MIDDLE EAST TECHNICAL UNIVERSITY

DEPARTMENT of INDUSTRIAL

SUMMER PRACTICE

IE 400

Performed by:

Youssef Nsouli

2487494

IE - 400

Performed at: Arçelik A.S.

18/07/2023 – 10/08/2023

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1. INTRODUCTORY FEATURES

What is the full title of the firm? When was it founded and where is it located? (Give the full mailing address)

The full title of the firm is Arçelik A.Ş. It was founded in 1956 and its headquarters lies in İstanbul, Sütlüce. The mailing address for the headquarters is: Karaağaç Caddesi 2-6, Sütlüce 34445, İstanbul.

The location where the internship was conducted is the Dishwasher manufacturing facility in Sincan, Ankara whose mailing address is: Altınordu Cd. No:3, 06935 Sincan Osb/Sincan/Ankara.

What is the type of ownership of the firm? State the main shareholders and their shares. Is the firm a partnership, a joint venture, a franchise, a part of a holding company or a part of a multinational group?

The firm is a part of a holding company, Koç Holding, that owns most of the company. The shares are valued at 675,728,205 TL. The shareholders and their shares are provided in figure 1:

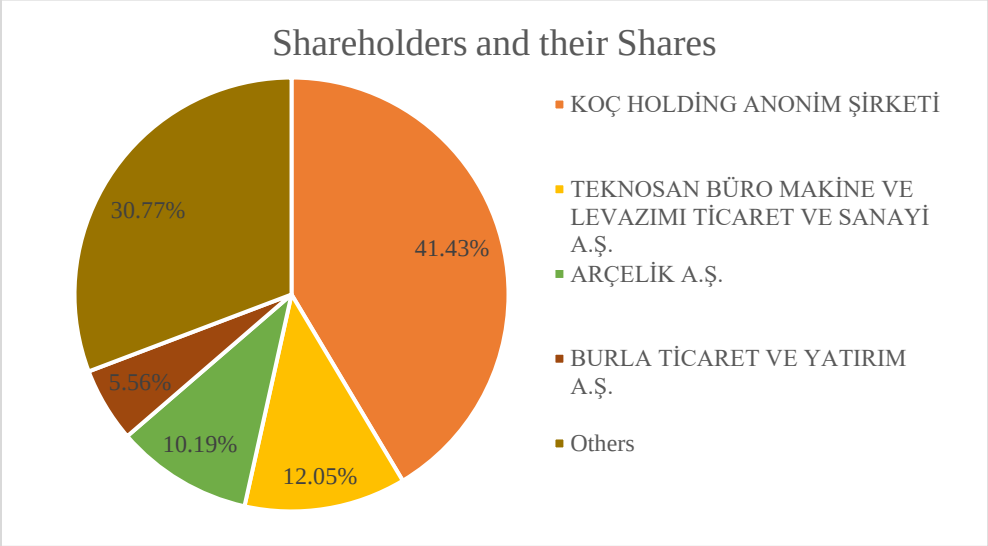


Figure 1: Shareholders of Arçelik and their respective shares (Kamuyu Aydınlatma Platformu, 2023).

> *Specify the sector and typical products the firm manufactures or typical services it provides to its customers. Include a few samplers of its advertising brochures or pamphlets or catalogue pages in your appendices to illustrate typical products or services, if available.*

Note: Question 1.3 split into two parts.

The firm as a whole has a wide range of electronic appliances and offers them at differing qualities and price ranges when including its child brands in the discussion (Beko, Grundig, etc.). The firm where my internship took place is a dishwasher manufacturing facility and produces around 60 types of dishwashers, varying by size, brand, and power/efficiency. There are multiple websites and brochures available to view the products that are offered. Some are provided in appendix A and all of them can be found in this link: https://www.arcelik.com.tr/urun-kataloglari

> *What are the firm's shares in the domestic market and (if any) in the international markets?*

The firm offers an extremely wide range category of products, and, on average, the market share of Arçelik amongst all the categories is around 50% domestically, 9% in the European market, and 10% internationally. When it comes to dishwashers, the figures rise to 60% domestically and 12% in the European market and internationally.

> *Who are regarded as the customers of your practice organization (consider the end users, retailers, other manufacturers, employees, etc.)? Identify the stakeholders, i.e. the groups considered by the organization to have any sort of interest in the organization's activities (such as certifying agencies, labor unions, professional societies, government, local community, potential customers, competitors and employees).*

Since the firm produces end products by its nature, the customers are individuals/homeowners, in addition to some organizations and companies that would like to purchase electronic appliances for their workplaces and headquarters.

In addition, the firm also sells some raw materials to other factories as a way of outsourcing the production of some components. For example, the plastic components are bought by Arçelik from a plastic-processing company, after Arçelik had already sold them tons of raw plastic material. In a certain manner, these plastic companies could be thought of as customers.

> *Provide a list of functions performed by the industrial engineers in the practice organization.*

Industrial engineers participate in many aspects and departments of the firm, including but not limited to:

- Production planning
- Quality control
- Research and development (R&D)
- Manufacturing line optimization
- A department tasked with "pure" industrial engineering concepts, aptly named industrial engineering department, such as mathematical and programming models and general optimization within the firm.
- Data science and big data analysis

2. ANALYSIS OF THE MACRO ASPECTS

> *Study the production (or service operations) system of your practice organization taking an overall view. Sketch the system as a black box identifying its inputs and outputs.*

Note: question 2.1 split into multiple parts

The production system at the dishwasher manufacturing facility consists of four assembly lines. There are many inputs to the assembly line as are the outputs. The inputs can be best categorized as plastic inputs, raw metal inputs, circuitry and CPU inputs, dishwasher body inputs, motor inputs, and compressor inputs. The outputs, as discussed before, includes around 60 different types of dishwashers, differing by brand, size, model, features, quality, and more. Lists of inputs and outputs in detail are given in tables B1 and B2 (Appendix B):

> *Does the firm produce goods and/or services only for the domestic market? If it exports some or all of its products, give some quantitative details of these for as many past years as you can find data for. Are there any constraints (or regulations) that prevent the firm from competing with similar products (or services) in the foreign market?*

The firm does not have any finished products solely for the domestic market, rather it has some finished products that are solely for the international market, as well as some products for both the domestic and international market. For example, Dawlance is a subsidiary of Arçelik, yet the products, which are produced locally, are sent all the way to Pakistan and the neighboring countries. Another example is Beko, where its products are meant for both the domestic and the

international market. Data was not given on the exact export level for these products, as that is deemed private data.

Rather than constraints in the foreign market, there are some constraints in the domestic market; some products intended for the foreign market are believed to not be received well in the domestic market, mainly due to the cheapness and lower quality that it entails.

> *Does the firm import raw materials, intermediate goods, or any of its inputs (in your black box diagram)? If so, list the countries from which imports arrive.*

The dishwasher plant imports plastic raw materials. The exact countries from which the imports come from are also deemed private data. In addition, the dishwasher plant buys some parts from the local market, such as sheet metal, motors, compressors, CPU's, heavy blocks, plastic components, and more.

> *What are the standards and certificates (such as ISO, TSE, EN, EC, etc.) the firm conforms to with regard to its activities? Describe briefly and exemplify any limitations or norms imposed by these standards.*

The firm as a whole has obtained multiple certifications, all of which can be reached here. When talking about the dishwasher plant specifically, it conforms to ISO 45001:2018, related to occupational health and safety during the production of dishwashers and their design.

For example, workers must wear steel shoes at all times and must wear luminescent gear. The lighting of the firm should be at a certain level and deaf workers need to have visual indicators on their gear that shows that they are audibly impaired. Also, the firm employs an automated guided vehicle (AGV) system where these automated vehicles have someone monitoring them from the cockpit at all times, and the vehicles have the capability to stop when they sense that a worker or another AGV is nearby. There are multiple panic buttons spread throughout the facility. The smoke detectors are checked weekly to make sure they are still working, and more.

