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Research paper

Development of Press Die for Aluminum Open - Type Scaffolding Board

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Abstract

Scaffolding as part of the temporary facilities category in construction has significant impact on construction sites must be thoroughly designed, manufactured, procured and managed. As part of the basic industry, the vessel plate is essential when working on a high level e.g. construction of the buildings or ships, can be regarded as an important. In order to increase the main performance and production volume of the footrest plates, the new open type aluminum ranch was developed through this research study and in which the production process line of the footrest plates was improved. The main contents of the research task is production of holes in aluminum plate which is drastically reduced from 10 to 5 process, thus increases production rate and a heavy reduction in production time and burden for the worker. By using aluminum instead of the existing iron material used in the iron sheets, makes lighter and easy to handle. Reviewing the choice of aluminum materials is verified through structural analysis to reduce product development costs, which can save time and shortening the press process. Initially FEM (Finite Element Method) were used for technical performance and Simultaneous processing of holes separated from the top and bottom plates, and structural analysis of new material (aluminum). As a result of our research study we lightening the weight of Scaffolding Board which causes reduction of shift time and work by increasing the working efficiency of workers. It also gives a positive impact on performance through such effects as easy to handle by workers and also effective to different environment conditions.

Keywords: *FEM, Footrest Plates, Photomechanical, Stress Distributions, Vessel Plate*

1. Introduction

Wooden plates are essential for ship-building or building work, and the volume of work on high-rise buildings is increasing as ships become bigger and buildings become taller. Generally, in industry sectors such as shipbuilding and construction, the scaffolding board is used as a conduit and footboard to ensure the safety of workers who work directly at high places and to provide a convenient environment for performing tasks [1-2]. A typical assembly of scaffolding at construction sites are shown in Figure 1.



Fig. 1: General shape of scaffolding assembly at construction site

In general the shape of the Scaffolding Board is that the head is installed by placing a wearer on a temporary installed frame vertically and horizontally, and attaching a wearer to the mounting frame by wire. The existing iron scaffolding board as shown in Figure 2 has a weight and product age, and the weight is more than 50 percent heavier than the aluminum, which puts a strain on the worker's handling of the product [3]. Also, in terms of service life, aluminum is nearly twice as durable.



Fig. 2: Previously used iron plate scaffolding board

Aluminum, which is applied to the vessels, was later separated than other metals due to the relatively large oxidation of aluminum after oxygen and silicon, and was known in ancient times as oxides such as aluminum oxide. Aluminum were known to be pure in the 18th century when refined technologies were developed by electrolysis. It was discovered by Danish chemist Hans Christian Oersted in 1825 [4].

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The abundance of aluminum, which accounts for 8.2 percent of the mass of the elements present on Earth, and its pure refinement have led to a rapid increase in the use of aluminum. It is used as a material for high-pressure electric wires because of its excellent conductivity and ductility. Although it reacts easily with oxygen, it has an excellent corrosion resistance since its coat acts as an oxygen contact barrier after formation of an oxide layer. It is used for parts where polishing such as window frames can last for a long time due to poor rust generation, and is also used for lighting the weight of specific objects. Because of its high thermal conductivity, it is also used as a material such as a kitchen container, and it is used to make alloys to compensate for the disadvantages of light but weak aluminum. It is widely used as a main material for aircraft, ships, and vehicles by using light and durable characteristics [5-6].

With these aluminum properties, the application of the wooden boards to be developed and the application of parts using aluminum will be expanded to a larger size, starting with the iron ingot plate and improving, developing, and increasing the use of aluminum head in the shipbuilding industry. It also needs technical skills that can match demands of customers such as changing size that they want. Therefore, it is required to secure foreign competitiveness by securing its own technical skills to keep up with the rapidly changing market conditions.

As mentioned earlier, aluminum in the interior was first discovered in 1825 when the Danish Oersted reacted to AlCl3 with a potted calcium amalgam. This method was improved by Wohler in 1827 to use potassium instead of potassium amalgam, the first commercially successful aluminum production process was improved in 1854 by replacing potassium with cheaper sodium in DeVillelauer's method, and in the same year Bunsen electrically dismantled molten NaAlCl4 [7]. The Hall–Héroult process, which is used today as the method of production of aluminum, was developed independently by the Hall of the United States and the Eru of France in 1886, and the advent of the process allowed us to produce aluminum cheaply [8]. This process is to melt alumina with a chryolite and electrolysis the solution to produce aluminum. Aluminum is a metal that is produced most often after iron, and is used to make alloys in almost all but for packaging such as aluminum foil. The most frequently used parts are transportation organizations such as cars and trucks, and about 28 percent of them are used. This contributes to reducing energy consumption by making vehicles lighter, and it is expected that more and more electric vehicles will be used in this area as they become more common. The next most commonly used item is aluminum foil (foil) and various containers that are used for packaging, which accounts for about 23 percent of all uses. And 14% are used as building materials such as window frames and roof materials, and 35% are used for heat exchangers, kitchen appliances, machinery, and special chemical facilities such as electric wires, home appliances, car engines, cooling and heating systems [9].

