

OM 380.17 Bagchi & Gutierrez
Group Homework – 1 (worth 2.5% of your course grade)

Case: Donner Company

Names of Group Members and Index Numbers

Name (First, Last)	Index Number	Signature
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***** By signing my name, I am affirming that:**

- **I have read the course syllabus.**
- **I have contributed as expected toward the fulfillment of this assignment.**
- **The work our group is turning in is the work product of our group.**
- **Our group did not get outside help in fulfilling this assignment.**

This homework is based on the *Donner Company* case. Please read the case carefully and answer the questions that follow on the next page. **Your submission must have this page as the cover page. Please submit on Canvas by the beginning of class on the day the assignment is due.**

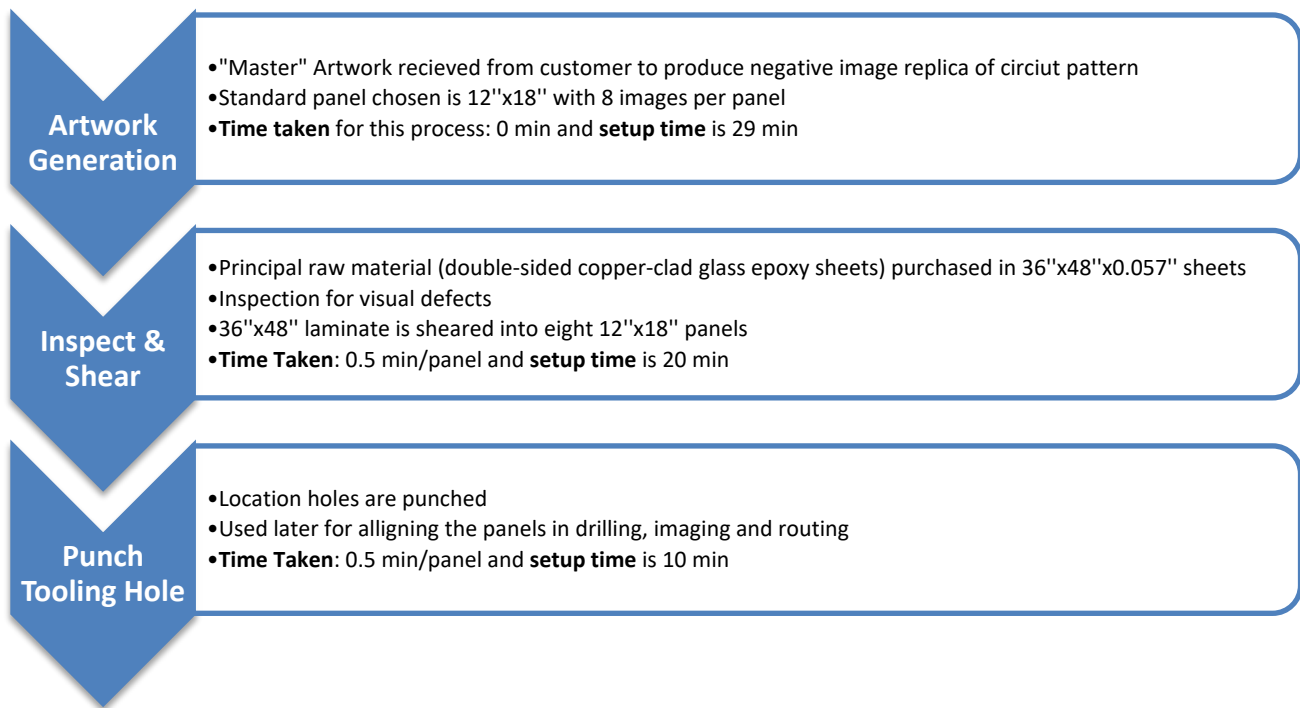
(1) Draw a process flow diagram of the production process at Donner.

To answer this question, follow a typical 8-board panel through the process. What are the steps and how long will each take? Assume that in the preparation stage, *artwork generation* can be done simultaneously with *Inspect & Shear* and *Punch Tooling Holes*; these holes are merely for aligning the panel.

