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TROUBLESHOOTING OF BOILER FINS MANUFACTURING

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Abstract — *This Paper deals with the case study and problem solving of Boiler Fins Manufacturing, The case study was done in M/s Anusaya Auto Press Parts Pvt. Ltd. Chakan, Pune. They are making these fins for Thermax LTD, Pune. In a day they require 100,000 fins. Boiler fins are used for increasing the surface area of the tube. Hence to increase the rate of heat transfer. The heat is firstly transfer from the boiler tube to the fins through conduction and then flows from fins to the surrounding. These fins are manufactured by the blanking process. When these fins are manufactured, due to the blunt edges of the punch the burr is formed on the edges of fins. And this burr is unwanted as they may create problem at time of welding. So it is important to remove the burr from the edges.*

Keywords- *Boiler Tube Fin, Burr, Blanking Process, Abrasives, Grinding Wheel, Wood Straws, Tumbler*

I. INTRODUCTION

The paper entitled Troubleshooting of Boiler Fins Manufacturing aims to solve the problems related to the manufacturing of the fins. The fins are used on a boiler tube to increase the heat transfer rate, the whole concept of finned tube is to increase the surface area of the tube. The heat is firstly transfer from the boiler tube to the fins through conduction and then flows from fins to the surrounding. These fins are manufactured by the blanking process.

1.1. What is Burr?

When the punch is used repetitively for a long time. The outer edges of the punch which is in contact with the workpiece gets blunt, i.e. the sharpness of the punch reduces, this blunt edged punch when used in shearing operation results in the formation of the Burr. Burr is the raised edge or small piece of material remaining attached to a workpiece after a modification process. It is usually an unwanted piece of material and is removed with a deburring tool in a process called 'deburring'.

1.2. The Abrasives.

Bonded abrasive finishing, also known as sanding, is found in most manufacturing facilities. Bonded abrasive products include sheets, belts, pads, disks, and wheels. The most common abrasives used include aluminum oxides, silicon carbide, or zirconia compounds. These abrasives range in size and grade from course to exceptionally fine for various applications. When this abrasives are tumbled together with the workpiece in a tumbler, the burr of the workpiece gets removed. Here white aluminium oxide is preferred as an abrasive.

1.2. The Tumbler.

Tumbler is a closed chamber a cylinder like structure usually made up of steel has an hexagonal shape, the one side shaft of the tumbler is connected to the electric motor via a chain drive to get continuously rotated, inside that tumbler a circular and axial shaft is attached with some teeth. It has a door like opening at the one side to get the things in and out from it.

II. PROBLEM STATEMENT

2.1. Excessive Burr remains on Fin.

The Burr is remains on the fins due to the blunt edges of the punch which is unwanted because the burr may interrupt the welding process and the weld is not been proper as wanted.

2.2. Time required for tumbling.

To remove this excessive burr from the fins the abrasives are used in tumbler which having approx. size of 10 to 15cm are used, but as the size of abrasives is greater the contact between the burred edge and abrasive not been properly made so it required more time for tumbling.

2.3. Requirement of 100,000 fins not completed.

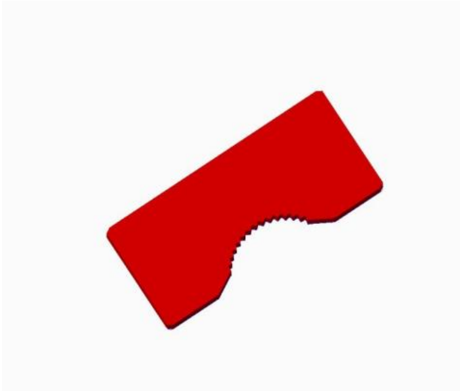
Due to more time required for tumbling and gauging the requirement of the 100,000 cannot be completed.

2.4. Gauging method:

The gauging method is used for inspection of the thickness of the fins, the required thickness of fin is 2mm and a tolerance of 0.2mm so, up to 2.2mm of fin thickness is acceptable above 2.2mm is rejected, to inspect this the horizontal gauge initially used and it required force to get the fins out of the gap of 2.2mm.