> *How can you state the mission of your practice organization? Are there differences in missions regarding different goods or services offered by the firm? What visions are there with regard to the services (or goods) and processes performed in your practice organization?*

Aside from the obvious answer – “to make as much money in the fastest way as possible” – the company has a vision to empower the society it lies in and nurture alongside it. This vision seems to manifest in the products in very subtle ways. For example, when I was given a tour of the facility, the workers took a non-small amount of time to explain that there are multiple workstations to make sure the machines do not get dented and that there are workstations dedicated to installing heavy bricks at the bottom of the dishwasher, so that when the user opens the machine, it is less likely to tip over.

Another way is the vision manifests is the after-purchase support. The brand and firm provide a way to sell spare parts to the users so that they won’t need to buy a whole new machine if the current one has broken. Many companies would prefer the customers to buy a whole new machine since this increases their revenue and decreases their costs in providing spare parts.

The vision seems to be consistent throughout the different line-ups that the plant produces, however the details between each line-up change to match the market. For the Dawlance line-up, the focus is more on providing value as cheap as possible since the intended market has lower buying power than the local market.

> *Specify the most prevailing factor for selecting the current location of the facility with regard to the factors listed above or the like. Support your ideas with quantitative or qualitative observations. (You may use a sketch, a table, a graph or a map, if necessary).*

The firm also houses a plant, making it categorized legally as a factory. As such, factories are not legally allowed to be within city limits and are as such grouped into industrial cities, such as the Organize Sanayi Bölgesi Area. This imposes many limitations and constraints, such as the fact that transportation for employees and workers is much more expensive. The firm transports its workers and employees between all of Ankara and the firm back and forth every day. Plus, the workers are transported before the employees, so the transportation happens over two phases each instance. Personally, I lived in the METU Dorms throughout the duration of this internship, and the shuttle service had to transport me and other fellow interns about 30km per trip (60km per day).

Dishwashers also need to be transported to the retail stores all over the country and the world after being manufactured. The facility is far from the airport (~53km), Ankara is

landlocked (nearest port is ~450km away), and other cities are far away (most industrially active city is Istanbul, which is ~400km away). Moreover, dishwashers have very delicate circuitry in them and need to be transported with care. They are also large compared to their value (the dollar value per m^3 is low), so transporting using land is not the best option. All these factors lead to a firm with very high logistics costs.

A way in which the location helps the firm cut costs is through the fact that multiple other firms exist in the same industrial area. Firms like Sarpplas that provide Arçelik with plastic components are within 1km from the dishwasher plant. Hence, it is cheap to sell Plastika tons of plastic and get the resultant components back. Other sheet metal processing firms also exist within the vicinity of Arçelik. A static map image is provided in figure 2.

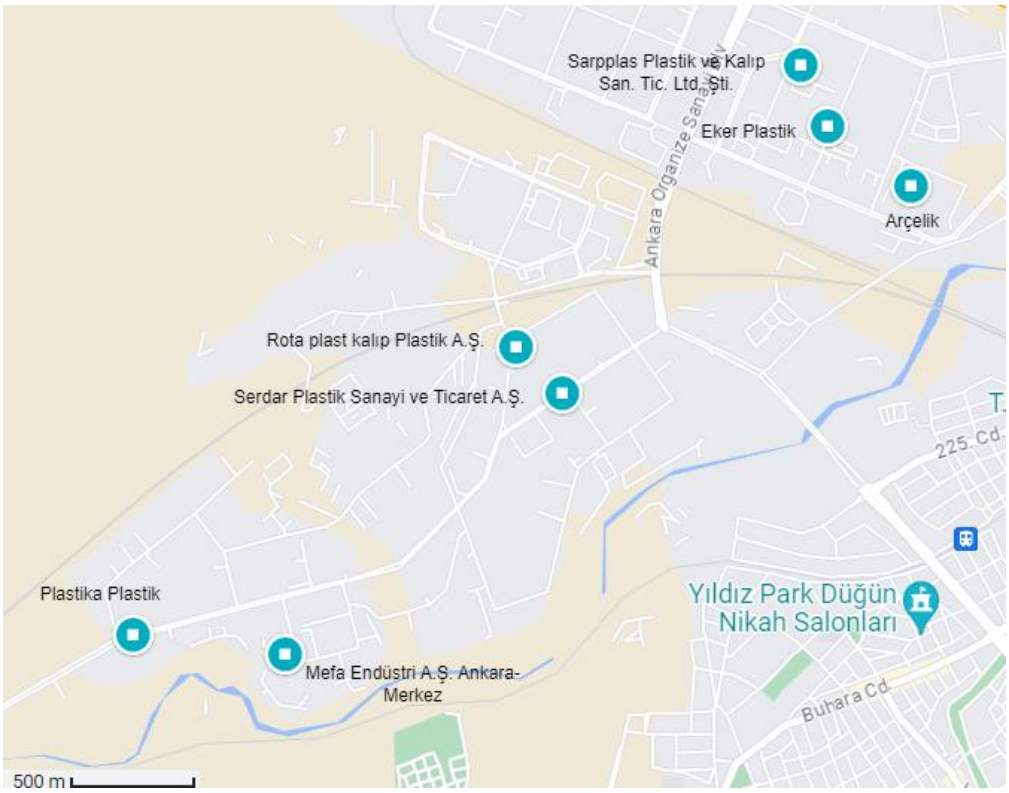


Figure 2: Static map image displaying Arçelik's proximity to its most active suppliers/customers.

> *Does top management have plans and proposals for capital investment? If so, state what these investment plans are. If not, explain why top management is not currently considering such plans.*

Note: Question 2.4 split into multiple parts

As discussed before, the company is planning to expand the dishwasher manufacturing to other countries. Current plans constitute expanding dishwasher manufacturing plant to Karachi, Pakistan. Top motivations for this expansion are lower wages and lower overall manufacturing costs, reducing transport costs from and to certain markets, and expanding into the South Asian market. Moreover, Arçelik is also trying to transfer some of its production load to Egypt in attempts of reducing costs and having another hub for foreign exports.

In addition, the firm is always researching new technology and new features to add into their products or entirely new products. For example, during the duration of the internship, some R&D engineers researched ways to reduce the water tank leakage in dishwashers overall. Another example is incorporating Active Noise Cancellation (ANC) into dishwashers.

> *What evaluation methods and criteria are used to select among several alternative investment proposals? Is there a procedure to take into account the effects of inflation in considering future investments? Provide an example as to how investment alternatives were evaluated in the past. If such a procedure is not used, propose and justify a selection procedure.*

Usually, standard B/C analysis is used in determining whether expansion to new markets is worthwhile or not. However, since the firm has relations that it has to maintain, sometimes it is better in the long run to spend capital to maintain said relationships. Mainly, such decisions are taken by the board of directors to decide whether it is best to spend millions of orders in order to maintain relationships, of course while considering the expected profits or losses. An example of this is Arçelik's relationships with Egypt, where the former has invested $100 million in the latter.

In other cases, where there are no relationships to be maintained, the firm spends money to estimate the costs and potential benefits and perform a B/C analysis. If the costs outweigh the potential benefits, the expansion is abandoned. If the potential benefits outweigh the costs, another analysis is made: if an expansion is made, is it worth the mental overhead for the top managers? Meaning, is the time spent by the managers to direct and approve/disprove ideas in the new expansion worth the new potential profit? If the managers spent, for example, a quarter of their time to direct the new expansion for only a 5% increase in profit, is it worth it? If the B/C analysis comes positive and the potential profits are worth the mental overhead, the expansion is thus approved.

3. AN OVERVIEW OF THE PRODUCTION SYSTEM

Provide a process (operations) chart of a major:

- *product/subassembly or*
- *routing for a group of products or*
- *service process.*

The operations chart for dishwasher manufacturing is a complex one. A summary of the process is provided in figure 3:

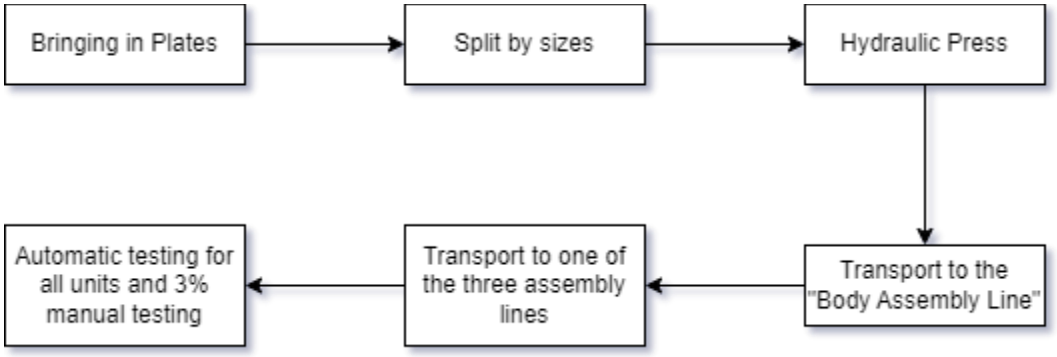


Figure 3: A summary of the dishwasher manufacturing process.

