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Mini Oreo Cup Production Plan with Aggregate Method to Minimize Production Costs

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A B S T R A C T

Manufacturing companya PT.Sinar Jatimulia Gemilang produces many types of plastic packaging, one of which is mini oreo cups.The production system in this company is based on job shop, changing product demand and limited product capacity make it difficult for the company to make a productin plan. The purpose of this research is to make a mini cup production plan to meet future demand with the aim of minimize production costs. At the initial stage a field study was conducted to obtain to required data. The data obtained through interviews with production employees from the company. Then do the literature study through books and articles from related journal as the theoretical basis used in this research. Production planning research using exponential smoothing forecasting method with α=0.6 and standard error of 617814.3 was selected with the criteria of the smallest mean square error and aggregate planning.The result of analysis I strategy of inventory level inventory cost is IDR. 441,654,900. In analysis II the strategy for variation in the number workers costs is IDR. 747,373,500. The cost for analysis III subcontracting strategy is IDR. 79,065,843,000. From the research that production cost before the calculation is IDR. 52,002,000,000 and the number of workers is 4. After the result of the research on optimization the number of workers that will be used by 2 .

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1. INTRODUCTION

Scheduling issues frequenly occur concurrently with the limitations of a set of task that must be completed with a finite number of machine or machine facilities and accessible production facilities (Safitri, 2019)(Aris et al., 2014).Minimizing the total time required to complete a series of jobs is one the efforts made to ensure customer satisfaction. The production process scheduling has two type of operations are flow shop scheduling where the machine order is different for each job, and job shop scheduling where the machine order is according to various manufacturing stages. Based on how it performs where the production eguipment be placed? (Juliantara & Mandala, 2020).

PT. Sinar Jatimulia Gemilang produces a variety of plastic packaging types. Including the mini oreo cup. This manufacture system is based the job shop, there for the product produced are orders from clients whose marketing department is responsible for fulliling that order (Nirwana & Setyawan, 2019). The PPIC division processes incoming orders to determine whether raw materials are required. The First Come First Service (FCFS) system ensures that the orders received first eill be fullfield first (Safitri, 2019).Based on experience from previous production the company difficulties in planning production in order to meet cusmoter needs. To overcome this problem in this research aggregate planning is used to minimize production costs and exponential smoothing forecasting method is use to determine changing demand data (Evans, JR, DR Anderson, DJ Sweeney, 1990)
The objectives of this research are planning production aggregates to minimize production cost. Determine changing demand patterns with the right forecasting method (Rosero-Mantilla et al., 2017)

2. LITERATURE REVIEW

Production planning can be define as a process for producting goods in a certain period according to what is predicted or schedule through organizing resources such as labor, raw materials, machines and other equipment (Buffa.S.elwood., 1996). The choice of the forecasting model depends on the data pattern and the time horizon of the forecasting . Forecasting models are basically divided into three categories , namely consideration, extrapolation and causal (Reicita, 2020)

Forecasting is an important tool in effective and efficient planning which estimate the level of product demand in a certain period of time in the future (Meutia et al., 2019). The exponential smoothing method is a moving average method that gives a stronger weight to the last data. The formula used is the simple exponential smoothing method(Taylor, 2004),namely

$$Ft = F_{t-1}\,\alpha\,(A_{t-1} - F_{t-1})$$

Where:
Ft = forecast for time period t
α = smoothing constant ($0 < \alpha < 1$
A_{t-1} = real value of period t-1
F_{t-1} = predetermined forecast for the current period.