Aluminum alloys are numbered from 1,000 to 7,000 depending on the type or amount of element that is required for alloys. The 1,000 series are nearly pure aluminum with less than 1 percent of the other elements, and the mechanical strength is weak while the other properties are superior, which is mainly used for chemical devices, reflectors, heat exchangers, finishing materials of buildings and decorations. The 2,000 series is an alloy containing approximately 5% copper (Cu), which has good mechanical strength, processing power, and excellent corrosion resistance, which is used for items requiring a greater weight/weight strength, such as a truck panel wall, aircraft structural parts [10]. The 3,000 series is an alloy containing about 1.2% manganese (Mn) and is mostly used as cooking utensils, storage containers, furniture, highway signboards, and roof materials because it has good processing power. The family 4,000 contains less than 12% silicon (Si) and is used for greying out castings, welding and aluminum due to its low melting point and low thermal expansion factor. The No. 5,000 unit includes 0.3 to 5% magnesium (Mg), which is very strong, wieldable, and has excellent insulating properties for sea water, so it is used in decorative finishes, ships, frozen containers, and crane parts. The 6,000 series shown ion Table 1, is an alloy of Mg/Si and is used in building materials, transportation equipment, bridges, welded buildings, and Joseon equipment. Finally, the 7,000 series is used for equipment such as aircraft structures that require high weight relative to their weight when heat treated with an alloy of 3 to 8% zinc (Zn)/Mg.

Starting with the aluminum lightening mentioned above and the corrosion and weldability of the Mg/Si alloys of 6,000 units, some domestic shipbuilders are converting to lighter-weight aluminum wearers.

Table 1: Major aluminum 6,000 series chemical compounds

type	Mg	Si	Cu	Ti	Mn	Fe	Cr	Zn	Al
A6061	0.8~1.2	0.4~0.8	0.15~0.4	0.15	0.15	0.7	0.04~0.35	0.25	Remanning %
A6N01	0.4~0.8	0.4~0.9	0.35	0.1	0.5	0.35	0.3	0.25	Remanning %
A6063	0.45~0.9	0.2~0.6	0.1	0.1	0.1	0.35	0.1	0.1	Remanning %

The A6N01 applied to the new OPEN TYPE aluminum cage has a medium strength for extrusion between A6061 and A6063 and has an excellent extrusion, corrosion resistance, and weldability compared to the A6061. Currently, most shipbuilders in Korea use iron and plywood, and the conversion to aluminum weasels is seen as the beginning.

Hyundai Heavy Industries has switched to aluminum in the shipbuilding and marine sectors and Hyundai Mipo Shipbuilding is converting to aluminum instead of iron-fisted. Daewoo Shipbuilding & Marine Engineering uses a steel mill in the shipbuilding and marine fields, but it is considering converting LNG vessels to aluminum, which can replace plywood. Although there are no cases outside the country where aluminum ranchers have been applied Japan is attempting to convert them from a Japanese universal vessel. The new open type aluminum scaffolding board involved in this task is manufactured from aluminum material and has been registered as a practical model and has excellent performance for lightweight and durability.

2. Designing and manufacturing of open iron scaffolding board

2.1. Mold Design of Aluminium iron scaffolding board

In this task, we are going to improve the process for producing aluminum plate, which will be included in the new open type aluminum ranch of shipbuilding materials. Existing piercings molds were difficult to process at the same time the hole on the top and bottom of the product with interior space, and even when the hole is machined, the shape of the product or the shape of the processed hole is distorted. To solve the problem of conventional piercing molds, the molds for forming holes on the top and bottom plates of products with internal spaces are prepared separately to form holes on the top of the product with internal space, but this will increase in the number of workers, fatigue and productivity of workers.