The more precise charts are provided by Arçelik in images 1 through 4:

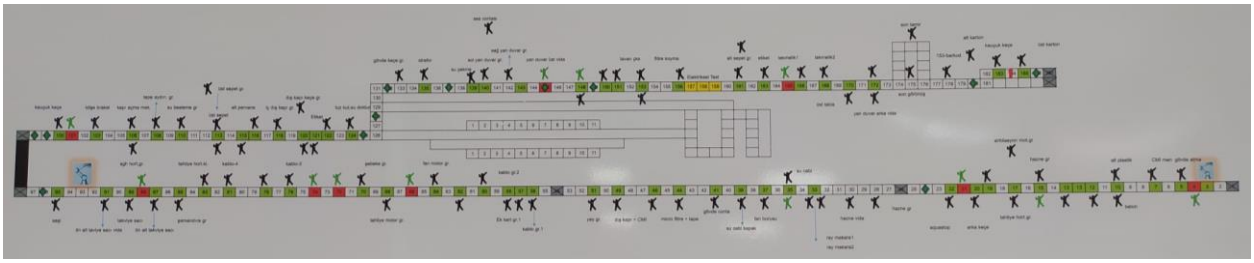


Image 1: The dishwasher body assembly line.

Image 2: Assembly line M1.

Image 3: Assembly line M2.

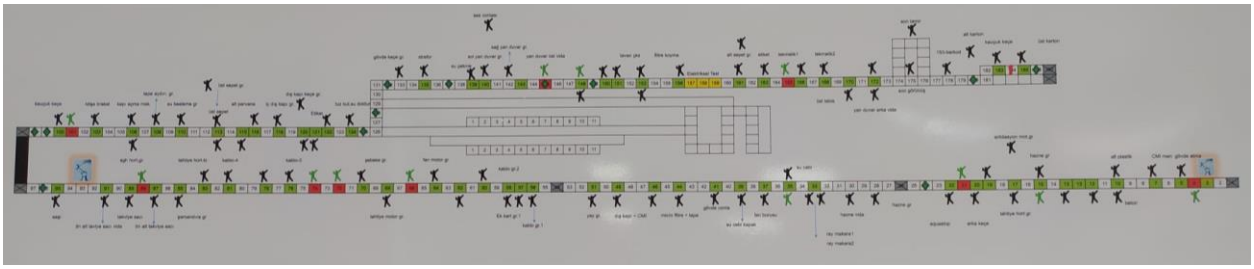


Image 4: Assembly line M3.

> *How is the rated capacity of your practice organization defined and measured?*

The rated capacity is defined as the expected number of dishwashers that would be produced under the assumption that all workers are at 65% efficiency and all workers take their lunch breaks and their PFD allowances. The rated capacity is currently 11,550 dishwashers per day and are planning to increase this number to 15,000 by the end of the year.

It is calculated as such:

$$Rated\ Capacity = (Maximum\ Capacity) \times (Utilization) \times (Efficiency)$$

$$Rated\ Capacity = (16{,}500) \times \left(\frac{7.5\frac{hrs}{shift} \times 3 shifts}{24\frac{hrs}{day}} \right) \times (65\%) \approx 11{,}550$$

The capacities (both rated and maximum) are distributed as follows:

Assembly Lines	Current Production	Maximum Capacity
M1	1500	2000
M2	1000	1250
M3	1350	1750
M4	0	500
Per Shift Total	3850	5500
Daily Total	11550	16500

Table 4: Current production rate and maximum capacity for each assembly line in the dishwasher facility per each 8hr shift. Note that assembly line M4 is, as of now, under maintenance and not operating.

Explain the type of operations or combination of types in your practice organization.

The type exhibited in the dishwasher manufacturing facility can be best described as **flow shop**, since it is a group of assembly lines with minimal backtracking. Also, each machine is used for one task; if multiple tasks require one machine, it is better to get several of those machines to complete the task. For example, there are multiple, identical axial robot arms that are each designed and programmed to do a specific task, whether that is tightening a screw or handling a piece or transporting a component from one side to another.

Moreover, even though there are as much as 60 types of dishwashers coming into these assembly lines, but the assembly lines are split in such a way that there are three major types of

dishwasher models, slim models, 60cm model, and 45cm models, which are designated for each of the assembly lines.

Additionally, even within each model type, an assembly line is expected to handle multiple types of dishwashers. The assembly lines were built to handle the differentiations and the workers are also trained according to each type of dishwasher.

Draw a block plan of your practice organization or provide a blueprint, if available.

A block plan provided by the organization is available in image 5:

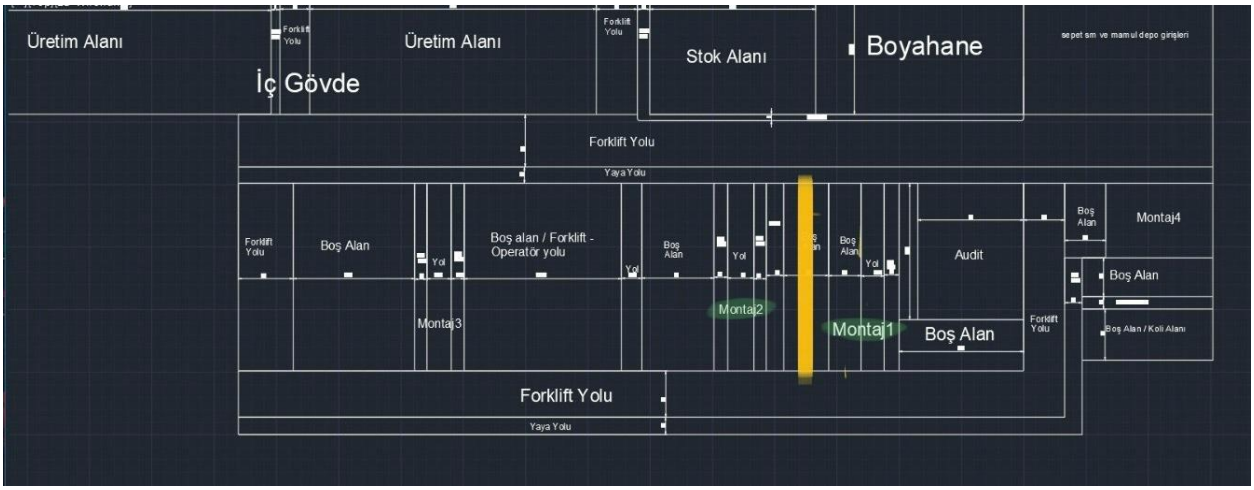


Image 5: Block plan of the manufacturing area.

Discuss the type or combinations of the types of layouts you have observed in your practice organization.

The only type of layout exhibited explicitly in the production area is the **product layout**, considering it is a group of assembly lines. One could argue that the layout also exhibits process layout by splitting the assembly lines according to dishwasher sizes, but that wouldn't be a valid reason since there are no specific departments for each operation type.

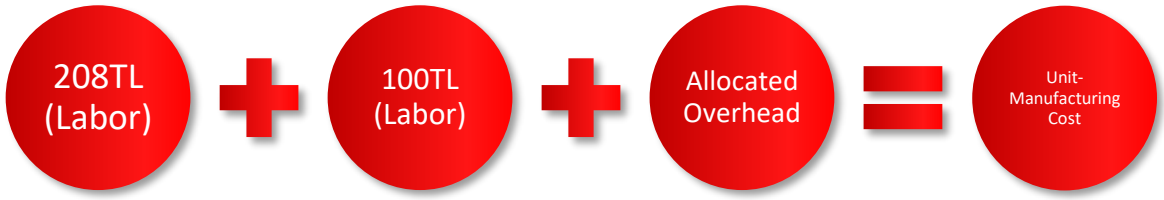
However, the offices, painting section, audit (testing) section, production section, assembly lines, and storage section are all separated, making the facility also exhibit a **process layout** in that manner. Even the office section within itself separates each department into its own block – i.e.: production engineering, finances, management, etc.

