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A New Design of Roller Chain 415

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Abstract

Chain 415 that used in racing, with original specification of chain: plate thickness 1.5mm, material steel 50C and total chain weight 870 grams per 130 links, can be improved to support its performance. In this thesis, a new design will be discussed to reduce weight of 415 chain. Weight savings of components, obtained from thickness plate reduction 20% and its pin height reduction. The thinner plate received more stress, therefore the new plate properties must be made better with more strength. With same material steel 50C, the new plate design heat treatment processed is improved from Heat Quench Temper to Austemper. From the prototype made, weight saving achieved is around 5-12%.

Keywords: Chain 415, Weight Saving, Austemper.

INTRODUCTION

Roller chain 415 are chain products that generally used in motorcycle racing for engine 100-135cc. Specifications are: plate thickness 1.5mm, material 50C, and chain 415-130 links weight 870 grams. Racing component parts are related to its weight. The lighter the parts the more acceleration can be achieved [1]. In the regulation lower weight limitation is also included, so the lighter the parts would support team racer to give more opportunities to modify their motorcycle. Fig. 1 shown the roller chain 415 and fig. 2 shown components of roller chain.

Figure 1. Roller Chain 415

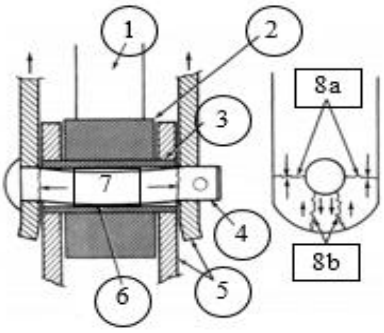

Figure 2. Roller chain components: 1:Sprocket; 2:Roller; 3:Bush; 4:Pin; 5:Plates; 6:Pin bending; 7:Pin Shear, 8a:Plate Tensile , 8b: Plate Shear. [2]

Based on the original roller chain 415-130 links with 870 grams, its performance can be improved by reducing its weight. Attached in table 1 here are data regarding original design 415 qualities.

Table 1. Original Chain 415 Qualities [3]

Chain Tensile	1780 kgf
Tensile Broken Part	pin
Pin Core Hardness	470 Hv
Plate thickness	1.5 mm
Plate Hardness	45 HRC

There was analytical research to reduce weight without changing material and other properties of the plate by making hole in the center of plate has been analyzed. The result achieved 3%-10% weight reduction of plate component. Fig. 3 shown the sketch method of weight reduction. [4]

Figure 3. Weight reduction by hole made in the center of plate [4]

In this paper the weight reduction that will be made by using 20% thinner plates, approx. 20% lighter plate. The thinner the plate, the more stress the plate received. With same material, the new plate design heat treatment processed is improved from Heat Quench Temper to Austemper.

Austempering is isothermal transformation for ferous alloy at temperature below pearlite transformation and above martensite transformation. Phase that is formed from Austempering process is called Bainite phase. The advantage of austempering process on steel alloy are:

- Ductility, toughness & strength improvement at same hardness [5]: Decrease the likelihood of cracking; may improve the hardness of component with less chance of crack.
- Shorter time-cycle within hardness range 35 – 55 HRC [5]: energy savings
- Reduce shape distortion [5] [6]
- Improve resistance to subsequence embrittlement. [5]

It was proven that austemper process resulting finer grain size compared to time-quench [7], Tensile strength/yield strength and elongation values of 1700 MPa/1300 MPa/5% and 1350 MPa/920 MPa/15% can be achieved with variables thermomechanical multipass rolling before austempering treatment [8] and significant improvement in two-step austempering process in yield and tensile strengths and fracture toughness of the material over the conventional single-step austempering process [9].

Target, weight saving of chain achieved is around 5-10%.

PROCEDURE

The main target want to be achieved are:

1. Designing new chain 415 that have lighter weight approximate 10%.
2. Lighter chain with same material, differences: thinner plate and different heat treatment process.

Research Equipment that being used are:

a) Milling NC machine to make test specimen

b) Continuous Furnace: Heat Quench Temper Furnace and Austemper Furnace with temperature control per 1 meter heated area.

c) Rockwell Hardness Tester

d) Universal Tester Machine: tensile

e) Manufacture machine: pin cut, progressive stamp and assembly machine.

