DEVELOPMENT FOR PNEUMATIC PLUG DOOR SYSTEM

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Abstract

There are many EMU lines in Korea. But only one type has been applied to passenger side door. This type is so called "Pocket sliding type". This type has some week points. To begin with, it is not good for decreasing the noisy from the outside of carbody. And the second time, if some obstacles are put between sliding door, only driver can operate re-open door switch manually in driver's cab. This type is so dangerous for passengers.

So many people want to the new door type that have no defect. KRRI joined forces with ANT corporation for pneumatic plug door system. This type will be good for decreasing the noisy, passenger's safe. The project was started at the last year on November and finished on June, this year.

In this paper, we will deal with the role of cylinder, complex planetary gear, door control unit, dynamic mechanism, and the report of FEM, type test. This paper will contribute to the electric motor control plug door system.

1. Introduction

The DCU(Door Control Unit) pneumatic door engine system has recently developed in Korea EMU. Until the 1990's conventional door system has only carried out "Open & Close" function. It did not have the role for passenger safety. Namely, it had not special equipment. Conventional door system has not re-opened for each door when an obstacle gets in between the doors. At then the driver must put the re-open switch at driver's cab. So the accident have happened frequently in Korea.

Of course there are several merits that are low maintenance fee, low total weight, easy design etc. Also new DCU door system has merits such as low noisy level, passenger safety by DCU, etc. Now a day EMU carbody is manufactured by aluminum and it's side structure shape is round. So it is difficult to adapt the conventional door engine type. We want to a new type.

Then KRRI joined forces with ANT corporation and designed the DCU control pneumatic plug door engine system. We manufactured the engine assembly, door panel, DCU program and tested successively. One conventional door engine system in EMU took place of this new door engine system. It was checked the operation data, DCU function, noisy, rain leakage etc. Checked data was good.

2. The composition of door engine assembly

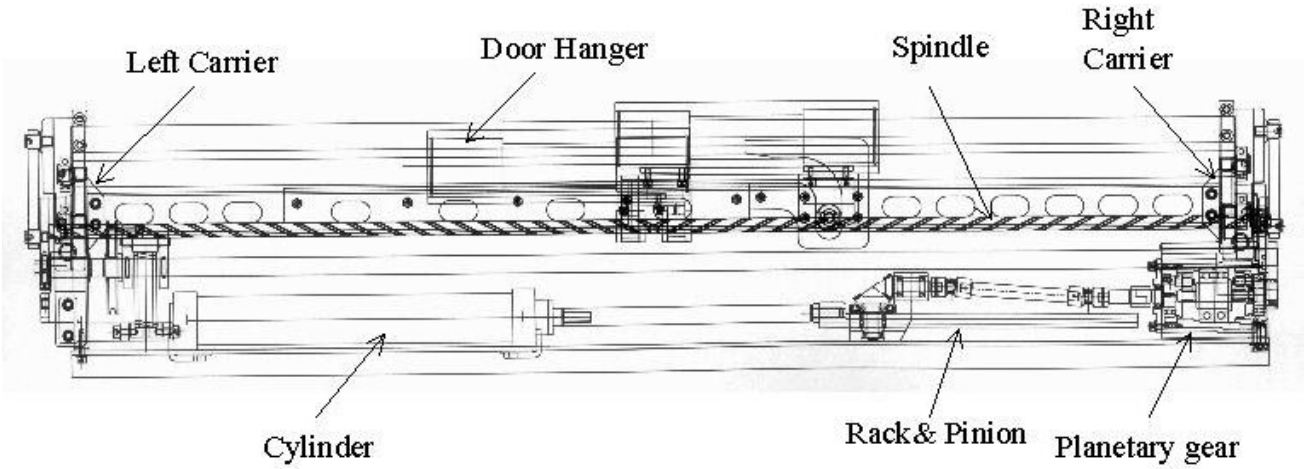
2.1 The characteristic of conventional door engine assembly

The conventional door engine system has no complex planetary gear. It is only operated by cylinder length to secure the opening width. It is so called "pocket type", not plug type. Pocket type only moved between outer frame and inner frame horizontally. So there are many space that the noisy pass into the inside of EMU. It may be applied to straight stainless steel carbody, but it is impossible to round aluminum carbody. Because it is very difficulty that horizontal movement go on.

