How Chinese Design Standards Contribute to Low Value Add and Poor Product Quality

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China is home to approximately 36,000 foreign invested enterprises (Zimmerman, 2012). A perception these companies are keenly interested in perpetuating is that products made in China from imported designs are of superior quality. Apple Inc. is at the forefront of this approach labeling each of its 34.6 million iPhones "Designed by Apple in California. Made in China." (Clover, 2019). In actuality, once foreign designs are in China many are changed to be in compliance with national, provincial and professional standards. This paper shows how adherence to Chinese design standards can negatively impact value added manufacturing and product quality.

Keywords: China Manufacturing, Chinese Design, Design Standards, Value Added Manufacturing

INTRODUCTION

The "Made in China" country of origin mark is seemingly everywhere. This is particularly true when purchases are made in any of the four product categories (i.e. electronics, clothing, machinery and plastics) which account for roughly 50% of Chinese exports (Workmann, 2020).Yet, with the exception of companies like Huawei, Xiaomi, Lenovo and Haier, many international consumers have very little knowledge of Chinese brands (Seidelson, 2020). Lack of Chinese brand awareness has its roots in the country's economic development model.

Under Deng Xiaoping's 1978 "Open Door Policy," the central government established free trade zones to attract export oriented, foreign manufacturers. Over the next 30 years foreign invested enterprises (FIEs) benefited from: an abundance of inexpensive labor and raw materials, subsidized land, loans and utilities, low taxes, duty free imports and VAT rebates. By 2014 China was not only the world's largest recipient of FDI (Jun, 2015) but also the leader in both manufacturing output (Hunter, 2012) and exports (Glenn & Sweeny, 2016). From the standpoint of rapid economic development manufacturing commodities in high volumes for export using imported designs has been very successful. For example, from 1990-2017 Chinese industrial output expanded 12% per year ("China Industrial Production 1990-2020", 2020). By 2017, China's $21.27 trillion GDP (as measured in purchasing power parity) was the world's largest (Amadeo, 2020).

LOW VALUE ADD AND POOR PRODUCT QUALITY

In recent years Chinese economic growth has stagnated. From 2009 through 2019 GDP growth was only half that of the prior decade. A key problem which manufacturers in China face is the rising cost of production. China's producer price index (PPI) averaged a 1.30 percent annual increase from 1995 to 2018. In 2018 alone, China's PPI increased 4.55 percent (Zhang, Zhang & Woo 2018). Pushing up the cost of production is the 64 percent increase in Chinese minimum wages from 2011 to 2018 (Yan, 2017). To offset higher costs manufacturers are attempting to make higher value added products. Unfortunately, comparatively little of what is made in China is of high value add. Apple Inc. is a good example. The world's largest electronics manufacturer, Foxconn, produced all iPhone 3GS models in Shenzhen, China. Of the $600 price tag only one percent of the value add was assembled from Chinese made components. Made in USA parts accounted for roughly 70 percent of the phone's value (Chen, 2011).

The central government is aware of the value add problem and has launched numerous programs to address it. The *Key Technologies Program* dates back to the 1980s. It seeks to develop new technologies, materials, techniques, and equipment in both the industrial and agricultural sectors. The *Thousand Talents Program* started in 2008. Overseas experts are offered financial incentives to set up high tech operations in China. In 2015 the government launched *Made in China 2025*. The aim is for China to be 70 percent self-sufficient in high technology by 2025 (McBride & Chatzky, 2019). Government programs such as these do not lack for money. According to the article "China's R&D Spending Sees Rapid Growth in Past Decades" (2018) R&D expenditure reached $257 billion in 2017.The issue holding back value added manufacturing is a lack of design capability.