III. WHAT IS A FIN?

The typical diagram of as is as shown in figure. It has dimensions as 90x40x2mm. It is made up of Steel having grade dd0179, it is used as a heat transfer medium to transfer heat from tube to surrounding. So the whole concept of fin is to increase the outside surface area of the tube.



3.1. Finned tube.

Finned tubes are used in applications involving the transfer of heat from a hot fluid to a colder fluid through a tube wall. The rate at which such heat transfer can occur depends on three factors: the temperature difference between the two fluids; the heat transfer coefficient between each of the fluids and the tube wall; and the surface area to which each fluid is exposed. In the case of a bare (fin less) tubes, where the outside surface area is not significantly greater than the inside surface area, the fluid with the lowest heat transfer coefficient will dictate the overall heat transfer rate. When the heat transfer coefficient of the fluid inside the tube is several times larger than that of fluid outside the tube (for example steam inside and oil outside), the overall heat transfer rate can be greatly improved by increasing the outside surface of the tube. In mathematical terms, the product of heat transfer coefficient for the outside fluid multiplied by the outside surface area is made to more closely match the product of the inside fluid heat transfer coefficient multiplied by the inside surface area. By increasing the outside surface area of the tube, the overall heat transfer rate is increased, thereby reducing the total number of tubes required for a given application. This reduces the overall equipment size and the cost of the project.

IV. LITERATURE REVIEW

Sr. No.	Ratio of abrasive grains and wood straw	Ratio of abrasive mixture and jobs	Size of abrasives	Time required for tumbling	Noise level in tumbler	Approx. no. of fins tumbled per day	Requirement status
1	50:50	30:70	10 to 15cm	30 to 35mins	high	36,000	Not completed
2	60:40	40:60	10 to 15cm	35 to 40mins	high	31,500	Not completed
3	50:50	50:50	3 to 5cm	20 to 25mins	less	54,000	Not completed
4	75:25	60:40	3 to 5cm	10 to 12min	less	1,08,000	Completed

V. THE ABRASIVES

The M/S. Anusaya Auto Press Parts Pvt. Ltd. has its own integrated Tool room. In that they also have grinding machines for the grinding of component, when this machines are used repeatedly the grinding wheel size reduces (in diameter) and they lost their grinding property. Due to this reason this rounded-up wheels are of no use. So these wheels are used as an abrasive material for removal of the burr. It also saves the cost of abrasives for tumbling and also uses the wheels which are in-plant.

A grinding wheel is a self-sharpening tool composed of discrete abrasive grains held together by a bonding agent with composite structure of many clearance allowance for the cutting edges. The characteristics of a grinding wheel depends upon the combined elements of abrasive, grit size, grade, structure and bond.

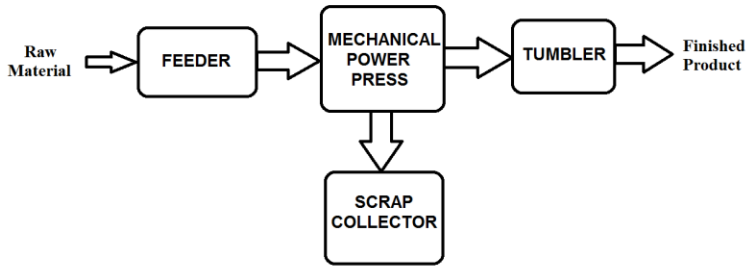
5.1. Main Components of Grinding Wheel.

Element	Character
Abrasive	The abrasive grain is the element that actually performs the cutting activity in the grinding process. And the choice of abrasive grain depends on the material to be ground.
Bond	The role of bond is to hold the individual grains together. The type of bond depends on the operating speed of wheel, the type of operation and the surface finish required.
Pore	The exists between grains and bond. In order to provide chip clearance, air space (pore) must be existed between grains and bond. Dense spacing is denoted by low numbers and open spacing by high numbers.

