Taiwanese Fastener Companies' Transition From Using Low Carbon Steel to High Alloy Steel

從低碳鋼到高合金鋼---台灣扣件材料轉型之路

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Foreword

The development of Taiwanese fastener industry has been over 30 years. In the beginning, domestic sales used to be the focus of the industry, which imported low carbon steel wire from Japan and manufactured wood screws or machine screws processed by hand or machines bought from Japan. Then, in the period of "10 Major Infrastructure" of Taiwan, China Steel Corp was established for supplying the domestic demand for carbon steel, though some products still had to be imported to cover insufficient sections. After that, Taiwanese manufacturers gradually introduced stainless steel billets from Japan. Yieh Hsing Enterprise and Walsin Lihwa purchased facilities from Germany and USA respectively. Walsin Lihwa and U.S. Carpenter even established a joint venture company in Tainan, which, through the introduction of foreign technologies and investment, is in a successful transition to a company that integrates the refining and rolling of stainless steel wire into one line. Major advanced countries are advocating industrial development and the fastener industry is a part of it. In terms of the fastener industry, materials should be taken into account. The commonly used materials for fasteners are steel, copper, aluminum, and plastics. In this article we will not expound upon non-ferrous materials and will otherwise focus on the transition of Taiwanese fastener industry from using low carbon steel to high alloy steel.

Materials for Fasteners

Coils are generally used in the production of fasteners. When the material is different, the mechanical property and grade will be different; when the mechanical property is different, technologies used to process fasteners will be different; when the grade is different, the finished product will be different. Major fastener materials can be divided into 2 categories: carbon steel and stainless steel. Carbon steel can be further divided into low carbon steel, medium carbon steel, high carbon steel, and alloy steel, while stainless steel can be divided into Martensitic stainless steel and Austenitic stainless steel. Selection of materials is based on 3 principles: One, whether the material can be used in a certain environment (e.g., anti-corrosion or physical properties under high/low temperature). Two, the application and structure of fasteners (e.g., tensile strength, torque, etc) should be taken into account. Three, if several materials are available, those with more simplified manufacturing procedures and stable sources can save manufacturing and purchasing costs. **Figure 1** shows main sources of steel materials and related wire plants of Taiwanese fastener industry.

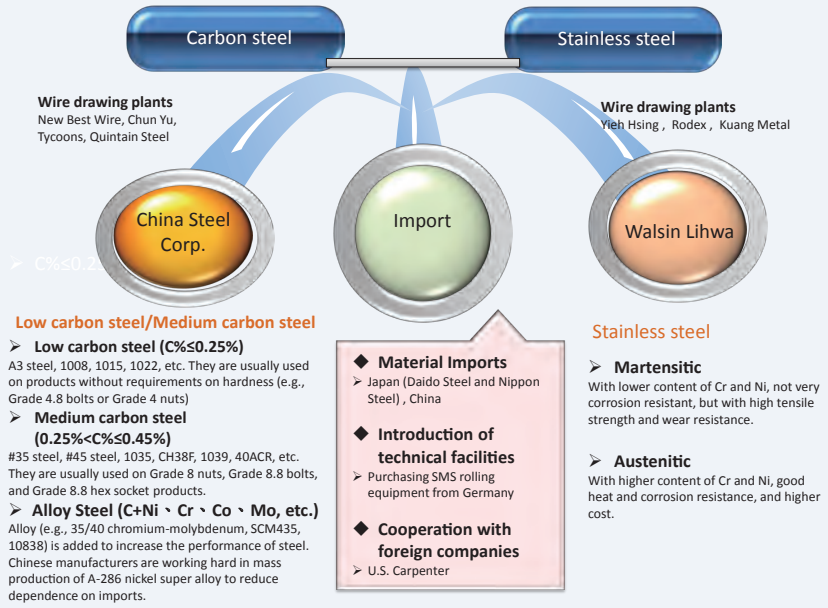

Figure 1. Main Sources of Steel Materials of Taiwanese Fastener Industry

Steel Type	Content of Carbon	Strength (Kgf/mm^2)	Used in Fastener Production
Low Carbon Steel	< 0.25	30-45	✓
Medium Carbon Steel	0.25-0.45	45-62	✓
High Carbon Steel	>0.45	62-72	✗ (Mostly used in screw molds, bearings, etc.)

