Design of semi-auto line for *gula Melaka* processing

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Keywords: *Gula Melaka*; demoulding; production; aluminium, conveyer

ABSTRACT – *Gula Melaka* is broadly used in ASEAN, mainly for cooking. The demands are impressive but the current production capacity is not enough. Hence, a new semi-auto line is design to replace traditional method to shorten its processing time. A thorough study is conducted for improvement and several new design concepts have been put into consideration. The final selected concept operates with manual pouring process and the remaining processes are in automatic mode. Design of mould, cooling time reduction, and automatic transporting and demoulding process enables the production capacity to increase by 500 %.

1. INTRODUCTION

Gula Melaka or Palm Sugar is a nutrient-rich, low-glycemic crystalline sweetener that tastes, dissolves and melts almost exactly like sugar. It is acquired from the flowers growing high on coconut palm trees; liquid flower nectar. In traditional method, the fresh sweet palm neera is boiled down shortly after collection to make palm syrup and *Gula Melaka*. To concentrate the nectar into solid sugar, the fresh juice is boiled down and evaporated before being poured into bamboo sections to form cylindrical shapes [1]. The demands of the *Gula Melaka* are currently very high and the manufacturers which use traditional method must take action to increase their production [2]. Hence, a new modern method are required to increase the capacity

2. METHODOLOGY

2.1 Design

The design processes are according to the engineering design processes proposed by Pahl and Beitz [3] that includes clarification of the task, conceptual design, embodiment design and detail design. In traditional process, we observed that the process arrangements are cooking, pouring, cooling, demoulding and packaging of *Gula Melaka.* Morphological chart is used by listing few possible solutions for the problem. It is to establish any essential aspects that are necessary to the process. Then, we made few concepts as in Table 1. For concept evaluation and screening, we utilize the Pugh Matrix Evaluation [4] and it shows that Concept 2 has the best features, with highest weighted total. The selection criteria are based on the performance, durability, ease of handling, safe to use, feasibility and cost.

Table 1 Concepts Generation

Concept	Process		
	Pouring	**Cooling**	**Demoulding**
1	Nozzle	Fan	Piston
2	Jar Pouring	Cooled Chillers	Piston
3	Injection	Room Temperature	Shaking Motion
4	Injection	Fan	Mould Opening

In traditional method, bamboo moulds need to get wet for easy demoulding process [5]. By eliminating this process, it will prevent water from the bamboo to be absorbed by *Gula Melaka*. Thus, aluminium mould that consists of "mould inserts" with tapered drilled bore hole is suggested as replacement for easy separation of the *Gula Melaka* from the mould by means of gravity as well as easy maintenance and cleaning. In addition, aluminium has a light weight, high strength to weight ratio, corrosion resistance and formability [6]. A set of mould has 36 pieces of standard size mould inserts as illustrated in Figure 1. This enable constant volume for each single piece of *Gula Melaka.*

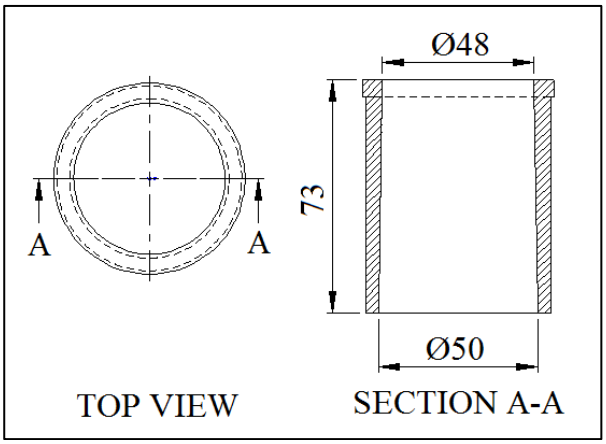

Figure 1 Mould Insert Dimension.