2.2 The movement mechanism of new DCU control pneumatic plug door engine assembly

As shown in Fig 1 the movement mechanism of DCU control pneumatic plug door engine is as follows.

Air injection _ cylinder working _ linear movement converted rotation movement by rack & pinion _ rotation of bevel gear _ rotation of universal joint(because of the axle disagreement) _ complex planetary gear working(locking release) _ complex planetary gear working(negative acceleration) _ complex planetary gear working(acceleration) _ spindle rotation _ door opened & closed _ locking by push-pull load

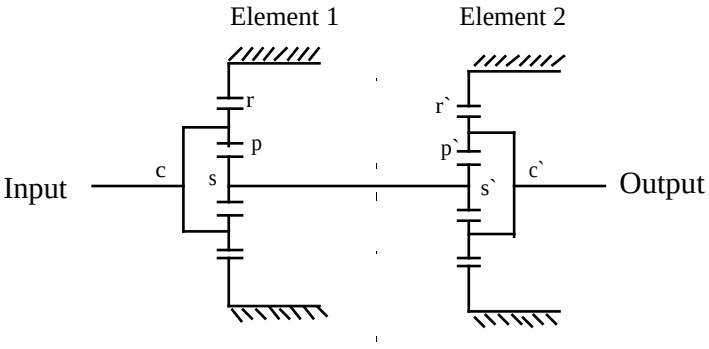


The composition of DCU control pneumatic plug door engine

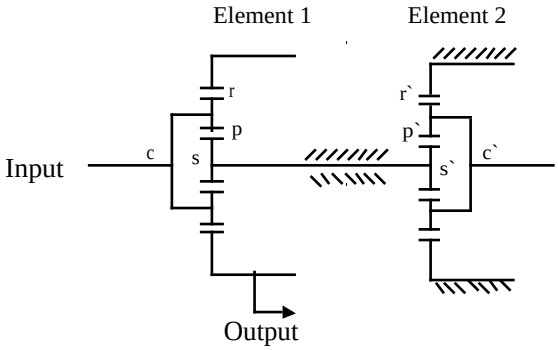
2.3 Development of complex planetary gear

Function of planetary gear will be divided into two contents

Mode I



Mode II



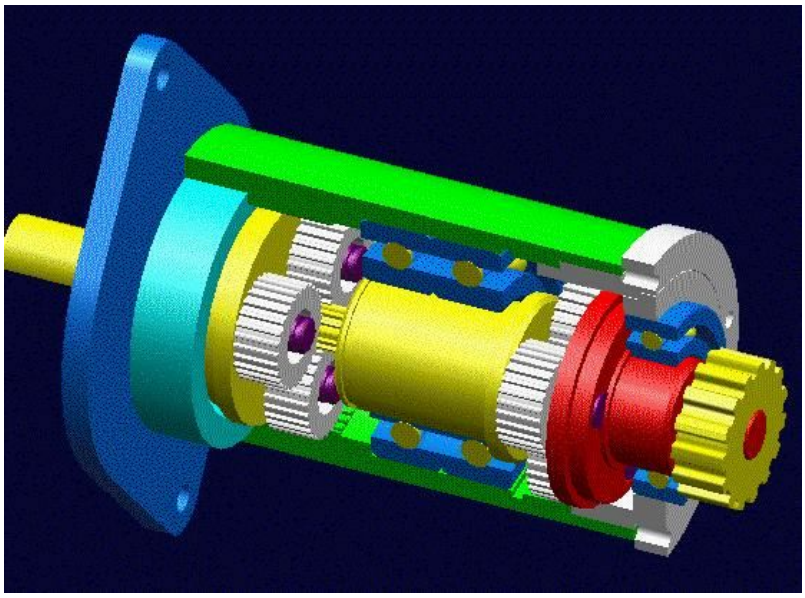
: Fixed component

Number of teeth : $Z_r = Z'_r = 70,\ Z_p = Z'_p = 28,\ Z_s = Z'_s = 14,$

Basic speed ratio for element 1 and 2 : $i_0 = \frac{Z_r}{Z_s} = i'_0 = \frac{Z'_r}{Z'_s}$