Forecast result that have good accuracy will affect the effectiveness of production. In addition accurate forecasting will give satisfaction to customer service (Sudiman, 2020)
According to Heizer (Heizer, J., 2015) the accuracy of the forecasting method is used as an indication of how far the forcasting model produces known data, which consist of :

a. Mean Absolute Deviation (MAD) a forcasting method using the number of absolute errors.

$$\textbf{MAD} = \sum \frac{(\,\boldsymbol{actual - forcat}\,)}{\boldsymbol{n}}$$

b. Mean Square Error (MSE), this method yields a moderate error which is probably for small errors

$$\textbf{MSE} = \sum \frac{(\,\boldsymbol{actual - forecast}\,)\ \mathbf{2}}{\boldsymbol{n}}$$

c. Mean Absollut Percentage Error (MAPE)indicates how big the error in forecasting is compared to the real value.

$$\textbf{MASE} = \sum (\frac{(\boldsymbol{actual - forecast})\boldsymbol{x}\ \mathbf{100})}{\boldsymbol{actual}} / \boldsymbol{n}$$

According to Gaspersz (Gasperz, 2017), the are three fundamental approaches to aggregation planning :

a. Analysis I strategy for variations in inventory levels by maintaining a constant average production level and saving excess production in certain month to be used in other month that experience excess demand
b. Analysis II of the strategy for variations in the number of workers by adding or reducing the number of workers according at the beginninga and end of the period, the number of workers must be kept the same
c. Analysis III subcontracting strategy, in this analysis the number of workers is determined according to the needs for the lowest level of demand.

3. RESEARCH METHOD

The research methodology used is exponential smoothing forecasting and aggregate planning. This research is to minimize production costs and much needed by the company for production planning (Gaspersz, 2011). At the initial stage, a field study was conducted to obtain the required data. The data obtained through interviews with production employees from the company. Do a literature search of books and journal articles related to the reseach's theoretical basis after that. Then identify the problems that occur, followed by formulating the problem for this research.

4. RESULT AND DISCUSSION

In forecasting it takes past data from the demand for mini oreo cups in the previous year. The deman for mini oreo cups in 2019 and 2020 is shown in table 1 below. With the exponential smoothing method where $\alpha = 0.6$, $\alpha = 0.9$ and moving average (N) = 3 and Naïve method.

Table 1. Data on demand for Mini Oreo cups for 2019 and 2020

Month	Demand Forecast 2019 (pcs)	Number of working days	Demand Forecast 2020 (pcs)	Number of working days
January	1,098,600	20	1,508,700	22
February	1,509,000	19	1,752,300	20
March	1,698,900	20	2,356,400	21
April	1,607,700	20	2,566,500	21
May	620,400	21	2,248,500	14
June	460,200	18	1,748,400	21
July	1,721,700	23	1,630,500	22
August	1,737,300	22	2,109,300	19
September	884,400	21	1,163,100	22
October	2,266,500	23	1,236,000	21
November	2,094,000	20	1,921,800	21
December	2,027,700	17	701,700	19
Total	17,726,400	244	20,943,200	243

Table 2. Data on aggregate planning costs

Labor cost (person/day)	IDR 103,500
Inventory holding costs (pcs/month)	IDR 100
Subcontracting marginal cost (pcs)	IDR 50,000
Cost of additional labor (per person)	IDR 103,500
Labor reduction costs (per person)	IDR 103,500
Working hours per day	24
Average production (per pcs)	8 hrs /person
First inventory	0
Number of workers at the beginning of the period	4
Number of employees at the end of the period	4