Select a typical department within your practice organization and indicate the type of layout of this department. Discuss how the characteristics of this layout type fit the characteristics of this particular department.

As discussed before, when it comes to the production area, the layout is strictly a **product layout**, since it consists of assembly lines, where the product moves from one workstation to another in a U-shaped assembly line and doesn't backtrack except at very specific workstations and when very specific defects are found. Workers stay in one place and the components are brought to them, either by other workers operating forklifts or by AGV's.

Are unit-manufacturing or unit-service costs calculated in your practice organization? If yes, explain how they are calculated and provide an example. If no, describe how expenses will be accounted for under different cost items for any one of the products/services.

Unit-manufacturing costs have been calculated; however, I was not given access to the full breakdown of the costs, which are as follows:



The allocated overhead could be calculated by considering all indirect costs, such as rent, employee salaries, cafeteria costs, power bills, water bills, transportation costs and dividing the cost across the products. The division of cost is up to the company, where the firm could consider each product of equal weight and divide accordingly or assign the bigger models more weight and the smaller models less weight and divide by the sum of the produced products times their weights and assign the overhead accordingly.

Carry out comparative ratio analysis using the balance sheets and income statements for the last two years and evaluate the financial standing of the organization. (Calculate all the necessary ratios for such analysis) or itemize titles for the balance sheet/income statement for the organization.

The balance sheet and income statements of the whole company for the years 2022 and 2021 are provided in figures 5 and 6:

	Notes	Audited December 31, 2022	December 31, 2021
ASSETS			
Current assets:			
Cash and cash equivalents	5	24,529,219	16,014,589
Trade receivables			
- Due from related parties	33	420,397	269,306
- Trade receivables, third parties	9	33,772,657	23,142,238
Derivative instruments	8	232,043	16,094
Inventories	11	29,237,120	16,828,699
Prepaid expenses	20	1,147,473	648,799
Current income tax assets	21	709,474	415,431
Other current assets	23	1,937,931	2,259,652
Total current assets		**91,986,314**	**59,594,808**
Non-current assets:			
Financial investments	6	38,956	10,531
Trade receivables			
- Trade receivables, third parties	9	42,387	45,865
Derivative instruments	8	-	19,157
Investments accounted for using the equity method	12	1,148,453	855,409
Property, plant and equipment	13	20,822,336	13,125,336
Intangible assets			
- Goodwill	15	3,781,614	2,844,448
- Other intangible assets	14	9,755,086	6,573,315
Prepaid expenses	20	612,155	186,057
Deferred tax assets	31	4,055,377	1,823,680
Total non-current assets		**40,256,364**	**25,483,798**
Total assets		**132,242,678**	**85,078,606**

LIABILITIES			
Current liabilities:			
Short-term borrowings	7	18,981,337	10,584,261
Short-term portion of long-term borrowings	7	16,248,013	2,459,839
Trade payables			
- Due to related parties	33	2,742,413	1,592,704
- Trade payables, third parties	9	28,185,125	18,076,327
Derivative instruments	8	179,692	245,292
Employee benefit obligations	22	1,638,321	775,090
Other payables			
- Other payables, third parties	10	1,756,300	1,245,608
Current income tax liabilities	31	50,265	55,292
Provisions			
- Other provisions	18	3,867,197	2,087,963
Other current liabilities	23	5,710,781	3,379,248
Total current liabilities		**79,359,444**	**40,501,624**
Non-current liabilities:			
Long-term borrowings	7	16,209,793	19,535,399
Provisions			
- Provision for employee benefits	19	2,619,763	935,609
- Other provisions	18	571,317	439,072
Deferred tax liabilities	31	2,043,930	1,528,994
Other non-current liabilities	23	4,332,751	1,082,693
Total non-current liabilities		**25,777,554**	**23,521,767**
Total liabilities		**105,136,998**	**64,023,391**

Figure 5: Balance sheet of Arçelik A.Ş. for 2023 and 2022 by the end of the second quarter for each year.

	Notes	Audited 2022	2021
Net sales	4,25	133,915,508	68,184,437
Cost of sales	26	(94,422,665)	(47,706,092)
Gross profit		**39,492,843**	**20,478,345**
General administrative expenses	26	(6,159,895)	(3,106,770)
Marketing expenses	26	(24,080,342)	(11,919,993)
Research and development expenses	26	(704,593)	(444,068)
Other income from operating activities	27	5,904,824	5,776,423
Other expenses from operating activities	27	(5,362,640)	(3,763,793)
Operating profit		**9,090,197**	**7,020,144**
Income from investment activities	28	1,523,455	316,840
Expenses from investment activities	28	(37,043)	(9,579)
Share of profit/loss of investments accounted for using the equity method	12	(69,400)	(44,514)
Operating income before financial income/(expense)		**10,507,209**	**7,282,891**
Financial income	29	7,150,100	11,309,358
Financial expenses	30	(13,439,295)	(14,969,635)
Profit from continuing operations before tax		**4,218,014**	**3,622,614**
Tax income/(expense), continuing operations			
- Taxes on expense	31	(1,002,450)	(759,496)
- Deferred tax income/(expense)	31	1,507,493	387,891
Net income		**4,723,057**	**3,251,009**
Attributable to			
Non-controlling interest		398,385	186,335
Equity holders of the parent		**4,324,672**	**3,064,674**
Earnings per share (kurus)	32	**7.048**	**4.608**

Figure 6: Income statement of Arçelik A.Ş. for 2023 and 2022 by the end of the second quarter for each year.

There are six main types of financial ratios to analyze balance sheets: liquidity, solvency, profitability, efficiency, coverage, and market prospect ratios (Bloomenthal, 2023). Each type of ratio has subtypes as well. For example, the liquidity ratio has three main subtypes: current ratio, quick ratio, and day sales outstanding ratio. For the sake of the question, only one type of subtype will be considered for each main type. So, for the documents at hand and for the year 2022, each ratio is calculated as:

1. Liquidity: $Current\ ratio = \frac{Current\ Assets}{Current\ Liabilities} = \frac{91{,}986{,}314}{79{,}359{,}444} \approx 1.159$
    - This ratio indicates that the firm has more assets than liabilities, namely, for every $1 of current liabilities, the company owns a corresponding ~$1.159 of current

assets. It indicates that the company is capable of paying its short-term obligations due within the year.

2. Solvency: $Debt - to - Assets\ ratio = \frac{Debt}{Assets} = \frac{16{,}209{,}793+18{,}981{,}337+16{,}248{,}013}{132{,}242{,}678} \approx 0.389$
   - Where:
     Debt = Long-term borrowings + Short-term borrowings + Short-term portion of long-term borrowings
   - This ratio being less than one indicates that the firm is more than capable of covering its debt, since its assets are valued at more than twice the debt does
3. Profitability: $Net\ Profit\ Margin = \frac{Net\ Income}{Total\ Revenue} \approx 0.031 = 3.1\%$
   - Where:
     Total Revenue = $\sum(all\ positive\ cash\ flows\ in\ the\ income\ statement) = 150{,}001{,}380$
   - This ratio shows a rough estimate of the percentage of revenue that is considered a profit. Of course, this ratio may never be more than 1, but this ratio shows that for every TL earned as income, almost 3.1 kurus is earned as a profit.
4. Efficiency: $Inventory\ Turnover = \frac{Cost\ of\ Goods\ Sold}{Avg\ Inventory} \approx \frac{Cost\ of\ Sales}{Invetories} \approx 3.23$
   - Note: It is assumed that the inventory stated in the balance sheet is approximately equal to the average inventory of the firm, due to otherwise lack of information.
   - This ratio achieving a number much higher than one means that the firm runs through inventory stacks multiple times per year – almost 3.23 times per year to be exact. This is a good indicator that the firm doesn't carry too much inventory relative to its sales and/or that goods in stock sell out quickly
5. Coverage: $Asset\ Coverage\ Ratio = \frac{Tangible\ Assets - [Current\ Liabilities - (Short-term\ Liabilities)]}{Total\ Debt} \approx 1.45$
   - Where:
     Tangible Assets = Total Assets – Intangible Assets
     and, Short-term liabilities = Short-term borrowings + short-term portion of long-term borrowings
   - This ratio indicates a firm's readiness to repay its debt by liquidating its tangible assets. The ratio indicates that should the firm liquidates its assets, then it would only be able to repay all its debt with around 45% of the tangible assets remaining
6. Market: $P/E\ Ratio = \frac{Market\ Value\ per\ Share}{Earnings\ per\ Share} = \frac{112\ TRY}{0.07\ TRY} \approx 1600$
   - Note: the market value per share of Arçelik was accessed from Yahoo Finance (2023).