Therefore, in order to solve the aforementioned problem, the hole which is formed on the top and bottom plates of a product with separated hole equipped is designed to improve productivity by

simultaneously processing the top and bottom plates with a single process. Generally piercing mold shall settle the product for processing the hole in the lower part and then the upper type pad shall lower the product first secure the product and then lower the pierce punch to form the product attached to the lower part so that the hole can be machined on the product. However, the top hole of a product equipped with a space section inside and separated hole can be machined. The hole in the lower part is difficult to form because it is not equipped with a pad, and there are problems where the shape of the product or the cross section of the manufactured hole is distorted because there are no pad's that can be fixed even if the hole is machined.

Here, "aluminum open type" is used in a passageway in which a product equipped with an internal space division can be connected so that the worker can perform the work standing on his feet in the development of this task.

In order to solve the problem of conventional piercing molds, the lower and pad functions were developed to simultaneously process for upper and lower hole's, thereby enabling the upper and lower whole cavity to be realized. At typical mold structure and comparison of the mold structure applied to this task are shown below in Figure 3 and 4.

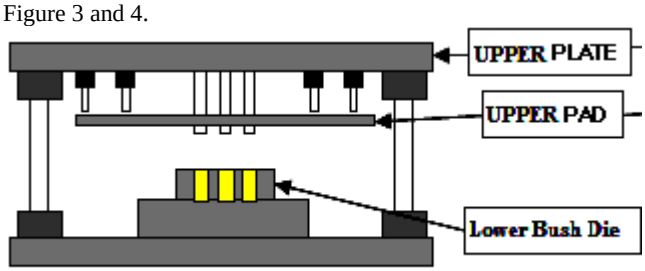


Fig. 3: Typical basic piercing mold structure

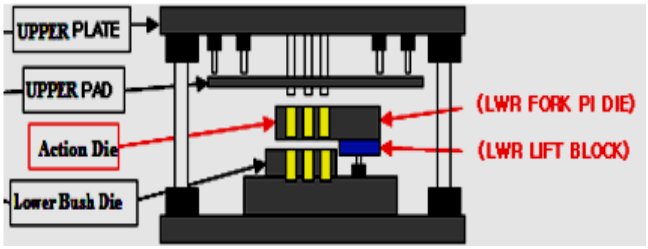


Fig. 4: Basic mold structure for application of this task

Based on the basic mold structure applied in this task, the 3D design required for mold production was performed in CATIA software and which is indicated through Figure 5 below.

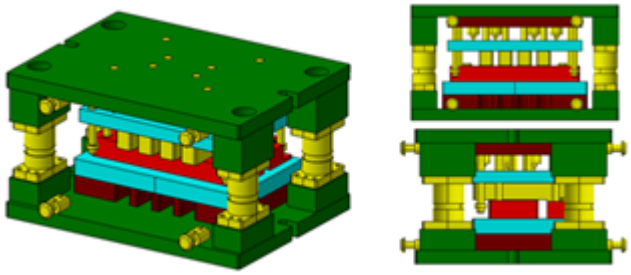


Fig.5: Aluminium plate 3D mold design using CATIA

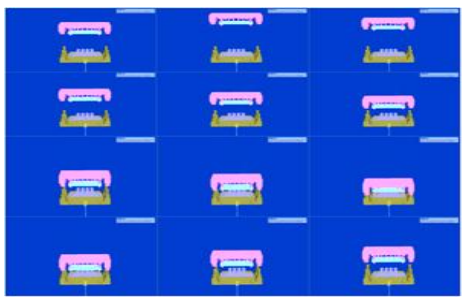


Fig. 6: Simulation of upper and lower parts of aluminum plate

Pre-simulation was carried out to identify potential problems such as mold breakage that could occur during actual try-out by making use of 'CHK' on the basis of 3D design drawings before try-out. The analysis result of the mold is shown in Figure 6.

2.2. Manufacturing of Aluminum ranch

The upper base plate (112) is the plane mounted on the press slider and the upper retainer block (114) hold the product when press down. Inserting the spring between the product's lining at the top of the PAD and the retainer block. Then, install guide bush and post to determine location and tighten retainer bolt (115) to prevent drop. The upper shape pad (116) face that effectively holds the product when the press is lowered.

