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Optimization of Preventive maintenance with Downtime and Setup Time Using Goal Programming Method at XY Sugar Factory

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ABSTRACT

This research analyzes downtime and setup time at XY Sugar Factory for the period May 2023 to September 2023. The main objectives of the study were to evaluate the difference between the actual downtime and setup time and the set targets, as well as optimize operational efficiency through the Goal Programming method. The results showed that the actual downtime at Boiler, Mill, and Power House stations exceeded the target, with a significant positive deviation. Similarly, setup times at all stations were higher than the set targets. Overall, the actual total downtime and setup time exceeded the target with a large positive deviation. This study suggests strengthening the preventive maintenance system, managing setup time more efficiently, and adjusting targets to improve efficiency. The results of this study are expected to provide practical recommendations in reducing downtime and setup time and increasing plant productivity.
Keywords: Downtime, Setup Time, Goal Progamming

A. INTRODUCTION

In the world of manufacturing there are several supporting production processes, one of which is machine maintenance. Maintenance or maintenance is any form of activity, both technical and administrative in nature, which aims to maintain the condition of the machine or equipment so that it remains in an optimal state. This also helps reduce operating costs and minimize the risk of losses due to unexpected machine damage (Shinta, 2020). Downtime is wasted time, where the production process does not run as usual due to machine damage.

XY Sugar Factory is one of the sugar factories under state-owned enterprises located in East Java Province. This sugar factory has two types of machine maintenance, namely preventive and corrective. Preventive maintenance is carried out when the milling season stops, generally from October to April. Corrective maintenance is carried out during the milling season, generally from May to September. Preventive maintenance carried out can still cause downtime during the milling process. By implementing proper preventive measures, such as routine maintenance and periodic inspections, the company can ensure that all equipment is functioning properly and reduce the possibility of damage that could disrupt the production process.

Translated with DeepL.com (free version)In 2022 downtime category A has a type of downtime caused by lack of water, late sugar cane raw materials, PLN outages, holidays, and other things, with a total downtime of 365.58 hours. Downtime category B is divided into 2 types, namely types B1 and B2. Type Bl is caused by technical events such as milling machines, boilers, power houses, and instrumentation. In type B2 it is caused by boiling house events such as refining, evaporation, and turning and packaging events. The total downtime of type B totals 138.93 hours,

However, in 2023 there was a decrease in downtime A for 189.55 hours. This can be caused by the climate that affects the sugarcane planting process, and the unavailability of transportation facilities to deliver raw materials. In downtime B, the total downtime increased for 177,46 hours with details of B1 downtime for 121.13 hours and B2 for 56.3 hours. This is due to the life time of machine spare parts, and the lack of operators who have the skills to carry out machine repairs. One aspect that needs to be considered in the implementation of preventive maintenance is downtime and setup time the time needed to prepare the machine before operating). Both have a direct impact on productivity and operational efficiency.

From these problems can be analyzed using the Goal Programming method. Goal Programming is a technique for solving multi-objective decision-making problems in finding a set of satisfactory solutions. The purpose of Goal Programming is to minimize deviations in achieving goals (Hasbiyati, et al 2023). With the Goal Programming method used in this study, it is expected to minimize downtime and setup time. Downtime is the time during which an equipment, facility, or machine cannot be used so that the machine or device cannot perform its function as expected (Munawir, et al 2020).

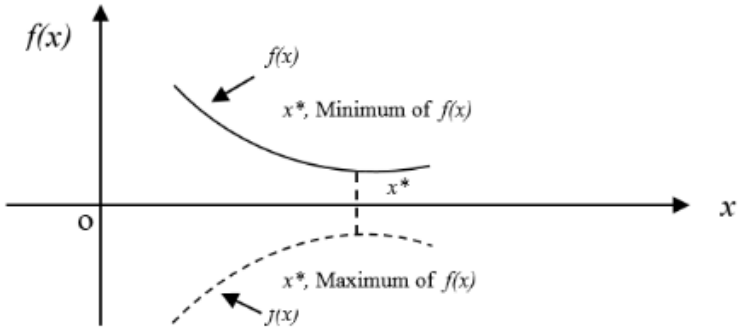
Using the Goal Programming method is expected to help the Company to optimize preventive maintenance by minimizing downtime and setup time. In addition, the Goal Programming method can be a comparison with the method used by the XY sugar factory.