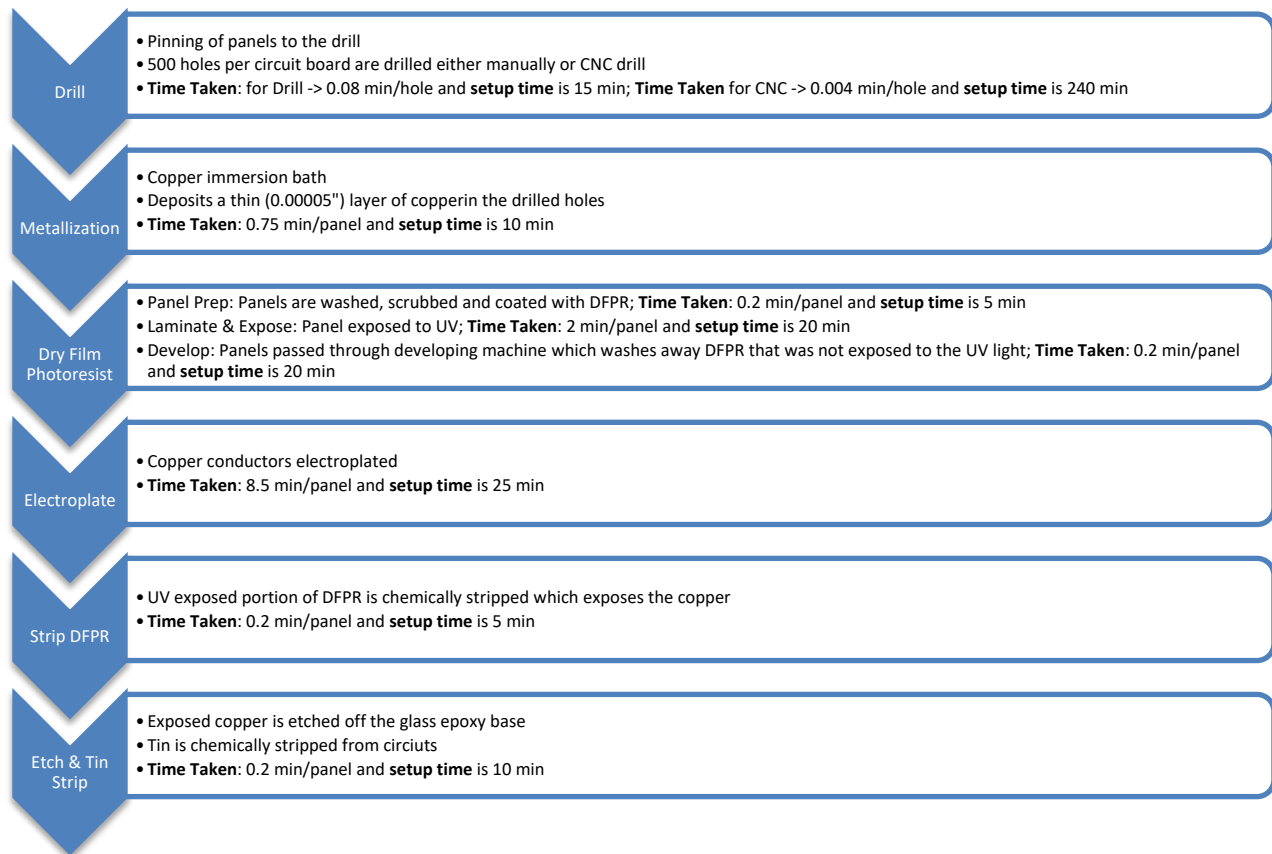
Answer (1):

*We have highlighted the time taken by each process inside the flowchart.