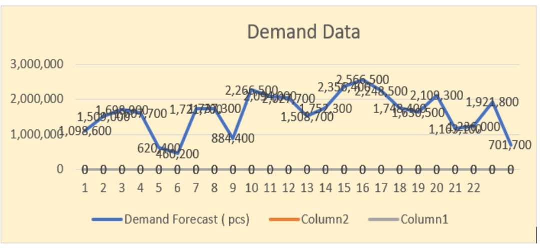

Fig. 1. Demand data pattern

Table 3. Forecasting calculation using exponential smoothing $\alpha = 0.6$

	Demand(y)	Forecast	Error	|Error|	Error^2	|Pct Error|
January	1098600					
February	1509000	1098600	410400	410400	1.68428E+11	27.20%
March	1698900	1344840	354060	354060	1.25359E+11	20.84%
April	1607700	1557276	50424	50424	2542580000	3.14%
May	620400	1587530	-967130	967130.4	9.35341E+11	155.89%
June	460200	1007252	-547052	547052.1	2.99266E+11	118.87%
July	1721700	679020.9	1042679	1042679	1.08718E+12	60.56%
August	1737300	1304628	432671.6	432671.6	1.87205E+11	24.91%
September	884400	1564231	-679831	679831.4	4.62171E+11	76.87%
October	2266500	1156333	1110168	1110168	1.23247E+12	48.98%
November	2094000	1822433	271567	271567	73748640000	12.97%
December	2027700	1985373	42326.75	42326.75	1791554000	2.09%
January	1508700	2010769	-502069	502069.3	2.52074E+11	33.28%
February	1752300	1709528	42772.25	42772.25	1829465000	2.44%
March	2356400	1735191	621208.9	621208.9	3.85901E+11	26.36%
April	2566500	2107917	458583.5	458583.5	2.10299E+11	17.87%
May	2248500	2383067	-134567	134566.5	18108140000	5.99%
June	1748400	2302327	-553927	553926.5	3.06835E+11	31.68%
July	1630500	1969971	-339471	339470.6	1.1524E+11	20.82%
August	2109300	1766288	343011.8	343011.8	1.17657E+11	16.26%
September	1163100	1972095	-808995	808995.3	6.54473E+11	69.56%
October	1236000	1486698	-250698	250698.1	62849550000	20.28%
November	1921800	1336279	585520.8	585520.8	3.42835E+11	30.47%
December	701700	1687592	-985892	985891.8	9.71983E+11	140.50%
TOTALS	38669600		-4238.75	11535030	8.01559E+12	967.81%
AVERAGE	1611233		-184.294	501522.8	3.48504E+11	42.08%
Next period forecast		1096057	(Bias)	(MAD)	(MSE)	(MAPE)
				Std err	617814.3	

Table 4. Forecasting calculation using Exponential Smoothing α = 0.9

	Demand(y)	Forecast	Error	|Error|	Error^2	|Pct Error|
January	1098600					
February	1509000					
March	1698900					
April	1607700	1435500	172200	172200	29652840000	10.71%
May	620400	1605200	-984800	984800	9.69831E+11	158.74%
June	460200	1309000	-848800	848800	7.20461E+11	184.44%
July	1721700	896100	825600	825600	6.81615E+11	47.95%
August	1737300	934100	803200	803200	6.4513E+11	46.23%
September	884400	1306400	-422000	422000	1.78084E+11	47.72%
October	2266500	1447800	818700	818700	6.7027E+11	36.12%
November	2094000	1629400	464600	464600	2.15853E+11	22.19%
December	2027700	1748300	279400	279400	78064360000	13.78%
January	1508700	2129400	-620700	620700	3.85269E+11	41.14%
February	1752300	1876800	-124500	124500	15500250000	7.11%
March	2356400	1762900	593500	593500	3.52242E+11	25.19%
April	2566500	1872467	694033.3	694033.3	4.81682E+11	27.04%
May	2248500	2225067	23433.5	23433.5	549128900	1.04%
June	1748400	2390467	-642067	642066.8	4.1225E+11	36.72%
July	1630500	2187800	-557300	557300	3.10583E+11	34.18%
August	2109300	1875800	233500	233500	54522250000	11.07%
September	1163100	1829400	-666300	666300	4.43956E+11	57.29%
October	1236000	1634300	-398300	398300	1.58643E+11	32.23%
November	1921800	1502800	419000	419000	1.75561E+11	21.80%
December	701700	1440300	-738600	738600	5.4553E+11	105.26%
TOTALS	38669600		-676200	11330530	7.52525E+12	967.94%
AVERAGE	1611233		-32200	539549.2	3.58345E+11	46.09%
Next period forecast		1286500	(Bias)	(MAD)	(MSE)	(MAPE)
				Std err	629337.6	

Table 5. Calculation using the moving average method (N=3 month)

