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Power Generation through Hybrid Micro wind Turbine Generator & Solar Module using Tracking Mechanism

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Abstract-In advancement of solar & wind power sector there are different types of research has been done in both large & small scale for power generation. In this paper we have focused on power generation to charge the battery of capacity 26Ah 12V, so we need 10% (2.6A) rated current to the battery and we are charging the battery through hybrid solar-wind system at micro level using tracking mechanism to capture more power from solar and wind. This experiment consist of 24 micro windmill with 6 bladed fan which consist of 3-3 dynamos each connected in series firstly and then output of 24 groups of series connected dynamos i.e. output of 72 dynamos taken in parallel finally and there are 10 solar panel of 3 watt each connected in series-parallel combination which are mounted on the top of panel structure also at the slope angle of 280 and tracking of solar started from 10 am to 3 pm & after 3 pm solar panel kept at home position or wind panel kept in west direction, after power generation from hybrid micro solar-wind system we store the energy in battery of 26Ah 12V using MPPT charger and lastly we compared the average efficiencies of hybrid solar-wind system separately i.e. with & without tracking mechanism and battery charging time also and found that the average efficiency of hybrid micro solar-wind system is higher and less charging time of battery in tracking mechanism in compare to without tracking mechanism.

Keywords- *Hybrid micro solar-wind system, MPPT battery charging, Micro windmill, Solar panel, Tracking mechanism.*

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I. INTRODUCTION

In this new era of technology there are different types of non-renewable and renewable energy sources are available and there are research is going on to conserve the energy and remove the energy crisis day by day.

As we know that there are different types of conventional energy sources like coal, petroleum, gas and other sources which are limited and it will be end in 300 years according to their use in different types of processes. So we are going towards the non-conventional sources like solar energy, wind energy, hydro, tidal and other sources which are available in bulk amount. These all types of energy sources having reliability in use and they are pollutant free so there is no effect on environment.

Now a days there are many companies in the world are going towards the solar and wind energy for power production and in previous 10 years there is a lot of changes in power production in these field.

Solar photovoltaic system is one of best non-conventional energy harnessing system which is use globally for solar power production without any complex changing mechanism. A PV system basically consist a panel, a solar inverter, and a battery and/or solar tracker for power production and supplies it for commercial and residential use. Solar panels absorb light energy (photons) from the sun to generate electricity through the photovoltaic effect. The panels use crystalline silicon or thin-film cells based on cadmium telluride or silicon. Electrical connections are in series to get a desired output voltage and/or in parallel to get a desired current capacity.

Now a day power production from solar photovoltaics in India is about 4684 MW by 30.11.2015 & Solar power generation is increasing day by day according to demand of energy and it will reach up to 20000 MW solar capacity up to 2022[MNRE]. After solar we are going towards the wind energy and there is lot of opportunity in future from wind power generation in India.

In India, Now a days wind power is one of the fastest growing source of energy because of wind availability in different areas and there are various types of research has been done on wind power generation through the wind turbine and also on the various components which is related to the wind turbine such as converter, controllers, charger for minimum power loss which in results more power generation and transmission. Modern wind turbine generators are much complicated machines, so there is need of improvements in aerodynamic and structural design, mechanical equipment, electrical, charging and control system for producing higher megawatts of electricity. Now a days 3 bladed HAWT are available in different length & many companies manufacturing blade of higher length as Suzlon made a rotor of diameter of 97 meter with rated power of 2.1 MW. The tubular towers range from 80 to 100 meters tall. A gear box is used for maintain the speed of the generator. Some of the turbine models operate at constant speed, but more energy can be collected by variable-speed wind turbines. In horizontal axis wind turbine there is pitch control and also yaw control is provided by yaw motor if wind velocity is higher than the limit. Now a day power production from wind turbine in India is about 23439 MW by

march 2015[IWEA] & it is increasing day by day according to demand of energy.