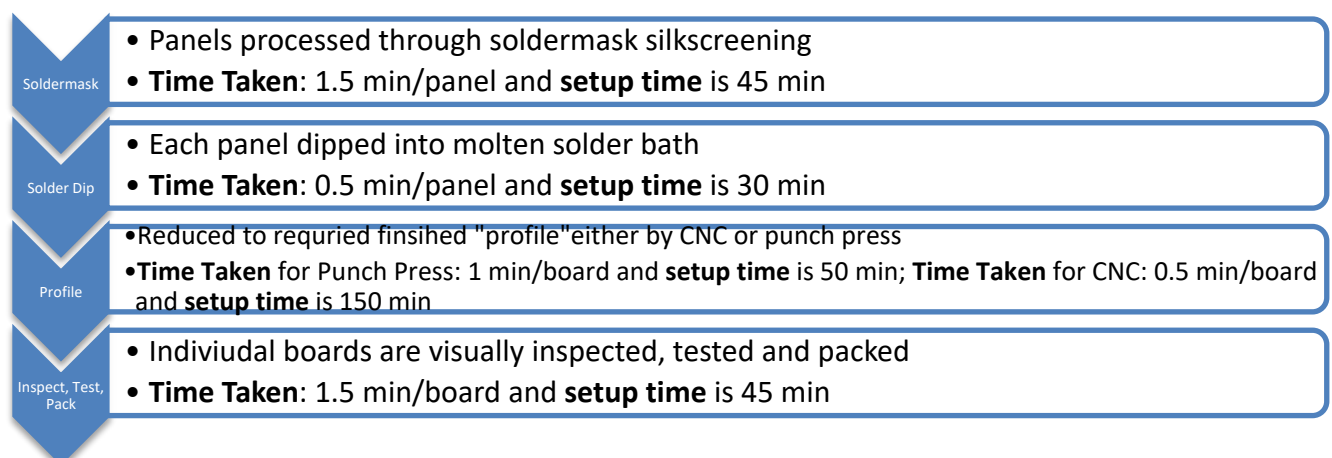
Stage 1: Preparation Stage



Stage 2: Image Transfer



Stage 3: Fabrication



(2) What orders would you schedule on the CNC drill? On the CNC router?

Consistent with the calculation of September's Total Standard Production in case Exhibit 2, assume that an order incurs just one setup irrespective of the number of boards in the order.

Answer (2):

Assume that the manufacturing stages are sequential which means that Image transfer starts once the preparation ends. This will make sure that CNC machine is available while drilling holes and while separating the individual boards and parallel use of manual drills is not possible.

To find the breakeven order size when choosing manual drill or CNC drill: assume the order size is x boards.

Time taken by manual drilling = $15 + 0.08 \times 500 \times x$

Time taken by CNC drill = $240 + 0.004 \times 500 \times x$

*setup time is not dependent on order size but only the number of orders

For CNC drill to be used:

$$15 + 0.08 \times 500 \times x \geq 240 + 0.004 \times 500 \times x$$

This gives: $x \geq 5.92$ i.e., $x \geq 6$ when rounded to nearest whole integer. Hence if the order size ≥ 6 then we should use CNC drill as it will take less time. Hence, use CNC drill if the order size is more than 6 boards and use manual drill if the order size is less than 6 boards.

To find the breakeven order size when choosing punch press or CNC router:

Assume the order size is x boards.

Time taken by punch press = $50 + 1 \times x$

Time taken by CNC router = $150 + 0.5 \times x$

*again, setup time is not dependent on order size here but only the number of orders

For CNC router to be used:

$$50 + 1 \times x \geq 150 + 0.5 \times x$$

This gives: $x \geq 200$. Hence if the order size ≥ 200 then we should use CNC router as it will take less time. Hence, use CNC router if the order size is more than 200 boards and use punch press if the order size is less than 200 boards.

(3) What is the capacity (= boards per day) of the Dry Film Photoresist area (assume the order size is eight)? How does the capacity change with order size?

Answer (3):

Assume that there are 8 working hours in a day.

Total time for one panel with 8 boards

$$\begin{aligned} &= (\text{setup time for Panel prep} + \text{Run time for Panel prep}) + (\text{Setup time for Laminate \& Expose} \\ &+ \text{Run time for Laminate \& Expose}) + (\text{Setup time for Develop} + \text{Run time for Develop}) \\ &= (5 + 0.2) + (20 + 2) + (20 + 0.2) \\ &= 47.4 \text{ minutes} \end{aligned}$$

Number of panels that can be made in a day = $(8 \times 60) / 47.4 = 10.126$

Hence, the capacity of the Dry Film Photoresist is 10 orders per day or 80 boards per day.

If the order size is 16 boards, then the time per order is 49.8 minutes (since only the run time will increase, in this double) and the capacity will be $(8*60)/49.8 \sim 9$ orders or 144 boards per day. Hence, capacity of orders will decrease with increase in order size but the capacity of boards will increase with increase in order size.

(4) What is the standard labor time (= labor time per board) for an order of 1 board? For an order of 8 boards? For an order of 200 boards?

Answer (4):

As derived in Q2:

If the number of circuit board in a single order is:

- ≤ 6 then we use Manual Drill + Punch Press
- 6-200 (not inclusive) then we use CNC Drill + Punch Press
- ≥ 200 then we use CNC Drill + CNC Router

Hence for this problem:

For 1 board we should use 'manual drill' for holes and 'Punch Press' for profiling

For 8 boards, we should use 'CNC drill' for holes and 'Punch Press' for profiling

For 200 boards, we should use 'CNC drill' for holes and 'CNC Router' for profiling

Time Calculations:

Assuming Standard process flow (since there is only 1 order, just that the number of boards change)
The setup time for each case is (values from Exhibit 2):