	Demand(y)	Forecast	Error	|Error|	Error^2	|Pct Error|
January	1098600					
February	1509000					
March	1698900					
April	1607700	1435500	172200	172200	29652840000	10.71%
May	620400	1605200	-984800	984800	9.69831E+11	158.74%
June	460200	1309000	-848800	848800	7.20461E+11	184.44%
July	1721700	896100	825600	825600	6.81615E+11	47.95%
August	1737300	934100	803200	803200	6.4513E+11	46.23%
September	884400	1306400	-422000	422000	1.78084E+11	47.72%
October	2266500	1447800	818700	818700	6.7027E+11	36.12%
November	2094000	1629400	464600	464600	2.15853E+11	22.19%
December	2027700	1748300	279400	279400	78064360000	13.78%
January	1508700	2129400	-620700	620700	3.85269E+11	41.14%
February	1752300	1876800	-124500	124500	15500250000	7.11%
March	2356400	1762900	593500	593500	3.52242E+11	25.19%
April	2566500	1872467	694033.3	694033.3	4.81682E+11	27.04%
May	2248500	2225067	23433.5	23433.5	549128900	1.04%
June	1748400	2390467	-642067	642066.8	4.1225E+11	36.72%
July	1630500	2187800	-557300	557300	3.10583E+11	34.18%
August	2109300	1875800	233500	233500	54522250000	11.07%
September	1163100	1829400	-666300	666300	4.43956E+11	57.29%
October	1236000	1634300	-398300	398300	1.58643E+11	32.23%
November	1921800	1502800	419000	419000	1.75561E+11	21.80%
December	701700	1440300	-738600	738600	5.4553E+11	105.26%
TOTALS	38669600		-676200	11330530	7.52525E+12	967.94%
AVERAGE	1611233		-32200	539549.2	3.58345E+11	46.09%
Next period forecast		1286500	(Bias)	(MAD)	(MSE)	(MAPE)
				Std err	629337.6	

Table 6. Naive method calculation

	Demand(y)	Forecast	Error	|Error|	Error^2	|Pct Error|
January	1098600					
February	1509000	1098600	410400	410400	1.68E+11	27.20%
March	1698900	1509000	189900	189900	3.61E+10	11.18%
April	1607700	1698900	-91200	91200	8.32E+09	5.67%
May	620400	1607700	-987300	987300	9.75E+11	159.14%
June	460200	620400	-160200	160200	2.57E+10	34.81%
July	1721700	460200	1261500	1261500	1.59E+12	73.27%
August	1737300	1721700	15600	15600	2.43E+08	0.90%
September	884400	1737300	-852900	852900	7.27E+11	96.44%
October	2266500	884400	1382100	1382100	1.91E+12	60.98%
November	2094000	2266500	-172500	172500	2.98E+10	8.24%
December	2027700	2094000	-66300	66300	4.4E+09	3.27%
January	1508700	2027700	-519000	519000	2.69E+11	34.40%
February	1752300	1508700	243600	243600	5.93E+10	13.90%
March	2356400	1752300	604100	604100	3.65E+11	25.64%
April	2566500	2356400	210100	210100	4.41E+10	8.19%
May	2248500	2566500	-318000	318000	1.01E+11	14.14%
June	1748400	2248500	-500100	500100	2.5E+11	28.60%
July	1630500	1748400	-117900	117900	1.39E+10	7.23%
August	2109300	1630500	478800	478800	2.29E+11	22.70%
September	1163100	2109300	-946200	946200	8.95E+11	81.35%
October	1236000	1163100	72900	72900	5.31E+09	5.90%
November	1921800	1236000	685800	685800	4.7E+11	35.69%
December	701700	1921800	-1220100	1220100	1.49E+12	173.88%
TOTALS	38669600		-396900	11506500	9.67E+12	932.71%
AVERAGE	1611233		-17256.5	500282.6	4.2E+11	40.55%
Next period forecast		701700	(Bias)	(MAD)	(MSE)	(MAPE)
				Std err	678527.1	

Table 7. Result of methods comparison

METODE	STANDAR EROR
EXPONENTIAL SMOOTHING (α=0.6)	617814.3
EXPONENTIAL SMOOTHING (α=0.9)	662299.2
MOVING AVERAGE (N=3 BULANAN)	629337.6
NAIVE METHOD	678527.1

The exponential smoothing method with a standar error of 617814,3 and a difference between standard error when the three methods are compared.

Production cost before the aggregate planning.