5.2. Aluminium Oxide Specification.

Chemical and physical Analysis		Typical value	Specification	
			Minimum	Maximum
Al_2O_3	%	99.0	98.5	99.5
Bulk Density	kg/m^3	955	930	1000
Angle of Response	degree	34	34	36
Specific Surface Area BET	m^2/g	75	67	83

VI. PROCESS OF FIN MANUFACTURING



6.1. Raw Material.

The Raw material used for fin is Mild Steel having grade dd0179, this has a dimension as 333000x290x2mm. Iron and the most common iron alloy, steel, are from a corrosion viewpoint relatively poor materials since they rust in air, corrode in acids and scale in furnace atmospheres. In spite of this there is a group of iron-base alloys, the iron-chromium-nickel alloys known as stainless steels, which do not rust in sea water, are resistant to concentrated acids and which do not scale at temperatures up to 1100°C. It is this largely unique universal usefulness, in combination with good mechanical properties and manufacturing characteristics, which gives the stainless steels their raison d'être and makes them an indispensable tool for the designer. The usage of stainless steel is small compared with that of carbon steels but exhibits a steady growth, in contrast to the constructional steels. Stainless steels as a group is perhaps more heterogeneous than the constructional steels, and their properties are in many cases relatively unfamiliar to the designer. In some ways stainless steels are an unexplored world but to take advantage of these materials will require an increased understanding of their basic properties.

6.2. Feeder Mechanism.

Devices used to feed cut sheets of paper in copiers and printers first apply a vertical (normal) force to one or more sheets of paper, and then move the paper horizontally (or at least at right angles to the applied force). The problem arises when the application of the normal force needed to feed the paper is not controlled adequately so more than one sheet of paper feeds. Eliminating multiple paper feeds – called multi-feeds – requires paper separation, which adds complexity and cost to the paper feeder. Historical solutions to paper separation include devices such as snubbers, retard pads, retard rollers, and sensor/electromechanical feedback/actuators. All depend on a delicate force balance to feed the top sheet of paper, while providing a resisting force to lower sheets. The simplest of these devices, while low cost, only separated paper reliably within a narrow range of paper types and operating conditions. More reliable devices usually were more complex and expensive. The paper separation roller consists of a passive (not driven) roller with a high friction coating containing a frictional torque (slip) device. When used with a driven roller, the separation roller provides reliable paper separation at a low cost. As shown below, the separation roller rotates to feed a single sheet, but stops turning when more than one sheet enters the roller combination. The separation roller keeps the top sheet away from the sheets below it. Its simplicity offers a low cost, yet reliable solution to the problem of paper separation.

6.3. The Press.

The mechanical power press is as shown in above picture, it is press of 150 ton, which having capacity to produce 60 strokes per minute. The major types of power presses used in the metalworking industry. These presses develop from several hundred pounds to several thousand tons of pressure to form metal, and require one to several workers to operate the press. The methods, techniques, and safety devices for safeguarding the point of operation were developed from 1914 (American Machinist)8 to current practices (National Safety Council, 1979), and include barrier guards, pull-out devices, two-hand controls, and presence sensing devices. A full revolution press is designed with a type of clutch that, when tripped, cannot be disengaged until the crankshaft has completed a full revolution, and the press slide, a full stroke. A partial revolution press is designed with a type of clutch that can be disengaged at any point before the crankshaft has completed a full revolution, and the press slide, a full stroke. Thus, providing adequate methods of operator safeguarding depends not only on the point of operation but also on the modes of press operation. Safety Standards for presses were first published in 1926 (U.S. Department of Labor) and revised periodically to the current Standard (ANSI B11.1-1971). Essentially, the Standard follows safeguarding criteria based on research conducted in 1949 (American Mutual Insurance Alliance, 1966), as shown in figure. These criteria provide design guidelines to prevent entry of hands or fingers into the point of operation.

6.3.1. Mechanical Power Press Specifications.

TECHNICAL SPECIFICATION

DESCRIPTION	5 TONS	10 TONS	20 TONS	30 TONS	50 TONS	60 TONS	80 TONS	100TONS	150TONS	200TONS	250TONS
CRANK SHAFT DIA	50	58	73	83	95	102	114	127	152	158	165
STORKE ADJUSTMENT	6X25	6 TO 50	10 TO 62	13 TO 75	13 TO 100	13TO112	13TO112	13TO125	13TO125	165	165
SLIDE ADJUSTMENT	30	40	50	50	50	60	60	60	60	70	70
HOLE IN RAM	19	25	32	38	51	51	51	55	60	63	63
HOLE IN BED	51	70	89	102	127	127	127	191	200	215	229
LENGTH & WIDTH OF BED	230x142	381x288	455x250	508x355	650x400	700x425	750x500	800x650	800x650	1016x736	1067x778
DIST BED TO RAM	150	203	230	266	350	350	450	450	450	519	544
H.P. / R.P.M.	0.75/1400	1/1440	2/1440	3/1440	5/1440	5/1440	7.5/1440	10/1440	15/1440	20/1440	25/1440
WEIGHT APPROX. KG.	255	525	1100	1300	2300	2600	3000	4500	5500	9100	11700