- The extremely high P/E ratio may indicate that the market value per share could be overvalued (Murphy, 2023).

4. PRODUCTION PLANNING AND CONTROL SYSTEM

Note: Questions 4.1, 4.2, 4.5 will be tackled.

> *Discuss the forecasting activities of the firm. Identify purposes of forecasts. Provide the forecasting methods that the firm uses. Choose an example of forecasting activities and specify factors such as: the need for forecasting, sources of data or method of collecting opinions, any model used, forecast accuracy measurement and computer support in forecasting.*

The purpose of forecasting in the firm is to determine how much raw material needs to be ordered in order to prevent material and inventory buildup, and thus halting the system at large. The source of data is mainly sales and orders from abroad. The forecasting method used in the dishwashing plant is the seasonal method without a trendline, meaning that the firm has identified seasonality in dishwasher demand, which the firm has correlated with the high season of weddings. The forecast is done manually each year using Microsoft Excel. After the forecast is completed, the demand is broken down to specific SKU's and broken down further into components then into raw materials, then sent to the warehouse master, so that they can order raw material accordingly.

The exact value of the seasonal factors and the monthly demand are given to me; however, I am not sure if I have permission to share the latter. I will only be sharing the seasonal factors (table 7). The seasonal factors sum up to six instead of 12, despite representing monthly seasonality.

Month	January	February	March	April	May	June
Seasonal Factors	0.55	0.49	0.57	0.45	0.49	0.55
$2C_i$	1.1	0.98	1.14	0.9	0.98	1.1

Month	July	August	September	October	November	December
Seasonal Factors	0.54	0.54	0.56	0.55	0.61	0.48
$2C_i$	1.08	1.08	1.12	1.1	1.22	0.96

Table 7: Seasonal factors of dishwasher demand for each month of the year.

Who makes (or has made) such decisions in your practice organization? How are these decisions made?

Note: Question 4.2 split into multiple parts.

Currently, the decision of producing a new type of dishwasher or not is owned by the plant manager. The plant manager also decides whether to increase or decrease production. Recently, the plant manager has asked employees to determine the consequences of increasing the production of the Ankara dishwasher plant from the current 11,500 to 15,500. As of the end of the internship period, a stern decision has not yet been made.

What resources are scarce and subject to a production or an activity plan to exercise a tight control for their usage? Name a few of these limited resources. What are the current limits? What determines these limits?

The scarce resources are land and AGV's:

- Land: the factory is tightly packed, and every centimeter is being utilized in some way, shape, or form. The workstations and assembly lines are so close together that the workers have trouble maneuvering about, and the tiny space they have for movement is also being shared with forklifts and AGV's. The factory layout has made it difficult to expand in a reasonable way. The factory has also utilized airspace to transport parts and WIP machines as a way of adapting to the tiny space.
- AGV: the automatically guided vehicles are scarce in that adding any more may cause the system to fall apart. Since these vehicles are automatic (as the name suggests), they go on about and need a lot of space and are incredibly slow. They hinder movement of workers and workers hinder the AGV's movements as well, since they are programmed to stop or slow down in the vicinity of human beings and forklifts. Despite all that, the firm has stated that the AGV's almost get no downtime because there are not enough of them to transport materials.

What are the main concerns (like customer satisfaction, total cost, time losses, utilization rate, etc.) in allocating such resources? Is there any measurement of the extent to which these concerns are fulfilled? If yes, describe a few examples. If no, suggest some measures. Evaluate such existing (or proposed) measures.

The concern of not buying more land is mainly that the land around the plant is owned by other firms. In addition, to fix the land and space issue, it is essential to move the assembly lines, which could prove extremely difficult and costly. Increasing the space in the vertical direction – upwards – could be a solution, but it is not feasible to install machines on the second floor of a firm; the machines have to be installed on the ground floor. Thus, there is not much that can be done at a higher level than transportation of parts and components, which is something already being done.

The utilization rate of AGV's is high, since they are in high demand, but their low numbers means also that a lot of time is being lost while some parts are waiting to be moved from point A to point B. There is a team dedicated to allocating the tasks to the AGV's, aptly named the AGV Pilots and their department is called the cockpit to suit that. The cockpit is filled with camera feeds in order to monitor the AGV's every step of the way. They are also responsible for maintaining and upkeep of the vehicles. The pilots try to minimize waiting times whilst allocating the tasks to each of the AGV machines.

> *Are there organized and focused studies for the purpose of reducing such undesired "slack"? If yes, describe an example. If no, state an example of allowance or slack you have observed, that is used in the organization to assure safe (uninterrupted) operation. What do you think has caused the need for such an assurance?*

There were studies to reduce the slack of waiting times or workers, waste, transportation times, delays, etc. conducted by the IE team in the firm. Also, the production engineering team regularly performs time studies to make sure there is no slack and slag in workers' approaches to work. An example of reducing delays is a study currently being conducted in the automation department. During auditing, there is a camera that takes a picture of the dishwasher and, using a neural network, a machine determines whether there are visual defects or not. The process currently takes 9 seconds to complete, and the automation department is hoping to decrease that using software like TensorFlow.

There are also times where slack is endured because it is not preferred. An example encountered is JIT practices of reducing inventory to near-zero levels. The managers and higher-ups believe such practices are detrimental to the firm's relationships with their suppliers because it means they have to instill many restrictions and criteria on the suppliers' deliveries, in addition

to having the inventory buildup at the suppliers' ends. As such, the dishwasher plant has decided to tolerate the inventory build-up slack for the sole purpose of keeping their relationships with their suppliers in

5. QUALITY PLANNING AND CONTROL SYSTEM

Note: Question 5.1 will be tackled.

> *Choose a product/service and explain how the organization defines quality of it. How are customer requirements translated into product or service specifications (or characteristics)? Provide examples. Also describe the quality control activities that take place throughout the life cycle of that product/service.*

The organization defines quality as the amount of calls the customer support receives on that product. No matter what the call content is, even if it is a "customer asking about powering the machine," quoting one of the quality engineers, the call content is counted and inserted into a database. After that, the quality department runs control charts to determine if there is an increase or decrease (shift) in the number of calls for each product and to remove outliers as well.

On top of that, they also filter the calls by which part of the dishwasher it relates to. If there are more calls about a certain part which is breaking, needs repairs, or is unclear on how to use, then a QA/QC operation is launched for that certain part.

In addition, during auditing if there are any faults caught, the type of fault is determined and logged. If a certain fault is being caught more than the others at a statistically significant level, a QA/QC operation is launched.

A more in-depth example is water leakage, where many customers were reporting water leaks from their dishwashers. A QA/QC operation was launched in order to decrease the water leakage.

6. MANAGEMENT INFORMATION SYSTEM

Note: All questions will be tackled.

> *Specify the decision makers (individual or group, their positions within the organizational structure) and the related subject of decision making with regard to one decision making activity in each of these decision levels.*

There are multiple decision makers at each level even within a manufacturing plant itself:

Starting from the bottom, there are less experienced individual employees who take decisions in completing the tasks allocated to them and how to approach these tasks. The employees usually consult each other about individual tasks and frequently ask each other to complete tasks that aren't within their own domains.

Then come the department heads who direct the department, employ growth projects, and look for gaps in the jobs. The department heads coordinate with one another if the need arises. They also hold meetings with other firms more frequently than most other employees.

