Re-design tony kart mitox gokart model (Re-design analysis of chain-drive components)

I Mubarak*
Departemen Pendidikan Teknik Mesin, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi no.229, Bandung, Jawa Barat, Indonesia
*barox82@upi.edu

Abstract. The purpose of this study was to determine the type of chain suitable for use on karts, besides that this study aimed to determine the safety factors of chain hinges and sprocket gears used in redesigned karts. The method used in this study uses descriptive analysis method, namely by describing the data about the chain wheel on karts, after describing the data, the data are analyzed theoretically about the forces that occur in the chain wheel and the safety of the use of chain wheels used in redesigned kart. After analysing the data, it was found that the chain wheels on the redesigned karts were safe to use. This is indicated by the acquisition of a hinge safety factor value of 4.02. The results of this study have an impact on the use of chain wheels on the redesigned karts in the safe category to be used for kart racing purposes.

1. Introduction
The development of the automotive world of Otto and Diesel Motorcycles almost touches all fields, even sports. Karting automotive sports branch which is better known as karting [1]. Karting uses Otto Motor 2 steps. The 2-step motor works with two cycles, for the same cycle. The construction becomes more compact and also simpler. The frame is a place where the engine components, steering and so on are attached. The steering system serves to direct the vehicle in accordance with the wishes of the steering wheel.

The kart drive consists of a combination of sprocket pinion which is directly channeled to the rear wheel shaft. Kart wheels are 4.5x10.5 for front and 7.1x11.00 for rear. The main feature of the chain drive is that as soon as it glides on with a sprocket tooth, the chain rotates as a single unit with a sprocket. By the way the chain works, collisions that occur in the tooth chain will be much smaller when compared to the roller chain [2]. The key connections found on the chain wheels can be useful for minimizing the effect of the arc.

1.1. Gokart review
Kart is a four-wheeled vehicle that has the characteristics of a motorcycle. Karting uses an engine that is almost the same as a motorcycle. But at first, the kart was introduced using a two-step type engine. The two-step motor works with a cycle twice the number of four-step motor cycles, for the same cycle. Thus the construction becomes more compact and also simpler because some moving machine parts can be eliminated. Therefore, the kart uses a two-step motor as a driver. In addition, because the kart does not have a shock absorber, the engine used must be as minimal as possible to produce vibration, and it is filled with a two-step engine. But along with the times and demands of the environment, now the
introduction of the four-step engine is being introduced. The karting championship regulation for 2004 also requires the use of a four-step motor as a driver.

1.2. Kart engines
Karting uses an engine type that is almost the same as a motorcycle. The two-step engine type is chosen because the engine has higher acceleration and speed than the 4-step engine with the same cylinder capacity. Rotax is one of the kart engine manufacturers, where FR125 is one type of engine that it produces. Rotax specializes in providing kart engines and spare parts. Rotax FR125 MAX has a cylinder capacity of 124.8 cm³. This engine is capable of issuing torque of 21 Nm at 8750 rpm [1].

Karting is divided into several classes according to their class (specifications), namely: cadet classes, junior classes, senior classes and gearbox classes [3].

1.3. Gokart construction re-design
Kart of The Tony Kart model uses the Rotax engine. Rotax FR125 MAX has a cylinder capacity of 124.8 cm³. This engine is capable of issuing torque of 21 Nm at 8750 rpm.

Power transfer system on the Tony Kart kart Mitox model uses chains as a link between the engine and the rear axle. The kart drive consists of a combination of sprocket pinion which is directly channeled to the rear wheel shaft. Kart wheels are usually dimensions 4.5 x 10.5 for the front and 7.1 x 11.00 for the rear.

The re-designed kart frame is made of cylindrical round section iron. H-type kart frame type with short dimensions. Carton material made of steam pipe material.

The power transfer system on the kart is re-designed using a chain as a link between the engine and the rear axle. The kart drive consists of a combination of sprocket pinion which is directly channeled to the rear wheel shaft. Karting wheels that are installed on the re-design result are not changed, because they use the original rim and tires which are 4.5 x 10.5 for the front and 7.1 x 11.00 for the rear.