II. LITRATURE REVIEW

There are a lot of work has been done in the field of power generation through solar and wind either in form of small or large scale. Dr. Vadirajacharya attracted to thinkover hybrid solar & wind for harnessing the energy in which collective benefits from both are used. He discussed in the paper about connecting the small rural sites with grid as the cost to set up and service for distribution lines are high for remote area and poor power supply reliability. Thus use of hybrid solar-wind, which compensate each other's power output according to winter-summer season which will be more reliable use of energy from both . So the point of the paper is to invite for use of hybrid system for power generation from renewable sources instead of conventional. Other paper by Mr. shuny kumar is about to explains the comparison analysis of large windmill over integrated micro windmill in which micro windmill can show a great potential in concern of easy design, efficient power production as there is no gear box is used, simple in creation, low maintenance, easy in fabrication, easy transportation and much more benefits are there than large windmill. A model of incorporated 16 micro windmill, horizontal axis in vertical plane is fabricated for simulation analysis and a range of wind velocity with voltage and lastly we get 18.46 volt with 30 m/s wind velocity.

In this research paper we designed a hybrid micro solar-wind system with tracking mechanism for power generation to charge the battery of capacity 26Ah 12V using MPPT charger and lastly we compared the average efficiencies of hybrid solar-wind system separately i.e. with & without tracking mechanism and battery charging time also and found that the average efficiency of hybrid micro solar-wind system is higher and less charging time of battery in tracking mechanism in compare to without tracking mechanism.

III. OBJECTIVE OF OUR WORK

- Power generation through hybrid micro solar-wind turbine system using tracking mechanism to charge the battery of 12V, 26Ah capacity.
- Comparison between average efficiencies of the system with and without tracking of solar and wind.
- Charging & discharging condition of battery.
- To consider that Solar-Wind hybrid system is applicable for domestic purpose or not.

IV. PERFORMANCE ANALYSIS

1.The efficiency of solar panel is calculated by the ratio of total output power and total input on solar panel

$$\eta = O/P\ /I/P. = Pm/E \times Ac \quad (1.1)$$

Where Pm is maximum output power, E is the solar radiation input on the solar panel, Ac is surface area of solar panel. Maximum power Pm can be calculated by the equation:-

$$Pm = Voc \times Isc \quad (1.2)$$

Where Voc is open circuit voltage, Isc is short circuit current.

2.The efficiency of micro wind turbine is calculated by the ratio of total power output and total input quantity on wind turbine blade.

$$Cp = O/P\ power\ /I/P\ wind = Pm / \tfrac{1}{2}\rho AV3 \quad (1.3)$$

Where Pm is output power, **ρ** is air density, A is swept area of blade, V is wind velocity, Cp is power coefficient. Maximum power can be calculated by the equation:-

$$Pm = Voc \times Isc \quad (1.4)$$

Where Voc is open circuit voltage, Isc is short circuit current.

V. METHODOLOGY

The objective of this project is to charge the battery of capacity 26Ah of 12V. So we need current of 2.6A (10% of battery capacity) and maintaining more than 13.5V to charge the battery & if voltage is less than 12V then battery will not charge.

Also we had to work on hybrid system so we decided to generate power from hybrid micro solar-wind turbine generator with and without tracking mechanism.

So we taken 10 solar module of 3 watt each, 2-2 in series-parallel combination which are mounted on the top of panel structure at the slope angle of 28^0 and tracking of solar started from 10 am to 3 pm & after 3 pm solar panel kept at home position or wind panel kept in west direction to get more than 14V and also we to generate 1.5 Ampere current from solar and rest 1.1 Ampere from micro wind turbine generator. There are 24 micro windmill with 6 bladed fan which consist of 3-3 dynamos each connected in series firstly and then output of 24 groups of series connected dynamos i.e. output of 72 dynamos taken in parallel finally All wind generator (72 dynamo with 24 fan) are mounted on this panel at the difference of 13cm each in horizontal way and 24cm in vertical way, after power generation from hybrid micro solar-wind system we store the energy in battery of 26Ah 12V using MPPT charger and lastly we compared the average efficiencies of hybrid solar-wind system separately i.e. with & without tracking mechanism and battery charging time also.

