Box production: from start to finish

Concluding their 3-part review of the development of the container manufacturing business, **David Tingle** and **John Holmes-Walker** analyse the methods of production used to build containers – and explain why the use of automation and robotics has not always been successful

PRODUCTION INVARIABLY BEGINS WITH WHAT IS known as the press shop, where - for high volume production - steel is in the form of coils; and, for low volume production, it is in the form of sheet and plate. De-coiling was unusual in Europe, although Adamson Containers pioneered the use of a de-coiler in combination with a cold rolling machine for the forming of side and end wall corrugations as early as 1967. This system was not considered economically viable in Asia in much later years unless a capacity of 50,000 TEU or more per year was planned, but stand alone de-coiling had come into common use mainly because it was more economic to purchase coil steel as opposed to flat sheet.

Apart from Adamson's methods, most European factories in the '70s and '80s used a combination of shears, guillotines, notching presses, saws and presses to form the components, with all machines usually manually operated. Typically, the formed parts were transported to minor sub-assembly welding stations for components such as sills, headers, corner posts and fork lift pockets, etc, before these parts in turn were transported to end-frame, base, roof and side wall jigs where the major sub-assemblies would be welded in one jig station - or occasionally two.

The major sub-assemblies, excluding the roof, to form a basic box would then be located and welded in a main assembly jig. This would sometimes be a rotating jig in order to achieve optimum welding positions. It was not unusual for all welding to be completed in a main assembly jig before being transported to a roof welding station.

This system of assembly was not conducive to high volume production, but those European manufacturers reaching output levels of 20,000 TEU/year (notably SIC Trailor and IWT) did establish proper flow line assembly techniques for the main assembly, as did Brugeoise, Luchaire, Morteo, but for lower output levels.

Tokyu concept

The manufacture of six major sub-assemblies has - from the beginning of the box building industry up to the present time - been a common feature of almost all container factories, but with some variations in the way that the side walls and base structure were produced and assembled. However, what we saw when we first visited Tokyu Car, who were, almost certainly, the first real high volume manufacturer, was that every minor sub-assembly was created on a mini-production line with more than one station wherever necessary to achieve a specific assembly time.

Each minor sub-assembly production line terminated at the major sub-assembly jig station in which it would be incorporated. For example: for the production of the rear end-frame and end-wall assembly, the mini-assembly lines for headers terminated very close to the top of the end frame assembly jig. Similarly, the left-hand and right-hand cornerpost assemblies terminated at each side of the end-frame assembly jig; and finally, the end panel with one automatic central butt weld, terminated at the second stage or third stage of the final welding process of the end frame and end wall sub assembly. The reason why no bottom sill has been mentioned will be clearly evident further on in this article.

Line for decoiling and cutting to length
(All photos used to illustrate this article were taken at the Balmer Lawrie factory in Chennai, India)

The key to this very efficient production technique was largely mechanical handling achieved mainly by a system of integrated roller conveyors for sub-assembly transfer as well as component positioning. We have tried to explain this process in some detail because the other major sub-assemblies of doors, front end frame, base and roof were constructed with a similar principle and these have been repeated in many of China's high output plants up to the present time.

Nevertheless, the most unusual aspect of Tokyu Cars' advanced production methods concerned the construction of the base and floor. Here, the steel base structure was assembled complete with bottom end frame sills and Tokyu Car had reasoned that this was the ideal stage at which to attach the plywood floor and it was done by automated drilling and the driving of some 250 screws! Subsequent welding over a wood floor had not been foreseen as a major problem - but it was. Not surprisingly, Tokyu Car's base and floor assembly method has never been repeated elsewhere but it was a brave, if not naïve, attempt to embrace the automation of the plywood floor assembly. Almost all large volume factories today manufacture six complete sub-assemblies on multi-station assembly lines before these are joined in a main assembly jig

Final assembly of the six major sub assemblies in a main assembly jig has always been a common factor in container production; but to achieve high volume production, the methods by which one or more jigs are loaded with the major sub-assemblies largely determines the cycle time. Tokyu Car achieved their goals through efficient integrated mechanical handling and positioning of the major sub-assemblies, similar to the way in which they were assembled, and this remains the preferred method today. All main assembly welds were carried out manually much as they were when Europe was the centre of the industry.