Higher than that comes the plant manager, who is a C-level manager. They steer the helm of production and monitor all departments to make sure everything is working smoothly. They also work on keeping and establishing relationships with suppliers and take part in C-level meetings. They also communicate directly with the board of directors of the firm and pass on the orders from higher up. The plant organization structure is shown in figure 8:

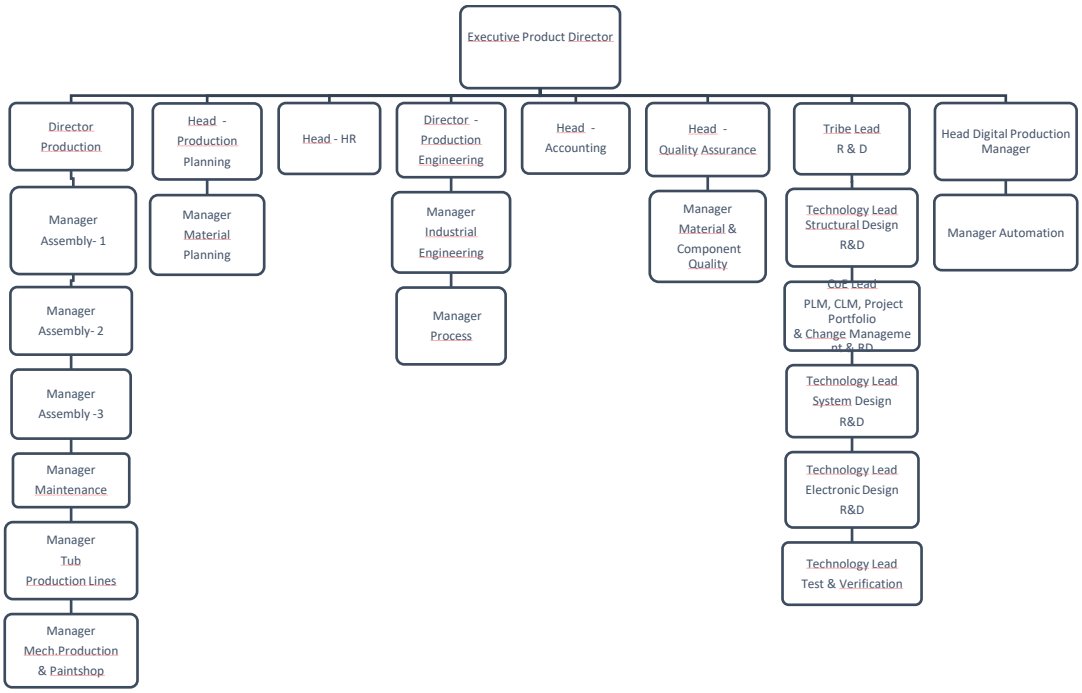


Figure 8: Organization structure of the firm.

I didn't get a chance to meet any B-level or A-level managers, but I assume that instead of deciding on micro-problems, they take part in decisions that affect the whole company and meet with country representatives sometimes.

> *Identify the computer system (computer networks, stand-alone PC's, workstations, main frames, etc.) their types and approximate capacities in use and their spread (functions or departments with extensive or low computer support in their operations) in your practice organization. Take a particular division or department that has access to a computer (as a system, as connected to a network or as a stand-alone computing facility). Itemize types of data recorded and processed. Discuss the level of decision supported in light of section 6.1 above. What is decided based on that specific data?*

> *Identify the software used in the firm. Name a few application programs available in the organization for enterprise-wide application (Enterprise Resource Planning (ERP), reservation system, stock keeping, accounting etc.) except standard office programs (word processors, spreadsheets, presentation organizers). Discuss the level of decision supported in light of section 6.1. Give an example of what is performed based on that specified software.*

Note: Questions 6.2 and 6.3 will be merged.

The ERP system used is SAP, which connects many aspects of the firm and makes everything almost reachable with ease. Everything from the employees' outputs, produced parts' serial numbers, number of errors, inventory, intellectual property, and more are saved on the cloud. All the employees have access to the software.

Moreover, the workers' output is also tracked using the same software; the workers ID's are associated with the serial numbers of the parts that they have worked on. The SAP ERP, with the help of some sensors and cameras on the production line, is able to "know" at which stage a product became defective. Knowing this, the firm is able to know which worker was working on a piece when it became defective and may start auditing the worker as need be.

The SAP also helps in controlling the three-axis mechanical arms, as well as the presses and many automatic machines, to some extent. The SAP also logs any defects that have been

found during auditing, and this log can be accessed later. If many customers call about certain defective products and give the serial numbers of their products and the quality department notices that the same defect occurred during auditing, then it is an indicator that the post-auditing maintenance team is doing something incorrectly.

The SAP software also connects the firms warehouses to the plants, and the employees can access the inventory levels whenever needed.

Other than SAP, other software is used to supplement data to SAP or process the data from SAP. Other than the obvious Microsoft Office suite of applications, some plants use software like TensorFlow for image analysis. Also, on the production line, there are many software applications being used that are either being fed data and/or feeding data from and to SAP.

Such interconnected software enables managers to access whatever data they require at any point and enables any employee to access data (that they are authorized to access) without the need for going to another employee, department, or even another plant. In short, it has made the job of accessing and analyzing data much easier and faster.

On a final note, there are multiple in-house software or adopted software and even lesser-known ones that have secondary objectives that are not strictly necessary for the firm's operations. These include, but are not limited to, a newspaper for ChatGPT and other AI-related news, a social media app for Koç employees to meet and greet one another, and some apps related to enhancing employees' mental health.

7. WORK STUDY

Note: Question 7.1 will be tackled.

> *Apply one of the work measurement techniques (stopwatch, predetermined time standards or work sampling, etc.) to either:*
>
> *a) a member of the office staff, or*
>
> *b) an assembly operator, or*
>
> *c) one or more machine operators, or*

d) any routine manual task operator

and evaluate the results. Apply method study to define more effective methods.

A time study has been conducted on the worker responsible for loading the dishwasher with the shelves. The time between the dishwasher arriving at the workstation of the worker and the worker finishing loading the shelves is measured using a stopwatch and recorded. This has been done 15 times and is available in table C1 (appendix C). The average is 10.34 seconds with a standard deviation of 1.13 seconds. To find out whether the observation amount is enough to determine the working time with 95% confidence level and within 10% of the real value:

$$z_{\frac{\alpha}{2}}\frac{\sigma}{\sqrt{n}} = 10\%\,\bar{x} \rightarrow n \geq \left\lceil \left(\frac{z_{0.25}\sigma}{10\%\,\bar{x}}\right)^2 \right\rceil \approx \lceil 4.59 \rceil = 5$$

Since the number of observations is much more than five, it is safe to assume that the working time is somewhere around 10.34 seconds with 95% confidence level and 10% margin of error. The cycle time is around 12.5 seconds as determined by the firm itself.

The firm also uses a formula in order to measure the productivity of each workstation, called productivity level, V, for workstation w, is:

$$V_w = \frac{working\ time\ for\ workstation\ w}{cycle\ time}$$

For the workstation at hand the productivity level is around 82%, which can be further increased without exceeding the 100% mark. The process chart is in table 9:

Process Description	*Event Symbol*	*Time (min)*	*Notes*
Open Door		0.5	
Grab Cloth		0.3	
Clean Interior using Cloth		2.3	In order to prevent dust from entering the crevices and holes
Place Cloth Away		0.3	Includes short inspection
Grab Top Shelf		1.3	Worker doesn't need to move about; the shelf storage is next to them
Transport Shelf		0.8	Transport from WIP storage to its place
Insert Top Shelf		1.2	
Grab Bottom Shelf		1.3	Worker doesn't need to move about; the shelf storage is next to them
Transport Bottom Shelf		0.8	Transport from WIP storage to its place
Insert Bottom Shelf		1.2	
Close Door		0.5	
Wait until Cycle is Over		2	Could also be float for other operations
Total		12.5	

Table 9: Current process chart of the shelf-installation task.

One thing to note is that all tasks require both hands, however it is possible to have the worker use both of their hands for different tasks each and utilize a machine/contraption to be more productive. The worker could be given an overhanging machine that is being loaded (automatically) with both shelves and is then pushed by the worker for the shelves to be placed in. The automatic loading of the shelves is easily done since there are already rails on the shelves and there are no screws to be used.