B. LITERATURE

B1. Optimization

The word optimization is global, because it is widely used as the most popular keyword. Optimization in general is to maximize or optimize something that aims to manage something that is done. So, optimization can be said to be a noun derived from a verb, and optimization can be considered both a science and an art according to the goals to be maximized. Many factors are related to optimization, such as computer optimization, Web optimization, boot optimization, CPU (Processor) optimization, bateray optimization (on laptops), sound optimization, display optimization, and so on, so optimization is indeed needed for anything to make something as good as possible or the most optimal. The issue of optimization is a very important issue to be applied to all systems and organizations. With optimization in a system we will be able to save in all respects including energy, finance, natural resources, work and others, without reducing the function of the system.

Mathematically, optimization is a way to get the extreme price either maximum or minimum of a certain function with its limiting factors. If the problem to be solved is sought for the maximum value, then the decision is maximization. Optimization in problem solving is a way of making decisions so that the optimal solution is obtained in accordance with the "state of nature" constraints that must be met. Widely used methods include Calculus, Dynamic Programming, Linear Programming, Geomatry and Inventory Theory. Optimization can also be defined as the process of obtaining a state that gives the maximum or minimum value of a function. It can be seen from Figure II.1, that if the point x corresponds to the minimum value of the function f(x), the same point also corresponds to the maximum value of the negative function-f(x). Without losing its generality, optimization can be interpreted as minimization, since the maximum of a function can be obtained through the minimum of the negative of the same function.



Gambar 2. 1 Minimum dari f(x) sama dengan Maksimum dari -f(x)
(Sunandar,2019)

B2. **Downtime**

In general, downtime is the stopping time of a work operation due to the maintenance of production facilities both carried out by implementing preventive maintenance and due to maintenance repairs due to damage. Basically, downtime is defined as the time a system component cannot be used (not in good condition), thus making the system function not running. In essence, the main principle of maintenance management is aimed at maximizing the use time of a tool without any interruption due to damage, so planning and scheduling the replacement of components or parts of the equipment system based on minimum downtime is very important so that the continuity of production using the equipment is guaranteed (Sihombing, 2023). Downtime losses are the time when production reduced due to internal and external disturbances from both machine breakdowns, power failures and so on. According to Nakajima (1988) in Wibisono (2021), Downtime consists of two kinds of losses, namely:

a. Breakdown losses or Equipment Failure

Breakdown losses are one of the losses caused by damage to production machinery that requires the machine to be repaired or replace damaged components. The percentage of machine effectiveness lost due to Breakdown losses can be calculated by the following formula Wibisono, 2021)

$$\text{Breakdown losses} = \frac{\text{Breakdown time}}{\text{Loading time}} \text{ x}100\%$$

b. Set up and adjustment losses

Setup And Adjusment Losses are losses that occur when set up or equipment preparation is carried out. According to Wibisono (2021),

According to Ardhani (2021) downtime can result in decreased production effectiveness so that the predetermined production targets are not met. Machine downtime will harm the company in various aspects, both material, economic and time aspects because it will hamper the ongoing production process. Downtime results in the loss of valuable time to produce goods and is replaced by time to repair existing damage. According to Suwarno and Supriyati (2024) there are several causes of downtime in the production process including, The failure of the machine maintenance planning and scheduling function causes irregular maintenance. As a result, matters relating to machine maintenance are less effective, which has the potential to disrupt the production process and reduce operational efficiency in the company. Downtime consists of two kinds of losses, namely breakdown and setup and adjustment.

B3. Goal Programming

Goal Programming is an extension of the linear programming model (Purwanto, 2023). The Goal Programming method is one method that can be used in optimizing production planning (Sutrisno et al., 2017; Muhammad et al., 2020). Goal Programming analysis aims to minimize the distance between or deviation from the goal, target or target that has been set with the effort that can be taken from linear programming (Muhammad et al., 2020).

