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Two Stage Planetary Gear System Configured as Auxiliary Power Drive for Robots

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ABSTRACT

This research paper address a novel auxiliary power drive design problem with planetary gear system. The proposed configuration can produce dynamic obstacle avoidance and robot safe evacuation during power failure. The proposed system uses two stage planetary gear systems. First stage acts as a speed reduction phase connected to constant power source such as engine. Since dynamic controls and system output are applied to the second stage, system dependency at first stage is reduced. In this proposed configuration, the second stage can be used to alter the output of first stage by increasing or decreasing speed. Further in case of first stage power failure for any reason, the second stage alone can produce the necessary output to evacuate the robot safely. This article covers the basic mechanical design.

Keywords : planetary gear system, variable speed and direction, dynamic obstacle avoidance, robot safe evacuation during power failure

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1. TRODUCTION

Planetary gears are useful where high-speed reduction, high levels of torque is expected.
Automatic transmission is a very famous application. Further the in-line shafting makes them not only compact but also less vibrations. This plays a finite advantage during shaft alignment procedure.

The simulations on this paper is performed using the planetary gear simulator in [2]

To simplify the robots power drive, in place of transmission a novel gearbox is introduced and mechanically tested in this research.

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As a common configuration primary power is connected to load via a reduction gear. Primary power source could probably be an engine. Since two planetary systems are used in this research, the first one denotes as stage1 in this paper, is configured as a reduction gear. The second planetary system denotes as stage2 in this paper will be the one that handle the output speed. Final output is from planetary carrier of stage2. The sun gear of stage2 will operate under microprocessor and sensor control that freely change the final output depending on operating conditions.

In conventional designs it is uncommon to rotate the ring gear. In this approach it is taken as a challenging design. As design outcome, overall design is expected to be simplified and desired dynamics to be achieved.

2. PROTOTYPE CONFIGURATION

Although the engine is considered as the primary power source, for prototype building in this research, shaded-pole motor that runs in single direction is used in place of engine. It can be stated that the proposed auxiliary power drive works in place of transmission while making overall system simple, energy saving and robust.

Gear configurations for first stage:

Number of planets: 4

Sun teeth: 40

Planet teeth: 20

Ring teeth: 80

Ring speed: 0 stationary

Sun speed: 3 connected to engine (primary power source)

Carrier speed: 1 connect to load

As a result it can be stated that 3:1 reduction ratio can be expected.

Which is not commonly practiced is performed here. That is such that connect the planets (carrier) of first stage to ring gear of second planetary system.

Gear configurations for second stage:

Number of planets: 4

Sun teeth: 40

Planet teeth: 20

Ring teeth: 80

Ring speed: fixed. Connected to carrier of stage1 (if the source such as engine shaft spins at speed3 this will be speed1)

For explanation purpose use x as driving parameter and use y as driven bellow. In other words we control x to obtain y.

Sun speed: x (motor controllable)

Carrier speed: y connect to final load (this is the actual output of robot)

3. FEATURED OPERATION

Scenario:

x = 0 by default y = 0.66 (no maneuvering at stage 2, system runs only on stage1 input)

Scenario:

When the robot sense an object and need to stop, then speed
x = -2.0 then y = 0
Robot needs to reverse then decrease the x further.
e.g. x = -3.0 then y = -0.33
Then speed x = -2.0 then y = 0 robot will stop

Scenario:

When the robot needs to increase its speed,

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x = 2 y = 1.33
x = 3 y = 1.66

Scenario:

If the primary is stopped for whatever reason (meaning ring speed of stage2 is 0),
x = 1 y = 0.33 move forward
x = 0 y = 0 stop
x = -1 y = -0.33