Table 1. Content of Carbon in Certain Carbon Steel and Strength

Stainless Steel Type	Contents of Ni and Cr	Anti-corrosion	Other Features	Common Applications
SUS302	Cr>12%+Ni>7%	Fine	With higher content of Carbon and strength better than SUS304	Furniture, construction, automotive parts, medical device, food, chemicals, agriculture
SUS304	18%Cr+8%Ni	Fine	Heat resistant, with high strength in cold temperature, with better harden-ability, non-magnetic	Furniture, construction, automotive parts, medical device, food, chemicals, agriculture
SUS316	17%Cr+12%Ni+ 2.5%Molybdenum	Excellent	High acid/alkaline resistance, better harden-ability, non-magnetic	Chemical engineering facilities, facilities for use in seawater

Table 2. Contents of Ni and Cr in Stainless Steel, Features, and Applications

Carbon steel can be divided into low carbon steel, medium carbon steel, high carbon steel, and alloy steel. Low carbon steel is commonly used on products without requirements for hardness (e.g., Grade 4.8 bolts , Grade 4 nuts, small screws). Medium carbon steel is usually used on Grade 8 nuts, Grade 8.8 bolts, and Grade 8.8 hex socket products. As the content of carbon in high carbon steel is too high, it cannot be forged easily and the fastener industry does not use this material currently. Alloy steel is formed by adding alloy into carbon steel which increases the performance of steel. Commonly used alloys are C, Si, Mn, P, S, Cr, and Mo. Currently the leading carbon steel coil manufacturer in Taiwan is China Steel Corp., which, in addition to supplying low/medium carbon steel, has been active in developing A-286 Ni super alloy coils in recent years. A-286 is a super alloy with high strength. It features high strength and corrosion resistance under 700℃ and is often used in fasteners for jet engines and automotive engines. At the present almost all A-286 coils used by Taiwanese manufacturers are imported, which is costly and may delay the lead time. China Steel Corp has supplied a small batch of A-286 to some Taiwanese automotive fastener manufacturers for testing the possibility of mass production. In the future Taiwanese fastener manufacturers can expect to get this material at a more reasonable price to reduce material cost and promote competitiveness in fastener production. **Table 1** shows the comparison of carbon steel.

Stainless steel can be divided into Austenitic with higher contents of Cr and Ni and Martensitic with low contents of Cr and Ni. The former is heat and corrosion resistant and shows excellent weld-ability, while the latter shows inferior anti-corrosion but has high strength and anti-wear performance. In addition to the supply from Walsin Lihwa, most of the products are imported from Japan (e.g., SUS302, SUS304, and SUS316). **Table 2** shows the comparison of SUS302, SUS304, and SUS316.

304M, 304HC, and 316 are materials widely used in 300-series Austenitic stainless steel. The comparison of magnetic force of materials after cold processing is 316<304HC<304M. 316 is corrosion resistant against chemicals and its anti-corrosion and seawater corrosion resistance are better than those of 304M and 304HC. In general, the strength and hardness of stainless steel under normal situations are equivalent to those of Grade 6.8 carbon steel, so it cannot be hammered or punched as is usually done to other carbon steel products. On the contrary, as stainless steel shows excellent malleability, it is likely to generate scrap steel on threads and thus increase friction that results in a deadlock. If carbon steel is used, in the long term it will also generate scrap steel but will not accumulate on threads, much less deadlock.