Labor per person = IDR 53,500.000 x 4 workers x 243 days = IDR 52,002,000,000

Analysis I strategy of inventory level variation

Table 8. Analysis I strategy for variation in inventory levels

Year	Month	Demand Forecast (pcs)	Number of Working Days	Production quantity	Inventory Change(pcs)
2021	February	1,098,600	19	1,264,507	165,907
2021	March	1,344,840	22	1,464,166	119,326
2021	April	1,557,276	21	1,397,613	(159,663)
2021	May	1,587,530	18	1,197,954	(389,576)
2021	June	1,007,252	21	1,397,613	390,361
2021	July	679,021	21	1,397,613	718,592
2021	August	1,304,628	20	1,331,060	26,432
2021	September	1,564,231	22	1,464,166	(100,065)
2021	October	1,156,333	20	1,397,613	241,280
2021	November	1,822,433	22	1,464,166	(358,267)
2021	December	1,985,373	21	1,397,613	(587,760)
2022	January	2,010,769	22	1,464,166	(546,603)
	Total	17,118,286	249	16,638,250	(480,036)

Workers cost =19 x 249 x IDR103,500
= IDR 489,658,500

Inventory cost = (- 480,036) x IDR100
= IDR (-48,003,600)

Total = IDR 441,654,900

Table 9. Analysis II of the strategy for variations in the number of workers

Year	Month	Demand Forecast (pcs)	Number of working days	Required workers
2021	February	1,098,600	19	2
2021	March	1,344,840	22	2
2021	April	1,557,276	21	2
2021	May	1,587,530	18	3
2021	June	1,007,252	21	2
2021	July	679,021	21	1
2021	August	1,304,628	20	2
2021	September	1,564,231	22	2
2021	October	1,156,333	20	2
2021	November	1,822,433	22	3
2021	December	1,985,373	21	3
2022	January	2,010,769	22	3
Total		17,118,286	249	27

Workers cost = 249 x 27 x IDR103,500
= IDR 695,830,500
Additional fee = 0 x IDR 150.000
= IDR 0
Deduction fee = 2 x 249 x IDR 103,500
= IDR 51,543,000
Total = IDR 747,373,500

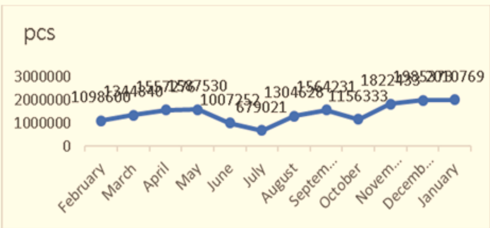

Fig. 2. Production graph at the lowest demand level

Table 10. Analysis III subcontracting strategy

Year	Month	Demand Forecast (pcs)	Number of Working Days	Production Quantity (pcs)	Supplies	Subcontract (pcs)
2021	February	1,098,600	19	1,185,600	0	(87,000)
2021	March	1,344,840	22	1,372,800		(27,960)
2021	April	1,557,276	21	1,310,400		246,876
2021	May	1,587,530	18	1,123,200		464,330
2021	June	1,007,252	21	1,310,400		(303,148)
2021	July	679,021	21	1,310,400		(631,379)
2021	August	1,304,628	20	1,248,000		56,628
2021	September	1,564,231	22	1,372,800		191,431
2021	October	1,156,333	20	1,248,000		(91,667)
2021	November	1,822,433	22	1,372,800		449,633
2021	December	1,985,373	21	1,310,800		674,573
2022	January	2,010,769	22	1,372,800		637,969
Total		17,118,286	249	15,538,000	0	1,580,286

Labor cost = 2 x 249 x IDR103,500
= IDR 51,543,000
Inventory cost = 0 x IDR 100
= IDR 0
Subcontract Cost = (1,580,286 xIDR 50,000)
= IDR 79,014,300,000

Workers subtraction and addition cost = (0 x IDR150,000) + (0xIDR103,500) = 0
Total = IDR 79,065,843,000

5. CONCLUSION

According to comparison of the three methods the exponential smoothing method has the lowest standard error with α = 0.6 and the standard error of 617814.3 . The total estimated production of 15,107,517 units in 227 working days, from February 2021 to January 2022 is calculated based on the forecasting result using the exponential smoothing method with α = 0.6 on mini oreo cups.

