Burr OAK Tool

COIL EVOLUTION:
Smaller Diameter Coil Production

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GLOBAL EXPERIENCE...LOCAL SOLUTIONS

Providing quality machines, tools and expertise to the heat transfer and tube processing industries for 70 years.

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The diameters and the patterns of tubing for refrigeration and air conditioning have changed dramatically over the years. It makes sense, in terms of efficiency, to reduce both the tube diameter and the distance between tubes, so that the same volume of coil can transfer more heat or a coil of lesser volume can be used to transfer the same amount of heat. The fin density (or number of fins per inch) has also changed dramatically. In the 1960's 12 fins per inch would have been a common fin spacing in a 3/8" coil. Today with some 3/8" coils, and certainly with 7mm and 5mm coils the fins per inch have moved into the 26-28 range. This has profound effects on production requirements because the same volume of coil now has twice as many fins as coils produced years ago. The tightening of the patterns and the use of enhanced fin surfaces increases the amount of work required per unit area of die surface, which means that any given size press has a higher tonnage requirement than would have been the case five, ten, or twenty years ago. This is illustrated in figure 1.

"The design of more efficient coils lead to smaller diameters."

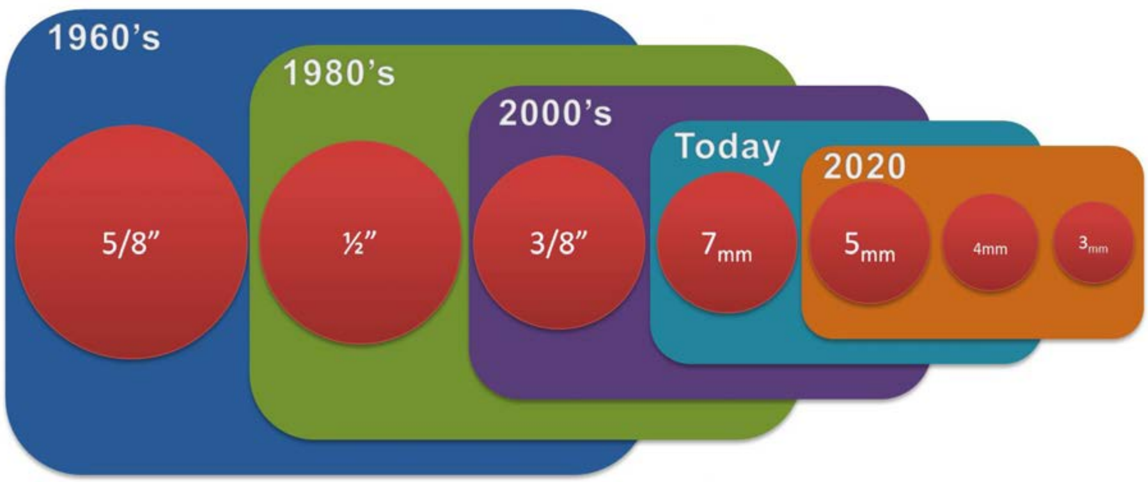

figure 1: Progression of Size

A second impact on tonnage requirements is changes in the alloys and the temper of the most common fin stocks used to make fins for air conditioners. From the 1960's to the 1990s, the most common alloy used around the world was AISI 1100 aluminum. It was typically O temper which means fully soft. The tensile strength of the material is low and the elongation properties are very good. These properties make it easy to form, cut, and draw the material in the die. The desire for less fin damage resulted in a move to harder tempers such as H-22, H-24, and H-26. The higher temper means higher tensile strength and lower ductility. The higher tensile strength increases the load on the press and the lower ductility means that the material cannot be formed as much without cracking. One recent solution to the cracking dilemma was to add iron to make the material stronger. The iron improved the elongation properties especially at the harder tempers. The downside to adding the iron was an even greater burden on the press as the higher tensile strength alloys required more effort to form and cut. Common aluminum alloys today include AISI 8006 or AISI 8011, in H-24 and H-26 temper.

The implications of the changes to alloy and temper are not well understood or appreciated in the industry. Figure 2 lists some typical dies used in fin stamping today. For example, a 3/8" 48-row, four progression die processing 1100 0 temper stock requires 67 tons from the press. Altering the alloy and temper to 8006 series H-26 changes the required tonnage to 124 tons. The amount of work required of the press has doubled. Since most dies of this size in the world today are running in 100 ton presses the change in material has exceeded the rated capacity of the press. Typically this process has been gradual: first the increase of temper over a period of several years or even decades then the more recent move to a different alloy. Gradually problems developed with fin forms like collar bases because the press gradually lost the capability to properly close the fin die. The life of the press main bearings has also dropped as the presses have been forced up and out of the designed range.