Goal Programming can be used to solve problems with more than one goal through its deviation variables and automatically capture information about the relative achievement of the goals. Goal Programming is an extension of the linear program developed by A. Charles and W.M Cooper in 1956, so all assumptions, mathematical model formulations and procedures and solutions are no different. Goal Programming is one of the mathematical models used as a basis for making decisions to analyze and make solutions to problems involving multiple objectives so that optimal alternative problem solving is obtained. The difference between linear programs and Goal Programming lies in the use of objective functions. In the linear program, there is only one goal function, namely maximizing or minimizing, while in Goal Programming the goal is expressed in the form of a constraint (goal constraint), and there is also a variable, namely the deviation variable or deviation variable in the constraint. This deviation variable is to determine the distance of deviation that occurs in the goal function. So that the goal of Goal Programming is to minimize the deviation distance that occurs.

In a linear program, there is only one goal function, namely maximizing or minimizing, while in Goal Programming the goal is expressed in the form of a constraint (goal constraint), and there is also a variable, namely the deviation variable or deviation variable in the constraint. This deviation variable is to determine the distance of deviation that occurs in the goal function. So that the goal of Goal Programming is to minimize the deviation distance that occurs. The basic concept of Goal Programming is whether the goal can be achieved or not, a goal will be expressed in an optimization that provides a result that is as close as possible to the goal to be achieved. So the goal of Goal Programming is to minimize the deviation of each goal target to be achieved (Abas, 2021). There are two methods in solving Goal Programming problems, namely:

1. Preemptive Goal Programming
   Preemptive Goal Programming is a goal program where each goal has a priority order. The division of priorities is said to be preemptive, namely prioritizing the achievement of satisfaction of a goal at the first priority before going to the next priorities. In this case, the priority factors are expressed as the relationship of the priority factors is as follows. Where >> means “much higher than”. The priority relationship shows that even if the priority factor is multiplied x times (where $x > 0$), the prioritized factor will still be higher. The form of the preemptive Goal Programming objective function is as follows, namely minimizing $\sum$. In this research, the preemptive goal programming method is used.
2. Non-Preemptive Goal Programming
   Non-preemptive Goal Programming or weighted Goal Programming is a method used to minimize more than one goal using weighting techniques. In this method, each deviation variable in the objective function can be given a different weight according to its importance.

B4. Machine Maintenance

The term Maintenance is often used and interpreted as maintenance or care. Maintenance is the concept of activities needed to maintain the quality of the machine so that it can function properly as its normal condition. Maintenance is a form of activity carried out to restore or maintain the condition of the machine so that it can always function. Maintenance is also a supporting activity that ensures the continuity of machinery and equipment so that when needed it can be used as expected. So that maintenance activities are a whole series of activities carried out to maintain machinery and equipment in operational and safe conditions, and if damage occurs it can be controlled.

Preventive maintenance is maintenance that is carried out periodically or based on certain criteria at various stages of the production process. The aim is to ensure that the products produced are in accordance with the plan, both in terms of quality, cost, and timeliness.

According to Mena, et al (2021) preventive maintenance, understood as the process of defining a series of maintenance activities that must be carried out on physical assets with a certain frequency or periodicity to prevent critical failure modes from occurring, is an important decision-making activity. The maintenance plan should also detail important information for the execution of maintenance activities, such as task guidelines, resource requirements, spare parts needs, etc., and is the main guide to the processes in the maintenance cycle. The optimization model developed is intrinsically opportunistic, as the planning process considers the economic dependencies among preventive maintenance activities and system components. In other words, it is taken into account that maintaining various system components or executing a work package of preventive maintenance activities simultaneously on one machine, allows sharing of setup and downtime costs and more efficient use of maintenance resources. According to Oke. S (2005) All these benefits relate to the optimization of system objectives in terms of:

1. Maintenance interval and duration
2. Maintenance material costs, etc. There are several factors of preventive maintenance namely:
    1. Maintenance interval
    2. Maintenance duration
    3. Maintenance history record
    4. Technical knowledge of maintenance and economical use of machinery

This research integrates several previously studied optimization techniques, as described by Purwanto (2023), who used Goal Programming for production planning. This research adapts the approach to the context of preventive maintenance in sugar mills.