Transition of Fastener Material Selection

Changing the situation of "Low Unit Price"

About 90% of production of Taiwanese fastener industry in the most recent 5 years are for exports and it represented about 19% of the global market share in 2014. With fierce competition in the global market, material cost and quality offered by the upstream suppliers will directly influence the competitive edge of Taiwanese

fastener industry. In Taiwan, carbon steel represents about over 60% of the total fastener manufacturing cost, which implies that selection of materials is a niche for the industry. If customized products or special parts require the use of high alloy steel or special processes, the cost will be higher; however, the price can also be increased. **Figure 2** shows the structure of fastener production cost.

The average export unit price of Taiwanese fasteners in 2014 was USD 2.66 per kg, which is 4-7 times those of other fastener exporting countries. Taiwanese fastener industry basically focuses on mass production of standard parts and has a medium level of R&D, but its techniques and product quality can reach the requirement of automotive fasteners. So far, Taiwanese fastener industry is in a transition and is dedicated to the development of high value-added products used in medical device, aerospace, and energy. “High added value” can be described as 1) high quality, high grade, and high-end product level, 2) the ratio of how much value is added (which is the proportion of net income in the total revenue when the manufacturing cost is deducted from the increased sales value, 3) the material cost should not exceed 50% of the total cost.

The most effective way to elevate the unit price and added value is not to endlessly reduce the cost. As the current supply of nickel is not enough to cover market demand, the price of stainless steel is increasing. Due to the increase in costs, the retail prices of finished products may go up further, which is good news to stainless steel suppliers (e.g., Rodex, Lu Chu Shin Yee, Sheh Kai, etc.). As for Taiwan Shan Yin and Alliance Global, both of which are dedicated to the development of artificial dental implants, their products are mostly

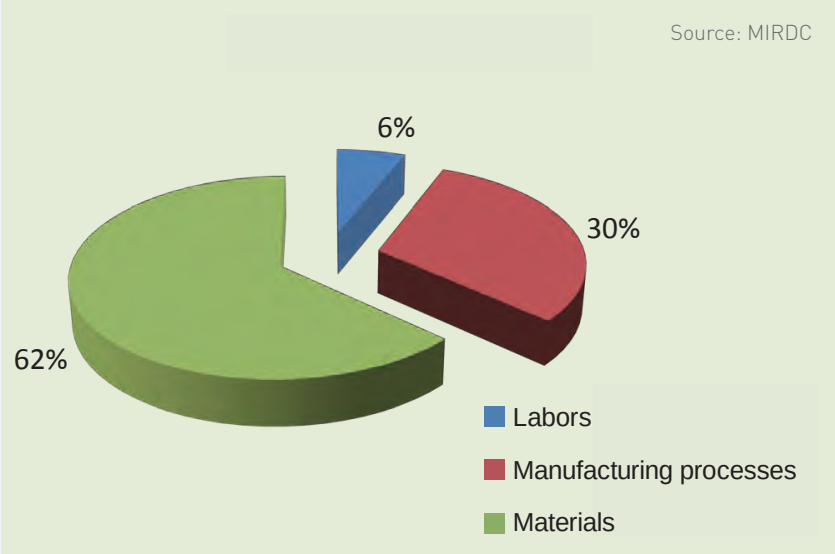

Figure 2. The Structure of Fastener Production Cost

customized and are only for a rather small market sector. As the industry is in a transition from standard fasteners to medical parts, they have to use alloy materials to meet the requirement of sophistication and special medical demand and the price cannot be calculated by weight but piece. Although the material cost increases, the ratio of how much value is added is also expected to increase when the market share gradually grows. The same situation can be seen in other fastener plants, which are actively seeking transition. Companies like Chun Yu, Lu Chu Shin Yee, Jau Yeou, and Boltun all develop high alloy fasteners used in places requiring special environments or functions, such as nuclear plants, high speed rails, sea water desalinization facilities, wind power generators, and solar energy facilities, in order to increase added value and create a fresh look of the industry.