Module(m) and cutting pressure angle(α_c) : m=0.75, $\alpha_c = 20^o$

Complex planetary gear has two movements mode and divided into element 1 and 2.(Refer to Fig 2)
Element 1 and 2 is 2K-H type I form.
In mode _ element 1 and 2 are inversion mechanism. So element 2 only carry out the negative acceleration , plug in-out of door engine, locking connected to push-pull load.
In mode _ all of element 2 is fixed. So element 2 has no any role.
In mode _ c is input, c' is output, r and r' is fixed. Belt drive fix r and f' is eternal fixing component



Complex planetary gear(3D shape)

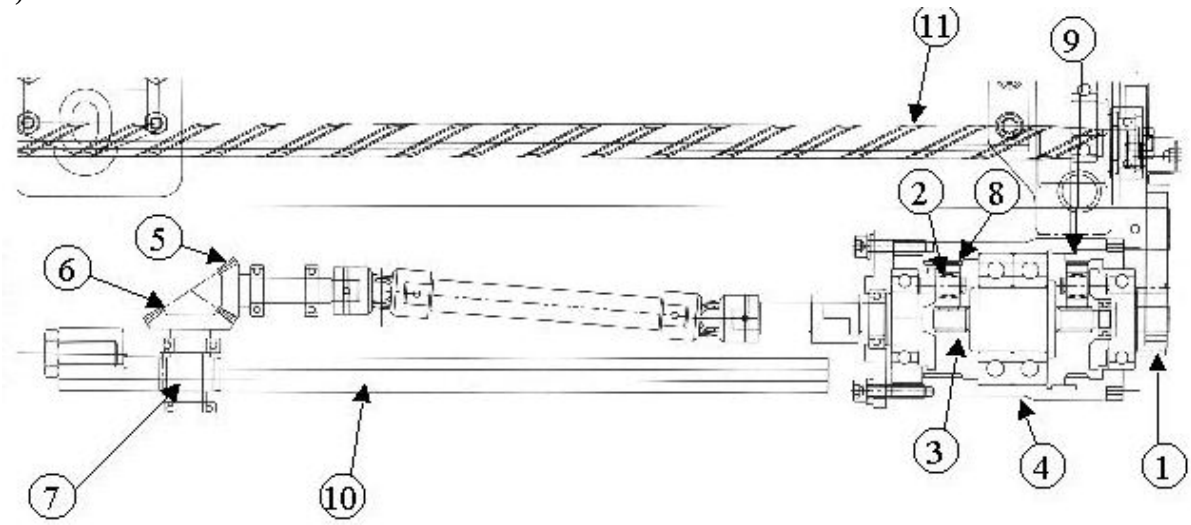
Speed rate in mode _

$$i_I = \frac{\omega'_c}{\omega_c} = (1+i_0) \times \frac{1}{(1+i'_0)} = \frac{\left(1+\frac{Z_r}{Z_s}\right)}{\left(1+\frac{z'_r}{Z'_s}\right)} = 1.0$$