6.4. Blanking Process.

The fig. shows the typical diagram of a die which going to be used for making fin. It has three lines of fin slots, these dies are designed and made in-house in the tool room. In the first stage two fins are formed and in the second stage one fin is form, the two outer side material is cut in first stage and the middle portion of sheet is cut in second stage. So that in one stroke of the Ram three fins are made. On the lower side of the lower die there is a cavity for extracting the workpiece manually. The upper die is connected to the ram of Mechanical press which moves upward and downwards. The lower die is fixed at lower end of the press.

Forming dies are typically made by tool and die makers and put into production after mounting into a press. The die is a metal block that is used for forming materials like sheet metal and plastic. For the forming of sheet metal, such as automobile body parts, two parts may be used: one, called the punch, performs the stretching, bending, and/or blanking operation, while another part that is called the die block securely clamps the workpiece and provides similar stretching, bending, and/or blanking operation. The workpiece may pass through several stages using different tools or operations to obtain the final form. In the case of an automotive component there will usually be a shearing operation after the main forming is done and then additional crimping or rolling operations to ensure that all sharp edges are hidden and to add rigidity to the panel.

- No. of fins per stroke= 3
- No. of stroke per minute= 60
- No. of stroke per second= 1
- No. of fin produce in 1min= 3x60 = 180fins.

6.5. The Scrap.

Scrap consists of recyclable materials left over from the product manufacturing and consumption. This scrap is collected in a scrap collector, this scrap is then used to sell.

VII. BURR REMOVAL PROCESS- THE TUMBLER

The tumbler is simply used for rotating the job with the mixture of abrasives and wood straws. It has a capacity to tumbled 1500 to 2000 jobs per turn. When the fins are made the oil which is used as a coolant remains on the fins after blanking process, so the wood straw is used for sucking the oil and to make the fins oil-free.

The outside view of tumbler is as shown in above picture Fig.7.1 It is simply a hexagonal shaped drum which has teeth on the inner shaft as shown in fig.7.1 This shaft is connected to the electric motor via a chain drive. Firstly the wood straw and then the abrasive which are the pieces of grinding wheel are thrown in the tumbler after that the jobs are taken into the tumbler, during a turn 1500 to 2000 jobs are rotated for a specific time to remove the burr. When the tumbler starts rotating, the bonded abrasives made contact with the burred edge of the job, due to the interaction between the abrasives and fin results in removal of burr. While doing this the wood straw is sucking the oil from the job and make the job oil-free. After completing of the specific time the door of the tumbler is open and the jobs are taken out. After that the abrasives are collected in one side and this is further use in the next turn, when the abrasives are repetitively used for a long time it get vanishes day by day. The wood straw which absorbed the oil is now in somewhat wet condition, so it need to be dry. For this these fine wood straws are dried in sunlight for 2 to 3 days.

Our project mostly concerned with the size of the abrasives in the tumbler which is briefly describe in the other matter. One consideration will show that as the size of abrasives decreases the noise level of the tumbler also reduces, this parameter will also depend on the ratio of the abrasives and the wood straw.