Follow the Future Trend

Lightweight

Experts already noticed the crisis in energy consumption 20 years ago and proposed the idea of “energy-saving and reduction of carbon emission”, now having evolved as a concept called “lightweight”. When this concept is applied to cars, construction, and electronics, the use of energy or materials can be reduced. MIRDC and China Steel Corp once cooperated in establishing the “Automotive Fasteners R&D Alliance” to develop technologies necessary to achieve lightweight automotive structure. In terms of fasteners used on airframes, high strength Ti-alloy fasteners can definitely compete with high strength stainless steel fasteners. Boeing 777 and Airbus 350 originally adopted high strength stainless steel fasteners, but after that, they both replaced the fasteners used on landing gears and beams with Ti-10-2-3 fasteners. With the lightweight trend and improvement of high alloy fastener technologies, B787 and A380 will definitely use more and more Ti-alloy fasteners.

Bi-metal screws

Bi-metal screws are made of of carbon steel and stainless steel. Its tapping point is made of hard carbon steel while the other part exposed after fastening is made of stainless steel with great anti-rust performance, prolonging the durability and reducing the maintaining cost. It is widely used in high-tech construction, and energy industries (e.g., solar panels). The price of bi-metal screws is calculated by piece and is generally 4 times the price of stainless steel screws, and is even 10 times the price of carbon steel screws. As the number of bi-metal screw manufacturers continues to increase in recent years, the price of bi-metal screws has been declining over the past 10 years. However, if analyzed by gross margin, bi-metal screws are still considered high-end products.

Conclusion and Suggestions

The structure of medium to upstream of Taiwanese fastener industry is well established and its downstream is export-dominant. Facing the competition from China, S. Korea, and ASEAN, segmentation is the only way to survival, which means business transition and upgrade of products are necessary. U.S./ European steel plants and their downstream fastener manufacturers were once at the crossroad of vertical integration 10 years ago. Most of the U.S. fastener manufacturers have steel plants behind as their supporters. Though Taiwan is called “the Kingdom of Fasteners,” it still has many things to worry about. The industrial structure is at the edge of transition. The vertical integration of Taiwanese fastener industry and steel plants may be a little hard to be accomplished in Taiwan; however, if the upstream steel plants can increase the quality of their steel, assist in the development of downstream industry, and break through material/immaterial confinement, it will be a great help to Taiwanese fastener industry.

Although Taiwanese fastener companies have stable customer bases, global industrial demand is not in the period of fast growth and the growth margin of demand is limited. Furthermore, more and more countries set their entry barriers against others, making it hard to develop new markets and easy to affect the survival of small-to-medium fastener plants. Small-to-medium fastener manufacturers produce products with high added value by focusing on materials, design, and manufacturing procedures. For example, they modified the original formula of fastener materials, making the proportion of materials in the total cost down to under 50%, or turn to use high alloy or non-ferrous metal fasteners to reach high quality, high grade, and high level that draw the attention of foreign purchasers.

In addition, the cost for R&D is usually a burden to small-to-medium plants. As a result, a mutual R&D center may be a solution. Northern American Buffalo Manufacturing Works, which is only open to members, cooperated with the industry and the academia to set up a USD 30 million worth of R&D and manufacturing center, which has been operational since the yearend of 2014. The mission statement of the center is to reduce R&D costs of companies. For example, Sherex, one of the members, used the place, facilities, and engineers of Buffalo Manufacturing Works to develop lightweight fasteners (replacing steel with carbon fiber) and applied for funds of New York State to pay the fee for R&D. Buffalo Manufacturing Works is like a training center and it acts as the medium between the industry and the academia. Many small fastener companies are its members. These small fastener companies without inclination to R&D are expected to upgrade the current technology due to the establishment of Buffalo Manufacturing Works. So far, Buffalo Manufacturing Works is a regional organization only servicing local members in Buffalo, New York State, which not only provides training, R&D facilities, and engineers, but also provides education of industrial knowledge and has introduced technical service from various technical colleges from North America. Transition of fastener materials can be done with the help of steel plants in the upstream. Most of the strategy alliances failed due to involvement in patents. However, Buffalo Manufacturing Works has another way to develop and research; that is, renting a space in the name of a special case in the mutual R&D center to have the R&D continue.

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