- **1 board** (We will not consider set up time for 'Manual Drill' and 'CNC router' in this case):
 - Setup time: Preparation $(29 + 20 + 10)$ + Image transfer $(15 + 10 + 5 + 20 + 20 + 25 + 5 + 10)$ + Fabrication $(45 + 30 + 50 + 45) = \mathbf{339 \text{ mins}}$
 - Run time: Preparation $(0 + 0.5 + 0.5)$ + Image Transfer $(40*1 + 0.75 + 0.2 + 2 + 0.2 + 8.5 + 0.2 + 0.2)$ + Fabrication $(1.5 + 0.5 + 1*1 + 1.5) = \mathbf{57.55 \text{ mins}}$
 - Total Time = 396.55 mins; Total time per board = **396.55 mins**
- **8 boards** (We will not consider set up time for 'Manual Drill' and 'CNC router' in this case):
 - Setup time: Preparation $(29 + 20 + 10)$ + Image transfer $(240 + 10 + 5 + 20 + 20 + 25 + 5 + 10)$ + Fabrication $(45 + 30 + 50 + 45) = \mathbf{564 \text{ mins}}$
 - Run Time: Preparation $(0 + 0.5 + 0.5)$ + Image Transfer $(2*8 + 0.75 + 0.2 + 2 + 0.2 + 8.5 + 0.2 + 0.2)$ + Fabrication $(1.5 + 0.5 + 1*8 + 1.5*8) = \mathbf{51.05 \text{ mins}}$
 - Total Time = 615.05 mins; Total time per board = $615.05/8 = \mathbf{76.88 \text{ mins}}$
- **200 boards** (We will not consider set up time for 'Manual Drill' and 'Punch Press' in this case):
 - Setup time: Preparation $(29 + 20 + 10)$ + Image transfer $(240 + 10 + 5 + 20 + 20 + 25 + 5 + 10)$ + Fabrication $(45 + 30 + 150 + 45) = \mathbf{664 \text{ mins}}$

- Run Time: Preparation $(0 + 0.5*25 + 0.5*25)$ + Image Transfer $(2*200 + 0.75*25 + 0.2*25 + 2*25 + 0.2*25 + 8.5*25 + 0.2*25 + 0.2*25)$ + Fabrication $(1.5*25 + 0.5*25 + 0.5*200 + 1.5*200) = \mathbf{1176.25 \text{ mins}}$
Since no of boards = 200, there will be $200/8 = 25$ panels and each additional panel will add to run time
- Total Time = 1840.25 mins; Total time per board = $1840.25/200 = \mathbf{9.20 \text{ mins}}$

The calculations are illustrated in the table below:

		Order Size						
		# (circuit boards)	1			8		
		# (panels)	1			1		
			Run time (1)	Run time (8)	Run time (200)	Total time (1)	Total time (8)	Total time (200)
Preparation	Artwork Generation	29	0	0	0	29	29	29
	Inspect & Shear	20	0.5	0.5	12.5	20.5	20.5	32.5
	Punch Tooling Holes	10	0.5	0.5	12.5	10.5	10.5	22.5
Image transfer	Drill Manual	15	40	320	8000	55	335	8015
	CNC Drill	240	2	16	400	242	256	640
	Metallization	10	0.75	0.75	18.75	10.75	10.75	28.75
	DFPR :Panel Prep	5	0.2	0.2	5	5.2	5.2	10
	DFPR :Laminate & Expose	20	2	2	50	22	22	70
	DFPR :Develop	20	0.2	0.2	5	20.2	20.2	25
	DFPR: Electroplate	25	8.5	8.5	212.5	33.5	33.5	237.5
	Strip DFPR	5	0.2	0.2	5	5.2	5.2	10
	Etch & Tin Strip	10	0.2	0.2	5	10.2	10.2	15
Fabrication	Soldermask	45	1.5	1.5	37.5	46.5	46.5	82.5
	Solder Dip	30	0.5	0.5	12.5	30.5	30.5	42.5
	Profile: Punch Press	50	1	8	200	51	58	250
	Profile: CNC Router	150	0.5	4	100	150.5	154	250
	Inspect and pack	45	1.5	12	300	46.5	57	345
Setup Time(1)	339	TOTAL Run Time	57.55	51.05	1176.25			
Setup Time(8)	564	Total Labour time per order (min)				396.55	615.05	1840.25
Setup Time(200)	664	Total Labour time per board (min)				396.55	76.88	9.20

Total Time and time per board for:

- 1 board = $339 + 57.55 = 369.55$ mins (369.55 mins per board)
- 8 boards = $564 + 51.05 = 615.05$ mins (76.88 mins per board)
- 200 boards = $664 + 1176.25 = 1840.25$ mins (9.20 mins per board)

As the number of boards increase, the set-up time increases but the run time per board decreases considerably with the use of machine components like CNC Drill and CNC Router.