Main components of system are as follow:-

1. Panel for complete system
2. Solar module
3. Dynamo of 12V as wind turbine generator
4. Rectifier circuit
5. Fan
6. Pulley
7. Belt
8. Wiper motor
9. Tracking circuit
10. Battery

Fig.1:- Hybrid micro solar-wind panel

Panel specification:-

Length of top inclined structure- 215cm
Breadth of top inclined structure- 20cm
Length of rectangular structure- 165cm
Breadth of rectangular structure- 135cm
Distance between iron sheets internally- 27cm
Thickness of rectangular structure- 3cm
Length & breadth of base structure- 240cm
Distance b/w base & panel structure- 25cm

Solar module:-

Fig.2:- Solar panels used in this project

Specification of a single solar module:-

Length of solar module- 20cm
Breadth of module- 20cm
Module capacity- 3W each
V_{OC} -10.25V
I_{SC} - 0.37A
Voltage at peak power- 8.75V
Current at peak power- 0.32A

No. of solar module	Generating voltage V_{OC}	Generating current I_{SC}
1	10.25	0.37
2(in series)	19.8(max)	0.34(max)
10(2-2 in series)	19.8(max)	1.7A (max)

There are 10 solar modules used in this project shown in fig.2 in which there are 5 pairs modules in series of 2-2 modules each for required voltage and the output of all the modules taken parallel for required current .

As we require voltage more than 14V and also working with micro solar so we decided to choose 3W solar module which provides Voltage 8.75V at peak power & Current 0.32A at peak power. So we connect 2 solar module in series to get 1.5 Ampere current from solar and rest 1 Ampere from micro wind turbine generator.

Micro Wind Turbine:-

In this project wind power generation is done with the help of Micro wind turbine which is shown in fig.3, which are basically small size of the turbine as compared to the large centralized wind turbine. The basic principle of the micro wind turbine is similar to the large wind turbine where energy available in the form of kinetic energy in the wind and this kinetic energy is transformed to rotational energy by the blade and this rotational energy converted in to DC power through dc dynamo and after generation the dc electric power is stored in the battery using the hybrid MPPT charge controller. Here number of wind turbine are integrated with horizontal axis in vertical plane in which there are 4 rows and 6 column of wind turbine are arranged in panel. As we are using 12V dc motor as dynamo or generator with 6 bladed fan for DC power generation. In this project the total power generation at 7 m/s is approx. 16.5 W.

Fig.3:- Electrical connection of micro wind turbine

Total no. of dynamos= 72
Total series connected dynamos group= 24
Total parallel connected dynamos group= 4 rows of 24 series groups
Total voltage generated by 1 series combination=14V (max) open circuited
Total current generated by 1 series combination = 70mA (max) short circuited
Total voltage generated in parallel combination= 20V (max) open circuited
Total current generated in parallel combination= 1200mA (max) short circuited
Total power generated without connecting load (open circuited) = 24 Watt
Total power generated with connecting load= 16.5 Watt at 7 m/s wind speed.

Arrangement of dynamos:-

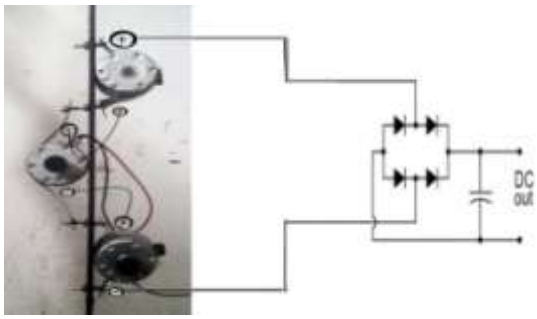

Fig.4:- 3 dynamos connected in series

Specification of single dynamo:-

Rated voltage – 12V
Rated current -50 mA
Rated power- 0.6W
Rated RPM = 3000 ± 10%

Rectifier circuit (for filtration & polarity maintenance):-

Bridge rectifier circuit shown in fig.5 is used in this project for maintaining polarity when power is generating either clockwise or anticlockwise rotation of wind turbine or fan. Bridge rectifier contain 4 diodes (IN4007) and 1 capacitor of 10f connected in parallel to maintain voltage. There are 24 bridge rectifier circuit used at output of every series connected dynamos. So after power generation voltage is 14.8V & current is 80 mA at the input of rectifier & 14V, 70mA at the output of rectifier.

Fig.5:- Bridge rectifier circuit

Fan:-

This fan shown in fig.6 is made up of plastic. It is a important part of wind turbine where wind strikes firstly on the blades of fan to convert kinetic energy of wind into rotational energy then this energy is converted into electrical one by the dynamo and then stored in battery.