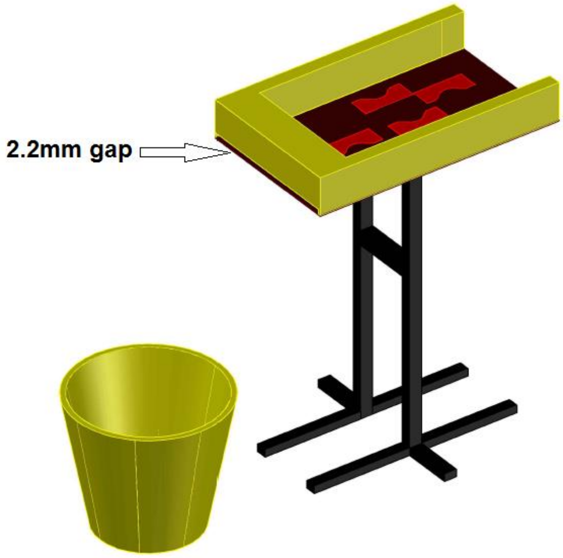
VIII. INSPECTION OF FIN THICKNESS

8.1. Need of inspecting thickness.

The requirement from *Thermax. Ltd*. to *M/S. Anusaya Auto Press Parts Pvt. Ltd*. is to manufacture 100,000 fins per days with almost no burr and having thickness 2.00mm and the tolerance limit is given as +0.2mm. That is the thickness of the fin should be in between 2mm to 2.2mm, and the job which having thickness more than this limit will be rejected. This may only possible by using an inspection method. So it is very much important to inspect the fin before delivering them.

8.2. Initial inspection technic in industry.

When we take a visit to that industry they are using the Gauging system for the inspection of fin thickness. The device which is used for that particular is as shown in above fig. At the one side of that, there is a 2.2mm gap which is used for the thickness inspection. whenever the fin which thickness is to be inspect passes through that gap the thickness is within the tolerance limit, and whenever a fin not able to pass through gap, it is said that the thickness of the fin is above the given tolerance limit.



For eg.

Sr. No.	Thickness of fin	status
1	2.0mm	Accepted
2	2.1mm	Accepted
3	2.2mm	Accepted
4	2.3mm	Rejected

Also the base side is perfectly horizontal, so to inspect the fins one needs to push the fins towards the gap. It require time and some physical work also. To eliminate this we have made improvements in this Gauge.

8.3. Improved Technic.

As discussed above the horizontal surface require to push the fins to go through the gap. So, some efforts are taken to solve that particular problem, and found that by making the horizontal surface inclined as shown in fig.., there is no need to push the fins one just has to the fin on the surface and the fin will automatically slides down due to gravitational force. The actual model of the gauge system is as shown in below fig. This improvement can be looked simple but it affects a lot. So now the process is going to be simple, one just have to take the job on the inclined surface and it then automatically goes downwards in the direction of the gap. Also if the thickness is within the tolerance limit the job will goes through the gap, and if its thickness is more than the tolerance limit it will not pass through that gap. In this way the inspection of the fin thickness is carried out in more simple way.

IX. EXPERIMENTS

9.1. Initial Condition in Industry.

Initially when we visit the industry, tumbling is used for removal of burr from the fins, they are using the ratio of abrasive grains and wood straw as 50:50. That means the weight of wood straw is equal to the weight of abrasives. Also the ratio of abrasive mixture and jobs as 30:70.

Size of grinding wheel pieces is approx. 10 to 15cm, due to this greater size of grinding wheel the noise level in tumbler is high. The fig.. shows this process of tumbling, but as the size of abrasives is greater there is no proper contact of it with the fins. So it requires 30 to 35 min, for tumbling. That mean for 1500 to 2000 fins it requires 30 to 35 mins.

i.e. In 12 hours, no of fins tumbled,
No. of Turns in 12 hours = 720/30 = 24turns
In one turn no of fins = 1500
No. of fins tumbled in 12 hours = 1500x24 = 36,000 fins.

But requirement is 100,000 fins per day so the requirement is not completed.

For troubleshooting this, we made experiments to complete the requirement of 100,000 fins. Following are the experiments which are carried out by us.

9.2. Experiment 1st.

In our first experiment, we kept the size of abrasive constant i.e. 10 to 15 cm but the ratio of abrasives and wood straws is taken as 60:40, Also the ratio of abrasive mixture and jobs as 40:60. This change in proportion of abrasives and jobs shows change in result, as the proportion of abrasives is less than the jobs, the time taken to remove the burr is greater from the earlier i.e. now it is taking 35 to 40 mins.

i.e. In 12 hours, no of fins tumbled,

No. of Turn in 12 hours = 720/35 = 21turns

In one turn no of fins = 1500

No. of fins tumbled in 12 hours = 1500x21 = 31,500 fins.