Speed rate in mode _

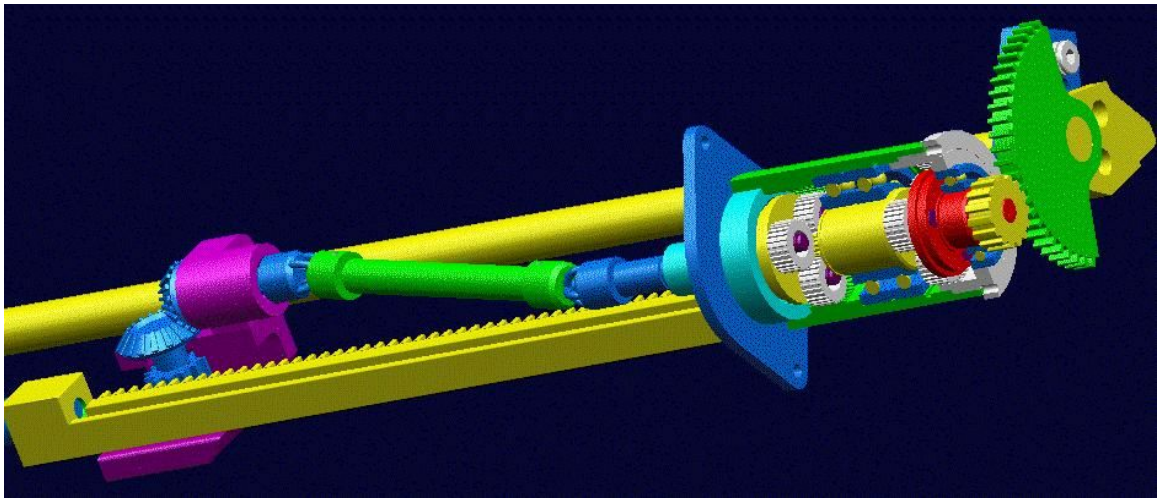
$$i_I = \frac{\omega'_r}{\omega_c} = \frac{(1+i_0)}{i_0} = \frac{\left(1+\frac{Z_r}{Z_s}\right)}{\frac{Z_r}{Z_s}} = \frac{Z_s+Z_r}{Z_r} = 1.2$$

In mode _ number _ planetary gear, number _ plug gear are rotated and number _, _ ring gear, _ carrier are fixed. Door panels are pluged by number _ plug gear and then power transmission mechanisms are to be mode _(Refer to Fig 3, 4)



Assembling of power transmission mechanism

In mode _ number _ plug gear, number _ sun gear, _ ring gear are fixed. Number _ planetary gear, number _ ring gear are rotated and then number _ carrier rotate. Because belt is connected to number _ carrier, door will be opened by number _ spindle rotation



Assembling of power transmission mechanism (3D

2.4 Development of DCU (Door Control Unit)

2.4.1 The characteristic of DCU

DCU is important equipment which achieve the main role in this system. It controls the door system and carry out the movement for passenger safety.

Input condition need to 100V DC. Micom board need to 5V DC by way of DC-DC converter.

PIC chip is joined to Micom board. It is displayed the situation of door opened-closed in micom board. Also micom board have two CPUs. Auxiliary CPU checks the main CPU for confirmation of operation. If DCU is out of ordered, door will be opened and closed normally by using the by-pass switch.

The roles of micom are as follows

· Self diagnosis(checking of the CPU operating state)

· Displaying(displaying the door operating state)

· Recognizing sensor(Recognizing the re-open signal through pressure sensor)

· Timer & Counter(setting the re-open time and the number of the time)

2.4.2 Principle of the operation

As soon as the driver push the closing signal button, an sensor perceive the obstacle and I/O receive the signal, micom perceive the obstacle then transfer the open signal to relay. The door is re-opened