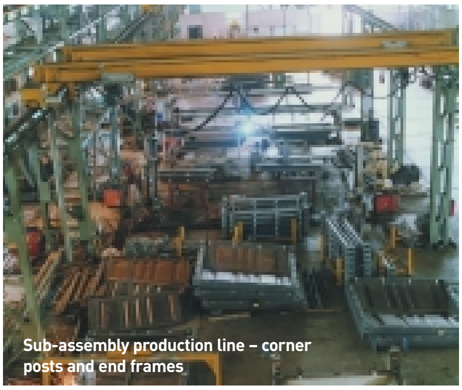
Welding

Minimum welding takes place in the main assembly jig but sufficient to keep the bare container shell as a structure. This is followed by a series of welding stations where, again, the time per station, is determined by the planned cycle time per TEU. The greater the


Production of front end-frames

volume of production, the lower the cycle time per TEU for a given plant. This results in a greater number of welding stations until around the 50,000 TEU per year or a cycle time per TEU of 5 minutes operating on 2 shifts is reached. From this point, trying to reduce the cycle time further (and thus increase the production volume) becomes impracticable - mainly because the station-to-station transportation time has become a much higher percentage of the cycle time. The principle answer to this as seen in many of the large volume plants today is to install a second line for all operations and the capacity of the plant has now jumped from 50,000TEU per year to 100,000TEU per year. Some automation on the main welding line following the main assembly jig stage has now become common practice. In particular, the roof periphery welds and the corner post to panel welds readily lend themselves to being automated since they are all straight line flat welds except the roof to header welds.

The process following the assembly of the steel container shell has changed little since the 1960s but nevertheless remains a very important manual operation. It concerns the removal of weld spatter and to make sure that there are no sharp edges on weld joints and that the steel is free from contamination such as oil that could be deposited by an overhead crane or press shop machine. If this operation is not carried out to a high standard, premature corrosion will almost certainly occur early in the operational life of the container.


Sub-assembly production line – corner posts and end frames

Blasting

The next operation is to prepare the steel shell for the application of coatings and this is generally carried out by manual abrasive blasting of all welded areas externally and internally. Since all the steel parts of the container now joined by welding will have been pre-abrasive blasted and zinc rich primer applied on all surfaces, typically, there is now approximately 230 metres of weld line to be cleaned on a 20ft container before the application of the second zinc rich primer coating. This is quite a formidable task bearing in mind the difficult and unpleasant conditions which are unavoidable in an abrasive blasting booth and the high standards of blasting required.

Blasting booths are dusty, dirty, dangerous, very noisy, and it is very difficult to maintain a good standard of lighting. The work is invariably performed by a team of operators working closely together in an integrated fashion to achieve the cycle time required. It must be a fact that this work to create a high quality substrate is mostly carried out to acceptable standards, since coating warranty claims, are, to a large extent, a subject of the past. However, if there is any operation in the steel container production cycle that is in urgent need of modernisation, hopefully, automation, this is it! Just ask your company MD or CEO to sample the manual abrasive operation in person - even for a short while - and we are sure he will readily agree.

But, modernisation and automation of the process has been given a fair chance. As mentioned in the last article, Adamson installed an automatic machine to carry out the abrasive blasting of a complete container shell nearly 30 years ago and Luchaire acted similarly but with a different system. These early processes virtually died until Tectrans specified a similar system to that of the previous Adamson for the Shanghai plant in 1980. After that, the exercise was repeated with a more advanced system based on 16 turbine abrasive blasting wheels specified and installed at TIMCO and QUIC in 1992 and later at Balmer Lawrie in India in 1995. For a number of years, these systems worked well and won the approval of many buyers because the complete steel container shell could be seen to be silver bright and clean prior to painting - but there was a commercial problem. This concerned the plant capacity and its ability to expand to meet the volume of customer orders despite the fact that the automatic machines were supplemented by a manual abrasive blasting station. Disappointingly, without installing a high investment, second automatic 16 wheel turbine machine for which there was no space on the treatment lines, the capacity of the two plants could not be increased to meet demand and a major redevelopment of both factories in China followed using the pre-abrasive blasting/zinc priming system as commonly used elsewhere.