4. PROTOTYPE ASSEMBLY

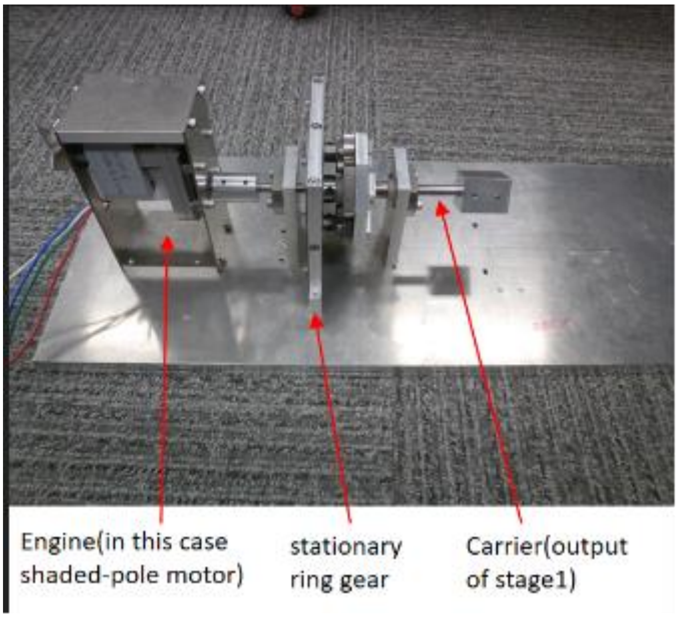

Fig1.Stage1 Assembled

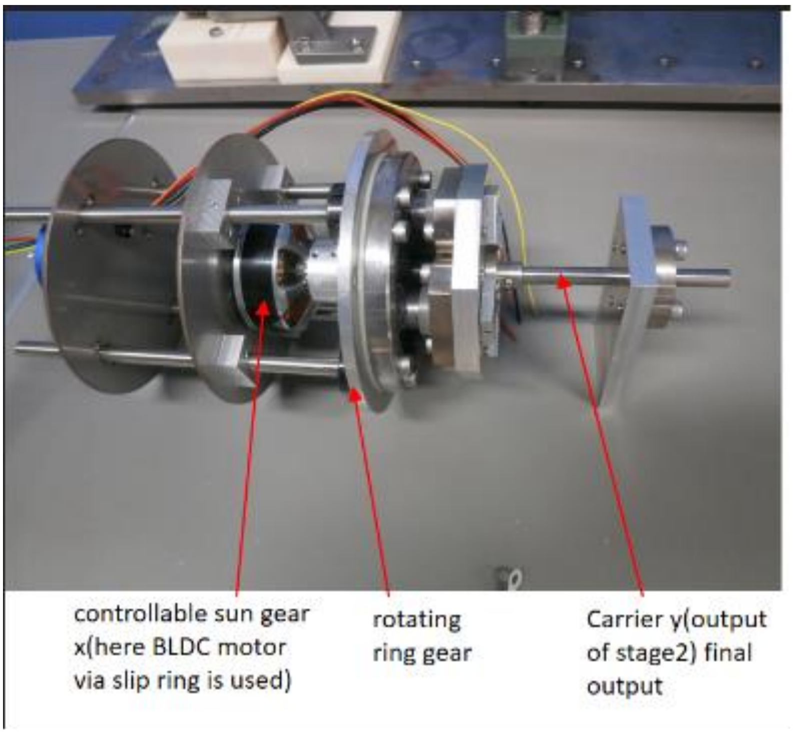

Fig2. Stage2 Assembled

Stage 1 and stage 2 are then connected together as auxiliary power drive in this research.

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Motor that runs the sun gear in stage 2 is powered via a slip ring.

5. CONCLUSION

The following conclusive points can be drawn from the test mechanical assembly and powering.

Basic tests proved the validity of the design. Vibrations are also low.

The first prototype already became a valid proof of concept (POC) machine

As future research, Sensing and control algorithm design should be done. Since BLDC motor is used here to control Sun gear's speed in addition to conventional ESC a bidirectional MOSFET switch has to be designed for rotation direction change. Also requires distance sensors, tilt sensors and relevant algorithm. That control part will be addressed in a future research article.

6. ACKNOWLEDGEMENT

Author acknowledges his sincere gratitude to the company for manufacturing the first prototype to be a valid proof of concept (POC) machine and registering the proposed as utility model [1] in Japan patent office.

7. REFERENCES

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[2]Ryan Cahoon, https://www.thecatalystis.com/gears/,2023/6/8

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