Number of chains used: 52 eyes
Number of front gears: 14
Number of rear gears: 25

Information:
- WA: The weight of the kart is empty (without passengers)
- WB: Heavy Weight (with passengers)
- F: Weight of frame (frame) + completeness
- E: Engine weight (RX-King)
- P: Passenger weight

1.4. Overview of the chain wheel
The power transfer system on the kart uses a chain as a link between the engine and the rear axle, besides being simpler it is also lighter both in terms of cost and weight. The kart drive consists of a combination of sprocket pinion which is directly channeled to the rear wheel shaft. Kart wheels are usually dimensions 4.5 x 10.5 for the front and 7.1 x 11.00 for the rear [4].

Power transfer elements with chains, consisting of two chain wheels and chains. The first chain wheel is driven by a driving motor (drive shaft) and the other one is mounted on the shaft to be moved.

The function of the chain is as a component of power transmission from the engine to the rear axle, where the displacement is like a transmission that moves the rear wheels with the rotation of the engine. The striking feature of this chain is that as soon as it glides on with a sprocket tooth, the chain rotates as an object with a sprocket. This is different from the belt (gears) or gears, where there is no sliding connection with sprocket teeth.

From the information above, it is clear that sound will be greatly reduced and the tooth chain does not require accuracy as high as the gears, and reduce the occurrence of breaking compared to the belt (belt).
1.5. *Chain review*
Chains that function as a power transfer on the machine can be divided into five types, including: Gall Chain, Bus Chain, Roller Chain, Pen Hook Chain, M Morse chain.

2. *Method*
The method used in this study is by means of theoretical analysis, namely by calculating various factors related to the strength of the chain and sprocket to be used on the redesigned karts. After a theoretical analysis, the next step is to choose the chain and sprocket that are in accordance with the results of the analysis, and apply it to the redesigned kart. The methods carried out include:

- Theoretical analysis of chain strength and sprocket
- Selection of chains and sprocket
- Give treatment to the sprocket so that it can be used on karts, including: sprocket turning, providing heat treatment and quenching on the sprocket to obtain surface strength
- Application to karts
- Empirical testing.

3. *Results and discussion*

3.1. *Result*

3.1.1. *Analysis of chain calculations*

*a) Correction factor (fc).* Correction factors are obtained from regarding correction factors (fc). Because the transmission used includes smooth transmission, piston motor, and without hydraulic transmission, the correction factor is 1.2 [5].

\[ F_c = 1.2 \]

- Plan Power (Pd) = P x fc = 13.62 x 1.2 = 16,344 kW
- Plan Moment (T1) = 9.74 x 10^5 (kgmm)
- Number of Large Sprocket Teeth (z2) = z1 x i = 14 x 4 = 56 (fruit)
- Chain Strength (Ftotal)

*b) Momen Puntir (T) T = 9.74 x 10^5. Kgmm.*

1) *Chain strength*

- In the A-A slice, there is a force of 0.5P which is held by the slice \( s_1 \times t \)

\[
\sigma_{s1} = \frac{0.5 \cdot F_{total}}{s_1 \cdot t} = \frac{0.5 \times 214,365}{10,4 \times 1.5} = \frac{107,1825}{15,6} = 6,871 \text{ (kg/mm}^2)\]

Description: \( s_1 = h \) = The width of the chain plate
\( t = T = \) hinge thickness

- In the B-B Slice, At the B-B slice there is a 0.5P force which is held by slices (s2 x t)

\[
S_2 = h - D = 10,4 - 3,97 = 6.43 \text{ mm}\]

\[
\sigma_{s2} = \frac{0.5 \cdot F_{total}}{2 \cdot s_2 \cdot d} = \frac{0.5 \times 214,365}{2 \times 6.43 \times 1.5} = \frac{107,1825}{19,29} = 5,556 \text{ (kg/mm}^2)\]

Información: \( D = \) Pen Diameter [5]

\[
\sigma_2 = \text{pull tension on B-B}\]