Cleaning and coating

Progressing down the main treatment line the


Twin assembly jig: base to body assembly – floor bearers, fork pockets or gooseneck tunnel components roll in to mail assembly jig to be welded to bottom side rails


Cleaning after auto-blasting

next operation is the all important clean down station following the abrasive blasting where all dust and discharged abrasive must be removed from the steel shell. This is usually performed using manually operated compressed air lances blowing debris into the dust extraction system supplemented in some cases by powerful industrial vacuum cleaners.

The next stage is the coating or painting operation, involving the application of the three-coat system in three stages where, typically, each stage will consist of a painting booth usually designed to accommodate 2 x 20ft containers or 1 x 40ft, 45ft or 48 ft container.

The painting booth will usually be followed by a flash off booth, heated booth (often wrongly called an oven) and cool-down booth, since it is undesirable to apply the next coat of paint over a very warm or hot surface. At the end of the line it is necessary to cool down the container shell before the final operations of floor installation, attachment of door gear and ventilators and the application of decals followed by the undersealing process. The coating or painting line, combined with the abrasive blasting operations, can result in a line length exceeding 300 metres for a high volume production plant. This often dictates the layout of the whole plant since it would clearly be difficult and certainly undesirable to try to transport containers laterally during the painting process.

Automation of the abrasive blasting line has already been discussed but there have been a number of attempts, some successful, to automate the painting processes. Two methods in particular have been installed in various factories. For the shell exterior, the first type consists of a static “goal-post” type structure, which incorporates paint gun reciprocators to coat the sides and roof of the container which operate as the shell is transported by conveyor through the goal-posts. The second type also consists of a goal-post structure, but this is mounted on an overhead transport system and the coating of the roof and sides of the shell takes place while the shell(s) remains stationary. The latter type has been shown to produce the more consistent results but is undoubtedly more expensive.

At this juncture, it is interesting to note that the Tokyu Car lazy corrugation has very much aided the success of automatic painting due to the fact that it presents a flatter surface than the previous “square” corrugations. With the multi-painting guns of each reciprocator set to an optimum angle its has been shown that the final paint film thickness, usually specified in the range of 100 to 120 microns, will not vary by more than 10%. If this is compared with the excess thickness of coatings necessary with manual painting, which is common practise, in order to achieve the specified minimum thickness, the saving in raw material coating cost can be as high as 25%. This means that the pay back time for the investment in automatic machines of the second type described is very attractive and it is surprising that there are so few external automatic machines in operation today. However, it has to be stated that, to date, total automatic painting of a container has not been achieved; and even with the automatic system described above, some areas of the container, including all the interior, have had to remain a manual operation immediately prior to the running of the automatic machines.

It could be said that painting methods have not kept pace with the early innovations in the industry. In the 1970s, Adamson, who installed the industry’s first multi turbine wheel abrasive blasting machine for the treatment of a complete steel shell, also installed both internal and external automatic painting systems at the same time, yet their plant capacity was only 10,000TEU per year. The external painting machines were of the static type but the internal machine was a robot “educated” by a human paint sprayer with the robot mounted on slave rails which had to be temporarily installed in and later removed from each container to be coated. During the same period, Luchaire installed the type of external machine which moved over a static container simultaneously with a triple reciprocating machine for internal roof and side wall painting which was mounted on a 40ft long cantilever which in turn was mounted on an external powered trolley. Neither of these systems were repeated or developed to their full potential but a few years later, Tectrans installed the first automatic painting only machines in Shanghai, and indeed the whole of China, for both external and internal paint application. These machines worked on a combination of the methods employed at Adamson and Luchaire but again, the development stopped there until simple electro-mechanical machines for external automatic painting were installed by Tectrans at TIMCO, QUIC and Balmer Lawrie in India.