2.2 Process Flow

The overall process flow from pouring to demoulding for the new semi-auto line of *Gula Melaka* is summarize in Table 2 and illustrated in Figure 2.

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Table 2 Flow Process of *Gula Melaka* Production

No.	Section	Description
1	Pouring	Manual pouring using a jar.
2	Conveyer	The conveyer will transport the molten *Gula Melaka* to chiller.
3	Chiller	Molten *Gula Melaka* will cool down and solidifies.
4	Conveyer	Transport the solid *Gula Melaka* to demoulding process station.
5	Demoulding	Process started with the pushing down of the *Gula Melaka*.
6	Rolling Conveyer	Transfer mould from demoulding to return conveyor
7	Return	Return empty mould to the pouring work station.

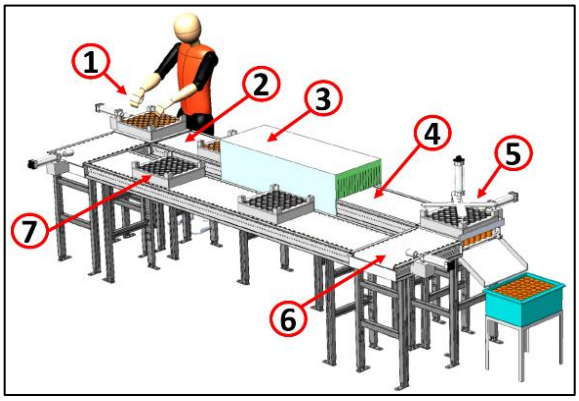

Figure 2 Process Flow of *Gula Melaka* Production

2.3 Cycle Time

In setting the target cycle time for the new semi-auto line, the cycle times for traditional process is use as a benchmark. To achieve the set target of increasing the production capacity by 500%, the new semi-auto line need to be able to produce five time faster. As the new design of mould set consists of 36 cavities, the cycle time for traditional method are also taken for every 36 pieces for reasonable comparison. The cycle time for each process in the traditional method are taken and recorded. The semi-automation ceiling cycle times are calculated for each process by setting the cycle times to be five times lower than the benchmark cycle times.

3. RESULTS AND DISCUSSION

Table 3 tabulate the cycle time comparison between traditional and new semi-automation for each process. The "bottle neck" can be determined from this table and are used to calculate the total line cycle time. The measured cycle time per piece for traditional process and the calculated cycle time per piece for semi-auto line are 37.5 and 7.5 seconds respectively. It also shows that the longest cycle time is the cooling process thus indicates the cooling process as the "bottle neck" which determine total line cycle time. Therefore an analysis have been conducted to determine the required cooling load to ensure the 36 pieces of *Gula Melaka* are able to solidified before it leave the cooling tunnel. For a 3 meters long cooling tunnel, the speed of the conveyor belt need to be set to 11 mm/s for the cooling time of 269 sec. The cooling load required for 36 pieces of *Gula Melaka* to reduce its temperature from 350°C to 24°C and solidified is about 2536 kJ/s. This calculated load is used to select the most suitable cooling tunnel according to its specification.

Table 3 Comparison of Traditional and Semi-Auto

Process	Categories	
	Traditional	Semi-Auto
Mould Arrangement	18 sec	3.6 sec
Pouring	108	21.6 sec
Cooling	1350 sec	269 sec
Demoulding	144 sec	28.8 sec
Total Cycle Time for 36 pieces (Bottle Neck)	1350 sec	269 sec
Cycle Time Per Piece	37.5 sec	7.5 sec

4. CONCLUSIONS

The application of automation control system to the production of *Gula Melaka* is a possible way to increase the food production. The theoretical calculation proves that the new production system can reduce the cycle time per piece from 37.5 seconds to 7.5 seconds. It means that the production of *Gula Melaka* by using the aluminium as a mould material can increase up to 500% compare to traditional method. As a result, the manufactures have enough capacity for the high demand, reduce manpower and therefore improves their productivity.

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