The re-open time and the number of times will be determined by program

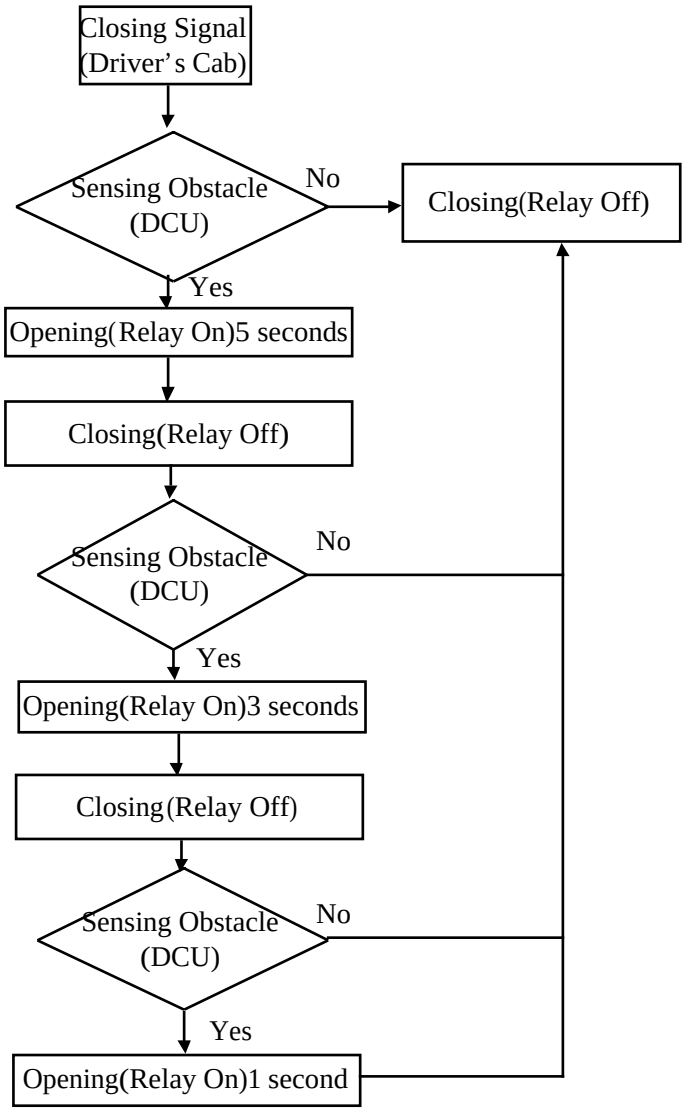


Fig 5. Re-opening operation for DCU

2.5 FEM(Finite Element Method) for door panel

2.5.1 Material property for door panel

The frame of door panel is aluminum ally A6061A T6, and it's inside is filled with honeycomb. Main frame is produced by extrusion method and welded altogether. Before FEM follow, it must be checked the material property. Table 1 shows standards of aluminum alloy A6061A T6

Table 1 Standards of aluminum alloy A6061A T6

Material		Tensile Strength (kgf/mm^2)		Yield Strength (kgf/mm^2)		Elongation (%)
		Base metal	Welded Joints	Base metal	Welded Joints	
A6061A T6	(1)*	27.5	16.8	22.9	11.7	8
	(2)**	26.5	16.3	21.9	10.7	8

* DIN 1748 thickness> 6mm(solid section, open section)