Presses in use today were not originally designed to deal with 8006 H-26 material. Many companies struggle with their press not closing correctly or have quality issues with their fins, and they don't know the cause. The OAK FP-3 is an example of a 100 ton fin press that served the world very well

Die	Die Specifications	Length	Width	Draws	Form	Enhance	Enhance Cut Length	Collar Height	Alloy	Material Thickness	ESTIMATED TONNAGES				
											1100 Temper 0	1100 H22	1100 H24	1100 H26	8006 H26
1	7mm x 49 rows x 4 progression	0.850	0.736	3	R	LAS	3.25	0.050	1100	0.004	42	52	62	68	78
2	9.52mm x 48 rows x 4 progression	1.000	0.866	4	W	LAW	4.06	0.071	1100	0.004	67	82	97	108	124
3	7.94mm x 48 rows x 4 progression	1.000	0.625	4	F	LOF	3.31	0.063	1100	0.006	83	102	121	134	154
4	9.52mm x 48 rows x 4 progression	1.000	0.866	4	F	LOF	3.25	0.100	1100	0.006	94	116	137	152	175
5	7.94mm x 48 rows x 4 progression	1.000	0.625	4	F	LOF	3.31	0.063	1100	0.006	83	102	121	134	154
6	9.52mm x 48 rows x 4 progression	1.000	0.750	4	F, W	LOF	4.65	0.100	1100	0.005	83	103	122	135	149
7	7mm x 48 rows x 4 progression	0.827	0.472	4	S	LAS	2.625	0.125	1100	0.008	86	106	125	139	160
8	9.52mm x 48 rows x 4 progression	1.000	0.866	5	R	LOF	5.2	0.087	1200	0.0051	101	125	148	164	187
9	9.52mm x 48 rows x 4 progression	1.000	0.866	5	R	LOF	3.3	0.071	1200	0.0045	79	97	115	127	146
10	5mm x 70 rows x 4 progression	0.630	0.546	5	F	LAF	3.7	0.056	1100	0.0038	73	90	107	118	135
11	5mm x 70 rows x 6 progression	0.630	0.546	5	F	LAF	3.7	0.056	1100	0.0038	110	135	161	177	204
12	5mm x 70 rows x 8 progression	0.630	0.546	5	F	LAF	3.7	0.056	1100	0.0038	146	180	214	235	270
13	7mm x 72 rows x 3 progresssion	0.827	0.526	4	F	LOF	2.75	0.071	3102	0.0045	62	77	91	101	112
14	7mm x 72 rows x 4 progression	0.827	0.526	4	F	LOF	2.75	0.071	3102	0.0045	86	107	120	135	148
15	5mm x 84 rows x 4 progression	0.750	0.449	5	F	LOF	3.7	0.063	1100	0.0038	99	123	138	160	176
16	5mm x 84 rows x 6 progression	0.750	0.449	5	F	LOF	3.7	0.063	1100	0.0038	148	184	207	240	264

FP-3 FP-1000 FP-1400 FP-2100 Outside Press Range

figure 2: Die Tonnage

from 1970 when it was first designed. As you can see in figure 2 the FP-3 was a great choice for large dies running the lower tensile strength materials for many years. As good as the FP-3 press is it can't properly close many large dies that are currently running 8006 material. In harmony with our mission to innovate to meet customer needs, we have designed and built the FP-1400. The 1400 part of the name signifies a 1400 KN rating.

The FP-1400, shown in figure 3, is the first OAK press designed using finite element analysis (FEA). The FP-1400 is also dynamically balanced resulting in much smoother operation at high speeds. The

figure 3: OAK FP-1400

FP-1400 utilizes a servo feed with integrated die support instead of the mechanical feed found on the FP-3. The robust die support is very useful for large dies that exceed the length of the press bed.