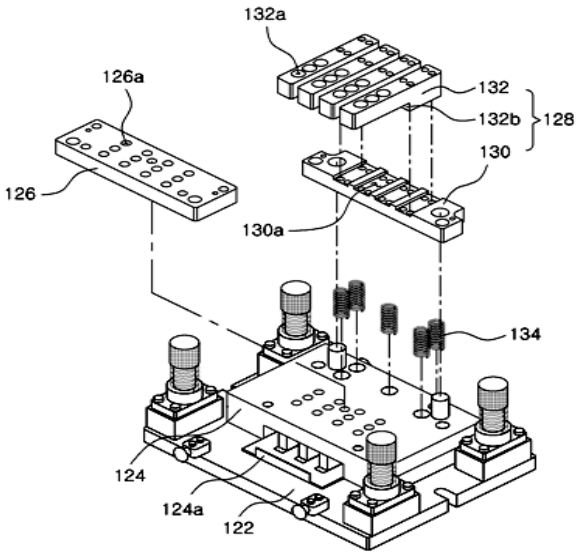


Fig. 7: Detailed drawings of the lower section

The lower base plate (122) is the face mounted on the press ball stand and lower scrap plate (124) path, scrap is ejected after processing the upper and lower plate's holes. It serves and supports the lower type operating die (128) and lower pi die (126) at lower part the role of lower type bush for processing the lower part hole. Ha-hyung operational dies (128) lower lift block (130) + lower fork die (132) perform the role of the lower pi bush (132a) during the top hole machining, and play the role of PAD (132b) to hold the lower surface when lower part hole is machined. After receiving steel, perform a bolt and Dowel Pin Bor'g operation so that the cotton can be machined and assembled on the first milling machine. The steel assembly units in the base plate with the bolt and down pin for NC processing is shown in Figure 8. In NC manufacturing we attach the assembled top and bottom body to the NC machine to perform shape processing according with the NC data.

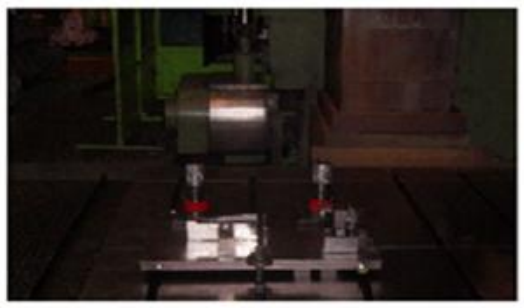


Fig. 8: Setup of NC Processing

After NC processing, we prepared die spotting by conducting thought work using grinder to remove fine cutting and cotton illumination. In final assembly after NC processing and thought completion, the required components such as standard parts and manufacturing parts were assembled.



Fig. 9: Assemble of die upper and lower body

3. Structural analysis results and Experimentation

3.1 Analysis results of open type wood-blocks

In order to calculate the performance of new aluminium scaffolding, we are performing analysis on sample wood block scaffolding and compare these results to the new aluminium plate scaffolding. The load is applied to the centre of the footrest plate in the same position as the new aluminium open type head plate. The creation of a finite element model was subdivided into solid187 elements (Tetra structure, 10 nodes), such as a new combined aluminium open type head plate. The total number of nodes and total elements of the open type headboard combined, is 240,213 and 385,757 respectively.

Table 2: Stress values and deflections for each condition of the new wooden block scaffolding

Force [N]	Max stress[MPa]	Min stress[MPa]	Deflection [mm]
100	26.8	0.410	0.087
250	67.1	1.02	0.2
500	152	2.37	0.48
750	201	3.07	0.93
1000	268	4.10	0.97
1020	274	4.18	0.98

Table 2 shows the analysis results for maximum stress, minimum stress, and deformation (deflection) of the wooden open type stock plate. Considering the maximum tensile strength of the material (260 MPa), the above corrugated plates can be used without modification to the product up to approximately 950 N.

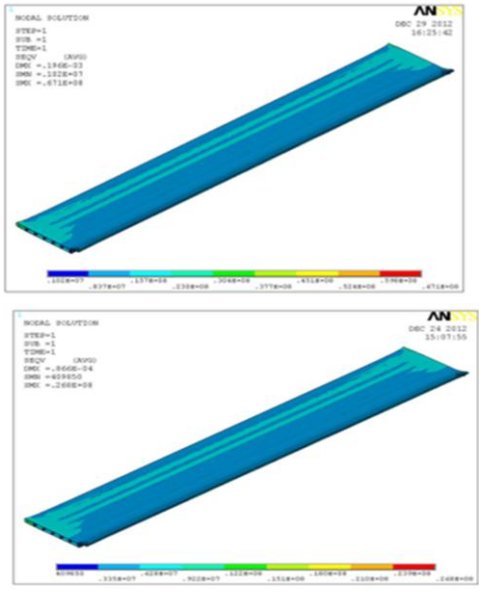


Fig. 10: Von-mises stress of wooden open type head plate for each condition stress distribution

Figure 10 shows the distribution of the Von-mises stress of the wooden open type head plate under each load condition, and the distribution of stress between 100 N, 250 N, 500 N, 750 N, 1000 N, and 1020 N sequentially from left to right. Figure 11 also showed that the small deflection is difficult to distinguish by identification, and that the maximum stress appears at the end of the footrests as a whole under each load condition.