To achieved the target, steps of that need to be done:

a) Making test specimen that follows JIS Z 2201 type 13B for material that less than 3 mm thickness.

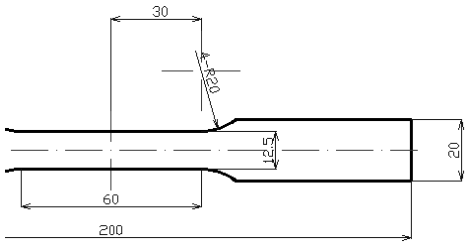

Figure 4. Test piece JIS Z 2201 type 13B

b) Heat treat the test specimen: heat quench temper and austemper.

c) Collect the properties of both process: heat quench temper and austemper with hardness and tensile test.

d) Design new plate thickness: calculating the strength and from fig. 5 constrain of:

1) Inner width of inner plate components. and
2) Roller outer diameter
3) Pitch of chain.

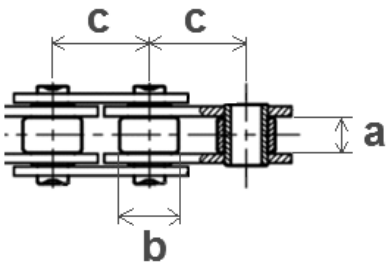

Figure 5. Chain dimension: a: inner width, b: roller diameter, c: chain pitch

Those constrains as seen in fig. 5 are caused by engagement of chain with sprocket. Therefore to make the chain lighter, we can make change: plate components to be thinner and pin length shorter.

Shorter pin length changes following the plate dimension. To be exact, shorter pin doesn't change shear stress that occur to the pin unlike thinner plate components resulting higher tensile stress to plate components.

New component dimension pin and plate design weight are estimated from proportional dimension changes from existing chain.

e) Prototype to confirm design result. Prototype made to confirm actual result of chain tensile and weight comparison from original design and new design. Tensile performed using standard test JCAS [10]: room Temperature, at least 5 links are effective (not clamped) with velocity 40-60 mm/min.

RESULT AND DISCUSSION

Properties of Plate

The properties of plate compared in the stress strain graph in fig 7 and test piece for tensile in fig 6. From table 2 & 3 we can see plate properties to calculate the strength. The strength of the plate should be calculated in the critical area, outer plate in fig 4 and inner plate in fig 5.

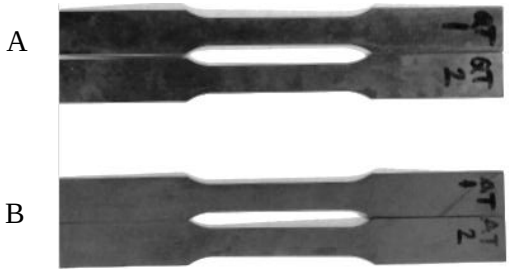

Figure 6. Test piece: A: quench temper, B: austemper

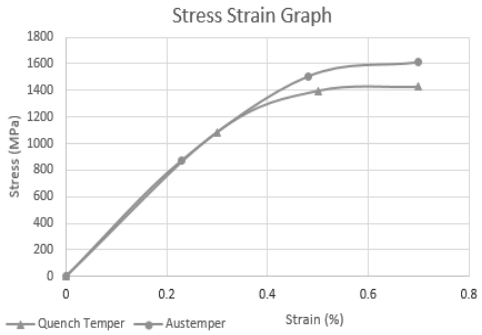

Figure 7. Stress Strain Graph Quench Temper Plate & Austemper

Table 2. Plate Quench Temper Properties [3]

No	Tensile Marking	Yield (MPa)	UTS (MPa)	Elongation (%)
Steel plate QT				
1	QT 1, 45 HRC	1,439	1,534	5.38
2	QT 2, 45 HRC	1,420	1,525	5.38

Table 3. Plate Austemper Properties [3]

No	Tensile Marking	Yield (MPa)	UTS (MPa)	Elongation (%)
Steel plate AT				
1	AT 1, 50 HRC	1,505	1,720	4.98
2	AT 2, 50 HRC	1,393	1,728	5.02