This would allow the worker to have more than enough time to undertake another task for the remainder of the cycle time. If an overhanging part is to be used together with differentiating the left- and right-hand tasks, then the process could be similar to the one in table 10:

Left Hand	*Time*	*Time*	*Right Hand*
Open Door	0.5	0.3	*Grab Cloth*
	(2.1)	2.3	*Clean interior*
Grab overhanging part	0.5	0.3	*Return Cloth*
Push downwards to dishwasher	1	(1.2)	
Fixate bottom shelf in its place	0.2	0.2	*Fixate top shelf in its place*
Raise overhanging part	0.5	0.5	*Grab door handle and close door*
Total	5.4	5.4	*Total*

Table 10: Left-Right hand chart.

For the remainder of the cycle time, which is about 7.1 seconds, the worker could be given another task and thus less workers will be needed, overall.

8. CONCLUSION

Note: Question 8.1 split into multiple parts.

> *Is the procedure you have followed in this summer practice sufficient in its scope, method and general approach? If not, identify the drawbacks. State your suggestions for an improved procedure. If you have found it sufficient, state what you enjoyed most about it. What was the most difficult part in your study of a potential IE problem?*

I believe that the summer practice manual focuses more on observations than actual work, and understandably so. For those who were given projects to work on during their summer practice, doing the observations, writing them down, and analyzing them took too much time, overall.

> *If you had another four weeks in the same firm, what would you be occupied with and why?*

I would probably be given another project, related to production planning, and would be working on it.

> *What do you expect to learn in your future training as an industrial engineer that will help improve your understanding of production systems? How can you further develop your capability of handling problems of these systems?*

I expect to learn more about the humans' interactions with machines and expect to dive more into this subject, since we learned a lot about the technical part of the socio-technical systems that IE's usually deal with.

> *Drawing on your experience of this practice, discuss the differences between industrial engineering and other engineering disciplines with respect to their responsibilities and ways of approaching their duties in the production environment*

As I have said in the previous summer practice manual, IE's usually deal with the system as a whole and do not care about the specific system components at a deep level. We care more about the system interacting with itself than with the individual parts of the system.

> *If industrial engineers are employed by the firm, what are the areas they work in? If no industrial engineer is employed, what activities (if any) do you think are suitable for IEs in your practice organization? Discuss top management's impression and attitudes towards industrial engineering functions and activities.*

IE's are employes everywhere from R&D to production planning to production engineering to a specific department called Industrial Engineering. The top management think that the IE's jobs are necessary and without them, the work and the huge scale employed by the company could not be pulled off otherwise.

> *You are required to fill out the online questionnaire on the website www.ie.metu.edu.tr/~sp. The questionnaire should be filled out by the submission date of your summer practice report. Otherwise, your report will be considered incomplete.*

-

PROBLEM FORMULATION

Two big problems the firm has been dealing with are expanding production from 11,550 units per day to 15,500 units per day and the AGV problem. Both problems are still in the study phase; however, the former problem is very recent, and no deep studies have been conducted yet, so I will be tackling the latter problem in its dimensions.

Short description of AGV (Automated Guided Vehicles): the firm uses two types of AGV's in order to transport some materials around the plant; one is used to transport huge mobile shelves that hold dishwasher shelves in the dozens, and the other is used to transport smaller carriages that can contain multiple types of raw and WIP material. They are led by a team called AGV Pilots and the department is called the Cockpit. The AGV's automatically navigate about the facility once given the tasks by the pilots. Each AGV is dedicated to an assembly line where an AGV is assigned tasks that are related to only one of the assembly lines. Currently, only assembly lines M1 and M3 utilize AGV's, whilst the others do not.

Problem identification: AGV's are always in demand, late, and their utility rates are high, but productivity rates are low. The causes are displayed in the fishbone diagram below (figure 11).

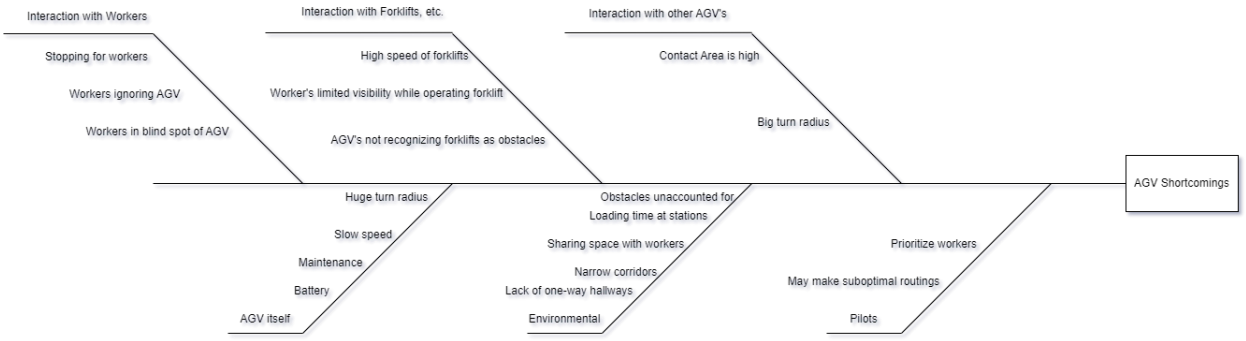


Figure 11: Fishbone diagram of the causes of the AGV problems.

Most of the causes of the problem are necessary – such as prioritizing safety of workers and the AGV's slow speed – or unavoidable – such as suboptimal routings or battery life. One thing to note is that the firm has stated that they have a good number of AGV's and the solution doesn't lie in increasing that number; the problem is more deep than that.

The decision maker is the manager of the plant, ultimately. However, he consults the department heads in order to determine the best course of action. The related departments are the production planning department, the production engineering department, industrial engineering department, automation department, and production department.

In order to analyze the level of deficit in performance, using a standard utilization rate isn't sufficient as it doesn't tell the whole picture, since the utilization rates are high. Moreover, using an efficiency measure is likely to not be very intuitive since the input and output are hard to measure and quantify. Plus, it is not easy to measure the cost savings of the AGV's compared to just using a worker to do the same tasks, as the tasks' monetary value is difficult to pinpoint, especially when considering that different tasks have a different volume, scale, time, urgency level, and automatability. Instead, another measure will be used: autonomous percentage.

The autonomous percentage is basically the measure of how much the AGV has traveled in a day divided by the maximum distance it can travel in perfect conditions: no breaking, no obstacles, no waiting, no delays, no breakdowns, etc. This maximum distance has been calculated by multiplying the number of seconds in a day, excluding breaks, with the speed of AGV's.

$$\%Auto = \frac{d_{traveled}}{d_{max}} = \frac{d_{traveled}}{v_{AGV} \times t_{day}} = \frac{d_{shift}}{v_{AGV} \times t_{shift}}$$

From the past data, the autonomous percentages have been determined to be 24.51% and 25.48% for assembly lines M1 and M3, respectively (table 12).

Assembly Line	M1							M3						
AGV Number	1	5	6	11	13	17	18	4	8	9	10	15	16	19
Distance	31,015	29,337	30,044	30,265	28,960	30,664	30,776	27,703	25,168	3,353	29,716	30,194	28,676	31,372
%Auto	30%	28%	29%	29%	28%	30%	30%	27%	25%	4%	29%	29%	28%	30%

Table 12: %Autonomation for each AGV currently operating.

There are multiple possible solutions to this issue. One is opening a hallway between assembly lanes M1 and M2 specifically for AGV's so that they do not get blocked on their way to M1 from the loading station and back. The potential improvements are estimated as 2 minutes

of productive time for the M1 AGV's, which translates to an overall enhanced autonomous ratio of 35%.

Currently, when AGV's are depositing their load that is placed in a basket, the AGV has to wait for a worker to unload the basket, then have the AGV move back with the basket later. Instead, the AGV could deposit the entire basket and its load and when going back to the loading station, the load is placed in a basket already, which further decreases loading time. Then, the AGV responsible for transporting back to the unloading station also transports the load and the basket is removed with the load altogether at the unloading station. The autonomous ratios could improve to 55% and 65% for assembly lines M1 and M3, respectively. Note: the calculations are based on waiting times at the loading/unloading stations and workstations.