Flooring

We cannot reflect on all aspects of container manufacture, but one of the last operations concerns the installation of the wood floors - or maybe, the plastic floors of tomorrow. For a typical 20ft container there will be a minimum of 200 countersunk screws, 6 or 8 mm in diameter. The installation process is today almost a totally manual operation and very


Manual interior painting

time-consuming - which translates into several floor installation stations and a large number of operators.

Firstly, the floor boards are positioned after the application of sealant to peripheral steel/wood interfaces; then the required position of the screws is drawn on the floor from previously defined steel structure marks. Manual drilling then takes place followed by driving of the screws, also manually, using pneumatic or electric hand power tools. Automation of this process looks almost obvious but few, if any, have succeeded in developing a reliable method. The reasons for this may include the frequent occurrence of drill breakages, and the time taken to use an automatic machine resulting in expensive investment in several machines in order to meet the short cycle times demanded by high volume production. However, Tokyu Car produced an automatic machine (as previously described) but the subsequent manufacturing processes were severely compromised. Brugeoise designed and built a successful automatic multi-drilling and screwing system, which powered itself in and out of the container but it became dormant when they ceased production and sold the plant inventory. The industry awaits the successful development of a reliable rapidly operating machine!

Future materials and methods

For the foreseeable future, we do not see that China will face any major competition from any other country or region - simply because they maintain relatively low, but efficient, labour production costs and high production levels of consumer goods for export.

But costs in China are rising and this should encourage more development of automated production methods which usually guarantee a more consistent level of higher quality. To be successful, economically, automation goes hand in hand with high volumes of production and China already has this more than any country before.

One of the visions of container manufacturers and users alike is to produce containers - or major parts of containers - from materials other than steel. Plastics are the logical choice, but during the 50 years or so of containerisation, while plastics have truly come of age in the automobile and aircraft industries, they have got virtually nowhere with containers.

The strength and testing standards for containers laid down by ISO and CSC have changed little for more than 30 years, but there have been dramatic changes in container shipping and handling operations and in some popular container designs and dimensions (such as the pallet-compatible types) so it would be logical to assume that changes to the standards should be in the pipe line.

And finally: will we ever see the end to the expensive triple inspection process, involving factory inspectors, classification society inspectors and the buyer's own inspectors – an inefficient system, which is probably unique to the container manufacturing industry ?

Ready for shipment

Fitting out line – floors, lock rods, vents, decals, gaskets, etc

ABOUT THE AUTHORS

David Tingle C Eng. M.I.Mech.E - Joined Sea Containers from the aircraft and weapons manufacturing industry in 1968 as General Manager of Engineering.

From 1968-1980, he was responsible for Sea Container's engineering and technology of containers, special containers, chassis and cranes. During this period started the founding of YMCL and became a director and part of the Sea Containers' management team to create: China International Marine Containers (CIMC), Chicago Marine Containers and Singapore Marine Containers - thus the gravitation to container manufacturing.

From 1980 – 2002, he worked for Tectrans Services Ltd and Tectrans Gmbh - as Managing Director & Engineering Director respectively. He designed the factories and project-managed the creation of HIM Containers in India, TIMCO & QUIC in China and Balmer Lawrie in Madras, India. He also acted as manufacturing consultant to: Xtra, Adamson, Trencor and SeaCold.

John Holmes-Walker D.M.S., C.Eng., M.Mech.E., M R Ae.S. - After spending 20 years in the Aircraft industry, focusing on propulsion systems research and development, John Holmes-Walker joined the engineering department of Sea Containers in 1973. He stayed there until 1992, rising to the position of General Manager – Engineering Management Department. During his time at Sea Containers, his responsibilities included Purchasing and M & R for all container and container related equipment produced or purchased by the company. He also established the company-owned factory to build refrigeration equipment designed by the Engineering Department. For his last six years at Sea Containers, he was responsible all new container projects, and had technical responsibility for the establishment of new company owned factories.

Since 1993, he has run his own consultancy company, Seagull Technology, providing engineering and management services to the container and related industries worldwide.