- In the Offensive of D-D, There is a 0.5P force detained by the focus area (d x t)
\[ \sigma_{t3} = \frac{0.5 \cdot F_{\text{total}}}{d \cdot t} = \frac{0.5 \cdot 214,365}{7.94 \cdot 1.5} = \frac{107,1825}{11.91} = 8,999 \text{ (kg/mm}^2\text{)} \]

Information: \( d = R = \text{Diameter of rollers} \) [15]

- Average tensile strength
  \[ \sigma_{\text{average}} = \frac{\sigma_{t1} + \sigma_{t2} + \sigma_{t3}}{3} = \frac{6,871 + 5,556 + 8,999}{3} = \frac{21,426}{3} = 7,142 \text{ (kg/mm}^2\text{)} \]

- Safety Factor (SF) = 2,8003

2) Power of pen hinges

- The power of pen hinges on C-C
  - Shear Stress (\( \tau \)) = 2,166 Kg/mm²
  - Bending Stress (\( \sigma_B \)) = 3,273 Kg/mm² = 3,273 Kg/mm²
  - Total Stress (\( \sigma_{\text{total}} \))
    \[ \sigma_{\text{total}} = \sqrt{(\sigma_B)^2 + 3 \cdot (\tau^2)} = \sqrt{(3,273)^2 + 3 \cdot (2,166)^2} \]
    \[ = \sqrt{10,7125 + 14,075} = \sqrt{24,7875} = 4,979 \text{ (kg/mm}^2\text{)} \]
  - Safety Factor (SF) = \( \frac{\sigma_{yl}}{\sigma_{\text{total}}} = \frac{20}{4,979} = 4,02 \)

- The power of the pen hinges on E-E
  - Safety Factor (SF) = \( \frac{\sigma_{yl}}{\sigma_{\text{total}}} = \frac{20}{22,998} = 0,87 \)

3.1.2. Gear wheel analysis. From the data in the field, the following data are obtained:

- Motor power (P): 13.62 kW
- Correction factor (Fc): 1.2 [6]
- Material: FC 20 [6]
- Permissible tensile stress (): 20 kg / mm² [5]
- Number of front sprocket teeth (z1): 14 (fruit)
- Number of rear sprocket teeth (z2): 25 (fruit)
- Distance for chain (p): 12.70 [5]

a) Analysis of calculation of front gear (sprocket)
  - Plan Power (Pd) = P \times fc = 13.62 \times 1.2 = 16,344 \text{ (kW)}
  - Puncture diameter (Dp) = 57.21 mm
  - Module (m) = 4.1
  - Outside Diameter (Dl) = Dp + 2. m = 57.21 + 2. 4.1 = 65.41 (mm)
  - Inner Diameter (Did) = Dp - (2.2-2.6).m = Dp - (2.4).m = 57.21 - (2.4). 4.1 = 577.21 - 9.84 = 47.37 (mm)
  - Gear thick (b) = (6-8). m = 7. m = 7.4.1 = 28.7 (mm)
  - Bending stress (\( \sigma_B \))= 1.92 (kg/mm²)
o Front sprocket shaft diameter \( (d_s) = 12,174 \text{ mm} \)
o Shear stress on the front sprocket \( (\tau) = 5,087 \text{ Kg/mm}^2 \)
o Safety Factor \( (SF) = 3,392 \)