But here also requirement of 100,000 fins per day is not completed. So, another experiment is carried out.

9.3. Experiment 2nd.

In this experiment the size of abrasives is change to 3 to 5cm, and the ratio of abrasive grains and wood straw as 50:50. That means the weight of wood straw is equal to the weight of abrasives. Also the ratio of abrasive mixture and jobs as 50:50.

This change of abrasive size affects a lot in this process, due to the smaller size of the abrasives there is a proper contact made between the burred edge and the grinding wheel stones, so it results in removal of more burr in less time. This also affects the noise level in tumbler because of small pieces of abrasives the noise level in tumbler is also less. And the most important thing is that the time require for deburring is now 20 to 25 mins for 1500 to 2000 jobs.

i.e. In 12 hours, no of fins tumbled,

No. of Turn in 12 hours = 720/20 = 36turns

In one turn no of fins = 1500

No. of fins tumbled in 12 hours = 1500x36 = 54,000 fins

This experiment shows somewhat better result but the requirement is not completed yet. So one more experiment is carried out.

9.4 Experiment 3rd.

In this experiment the size of abrasives is 3 to 5 cm and and the ratio of abrasive grains and wood straw as 75:52. That means the weight of wood straw is equal to the weight of abrasives. Also the ratio of abrasive mixture and jobs as 60:40.

This change in proportion of this abrasive mixture and jobs required less time for tumbling i.e. it now required 10 to 12 mins only.

i.e. In 12 hours, no of fins tumbled,

No. of Turn in 12 hours = 720/10 = 72turns

In one turn no of fins = 1500

No. of fins tumbled in 12 hours = 1500x72 = 108,000 fins

So, we found that by implementing this proportion of abrasive mixtures and jobs the requirement of 100,000 is completed.

X. FUTURE SCOPE

kinds	Character	Application
A Regular aluminium oxide	High hardness and toughness ·Crystal Form : α-Al2O3 ·True density : 3.96g/㎤ ·Melting point : 2000℃ ·Hardness : Mohs 9.0	Unhardened common steel SS
WA White Aluminium Oxide	Crystal Form : α-Al2O3·True density : 3.96g/㎤ ·Melting point : 2000℃ ·99% Al2O3 ·Hardness : Mohs 9.0	·Hardened carbon steel ·Alloy steel ·Tool steel (SxxC, Scr, SK, SUH)
32A SA	Single crystal ·True density : 3.96g/㎤ ·Hardness : Mohs 9.0 ·Melting point : 2000℃ ·Particle shape : sharp	Including Cr.W stainless steel ·Tool steel(SUS, SKH, SUH)
C GC	98% SiC ·Crystal Form : Hexagonal system ·True density : 3.20g/㎤ ·Hardness : Mohs 9.0 ·Melting point : 2300℃	·Ceramics polishing ·Plastic ·Rubber ·Non-ferrous metals
PA RA Pink Aluminium Oxide	99.5% Al2O3, Crystal Form : α-Al2O3 ·True density : 3.97g/㎤ ·Melting point : 2000℃ · Hardness : Mohs 9.0	Hardened carbon steel ·Alloy steel ·Tool steel (SxxC, Scr, SK, SUH)
Z AZ Zirconia Aluminium Oxide	Crystal Form : Mono-Clinic ·True density : 3.97g/㎤ ·Melting point : 1900℃ ·71% Al2O3 +25% ZrO2	·Alloy steel ·Stainless steel ·Cast iron

XI. CONCLUSION

- From the above experiments on the size and proportion grinding stones (abrasives), we can conclude that the best size of abrasives found to be 3 to 5 cm, also the ratio of abrasive and wood straws as 75:25. That means 75% abrasives and 25% wood straw.
- It may be seen that, as the proportion of mixture of abrasives and sand increases with respect to the weight of job, the rate of burr removal ultimately increases. The best proportion is found to be 60% of abrasive mixture and 40% of jobs.
- Another one is that, by changing the horizontal surface of Gauge to inclined, the time and efforts required to inspect the thickness of job reduces.