The main objectives of implementing a maintenance management system, according to the Japan Institute of Plant Maintenance and TPM India, can be summarized in the following points:

1. Extend the service life of production facilities, so that the investment that has been spent can provide longer and sustainable benefits for the company.
2. Ensure an optimal level of availability of production facilities, so that all equipment and machinery are always ready to be used when needed, so as to support the smooth production process
3. Ensure the operational readiness of all facilities required for emergency situations, so that the company can quickly respond to urgent needs without experiencing significant disruption.
4. Ensure the safety of operators and facility users, by ensuring that all equipment functions properly and safely, thereby reducing the risk of work accidents and protecting employee health.
5. Support the ability of machines to function according to their specifications, so that production performance remains optimal and in accordance with established standards.

Maintenance is closely related to preventive and corrective measures, which consist of:

a. Inspection, which is an examination of the system (machine) to ensure that it is functioning under normal conditions.
b. Service, which is an action performed on the system (machine) that is usually scheduled in the maintenance book.
c. Replacement, which is the act of replacing damaged components, which can be done suddenly or according to a prevention plan.
d. Repair, which is action taken when minor damage occurs.
e. Overhaul, which is a major repair that is usually carried out at the end of a certain period.

Machine readiness for production is the most important factor so that the products produced are in accordance with the set production targets (Auliyak, 2024). According to Prabowo, et al (2020) the smooth production process is influenced by several factors including human resources and the condition of production facilities such as machinery and other supporting equipment. If machine productivity is low (a lot of downtime), the company will experience losses due to ineffective and inefficient use of the machine. To get a concise production process and machine performance that is always competitive, a manufacturing management concept that involves many parties in the company is needed to improve and maintain high-quality machine output performance.

Maintenance activities consist of three activities, namely

1. Activities to Prevent Performance Degradation. This is a type of maintenance that is carried out to avoid the occurrence of performance degradation in the equipment. By implementing proper preventive measures, such as regular maintenance and periodic inspections, companies can ensure that all equipment is functioning properly and reduce the chances of breakdowns that could disrupt the production process.
2. Activities to Measure Performance Degradation. This activity aims to identify and measure the extent to which performance degradation has occurred in the equipment. By conducting regular evaluations, companies can obtain accurate data to assess the condition of the equipment, so that clear benchmarks can be made to determine the necessary corrective measures.
3. Activities to Restore Performance. This is a maintenance action focused on repairing and restoring equipment performance that has decreased. The purpose of this activity is to restore the condition of the equipment to its optimal level, so that it can function as before and support the smooth operation of the company. By conducting effective recovery activities, companies can minimize downtime and increase overall productivity.

According to Jatira and Abdulah (2021), in the context of maintenance, there are two types of work called “maintenance” and “repair”. Maintenance refers to activities undertaken to prevent damage from occurring, while repair refers to actions taken to correct damage that has already occurred.

In general, based on the time of implementation, maintenance work can be divided into two types:

1) Planned maintenance.
2) Unplanned Maintenance.

According to Prawirosentono (2000) in Darsini and Prabowo's research (2021), maintenance consists of two types, namely:

a. Planned maintenance (planned maintenance)
b. Planned maintenance is a maintenance activity that is carried out based on a previouslyprepared plan. This planned maintenance is tailored to the series of production processes. Planned maintenance consists of:
c. Preventive maintenance (preventive maintenance)
d. Preventive maintenance is maintenance that is carried out periodically or based on certain criteria at various stages of the production process. The aim is to ensure that the products produced are in accordance with the plan, both in terms of quality, cost, and timeliness.

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1. Planned maintenance (planned maintenance)

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a. Preventive maintenance (preventive maintenance) Preventive maintenance is maintenance that is carried out periodically or based on certain criteria at various stages of the production process. The aim is to ensure that the products produced are in accordance with the plan, both in terms of quality, cost, and timeliness. According to Mena, et al (2021) preventive maintenance, understood as the process of defining a set of maintenance activities to be performed on physical assets with a certain frequency or periodicity to prevent the occurrence of critical failure modes, is an important decision-making activity. The maintenance plan should also detail important information for the execution of maintenance activities, such as task guidelines, resource requirements, spare parts needs, etc., and is the main guide to the processes in the maintenance cycle. The optimization model developed is intrinsically opportunistic, as the planning process considers the economic dependencies among preventive maintenance activities and system components. In other words, it is taken into account that maintaining various system components or executing a work package of preventive maintenance activities simultaneously on one machine, allows sharing of setup and downtime costs and more efficient use of maintenance resources. According to Okay. S (2005) Preventive maintenance activities that are considered the foundation of manufacturing systems. evolved from a reactive approach to a preventive approach. The term "preventive maintenance" refers to a set of activities performed to maintain an item or return it to an acceptable condition.
b. Scheduled maintenance (scheduled maintenance) Scheduled maintenance is maintenance that aims to prevent damage, carried out periodically within a certain period of time. This maintenance time span is determined based on experience, historical data, or recommendations from the manufacturer of the machine in question.
c. Predictive maintenance (predictive maintenance) Predictive maintenance is a maintenance strategy that is carried out based on the actual condition of the machine. It is also known as condition-based maintenance or machinery condition monitoring, which means determining the condition of the machine through regular checks. In this way, the reliability of the machine can be known, and work safety is guaranteed.