Fig.6:- 6 bladed fan

Fan specification:-

Total no. of fan used in project = 24
Number of blades in a fan = 6
Diameter of fan = 25cm = 0.25m
Radius of fan = 0.125 m
Swept Area of a single fan = 0.049m^2
Total swept area of 24 fan =1.17m^2

Pulley & Belt Mechanism:-

There are 2 types of pulley used in this project, to achieve the maximum output by connecting 3 dynamos in series with the help of 2 small pullies connecting with big one pulley in series through the belt which is shown in fig.7 where big pulley is working as driving pulley. Pulley & belt arrangement is done for 2 purpose:-

- For increasing speed of dynamo for better output
- For eliminating the problem of using numbers of fan for each dynamo

Pulley & belt specification:-

Diameter of small pulley = 1cm (0.39 inch)
Diameter of big pulley = 4cm (1.57 inch)
Total big pulley used in project = 24
Total small pulley used in project = 48
Total rubber belt used = 24
Belt length= 10cm

Fig.7:- Arrangement of pullies and belt mechanism

TRACKING SYSTEM:-

Tracking means detect the movement of anything according to time & position. In the same way here we are using tracking mechanism for tracking the solar radiation & wind for the system to gain maximum output in compare to the system without tracking. This tracking system firstly track the sun from 10 am to 6 pm then after, it track the wind (average of month) but after 6 pm the face of wind turbine mostly kept in North-West direction and the solar panel's face kept at home position i;e in east direction for maximum power generation with both system at same time. There are some equipment which are used for tracking mechanism are as follow:-

Wiper Motor:-

In this project wiper motor shown in fig.8, is used & mounted at the base of the panel only for the tracking purpose because it having high torque with low speed characteristics. Basically wiper motor consume higher current due to high torque at 12V DC .The minimum required current for wiper motor is 1.6A at 70 rpm, 0.9A at 41 rpm. But in this project its speed is about 10 rpm and we are providing current to it of 1-1.2A for 500ms at interval of 1hr from 10 AM to 3 PM in a day up to 6 times.

Fig.8:- Wiper motor

Tracking circuit & its block diagram:-

The circuit shown in fig.9 is used to track the solar and wind for maximum power generation using wiper motor by giving pulse or required current to wiper motor for rotation. Basically we provide PWM technique to the motor for speed controlling according to movement of sun by using real time clock circuit in which microcontroller gives the pulse to the wiper motor as real time.

Fig.9:- Tracking circuit

Block diagram of tracking circuit:-

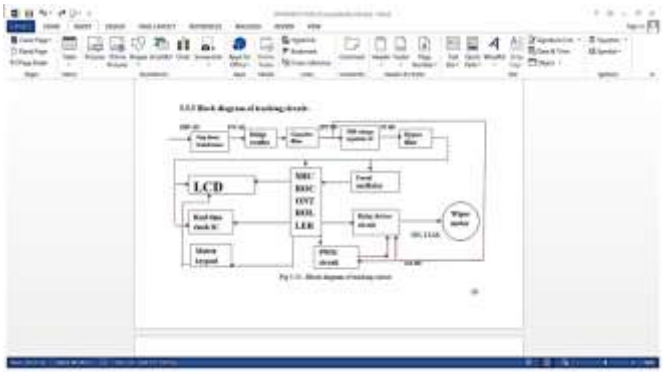

Fig.10:- Block diagram of tracking circuit

BATTERY:-

Here in this project Battery is used to store the current in form of charge which is produced by both solar panel and wind turbine generator with the help of hybrid MPPT charger.

The battery used in this project is rechargeable and made up of lead-acid which storage having very long life when it must not to be overcharged otherwise its lifetime will be decreased. Here battery voltage is 12V and capacity is 26 Ah which is shown in fig.11. So Battery must not be discharged below 40 %.