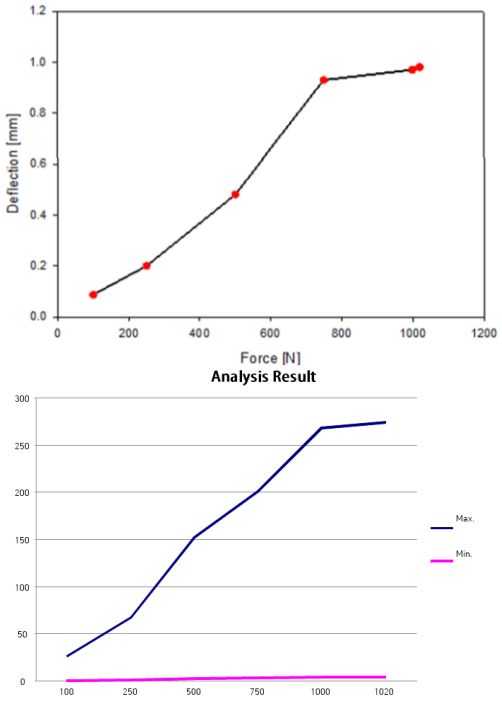


Fig. 11: shows linear increases in each load condition, as shown in the Von-mises stress of the wooden open type head plate.

3.2 Modelling of the new aluminium open type cladding plates

The modelling of the new aluminium open type was performed in ANSYS as shown in Figure 12. To facilitate interpretation, the non-slip jaw and anti-theft tappets on the top-board that do not significantly affect the analysis results were modelled. 3D modelling is the same size as the actual size of the new aluminium open type corrugated plate, and the radius of the perforation part, the thickness of the pommel plate is modelled as the same as actual product.

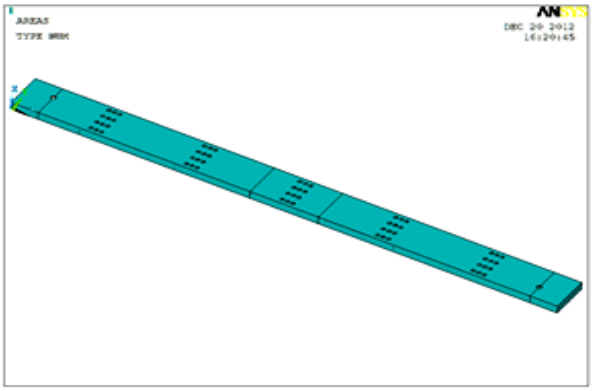


Fig. 12: 3D modelling of the new leader of aluminium open type

3.3 Analysis criteria of new aluminium open type plates

The interpretation of the new aluminum open type was performed by dividing the analysis into the case where one of the scaffolding boards was used alone and the other two were used in the tighten-

ing process. The load conditions and boundary conditions were considered to be applicable at the actual application site.

The load conditions are eight loads (100N, 500N, 1000N, 1500N, 2000N, 2500N, 3000N, 3350N) combined for the new aluminium open type scaffoldings, 6 new aluminium open members (one part that has not been combined), and six loads of the new aluminium open members (1,500N, 1 As shown in figure 13, the area represented by the red line with the most deflection is placed on (long-direction 500 mm * wide direction 300 mm, total number of nodes: 594 nodes).

When the load was applied, a deflection occurred on the headboard, and the border of the headboard was displaced, the boundary conditions were limited only in the UY direction as shown in Figure 15. The materials of the new aluminium alloy are relatively lighter than the existing iron material with the A6NO1-T5 (ASME CODE: 6005A), which is stronger than the used material. Table 3 below shows the mechanical properties of A6NO1-T5.