To enhance the overall efficiency of the fin line, OAK also has a newly designed stacker unit. Previously a large stack of fins might weigh between 400 and 600 pounds. With the change to 24, 26, or 28 fins per inch the fin stack can weigh over a thousand pounds. The new stacking system is 3 times stronger than the previous design and has the power necessary to lift a stack of fins. This lift feature is a great help in moving fins to the lacing station. The stacker rods have also been updated. Most steel stacker rods are prone to corrosion which can cause interruptions in production. The newly designed stacker rods are non-corrosive, stronger, and electro-polished. Corrosion is no longer a problem and the polished finish allows fins to slip more easily down the rods for uniform stacking. Another new feature is the double-delta tip. The new tip design is especially effective for fins with small hole diameters.

Design changes in the suction unit enhance fin control, especially single row or two row 5mm fins, which are very fragile and thin. If there is any air movement in the factory, the fins can lose position relative to the rod tip which slows production. Our new design uses part of the suction sheet to place the fin over the rod tips. We no longer rely only on gravity to correctly place the fins on the stacker unit. There is also a newly redesigned blower unit that is more energy efficient while at the same time much more effective.

Fin stock lubrication is a challenge for many customers. Using evaporative lubricants in a dip type tank requires customers to continually monitor that the right amount of lubricant is being applied to the material. Too much lubricant wastes money and negatively impacts the environment and too little can ruin fin die tooling (see figure 4). Our solution is the ESL (electrostatic lubrication system). The ESL applies an electrical charge to micro droplets of oil, and the oil droplets adhere to the fin stock surface. The deposition rate is adjustable and consistent. Customers have reported reductions in lubricant usage of up to 90%. Longer tool life, safer working conditions, zero VOCs, and a cleaner machine and environment make the ESL a good solution.

figure 4: Close up of fin die

There is another new press joining the Oak family, the FP-400, figure 5. It is a 45 ton straight side press that replaces the 30 ton C frame FP-1 press. The FP-400 is designed as a much stiffer press and has higher tonnage per square unit area. The same methodology used in designing the FP-1400 produced the FP-400. In comparison to the FP-1A it has better die removal capabilities as well as next generation line equipment. The new FP-400 press and line equipment provide an effective low cost solution to produce 5mm fins.

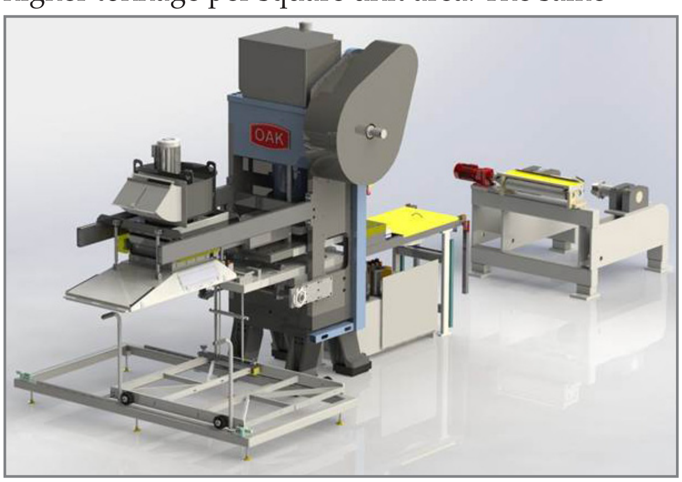

figure 5: OAK FP-400

The new OAK Triumph hairpin bender, represented in figure 6, presents a completely new approach to hairpin bending. It provides a more productive and effective solution than any other hairpin bending machine available today. Compared to our hydraulic bender there is up to a 70% increase in productivity, accomplished by bending 8 tubes per cycle and a faster cycle time. Length changes are made in a matter of seconds using the operator's touch screen; floor space is 30% less than a traditional hydraulic bender. The price point is lower than the OAK hydraulic machine it replaces. Currently the machine can produce hairpins ranging in length from 150-4,000mm.