To calculate the applicable force that chain can formula will be used is:

$$F = \sigma y \times (Critical\ Area) \quad (1)$$

Outer Link Plate (*Outer Plate*)

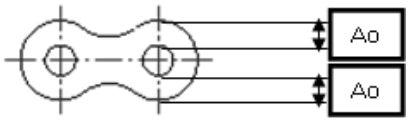

Figure 8. Ao Critical Area of OLP

for OLP :

original design maximal Force endurance,

Fo_1 = 1420 MPa x (2x9.15 mm^2) / 9.81m/s^2

Fo_1 = 2648.92 kgf

new design maximal Force endurance,

Fo_2 = 1500 MPa x (2x7.32 mm^2) / 9.81m/s^2

Fo_2 = 2238.53 kgf

Inner Link Plate (*Inner Plate*)

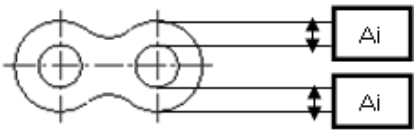

Figure 9. Ai Critical Area of ILP

for ILP :

original design maximal Force endurance,

Fi_1 = 1420 MPa x (2x9.36 mm^2) / 9.81m/s^2

Fi_1 = 2709.72 kgf

new design maximal Force endurance,

Fi_2 = 1500 MPa x (2x7.488 mm^2) / 9.81m/s^2

Fi_2 = 2289.91 kgf

We can compare load from table 1 that new design light weight plate with thinner austemper plate are capable to withstand chain properties breaking load.

New Design Chain

New component dimension pin and plate design weight are estimated from dimension changes. The estimation of weight can be seen in table 4 below resulting 12% lighter than 415 original design.

Table 4. Estimation of chain's weight

	415	130 link	415new	130 link
Part	gr/ pcs	gr/ chain	gr/ pcs	gr/ chain
Pin	1.28	163.58	1.25	160.51
Bush	0.71	92.69	0.71	92.69
Roller	0.70	91.26	0.70	91.26
ILP	2.14	277.81	1.72	223.60
OLP	1.83	237.90	1.47	191.10
conn set	1 set	5.49	1 set	5.49
Total		868.73		764.65

Prototype

Prototype is made to confirm new design actual result.

Breaking Load Result

Average Breaking Load result for original 415 chain is 1804 kgf with broken part **pin**.

Average Breaking Load result for new design 415 chain is 1760 kgf with broken part **pin**. Minimum requirement chain standard breaking load standard result 1660 kgf, this light weight 415 chain has meet the strength requirement.

The decreased thickness plate component still stronger than the pin. Hardness increment in effect of bainite structure changing heat treatment process to austemper is effective.

Chain Weight

Original 415 Chain is 870 gr, compared to the new design weight is 820 gr as seen in fig 10 and 11. From prototype chain weight reduction is 5.75%, the result may vary caused by actual tolerance of parts/ components dimension.

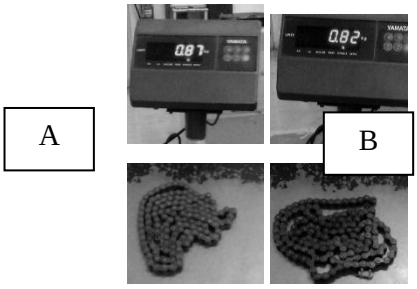

Figure 10. Chain 415 – 130 links Mass compare. A: orginal design and B: new design

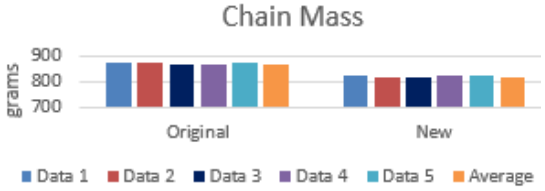

Figure 11. Chain 415 Mass Comparison

CONCLUSIONS

From the comparison, we can conclude the quality of chain:

1. The modification of reduction plate thickness and heat treatment to austemper is effective,
2. Chain Weight Saving from prototype is 5.7-12%

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