Table 3: Mechanical properties of A6N01-T5

Physical Property	Density	Modulus of Elasticity	Tensile Strength	Shear Strength	Poisson's Ratio
Value			2.70 g/cm3		70 Gpa
260 Mpa		205 Mpa		0.33	

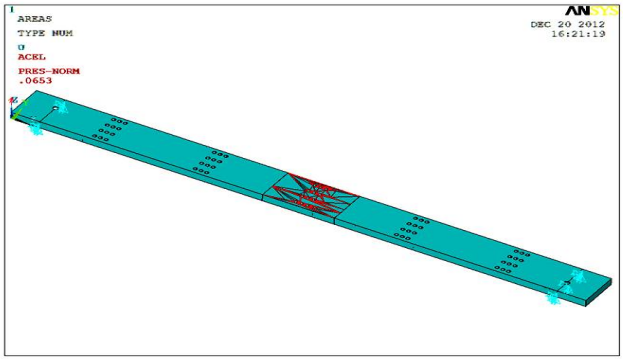


Fig. 13: Load conditions of aluminium open type Plates

3.4 Results of new aluminium open type head combined

The analysis was carried out by applying a load to the centre of the new aluminium open type corrugated plate. By using mesh tool in ANSYS APDL the creation of a finite element model was subdivided into solid 187 component (Tetra structure, 10 nodes), which is a sided shape as shown in figure 14. The total number of units, nodes and total elements of the new combined aluminium open type family register is 31,869 and 34,886 respectively.

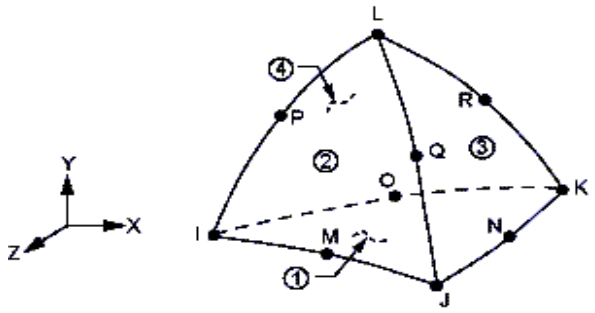
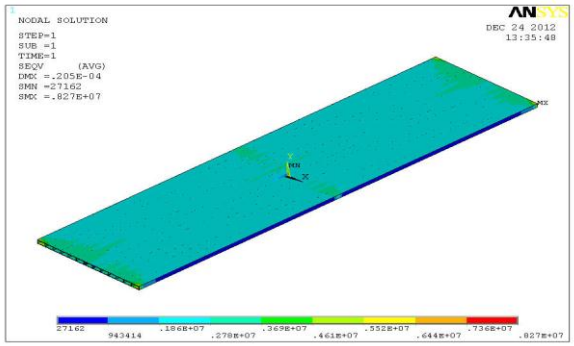


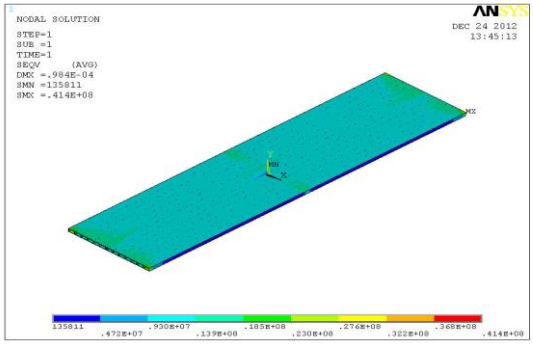
Fig. 14: Components shape of solid187 Geometry

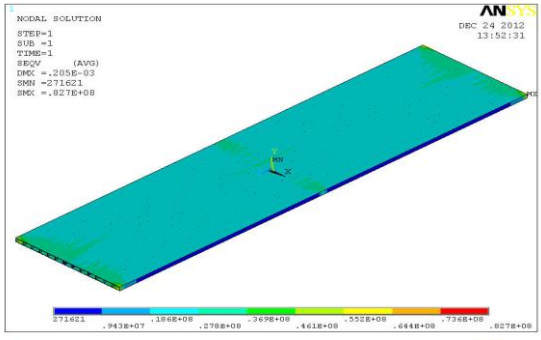
Table 4: Stress values and deflections for each condition of new combined aluminum open type corrugated plates