b) **Analysis of calculation of rear gear (sprocket)**

o Power plan \( (P_d) = P \times f_c = 13,62 \times 1.2 = 16,344 \text{ (kW)} \)
o Puncture diameter \( (D_p) \) (mm)
\[
m = \frac{D_p}{z_2} = \frac{101.6}{25} = 4.064
\]
o Modul \( (m) \)
o Outer Diameter \( (D_l) = D_p + 2.m = 101.6 + 2.(4.062) = 109,728 \text{ (mm)} \)
o Inner Diameter \( (D_d) = D_p - (2.2 \div 2.6).m = D_p - 2.6.m = 101.6 - 2.6. (4.064) \)
o Gear thick \( (b) = (6-8).m = 6. (4.064) = 24,384 \text{ (mm)} \)
o Load plan \( (F_t) = 35,004 \text{ Kg} \)
o Bending stress \( (\sigma_B) = 1,042 \text{ Kg/mm}^2 \) (kg/mm$^2$)
o Rear sprocket shaft diameter \( (d_s) = 16,644 \text{ mm} \)
o Shear stress on the rear sprocket \( (\tau) = 1,955 \text{ kg/mm}^2 \)
o Total stress \( (\tau_{max}) = 2,023 \text{ Kg/mm}^2 \)
o Safety Factor \( (SF) = 4,943 \)

3.2. **Discussion**

Based on the results of the analysis and comparing the existing provisions, and also the results of the discussion, the following information is obtained:

The calculation of the chain is obtained \( Z_2 = 56 \) is not used, because in addition to rarely available in the market, also because the wheel diameter on the kart is much smaller than the motorbike in general (18 inch) that is equal to 7.1 inch. Then the comparison of these gears is considered to have approached the actual comparison (meeting the requirements).

- Safety factor of the chain is obtained, then the chain is safe to use, because the safe limit of safety factor = 2 ÷ 6.
- The safety factor of the chain hinge pen is obtained, then the pen chain hinges on the C-C are safe to use, because the safety limit of the safety factor = 2 ÷ 6
- The safety factor of the chain hinge pen on E-E is not safe to use, because the safety limit of safety factor = 2 ÷ 6. So the solution for the material from the pen hinge to the E-E slice must be replaced.
- Safety factor obtained, then the front gear (sprocket) used is safe to use on this kart, the limit of safety factor = 2 ÷ 6
- Safety factor is obtained, then the rear gear (sprocket) is safe to use on this kart, the limit of safety factor = 2 ÷ 6.

4. **Conclusion**

The calculation results from the Re-Design of the Tony Kart Mitox Model (Re-Design Analysis of Chain Wheel Drive Components) that have been carried out, the chain used is a roller chain, because the roller chain is more resistant to field pressure, so it can accept greater chain pull. The strength of the material on the front sprocket gear is based on the type of material, the material used for the chain in the kart design is material with a group of cast iron materials, the symbol of FC 20 material, and the strength of the material is 20 kg / mm$^2$.

Both of the above do not affect the safety of the use of gear components (sprocket) on karts, because from the results of the calculation of the safety factor obtained is equal to 4.943. This indicates that the gear components used in the kart are safe to use, because of the SF limit, which is equal to 2 ÷ 6.
For the Pen Hinge Chain E-E slice on the kart, so that the material is safe to use, if possible the pen hinge material should be replaced with material SC 46 Cast Steel. Further information can be seen in Appendix I, page 64.

For the number of teeth on the rear sprocket (z2), if possible, it should be replaced with a gear (sprocket), which amounts to 56 (pieces).

For the shaft diameter used in karts the results of re-design are 40 mm, while the calculation results are 16.64 mm. The results of this calculation are not used, because the axis of this calculation results is a type of solid iron (containing), while in the kart the re-design results are used iron pipe (kopong). So that the pipe in the kart is considered to have met the requirements.

References
[1] Raghuvanshi A C, Srivastav T and Mishra R K 2015 Design and Development of Foldable Kart Chassis 4th International Conference on Materials Processing and Characterization 2 1707-1713
[2] Dijk M 2011 Technological Frames of Car Engines Technology in Society 33(1-2) 2-7
[3] Stolk J C 1986 Elemen Konstruksi dari Bangunan Mesin (Jakarta: Erlangga) p 484
[4] Fuglede N and Thomsen J J 2016 Kinematic and Dynamic Modeling and Approximate Analysis of a Roller Chain Drives J. Of Sound and Vibration 12 (028) 8
[5] Winarno A 1997 Panduan Service Yamaha RX-K (Jakarta: YMKI)
[6] Dobrovolsky 1982 Machine Elements (Jakarta: Erlangga)