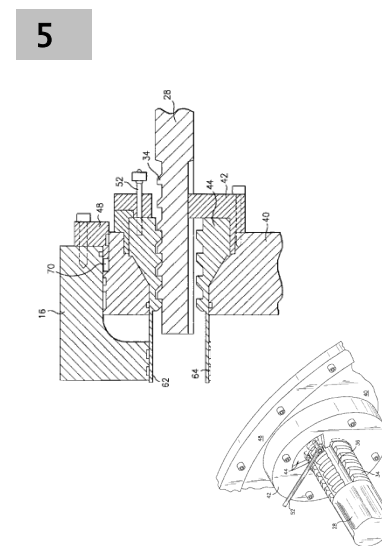
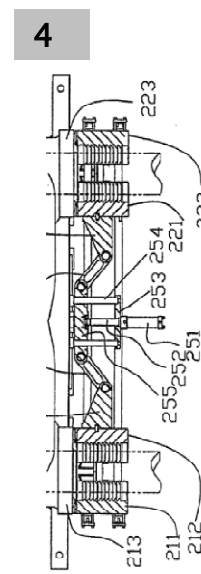
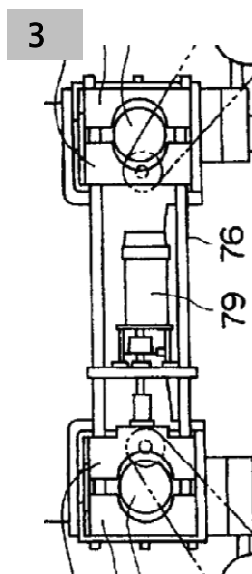
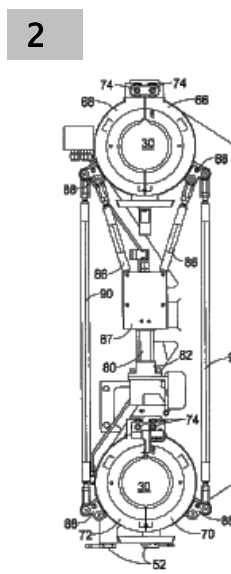
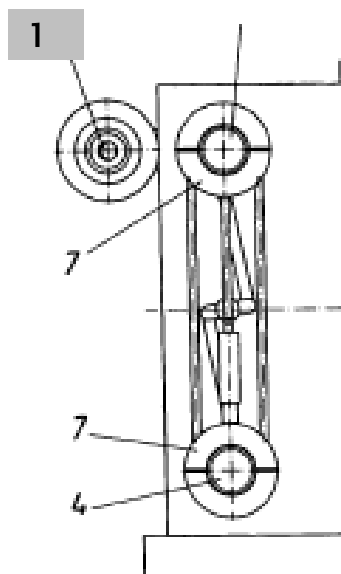
; There are so many patent networks related to HTM that We have not found any competitive solution to avoid them until now.



Development of the High Speed  
Halfnut Tightening Mechanism (HTM)

• Main Patents related to HTM

No	Country	Application No.	Assignee
1	AT	8010/08	Engel
2	US	1999-326237	Milacron
3	JP	2001-065933	Mitsubishi
4	US	2008-665536	Chen Hsong
5	US	2000-724989	Husky