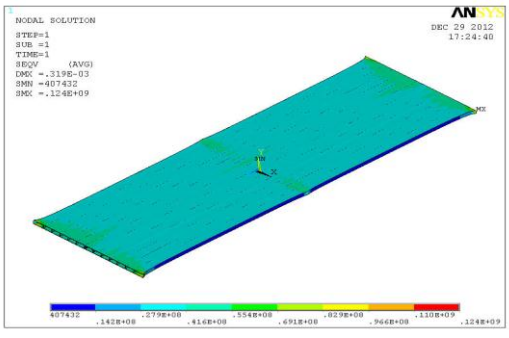
Force [N]	Minimum stress [MPa]	Maximum stress [MPa]	Deflection [mm]
100	8.27	0.027	0.02
500	41.4	0.135	0.1
1,000	82.7	0.272	0.2
1,500	124	0.407	0.32
2,000	165	0.543	0.4
2,500	207	0.679	0.5
3,000	248	0.815	0.6
3,350	275	0.901	0.73

Table 4 shows that, the analysis result values for the maximum stress, minimum stress and deformation (deflection) of the new combined aluminum open type head plate. Considering the maximum tensile strength of the material (260 MPa) the above corrugated plates can be used without deformation up to approximately 3200 N.









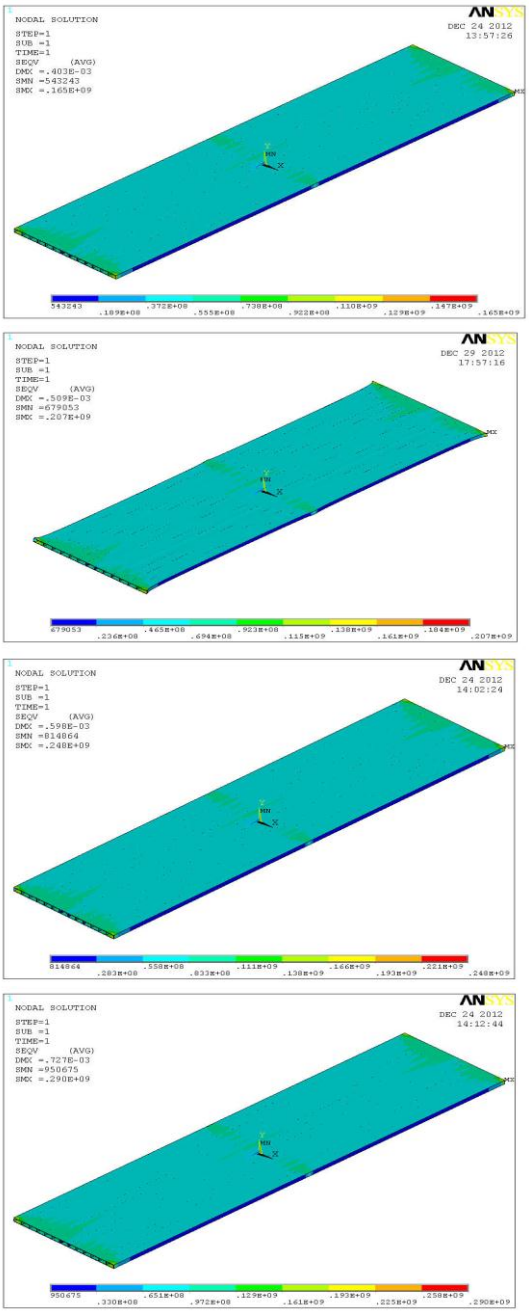
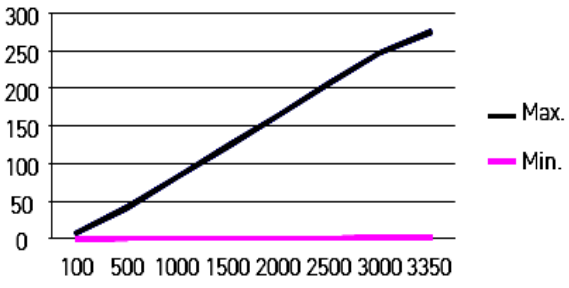


Fig. 15: Von-Mises stress distribution of new aluminum open type corrugated Plates according to each load condition

Figure 15 shows the distribution of the Von-Mises stress of the new aluminum open type head plate combined according to each load condition and the distribution of stress between 100 N, 500 N, 1000 N, 1500 N, 2000 N, 3000 N and 3350 N in sequence from left to right. In the figures, small deflections make it difficult to distinguish them and the maximum stresses appear at the end of the foot rests as a whole under each load condition.