B5. Setup Time

Setup time or preparation time is defined as the length of time it takes when the last good product is completed until the first good product comes out. So in the setup time there is organizational time such as stopping the machine and calling maintenance, preparing setup equipment, setup time, changeover, and startup itself, making adjustments, trial runs to produce the first good product. While setup time according to Marchwinski & Shook (2003), setup time is a process of changing from a product to another product on a machine or row of machines related to changing parts, molds or other functions. The time spent involves time setting up machine components, time supplying work equipment, and so on. Setup activities that are generally carried out in industry can be grouped into several types, namely making preparations, moving materials, measuring, setting, calibrating, producing, and so on (Hidayat, et al, 2020). According to Setiawan (2023) setup time is divided into 2 types, namely:

a. Internal setup: activities that can only be done when the machine is off.
b. External setup: activities that can be carried out when the machine is on or in use.

C. RESEARCH METHOD

The downtime data used in this study was obtained through interviews with operators and direct observation of the production process at the sugar factory. Historical data from 2022 and 2023 is used to evaluate the target time that has been previously set.

C1. Identification and Operational Definition of Variabels

Variables are objects that are the focus of research. So the variables related to this research are identified:

a. Dependent Variable

The dependent variable is the variable that is influenced by the independent variable. In this study, the dependent variable is to minimize downtime and maximize production targets at XY Sugar Factory.

b. Free Variable

Independent variables are variables that affect changes in the value of the dependent variable. The independent variables in this study are:

1. B1 Downtime Type Data
2. Setup Time Data

C2. Troubleshooting Steps

In solving the Goal Programming problem, it is necessary to determine the steps that will be taken so that it can be resolved in a structured manner, the following are the steps:

In the first stage, determining the theme of the purpose of making a thesis based on the problem under study is carried out. Then continued with a literature survey which aims to collect data and theories used as the basis for analyzing the object of research, as well as to broaden and deepen the researcher's insight into the theories related to the research. After that, a field survey was conducted to identify influential elements in the research, with the aim of assessing the relevance between reality and existing theory and to determine the feasibility of the research. Based on the field survey, a problem formulation was made to focus the problem that became the main point of the research, with the aim of digging deeper in accordance with the objectives, limitations, and assumptions of the research. In this case, the problem formulation focuses on "How to optimize preventive maintenance by minimizing downtime and setup time at XY Sugar Factory using the Goal Programming method?".

The purpose of this research is to optimize preventive maintenance by minimizing downtime and setup time at the sugar factory using the Goal Programming method.

Furthermore, variable identification is carried out to determine the influential independent and dependent variables in the study, which are expected to produce relevant strategies and achieve targets. Data collection was carried out by obtaining primary data from interviews and observations of the company, as well as secondary data from the company's historical data. The data used to minimize downtime includes B1 Downtime Type Data and Setup Time Data.

The next step is the calculation of downtime in real terms and the calculation of downtime with the Goal Programming method as a comparison to see its effectiveness in minimizing downtime. Goal Programming model formulation is made using decision variables that include downtime values and target constraints to meet production targets, minimize downtime, and maximize production targets. The decision variables include downtime (x) and setup time (y) on the machine, which will be calculated for each machine. The objective function is set to optimize preventive maintenance by considering positive and negative deviations from the desired values of downtime and setup time. Target constraints are set to minimize downtime and setup time with predetermined targets.