# 4. Generate Ideas

## • Function Analysis

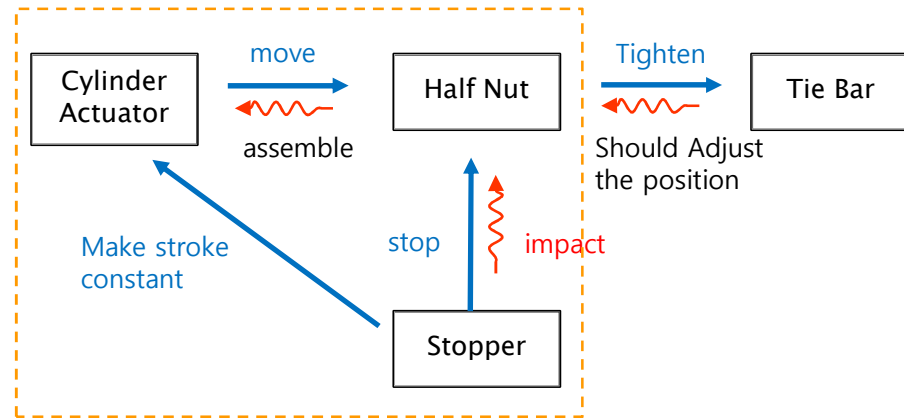
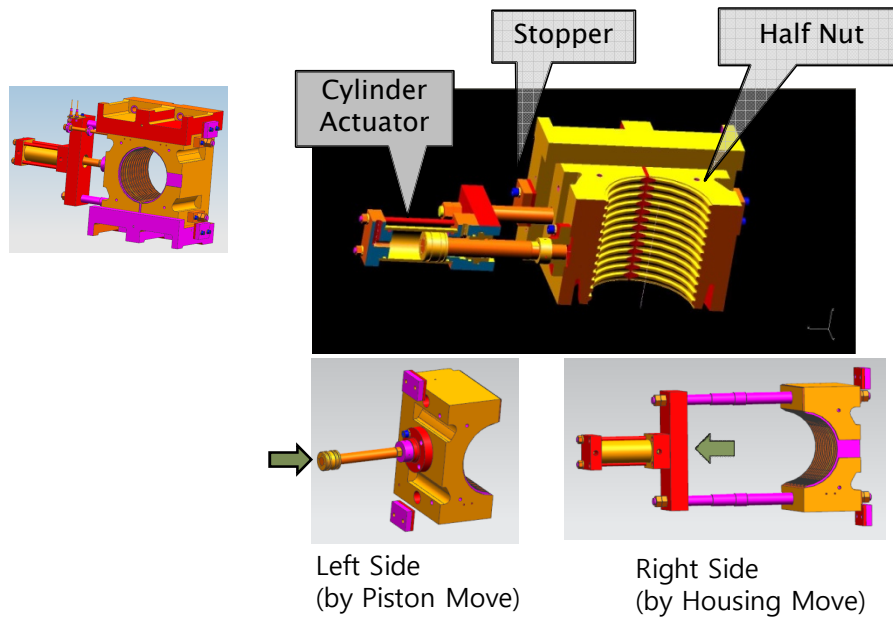


Fig 2. Current Halfnut

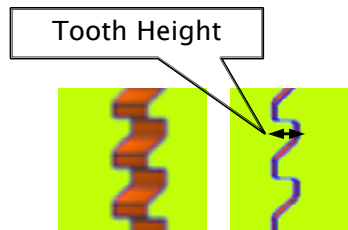


Fig 3. Halfnut Tighten (before / after)