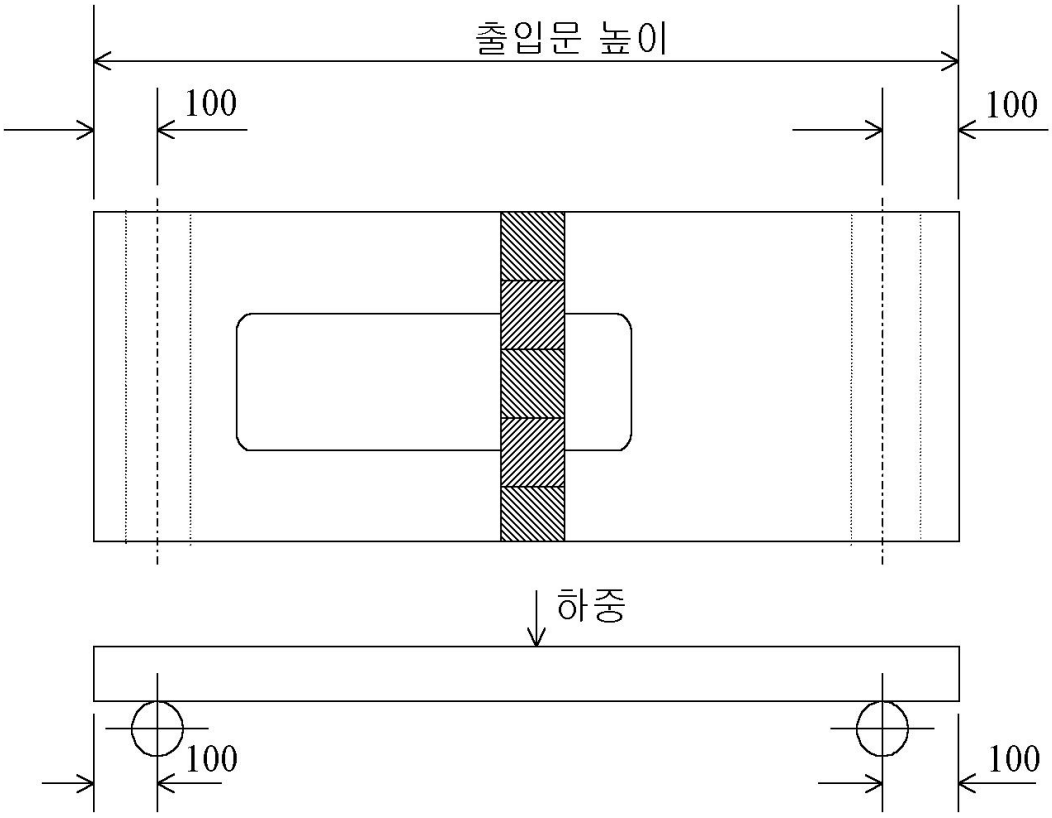
** DIN 1748 6mm thickness < 10mm(solid section), 10mm<thickness (hollow section)

Table 2 shows mechanical properties of the A6061A

Material	Tensile Strength (kgf/mm^2)	Yield Strength (kgf/mm^2)	Elastic Modules (kgf/mm^2)	Poisson's Ratio	Density ($kgf\ s^2/mm^4$)
A6061A	26.5	21.9	7.3×10^3	0.33	2.857×10^{-10}

2.5.2 Weight and restriction condition

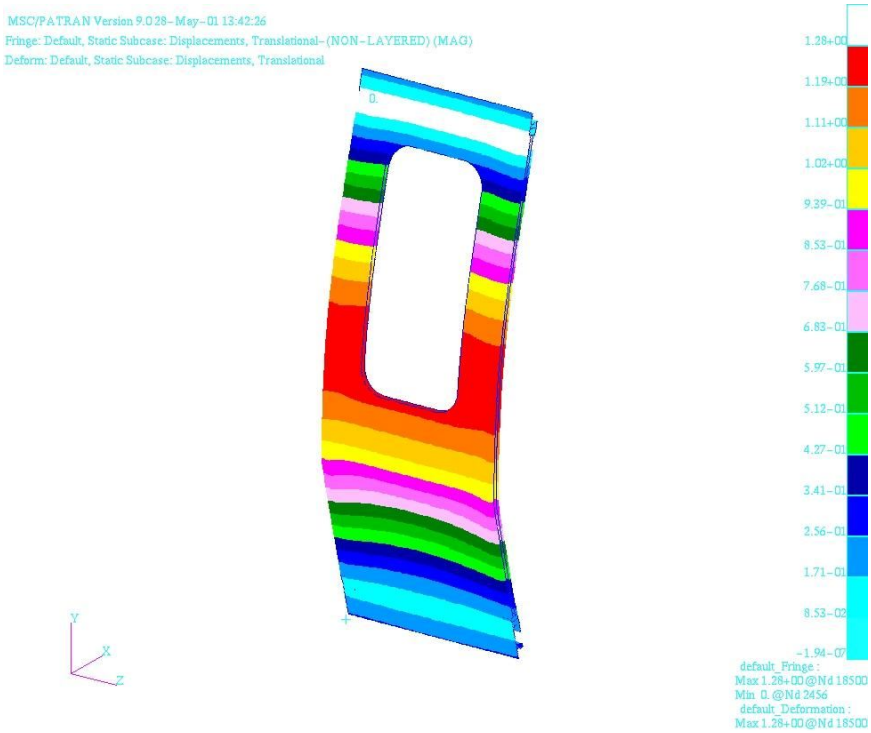
As shown in Fig 6 weight condition load 100kgf in the center of the door panel. Restriction condition is 100mm distance to the end of the door panel. At then it should be checked the displacement. The checked data must not over 5mm