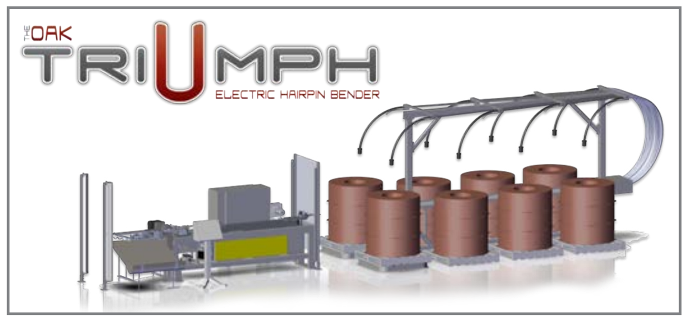

figure 6: OAK Triumph Bender

Tube expansion is the final discussion point. As tube diameters shrink, it becomes very difficult to do mechanical expansion. Considering how small the bullet is and how small the rod has to be that pushes the bullet for 5mm tubing, there is very little column strength in the rod and it must work hard to expand the tube. This means additional expander guide plates to provide sufficient support to the rods so they don't bend. It is especially challenging in a single row or a two row fin because the fin pack itself has no strength. Alignments must also be very accurate between the tooling and the holes in the fins. The research and development efforts at OAK have focused on pressure expansion as an answer to these challenges. The process works well with copper tubes and aluminum fins. This has several advantages such as the coil will not crush during the expansion process, and any enhancement inside the tubes will be preserved. Initial customer tests indicate that the heat exchange properties are similar to mechanically expanded coils.

FREQUENTLY ASKED QUESTIONS

What difficulties exist in working with smaller diameter tubing (5mm or smaller)?

Expansion is likely the greatest difficulty with 5mm tubing. The second is the tonnage requirement for the fin press and third is probably the tubing suppliers. Many of the tubing suppliers today don't make 5mm tubing. In some locations right now there is only a choice of one supplier for 5mm tubing.

Using a four or even six progression die in the new 1400, what increases could I expect to get in production? Will quality suffer on fin stamping?

On a 3/8" die, a four progression die is common. A four progression die can run almost as fast as a two progression die. A 48 row four progression die will make almost twice as many fins every hour, every day in the same amount of floor space as a 48 row two progression die. Will quality suffer on fin stamping? With the proper press for the required tonnage of the die and material, quality will not suffer. However, placing a four progression die in a press that can't effectively close it, will quality suffer? Absolutely.

Is a four progression die more difficult to manufacture than two progression die?

Yes. There are only two companies in the world that can build a large, high quality, four progression fin die. They are not difficult to operate, and not much more difficult to maintain. The challenge with large four progression dies is in the component manufacturing. Most die companies simply do not have the equipment or the facilities necessary to do the required work.

What are you doing to more fully automate the manufacturing process?

We have added robotic automation to some of our expanders. Some U.S. manufacturers claim this enabled them to maintain manufacturing in the United States versus moving offshore. There are software changes in some of our machines, which allow more flexibility for the operator in setting part batches. This works especially well in a smaller "job-shop". We also have a capability in both the cutoff machine and in the hairpin bender to identify and sort out bad section of tubing. This saves time and saves on labor costs.

Are there advantages of small diameter round tube versus micro channel?

There are pros and cons to both. Aluminum is less expensive than copper; brazing copper is much easier than brazing aluminum. One of the issues with micro channel that does not exist in round tube is a phenomenon called "plugging". In all air conditioning systems the lubricant circulates through the system in droplet form along with the refrigerant. In a micro channel coil there is a critical velocity movement inside the tube. If not maintained, oil can actually plug the micro channel passages because they're so small. Unfortunately, the nature of the problem is such that if the passage gets plugged it stays plugged. Another challenge with micro channel coils is apparent when viewing a thermal graph of the micro channel coil in operation; there's a zone in one corner where heat transfer isn't working very effectively. It's very difficult on a micro channel coil to get the gas and liquid in the places they need to be in terms of circuiting it, so the coil isn't as efficient or effective as it should be for a given coil volume. The Controlled Atmosphere Brazing (CAB) furnaces used to braze micro channel coils are very expensive to install, operate and maintain. They use large quantities of nitrogen gas because there can't be any oxygen inside the furnace and the end of the furnace is open because most of them are a through process operation. Any factory that has a CAB furnace has a big liquid nitrogen tank outside constantly providing the gas necessary to flow through the furnace. The final stage of the furnace is electric. It must be electric because close control of the temperature is essential. The window of brazing temperature for aluminum is only about 25C wide. Cleanliness of the coils and inside the furnace is also critical to a good aluminum braze. Micro channel coils wash well in the field. It has a corrugated fin that is brazed to the tubes making a very robust fin and tube joint. The micro channel works well on condenser coils, but evaporative coils get wet because they're pulling water out of the air. If the coil can't effectively shed water, the coil can freeze resulting in reduced air flow. We are not aware of any company successfully producing and using micro channel coils for evaporator coils outside of the automotive industry.

A major benefit to small copper tube coils is that most manufacturers are well versed in the production of this type of coil already.

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