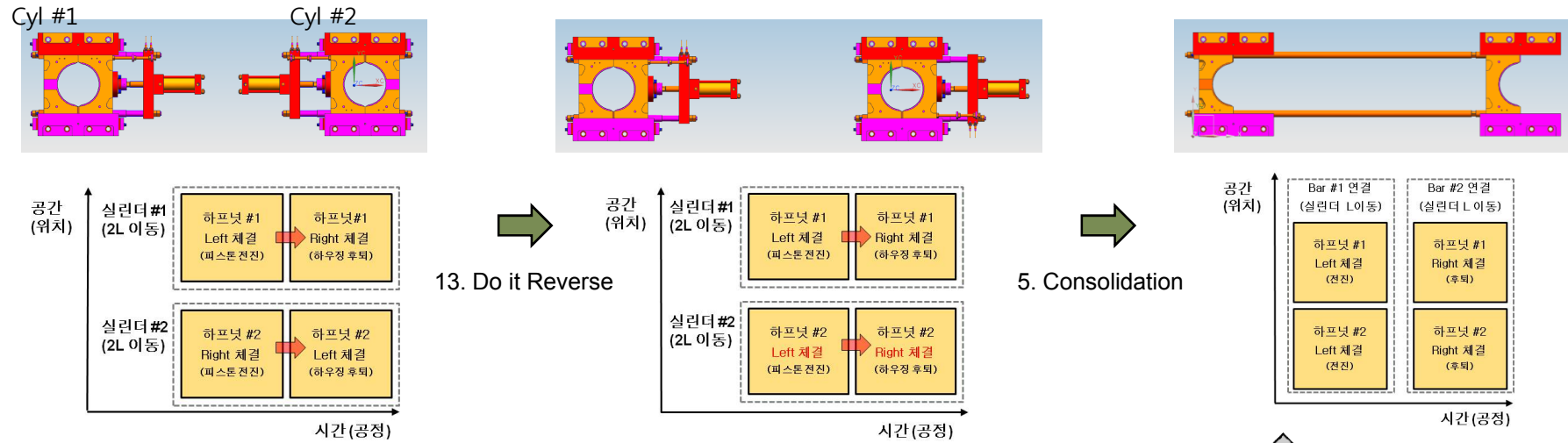
## • Technical Contraction

$$\text{Time} = \text{Stroke} / \text{Velocity}$$

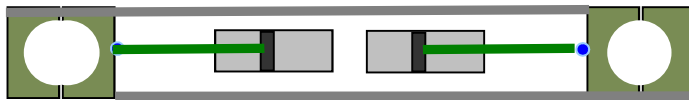
Goal	Consideration	Simple Solution	Harmful Effect
To Make Time Shorten	Stroke Short (↓)	Decrease Tooth Height	Decrease Tightened Strength ☀
	Velocity Up (↑)	Increase Oil Flow Rate	Occur Impact Noise ☀

• Generate ideas by using TRIZ Inventive Principles

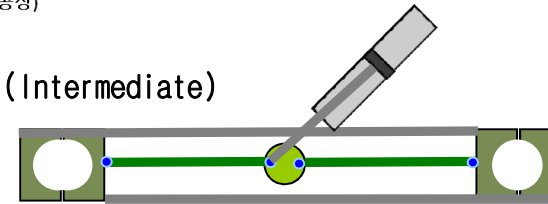
Halfnut Stroke can be shorten into half  
by 13 (Do it Reverse) and 5 (Consolidation)



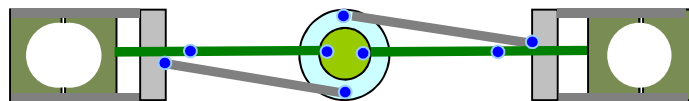
by 9 (Segmentation)



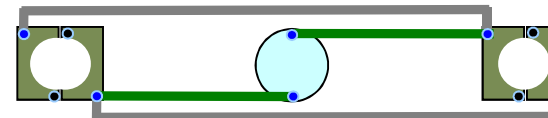
by 24 (Intermediate)



by 7 (Nesting)

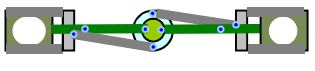
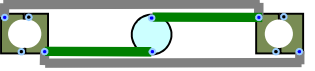

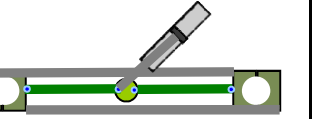


by 14 (curvature increase)