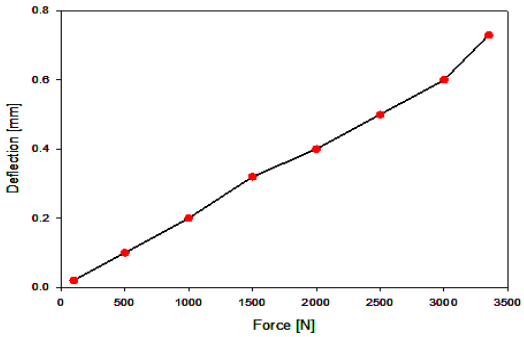


Fig. 16: deflection of new aluminum open type corrugated plates with different load conditions

Figure 16 shows a graph of the Von-Mises stress of the new aluminum open type headboard combined under each condition. It can be seen that by linearly increasing load variables, the stress value for this is also derived from a constant linear value. The deflection also increases linearly, as with the maximum stress value. The top and bottom view of the Aluminum plate after die-hole process is shown in figure 20.



Fig. 17: Aluminum plate top and bottom view after complete process

4. Conclusion

As part of the basic industry, the vessel plate which is essential when working on a high level when building a ship or a building can be regarded as an important. In order to increase the main performance and production volume of the footrest plates, the new open type aluminium ranch was developed through this research work and the production process line of the footrest plates was improved. From the analysis result we can clearly see the improvement of our new aluminium type scaffolding board over typical wooden plate open type scaffolding.
The main contents of the research task are as follows.

(1) Reduced press process: One of the great technical achievements of a research task can be seen as a reduction in the press process. The process, which was carried out separately from 10 processes, was reduced to 5 processes through modification of new mold design. With Know-how accumulated, future product development research has increased the possibility of technology development that can be reduced to less than 5 processes due to mold design change or process change, and this experience has resulted in technical achievements that can be applied to products with similar specifications.

(2) Simultaneous processing of hole separated from top and bottom plates: The existing pierced molds for processing holes were difficult to process at the same time, the holes on the top and bottom plates of the products with interior spaces, and even if the holes were machined, the shape of the products or the processed holes would be distorted. To solve this problem, the new open type aluminum corrugated plates has developed molds to form

holes on top and bottom plates with internal space. The developed molds were processed simultaneously on the top and bottom plates of the product with separated holes. Through the research study, the above unique technologies were secured and the technical achievements of the research study are shown above.

References

[1] H. Watari, H. Ona, 1997: Application of urethane rolls for producing section with holes at regular intervals: *Proceedings of the 32nd International MATADOR Conference*, UK, , pp. 463–467.

[2] H. Watari, H. Ona, (1998): Characteristic features of shape defects occurring in the cold roll forming of pre-notched products: *J. Mater. Process. Technol.*, 80–81 pp. 225-231.

[3] K. Sato, R. Miya, K. Ozaki, H. Nishimura, Y. Ishikawa, O. Ishishita, (1981): Punching aluminum sheets with urethane elastomer tools: *J. Jpn. Inst. Light Met*., 31 (3) pp. 164-168.

[4] K. Sato, R. Miya, K. Ozaki, H. Nishimura, Y. Ashikawa, (1982) :Punching square holes in aluminum sheets with urethane elastomer tools: *J. Jpn. Inst. Light Met.*, 31 (9), pp. 608-613.

[5] K. Sato, R. Miya, K. Ozaki, H. Nishimura, (1982): Improvements of punched edge in aluminum sheets with urethane elastomer tools: *J. Jpn. Inst. Light Met.*, 32 (8) pp. 389-394.

[6] M Kiuch, T Koudabashi, F Eto, (1986) :Development of simulation model of roll-forming processes: *J. Jpn. Soc. Technol. Plast*, 27 (306) pp. 874-881.

[7] N Duggal, M.A Ahmetoglu, G.L Kinzel, T Altan, (1996): Computer aided simulation of cold roll forming a computer program for simple section profiles: J. Mater. Process. Technol., 59 pp. 41-48.

[8] Cho K.L. & Jonassen D.H. (2002): The effects of argumentation scaffolds on argumentation and problem solving: *Educational Technology Research and Development* 50, pp5–22.

[9] H. Kim, H. Ahn, (2011): Temporary facility planning of a construction project using BIM (Building Information Modeling): *Proceedings of the 2011 ASCE International Workshop on Computing in Civil Engineering*, pp. 627–634.

[10] Mueller Bruno, (1989): Scaffolding board formed from plastics materials, a method of producing same, and an apparatus for implementing the method: *Polytex Plastic SA*, pp 436-452.