Analysis I strategy variation of inventory level available costs is IDR 441,654,900 . The number of workers cost that are currently available in analysis II of the variation method is IDR. 747,373,500 The costs for analysis III subcontracting strategy are IDR 79,065,843,000
According to the findings og the research ,the production planning with the aggregate method the production cost before the calculation is IDR 52,002,000,000 and the number of workers is 4 . then after the results of the optimization calculation research with analysis II strategy the number or workers is IDR 747,373,500 with the number of workers that will be use by 2 .

REFERENCES

Aris, A. R., Bakhtiar, A., & Suliantoro, H. (2014). Penerapan Sistem Make to Order serta Penjadwalan Jobshop Guna Mencegah Keterlambatan Pada Customer. *Teknik Industri*, 1–7.

Buffa.S.elwood. (1996). *Production-Inventory System:Planning and Control*. Willey Series in Production. New York.

Evans, JR, DR Anderson, DJ Sweeney, and T. W. (1990). *Applied Production & Operations Management* (3rd ed.). St. Paul, MN: West Publishing.

Gaspersz, V. (2011). Total Quality Management untuk Praktisi Bisnis dan Industri Cetakan ketujuh/Edisi Revisi dan Perluasan. In *Vinchristo Publication*.

Gasperz, V. (2017). *PRODUCTION PLANNING AND INVENTORY CONTROL* (7th ed.). PT. Gramedia

Pustaka Utama.

Heizer, J., & R. (2015). *"Manajemen Operasi Buku 1*. Salemba empat.

Juliantara, I. K., & Mandala, K. (2020). Perencanaan Dan Pengendalian Produksi Agregat Pada Usaha Tedung Ud Dwi Putri Di Klungkung. *E-Jurnal Manajemen Universitas Udayana*, *9*(1), 99. https://doi.org/10.24843/ejmunud.2020.v09.i01.p06

Meutia, S., Industri, J. T., Teknik, F., Malikussaleh, U., & Utara, A. (2019). *ANALISIS PERENCANAAN JUMLAH PRODUKSI UNTUK MENINGKATKAN KEUNTUNGAN MAKSIMAL DENGAN METODE LINEAR PROGRAMMING PADA UKM MATAHARI KOTA MEDAN*.

Nirwana, P., & Setyawan, W. (2019). *Penerapan Metode Rencana Proses Agregat Untuk Merencanakan Jumlah Pegawai Berdasarkan Jumlah Permintaan yang Berfluktuatif*. 2–3.

Reicita, F. A. (2020). Analisis Perencanaan Produksi Pada Pt. Armstrong Industri Indonesia Dengan Metode Forecasting Dan Agregat Planning. *Jurnal Ilmiah Teknik Industri*, *7*(3), 160–168. https://doi.org/10.24912/jitiuntar.v7i3.6340

Rosero-Mantilla, C., Sánchez-Sailema, M., Sánchez-Rosero, C., & Galleguillos-Pozo, R. (2017). Aggregate Production Planning, Casestudy in a Medium-sized Industry of the Rubber Production Line in Ecuador. *IOP Conference Series: Materials Science and Engineering*, *212*(1). https://doi.org/10.1088/1757-899X/212/1/012018

Safitri, M. D. A. (2019). *Penjadwalan Produksi Untuk Meminimasi Keterlambatan DISTRIBUSI DENGAN METODE EARLIEST DUE DATE*. *1*, 48–55.

Sudiman, S. (2020). Peramalan Untuk Perencanaan Produksi Stop Valve Tipe Tx277S Menggunakan Metode Peramalan Deret Waktu (Time Series) Di Pt. Xyz. *JITMI (Jurnal Ilmiah Teknik Dan Manajemen Industri)*, *3*(1), 7. https://doi.org/10.32493/jitmi.v3i1.y2020.p7-14

Taylor, B. W. (2004). *Introduction to Management Science* (8th ed.). Prentice Hall. www.prenhall.com