Fig.11:- Lead acid battery of 12V 26Ah capacity

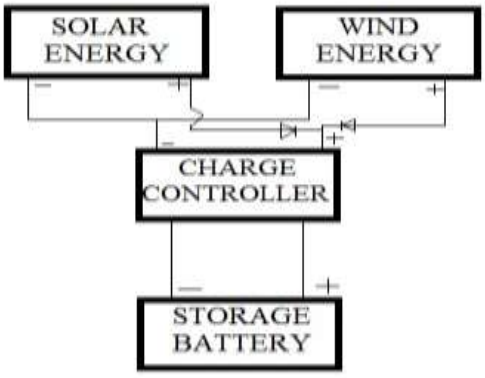

Fig.12:- Battery charging with hybrid solar-wind system using charge controller

VI. RESULT & DISCUSSION

The main objective of hybrid micro solar-wind system is completed after observation process, we put it on the top floor of ISBM building of Gyan Vihar University which is 40 feet above the ground level and then observed different type of data of solar and wind for power generation by the tracking mechanism and without tracking also. The observation is completed in the month of September and in October also between 10:00 am to 3:00 pm at the interval of 30 minutes.

In this observation there are different data like solar radiation, solar panel voltage & current, wind speed, wind turbine generator voltage & current, battery voltage & current. These all data is taken for the measurement of efficiency of the hybrid solar-wind turbine system.

Type I with Tracking (Solar-10/09/2015)

Tracking started at 10:00 AM from east side (Assume Home position) to west side till 3:00 PM

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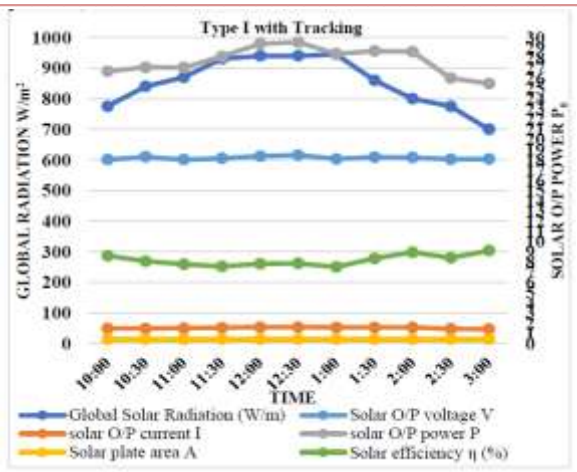

Fig.13:- Solar O/P power variation according to solar radiation with time

Type II without Tracking (Solar-30/10/2015)
Observation started at 10:00 AM & wind panel kept in north side (no movement) & solar panel kept in south side till 3:00 PM

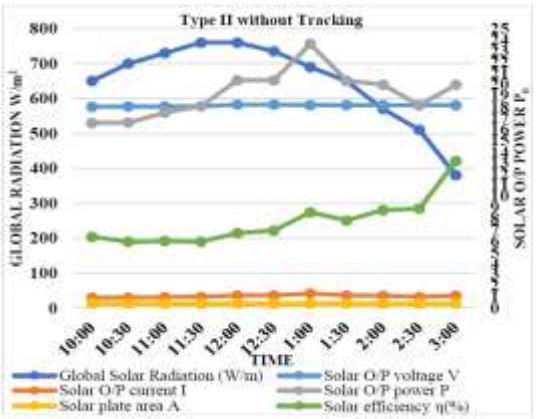

Fig.14:- Solar O/P power variation according to solar radiation with time

Type I with Tracking (Wind-10/09/2015)
Tracking started at 10:00 AM from east side (Assume Home position) to west side till 3:00 PM

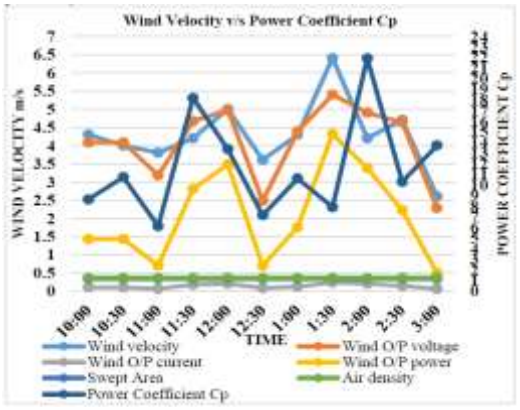

Fig.15:- Power coefficient & Wind O/P (power, voltage, current) according to wind velocity with time

Type II without Tracking (Wind-30/10//2015)
Observation started at 10:00 AM & wind panel kept in east side (no movement) & solar panel kept in west side till 3:00 PM

