Development of the Vibration Absorption Caster-wheel for Wheelchair

--The effect of the vibration absorption and endurance--
Introduction

• Wheelchair users feel vibrations through caster & seat
• Vibrations lead discomfort make users get tired
• Needs of additional function: vibration absorbing on wheelchairs / casters
• Main cause of vibration is on the front casters (Rear wheel are air-tire)

→ Focus on front caster wheels
Caster Types

• **Air tire type:** adjustable hardness, comfort air leak, flat tire (puncture)

• **with Shock-absorber:** comfort, no-puncture, very expensive (about $160)

• **Low repulsive urethane:** comfort, no-puncture, still expensive (about $115) some of them are insufficient function
Development of inexpensive caster wheel that has the function of vibration absorbing.

• Material: Low repulsive urethane
• Price: $50.00 /each or less
• Main requirements:
  1. absorb vibration:
     Ruggedness of 10mm height or less (5~8mm)
  2. without increasing Running Resistance
  3. enough stiffness for Running Endurance
Introduction

In our previous research:
clarified the basic characteristics.

• **Function of vibration absorbing:**
  Passageway with bumps (indoor) ➔ good!
  Stone paved roads (outdoor) ➔ good!

• **Running resistance:**
  not increase so much (easy to propel)
  ➔ Well-balanced design !!!!

How about Endurance ??
Objective

Investigate the running endurance of the caster we have developed
Methods

(A) Caster we developed (D=75mm)
(B) Urethane type 1 (D=75mm)
(C) Urethane type 2 (D=75mm)
(D) with shock-absorber (D=65mm)
(E) Normal solid caster (D=80mm)
Methods

**Running Endurance Testing Machine:** (JIS-T9201)
- double drums
- driven by speed controlled motor
- with bumps of 12mm height
- 200,000 machine’s drum revolutions (157km)

**Fix the wheelchair on the testing machine**
- with dummy weight of 75Kg
Methods

- **Acceleration Pick up Sensor**: TEAC 707LF (Max 150 m/s²) mounted on the housing frame of front caster
- **Amplifier**: TEAC SA-611
- **Data logger**: TEAC ES-8 (Max 2 kHz)
- **Filter**: cut ~0.2 Hz (DC), 1 kHz ~
- **MAA**: Maximum Amplitude of Acceleration (m/s²)
Results (visual observation)

- Caster (A) : Tiny crack around interface of wheel and tire
- Caster (B) : none
- Caster (C) : none
- Caster (D) : none
- Caster (E) : wear-out, and scar on the surface
Results (MAA)

Caster E

- MAA were ranged around 122 m/s².
- Almost flat data.
  (not increase according to the increasing of mileage)
Results (MAA)

Caster A

- Start from about 80m/s², reach about 100m/s².
- Reduce 15~35% of MAA against Caster(E).
- MAA increases according to the mileage.
Results (MAA)

This result was dissatisfaction!
Discussions

• In our previous research:
  **Function of vibration absorbing**: GOOD!
  - Passageway with bumps (indoor)
  - Stone paved roads (outdoor)

• In this research (Running Endurance test):
  **Function of vibration absorbing**: not so good!

  Why ???
Discussions

• Every crack were at the interface of tire and inner-wheel
• Thin urethane tire & too high bump (vs design spec.)
• Rim of the inner-wheel hits into edge of the bump
• Urethane tire was damaged (crack)
• Leads decreasing of the function
• As the design specification:
  absorb the vibration of 10mm height or less.
  (mainly 5~8mm)

• The height of the bump of this test was 12mm.

→ Testing condition of 12mm height
  was excess specification !?
Re-arrange and re-produce new trial caster:

• Thickness of Urethane tire $\rightarrow +3\text{mm}$
• Diameter of inner wheel $\rightarrow -6\text{mm}$
• Increase hardness of urethane tire
Conclusions

- Investigate the running endurance of the caster we have developed.
- MAA had decreased 15~35%.
- MAA increases according to the mileage.
- The effect of the vibration absorption was not sufficient.
- Re-designing of thickness of tire and inner-wheel could be the solution.
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