Another, less tangible solution is to educate the workers more about how AGV's operate and perform proactive maintenance.

As far as now, no solution has been implemented, the problem is still in the study phase.

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APPENDIX A

Picture A1: A sample from a brochure about the products offered at Arçelik.

Picture A2: A sample from a brochure about the products offered at Arçelik.

APPENDIX B

Inputs	
TOZBOYA (ARC 729)	0.60x663x559 AISI 430 FIRCALI IZSIZ
PA11-Ral7016-Coating (GRIS 7452 _ 9.8132	0.60x712x709.5 AISI 430 (PARMAK IZSIZ)
304 0_40 X275 MM PERFORE SAC R0_8 T1_75	0.80X128XRULO DX51+Z075A
POM-TF20-NAT-I-HB	0.70_602_RULO DX51+Z075A
0.50X840.5X RULO DX51D+100A	0.70_477_RULO DX51+Z075A
1.00x280 _RULO_DX51D+Z101A	1.00*286*RULO DX51D+Z075A
0.5X840.5X565.5 DX51D+100A	BE50
0.80x470xRULO AISI 430-BA	PPHO-NAT-I-V0+GWT850
0.6x734.5x795.4-430 FIRCALI iZ KALMAYAN	PPHO-NAT-I-HB
0.6x734.5x795.4-DC01	PC-Toz-Fume-MB
0.6x734.5x795.4-Dark Inox	PPHO-NAT-I-HB-TR
0.40x795xRULO AISI 304-BA	PPHO-NAT-I-HB
0.40x560xRULO AISI 430-BA	PA66-BLK-I-GF30-HB-HS-HR
0.40x590xRULO AISI 430-BA	PPCO-NAT-I-HB-HG-FDA
0.40x729xRULO AISI 304-BA	POLYAR GRI MASTERBATCH
0.50x144xRULO AISI 304-BA	MB-ABS-P1-WH-UV
0.50x625xRULO DX51D+Z101A	TG13 T.AYD K.FAN CMI RUL CKS K.ACM M.KRT
0.50*831*RULO DC 01	TG15 T.AYD FAN CMI CKS Yeni K.ACMA
0.80x196x573 AISI 430 FIRCALI BOB	ATLANTIS KENETLI GOVDE GR MAKARALI
0.50x120x860 AISI 430 FIRCALI PAR.IZSIZ	ATLANTIS KENETLI GOVDE GR MAKARALI TG3
0.80x196x573 DC01	Atlantis ic govde C prc fansiz
0.60x635x684 AISI 430 FIRCALI SAC	Atlantis ic govde C prc fansiz CMI
0.70_708.2_808.2 AISI 304 FIRCALI SAC	POSEIDON KENETLI GOVDE GR 45CM
0.50x500xRULO DX51D+Z101A	Poseidon ic govde ust parca 45cm t.ayd.
1.00_73.6_RULO DX51D+Z075A	Poseidon ic govde ust parca 45cm
0.60x224R 304-BA	Poseidon ic govde C prc fan emis yok
0.60_630_552 DC 01	Poseidon ic govde C prc fan emis var
3.00x72xR DX51D	ALUMINYUM SARGILI TAHLIYE MOTORU
0.4x120x500 AISI 304-BA	5V DC LED Karti
0.60x153x725 DC01	12V DC LED Karti
0.40x175xR AISI 304-BA	6V AC LED Karti
2.00x176.5x RULO DX51D+Z450A	KENET YAPI PARCA BIT.FANSIZ TK.SUZ
0.60x600x900 AISI 304 FIRCALI AFP	KENET YAPI GR.TAM BITUM
0.60X663XRULO DC01	KENET YAPI GR.PAR BITUM FAN
KENET YAPI GR.PARCA BITUM FAN2	KENET Y.GR.PAR BIT.FAN2 ALT 4 mm ARKA 3
KENET YAPI GR. TAM BIT 04 FAN2	

Table B1: Detailed list of inputs for the ~60 types of dishwasher models.

Output	
YMESE ASENKRON T14 ANA KART GR	Tam ankstre 80mm prtl panoE8-E9 MBGrayYK
YMESE T8 ANA KART GR	Tamankstre 80mmprtlpanoE8-E9 MBGrayYK PL
YMESE T3 ANA KART GR	Tam ankastre 80mm prtl pano E8-E9 ARC 54
YMESE ASENKRON T12 ANA KART GR	Tamankstre 80mmprtlpanoE8-E9-E11 MBGray
D114861 ANA KART GR	Tam ank.portal 80mm E10 pano arc542(PL)
D114954 ANA KART GR	Tam ankastre 80mm pano E10 MB Gray YK
GIY.DISKAPI CAMI BASKILI ARC(Mah Brown)	Ank. kaynaksiz kapi panosu 598mm siyah
E5 Fonksiyon tusu GRUNDIG F3 BLACK	Cornerwash alt pervane gr. Ral7037
E5 Fonksiyon Tusu GRUNDIG F3 - ARC 745	Beko17 kaynksz kapi ahsap destek parcasi
E5 Fonksiyon Tusu GRUNDIG F3 - ARC1050	Karbonfiber kapi ahsap destek parcasi
E5 Program Tusu GRUNDIG-EN-BLACK	Thincut logo Beko_ALT
ATLANTIS UST PERVANE BORUSU GR.	Thincut logo Arcelik_ALT
BITRON DETERJAN KUTUSU GR AC BESLEME	Thincut logo Beko_UST
BITRON DET. KUTUSU GR AC BES. ARC CONTA	Thincut logo Arcelik_UST
BITRON DETERJAN KUTUSU GR 110V 60HZ	Onden takip inlay siyah
Atlantis tavan cks Grundig2 kaplamali	B18 DISPLAY ON PARCA GR ABS SIYAH ARC716
Atlantis t. cks Grd2 Ral7016 kaplamasiz	B18 DISP. ON PRC GR ABS V0 SIYAH ARC716
EU3 BEKO UST SEPET RAF GR.RAL7037	B18 DISP. ON PRC GR ABS SIYAH ARC716 E9
D1 B6 display kart tut arka PC ABS V0	B18 DISP. ON PARCA GR ABS MALBIS P2B5 B8
D1 B6 display kart tut arka PPO V0	DEEP WASH SISE TUT KLIPS GR EU RAL7016
EU3 MEKANIZMA GRUBU SOL MOR	Deep wash yatar tel tutucu parca
EU3 MEKANIZMA GRUBU SAG MOR	TEPSI TUTUCU GR RAL 7016
EU3 MEKANIZMA GRUBU SOL BORDO	DEEP WASH ZONE PER. GR KOMPLE MAVI
EU3 MEKANIZMA GRUBU SAG BORDO	BEYOND BU CAM KAPI GR Beyaz
EU3 MEKANIZMA GR. SOL SU ALTI MAVI	BEYOND BU CAM KAPI GR Siyah
EU3 MEKANIZMA GR. SAG SU ALTI MAVI	BEYOND BU CAM KAPI GR Manhatten
EU3 MEK. GR. SOL MOR BILYELI TEKER	INLAYLI PANO GRUBU
EU3 MEK. GR. SAG MOR BILYELI TEKER	INLAYLI PANO GRUBU
EU3 MEK. GR. SOL BORDO BILYELI TEKER	Tam ank. portal pano arc1025 mb gray(PL)
Tam ank. portal E10 pano arc1025 mb gray	Tam ankstre 80mm prtl pano E8-E9 SiyahYK
Tam ank.portal E10pano arc1025mbgray(PL)	Tam ankstre80mmprtlpano E8-E9 SiyahYK PL
Tam ank. portal pano arc1025 mb gray	Tam anks 80mm prtl E8-E9 SiyahYK 542 PL
Tam ank. portal pano arc1025 mbgray(PL)	

Table B2: Detailed list of outputs, which includes parts and components.

APPENDIX C

Times				
10.84	12.91	9.87	10.7	9.39
11.38	9.92	10.56	11.04	8.84
10.51	11.1	10.55	8.5	9.03

Table C1: Values of the 15 measurements used for the time study.