On the surface, Chinese companies should be very good at design. A 2005 Duke University study estimated Chinese universities graduate some 350,000 engineers per year (Bracey, 2006). That is nearly 3x the number of engineering graduates coming out of U.S. universities. The article "China's Intellectual Property Development: New Dynamics and Opportunities" (2014) China has been worldwide leader in patents and trademarks since 2012. But, filing patents and trademarks is only one part of innovation. The other part is bringing innovations to market. In 2016, an intellectual property management company examined 1,000 Chinese patents. Less than 5 percent were found to have any commercial potential. By comparison, the same study found 50 percent of US patents were commercially viable (Koch, 2016). A key reason for the lack of marketable design in China is the way engineers are trained.

Unlike their counterparts in the US, Chinese undergraduate engineers aren't required to pass a state certified Fundamentals of Engineering (FE) exam. As a result, qualifications can vary widely by school and discipline. Dai (2013) found 35% of students completing a 4-year degree in China lacked sufficient skills to find work in their field. A skill which is largely absent from engineering curriculum is design. This is because China's system of standards defines virtually every aspect of how products are designed and made.

China's highest executive body, the State Council, manages the national system of standards through the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ). Through 28 departments, 18 institutes, 4 Admin. offices, 14 agencies, and 11 bureaus, AQSIQ oversees:

1. The Standardization Administration of the People's Republic of China (SAC) which develops standards.
2. The Certification and Accreditation Administration of China (CNCA) which oversees both the national quality and safety mark of China (CCC) and the national accreditation body (CNAS).
3. The China Inspection and Quarantine Bureau (CIQ) which oversees import and export commodity inspection, safety and quality licensing.
4. And, the Bureau of Quality and Technical Supervision (QTS) which writes and implements policies covering calibration and measurement to support standards and quality control.

In the area of standards development, SAC is divided into three departments.

1. Agriculture and Food Standards
2. Industrial Standards
3. Service Industry Standards.

Industrial standards follow a hierarchy. At the bottom are enterprise standards (identified with a Q prefix). Companies create Q standards to communicate requirements when higher level standards do not exist. Superseding Q standards are local standards (DB). DB standards typically deal with issues of safety or industrial hygiene. Compliance with DB standards is mandatory while “DB +” or “DB/T” standards are highly encouraged albeit voluntary. Professional standards sit atop local ones. Chinese professional standards cover 48 industries. The industries and code designations are shown in TABLE 1.

TABLE 1
CHINESE PROFESSIONAL STANDARDS

Code	Content	Code	Content	Code	Content	Code	Content
BB	Packaging	HJ	Environmental Protection	MZ	Civil affairs	TD	Land administration
CB	Ship	HS	Customs	NY	Agriculture	TY	Sport
CH	Surveying	HY	Ocean	QB	Light industry	WB	Goods
CJ	Urban construction	JB	Machinery	QC	Automobiles	WH	Culture
CY	Press and publication	JC	Building materials	QJ	Space	WJ	Civil products from arms industry
DA	Archives	JG	Construction industry	QX	Meteorology	WM	Foreign trade
DB	Earthquake	JR	Finance	SB	Commerce	WS	Hygiene
DL	Power	JT	Communication	SC	Water product	XB	Rare earth
DZ	Geology mineral	JY	Education	SH	Petrol chemical industry	YB	Ferrous metallurgy
EJ	Nuclear industry	LB	Tourism	SJ	Electronics	YC	Tobacco
FZ	Textiles	LD	Labor and labor safety	SL	Water resources	YD	Telecommunication
GA	Public security	LY	Forestry	SN	Commodity inspection	YS	Non-ferrous metallurgy
GY	Radio, film & TV	MH	Civil aviation	SY	Petroleum gas	YY	Medicine
HB	Aviation	MT	Coal	SY(>10000)	Oceanic petroleum gas	YZ	Posts
HG	Chemical Industry			TB	Railways transportation		

At the top of the hierarchy are national (GB) standards. GB standards are mandatory while GB/T or GB/Z are voluntary. Of the approximately 22,000 GB standards, over three fourths are voluntary. For all practical purposes, manufacturability depends upon compliance with the system of voluntary standards. For example, in terms of industrial design, GB/T 14689-93 defines how information on drawings should be presented. GB/T 14665-1993 goes into more detail about projection angles, lines, symbols, etc. By enlarge, machinist can only understand drawings made to national and professional standards. When Chinese engineers are translating foreign drawings they are doing a lot more than simply altering presentation for machinist. JB/T standards establish rules of mechanical construction. These rules are compiled into component design manuals which are subdivided by topic. Engineers follow these design manuals step-by-step for:

1. Material selection
2. Size, hardness, and strength requirements by application
3. Component features (i.e. shoulders, radii, diameters, undercuts, tapers, keyways, etc.)
4. Classes of fit by application and assembly
5. Calculations of design statics & dynamic

Regarding classes of fit, the GB/T1184 standard specifies 4 geometric tolerances. Each is broken down into 3 classes (H, K and L) by nominal dimension per TABLE 2.

TABLE 2
CHINESE STANDARD GEOMETRIC TOLERANCES

Linearity/Flatness

mm	<10	10-30	30-100	100-300	300-1000	1000 - 3000
H	0.02	0.05	0.1	0.2	0.3	0.4
K	0.05	0.2	0.2	0.4	0.6	0.8
L	0.1	0.2	0.4	0.8	1.2	1.6

Perpendicularity

mm	<100	100-300	300-1000	1000 - 3000
H	0.2	0.3	0.4	0.5
K	0.4	0.6	0.8	1
L	0.6	1	1.5	2

Symmetry

mm	<100	100-300	300-1000	1000 - 3000
H	0.5	0.5	0.5	0.5
K	0.6	0.6	0.8	1
L	0.6	1	1.5	2

IR (indicator run out)

H	0.1
K	0.2
L	0.5

The GB/T 1804-92 standard specifies product fillet and chamfer tolerances per TABLE 3.

TABLE 3
CHINESE STANDARD FEATURE TOLERANCES

mm	0.5-3	3-6	6-30	>30
f	+/- 0.2	+/- 0.5	+/- 1	+/- 2
m	+/- 0.2	+/- 0.5	+/- 1	+/- 2
c	+/- 0.4	+/- 1	+/- 2	+/- 4
v	+/- 0.4	+/- 1	+/- 2	+/- 4

Engineers are not being taught in depth design because so much is already defined for them in design manuals. But, why are local engineers changing foreign designs to meet Chinese standards when products are intended for export? Chinese machinists are only accustomed to working in standard tolerances as defined for them in design manuals. Even if a machine operator had the skill to produce parts outside the system of standards it is very unlikely machine tools would be capable. Chinese equipment makers produce machines to meet tolerances according to design manuals. The same is true for raw material suppliers as well as gauge, tooling and die makers. In other words, made in China only works when product designs follow national, provincial and professional standards. Therefore, engineers are changing drawings (and failing to innovate) because it is very difficult to make, buy or measure anything outside the Chinese system of standards. International design standards (such as ISO or ASTM) offer little help. Only about 2% of GB standards reference ASTM standards (Seidelson 2020). What happens when imported design intent is inconsistent with Chinese standards? More-often-than-not changes are made for the sake of manufacturability and quality suffers.

CONCLUSION

Manufacturers in China clearly know how to make products. They make more than any other country in the world. Manufacturers also understand quality as Chinese factories have more ISO quality certifications than anywhere else in the world (Paris, 2014). Yet, Schniederjans et. al (2011) found the average rating for Chinese-made products fells somewhere between "I feel cheated" to "poor value." Over the years not much has changed. A follow up study by the same group in 2011 found the results were even lower than 2004. By 2014, Chinese made goods accounted for 51 percent of all product safety recalls made by the U.S. Consumer Product Safety Commission (Snyder & Carfagno, 2017). At the heart of China's quality problem is manufacturability depends on making products within the system of standards. Changes to foreign designs are being made even when changes do not align with original design intent. Moreover, changes are being made even though weaknesses in the system of standards are well known. For example, standards are written from the producer's point of view (Seidelson 2020). Little consideration is given to resulting customer quality level. Other problems include: excessively long development times, poor implementation, and outright errors.

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