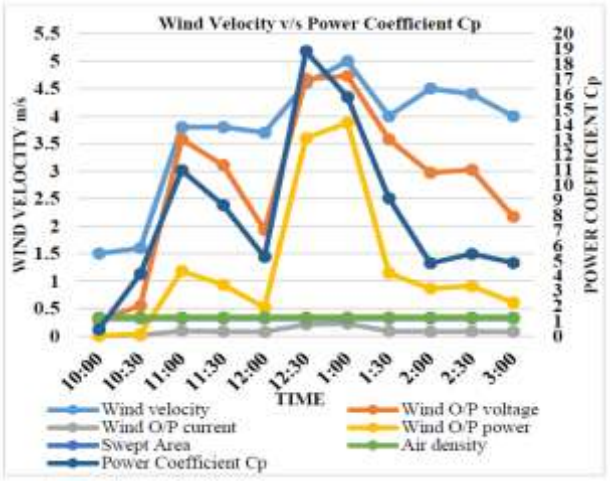

Fig.16:- Power coefficient & Wind O/P (power, voltage, current) according to wind velocity with time

Type I Battery charging with tracking

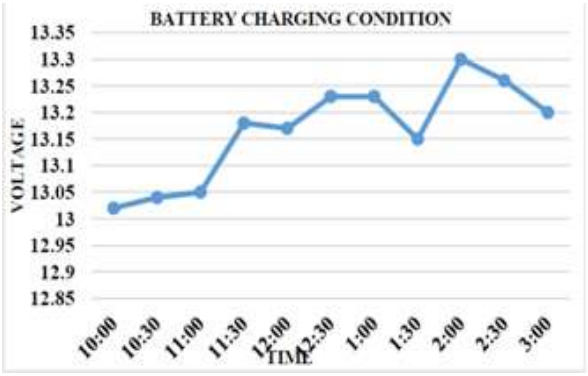

Fig.17:- Battery charging profile with tracking v/s time

Type II Battery Charging without Tracking

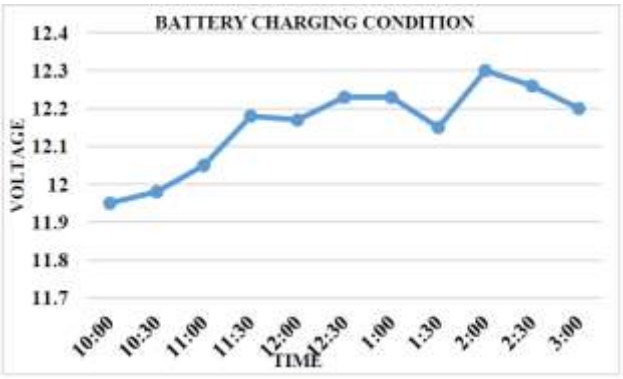

Fig.18:- Battery charging condition without tracking v/s time

After observation of solar & wind the result are found that the average efficiency of solar panel with & without tracking mechanism are 8.17% & 7.73% and the average efficiency of wind turbine generator with & without tracking mechanism are 11.69% & 8.02%. So we observed that the result in tracking mechanism is higher than without tracking of solar & wind. Battery voltage is greater at the time of charging (10:00am-3:00pm) in Type I so Battery charging time is less in Type I with tracking as compare to Type II without tracking mechanism.

VII. CONCLUSION

The papers motive is to attract towards the renewable energy sources with development of hybrid micro solar-wind system with tracking mechanism can generated power with better flexibility regarding the operation ,maintenance, and other attributes. We can take power in any season through hybrid solar-wind system and it is an off-grid system also. This may prove a better way to harness solar & wind energy .The average efficiencies of micro solar-windmill system has to be increased to higher level to get overall output with greater work for same solar radiation and wind speed. There is much research opportunities in this field.

VIII. FUTURE SCOPE

- Tracking for both the system is fair but if implemented and it will face exactly the solar PV cell in the direction of the sun and wind turbine in the direction of the wind that can improve efficiency of the system.
- Method of Tracking mechanism of the system should be in such way that it will save more power, than its consumption.
- Dynamo can be used of large size for better output.
- Whole system can be designed in other way or material for better output, look and light in weight.
- System can be designed in other way to achieve economical condition.

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