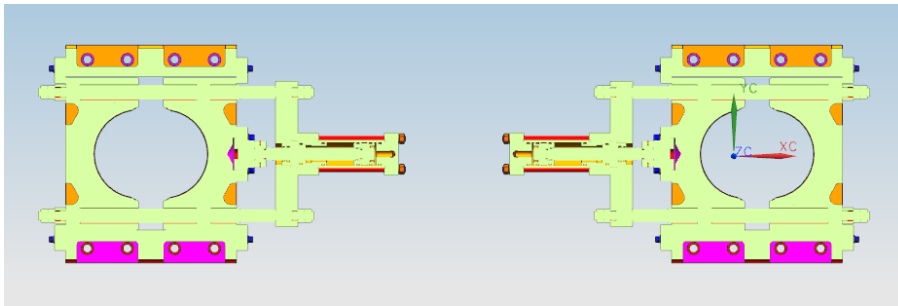


We had registered several patents with these Ideas

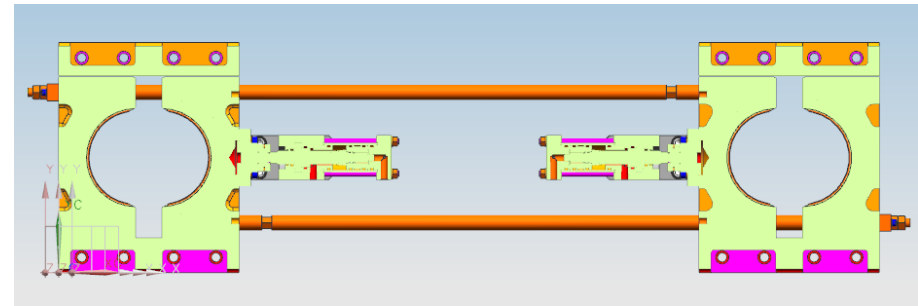
• Evaluate the main Ideas

Consideration		Case 1	Case 2	Case 3	Case 4
Schematic Drawing	Tight Condition				
Productivity	Layout	△ (4)	△ (3)	O (5)	△ (5)
Cost	No. of Part	△ (3)	△ (4)	O (5)	△ (4)
Reliability	Tightened Strength	△ (3)	△ (3)	O (5)	O (4)

After a evaluation, We finally decide that Case 3 solution is better than the other solutions (Case 1,2,4)



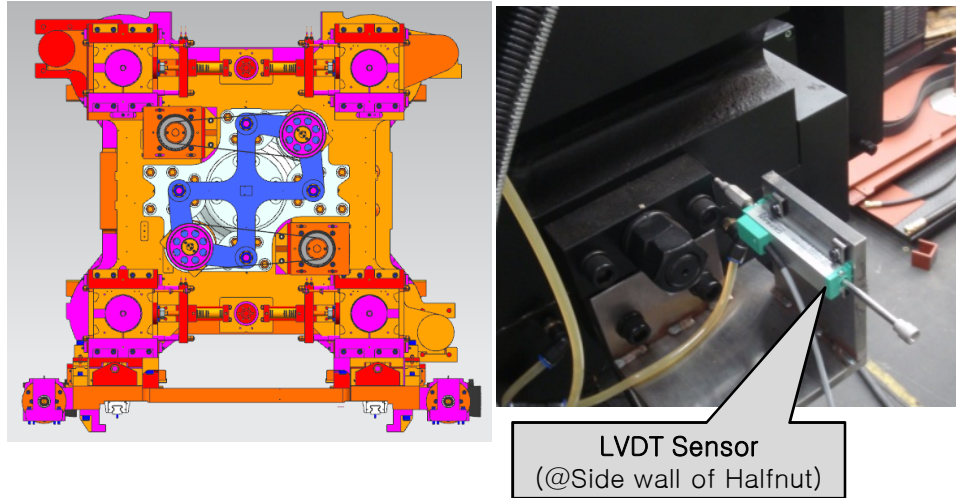
[Current HTM]



[New HTM: Case 3]

• Performance Test at the same hydraulic condition

Measure HTT by LVDT sensor at side wall of each Half Nut



We made the proto type sample and installed them at the same machine and same position and then compared the measured time with that of current halfnut. As a result, We can confirmed that the new HTM can shorten the halfnut tightening process time into the half level of current HTM and greatly reduce the impact noise.

Specification	Current Halfnut ; <b>Impact Noise occurs</b>		New Halfnut ( Case 3 ) ; Impact Noise greatly reduces	
	Tighten	Untighten	Tighten	Untighten
Halfnut Tightening Process Time [sec]				



## 5. Results and Discussion

- TRIZ application is a good way to start to change one's way of thinking when it comes to solving the contradicted problem.
- We can generate the new High-Speed Halfnut Tightening Mechanism by using 40 inventive principles of TRIZ, and we expect that the new HTM would differentiate our products from the competitions in the market.
- We will continuously spread the TRIZ applications into our company for getting the innovative outstanding outcomes.



**Thank you !**