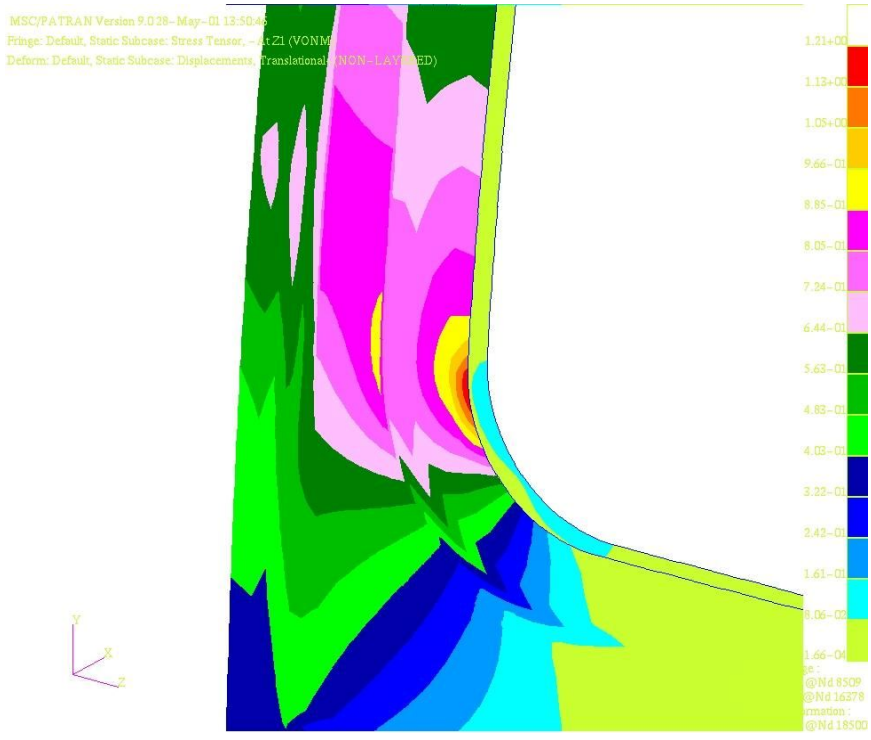
Weight condition of door panel

2.5.3 Result of the analysis

Shown in fig 7, 8 the maximum displacement is 1.28mm, stress is 2.68 kgf / mm^2



Displacement value



Stress value

The corner of window is weak point, but the value is within the standard. So it is decided that the door panel is safe sufficiently

To comparison with the real test data the initial door panel was tested by pressure machine. The tested data is 3.29mm. The difference of the value between FEM and real test is not important, because of the data is good.

3. Conclusion

In order to improve the maintainability and safety of the train system, Korea government (Ministry of Construction and Transportation) revised the Urban Transit Law in 1995, and initiated the project which is called "standardization and development of the urban rail vehicle". This project has been performed by KRRI in cooperation with related authorities and companies from 1995 to 2000. But the conventional door engine type was installed to this EMU.

So it was decided that all of door systems was replaced. After all "DCU control pneumatic plug door engine system" was applied to the standardization EMU successfully. The new door system will be applied to Light Rail Vehicle later on.