The data that has been collected is then processed using the Goal Programming method to achieve the predetermined objective function. Verification of the optimization model is done by comparing the results of manual calculations and the results of calculations using software, while validation of the optimization model is done to ensure the results obtained are in accordance with the existing data. After that, the calculation of real total downtime and total downtime using the Goal Programming method is carried out to compare the results. If the results of the Goal Programming method are smaller, then the method can be accepted as a more efficient solution.

Furthermore, results and discussion are carried out by processing data in accordance with existing theories and methods to be concluded and given relevant advice on how to optimize preventive maintenance by minimizing downtime and setup time at XY Sugar Factory. This study ends with conclusions and suggestions regarding the implementation of the proposed method and machine maintenance steps in the next period.

D. RESULT AND DISCUSSION

In this chapter, we will discuss the results of calculations and analysis related to downtime and setup time at the XY sugar factory, obtained through the application of the Goal Programming method. This research is focused on the B1 type of downtime which includes four main stations in the production process, namely the Mill Station, Boiler Station, Power House Station, and Instrumentation Station. The data used in the calculation includes the target downtime and setup time during the period May 2023 to September 2023, as well as the realization of downtime and setup time that occurred at each station. By using the Goal Programming method, this research aims to minimize the deviation between the actual downtime and setup time against the predetermined targets, in order to optimize preventive maintenance at the XY sugar factory. The following presents the calculation analysis based on the available data.

D.1. Downtime Type Data

XY sugar factory is a company that produces sugar and drops. However, the production process has downtime that hinders the production process. In this study, it is only limited to the type of B1 downtime, B1 downtime includes Stasisun. The types of B1 downtime are:

a. Grinding Station
b. Boiler Station
c. Power House Station
d. Instrumentation Station

D.2. Goal Programming Method Calculation

After knowing the downtime and set up time owned in each downtime, calculations will be made using the goal programming method. The following table will be presented regarding the target and realization of downtime and setup time:

Table I
Target downtime and setup time May 2023- September 2023

Minutes Units	Boilers	Mill	Instrumentation	Power House	Total
Downtime	2521	3147	385	1215	7268
Setup Time	1512.6	1888.2	231	729	4360.8
Target Downtime	1764.7	2202.9	269.5	850.5	5087.6
Target Time Setup	1058.8	1321.7	161.7	510.3	3052.56

(Source: Research Data)
After knowing the target and realization of downtime and setup time May 2023-September 2023, calculations will be made using the goal programming method.

D.3. Menentukan Variabel Keputusan

Decision variables are elements that can be controlled or changed to achieve goals or solve problems. The variables in this study are respectively downtime (x) and set up time (y) on the machine, where x_i and y_i, or the i-th machine (i = 1, 2,3,and 4) are:
x_1 = Total downtime for boilers
x_2 = Amount of downtime for the mill
x_3 = Amount of downtime for instrumentation
x_4 = Total downtime for power house
y_1 = Total setup time for boilers
y_2 = Total setup time for the mill
y_3 = Total setup time for instrumentation
y_4 = Total setup time for power house

D.4. Objective Function

The objective function of this research is to optimize preventive maintenance by minimizing downtime and setup time. The objective function can be formulated as follows:

$$Z = \left(\sum x_i + \sum y_i - \left(\sum D_{xi}^{+} + \sum D_{yi}^{+} - \sum D_{xi}^{-} + \sum D_{yi}^{-}\right)\right) \text{for i = 1, 2, 3,and 4}$$

Description:
Z = optimization of preventive maintenance
x_i = total downtime
y_i = total setup time
D^+ = positive deviation
D^- = negative deviation

D.5. Constraint Function

the target constranit minimizes downtime to reduce the real downtime to target, the foemula is:

$$x_1 + x_2 + x_3 + \cdots + x_n \leq P_i \quad \text{.....(3)}$$

Keterangan:
x_i= Machine Downtime i
P_i= Target Downtime i

The target constraint minimzes the set up time to lower the real setup time to the target the formula is:

Kendala sasaran :

$$y_1 + y_2 + y_3 + \cdots + y_n \leq T_i \quad \text{.....(4)}$$

Keterangan:
y_i= Machine setup time i
T_i= Target waktu setup mesin i

Form the result the formulation using the goal programming method above by paying attention to the exsting functions, the results are obtained:

Table II
Calculation results with the goal progamming method

Category	Aktual Downtime	Actual Setup Time	Target Downtime	Target Setup Time	D+ Downtime	D- Downtime	D+ Setup Time	D- Setup Time
Boilers	2521	1512.6	1764.7	1058.82	706.3	0	433.78	0

Category	Aktual Downtime	Actual Setup Time	Target Downtime	Target Setup Time	D+ Downtime	D- Downtime	D+ Setup Time	D- Setup Time
Mill	3147	1888.2	2202.9	1321.74	894.1	0	546.46	0
Instrumentation	385	231	269.5	161.7	65.5	0	49.3	0
Power House	1215	729	850.5	510.3	314.5	0	198.7	0
Total	7268	4360.8	5087.6	3052.56	1980.4	0	1228.24	0

(Source: Research Data)

This study analyzes *downtime* and *setup* time at four main stations of XYY Sugar Factory, namely Boiler Station, Mill, Instrumentation, and Power House, for the period May 2023 to September 2023. The purpose of this analysis is to evaluate the difference between the actual *downtime* and *setup* time and the predetermined targets, as well as to optimize *preventive maintenance* using the Goal Programming method

The analyzed data shows a mismatch between the actual *downtime* and the predetermined target. At the Boiler Station, the actual *downtime* (2521 minutes) was higher than the target (1764.7 minutes) with a positive deviation of 706.3 minutes. Likewise, the *setup* time (1512.6 minutes) exceeded the target (1058.82 minutes) with a positive deviation of 433.78 minutes. Gilingan station also experienced significant deviations, with actual *downtime* (3147 minutes) higher than the target (2202.9 minutes), as well as actual *setup* time (1888.2 minutes) exceeding the target (1321.74 minutes). Positive deviations in *downtime* and *setup* time amounted to 894.1 minutes and 546.46 minutes, respectively. At the Instrumentation Station, although the deviation of *downtime* and *setup time is* smaller, the actual *downtime* (385 minutes) remains higher than the target (269.5 minutes), and *the setup* time (231 minutes) also exceeds the target (161.7 minutes), with positive deviations of 65.5 minutes and 49.3 minutes. The Power House station also experienced similar deviations, with actual *downtime* (1215 minutes) higher than the target (850.5 minutes), as well as *setup* time (729 minutes) exceeding the target (510.3 minutes), with positive deviations of 314.5 minutes and 198.7 minutes.

Overall, the actual total *downtime* (7268 minutes) and actual total *setup* time (4360.8 minutes) exceeded the target *downtime* (5087.6 minutes) and target *setup* time (3052.56 minutes), with a total deviation of 1980.4 minutes and 1228.24 minutes, respectively. This shows that all stations experience a mismatch between actual and target time that can affect production efficiency. The results of this analysis suggest the need for improvements in the management of *downtime* and *setup* time to reduce existing deviations, with the aim of optimizing the performance and efficiency of the XY sugar factory, as well as increasing the effectiveness of *preventive maintenance* activities carried out.

Dengan mengoptimalkan waktu setup dan downtime menggunakan metode Goal Programming, pabrik gula dapat mengurangi waktu henti total sebesar 1980,4 menit, yang setara dengan peningkatan produksi sebesar 64670 ton. Hal ini dapat dicapai dengan memperbaiki manajemen pemeliharaan preventif dan penjadwalan ulang penggantian komponen mesin

E. CONCLUSION

From the analysis of downtime and setup time at XYY Sugar Factory, this study shows that by applying the Goal Programming method, there is a significant reduction in downtime and setup time that exceeds the target. For this reason, it is recommended that the sugar factory strengthen the preventive maintenance system, manage setup time more efficiently, and adjust targets to improve operational efficiency.The actual downtime at the Boiler Station, Mill, and Power House is higher than the target, with a significant positive deviation. In addition, the setup time is also higher than the set time at each stage, which indicates that the machine or

equipment process takes longer than expected. Overall, the total downtime (7268 minutes) and total setup time (4360.8 minutes) were higher than the targets of 5087.6 minutes and 3052.56 minutes, respectively, with a significant positive deviation. This indicates that there is great potential to improve operational efficiency by reducing downtime and setup time.

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