Design for Joint module of NTD Hydraulic Rotation Device

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1. Introduction

For many year operation of NTD(Neutron Transmutation Doping) facility in The HANARO, a research reactor in KAERI, new ideas to improve the efficiency and convenience of irradiation work have been deliberated. In particular, a hydraulic-driven system is proposed to make up for the weakness of the conventional motor-driven system, which is expected to enhance the convenience and reliability [1]. In the case of a motor-driven system in which a chain is connected to a motor at the upper part, a joint module is not necessary. However, NTD irradiation rig needs to design the joint module to deliver the rotational force of the NTD hydraulic rotation device (NTDHRS) to NTD rig.

Accordingly, it is a required to design and study a joint module for rotating the upper irradiation basket by transmitting the rotational force of the lower hydraulic rotation system.

2. Methods and Results

2.1 Type of Joint module

A joint module is intended to transmit a stable rotation force and to securely fasten the upper and lower parts when fastened. The clutch, which is a type of joint module, is a shaft joint designed to transmit the rotational motion of the main coaxial shaft to the driven shaft. It transmits necessary torque in driving situation and protects parts of engine and power train from overload in advance. Fig. 1 is classified according to the shape of the teeth type in the form of a clutch, which are usually rectangular, spiral and trapezoidal [2].

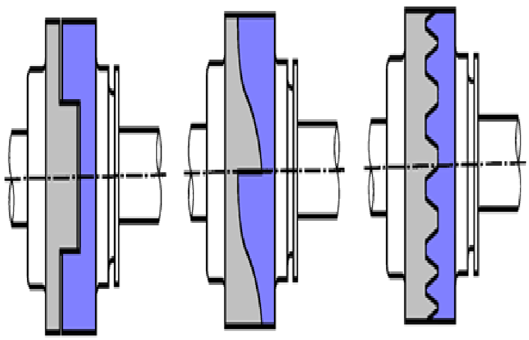

Fig. 1. Teeth type, claw clutch

2.2 Joint Module shape design

In designing a clutch, the friction coefficient (Z) of the contact surface should be a proper size and small and lightweight to reduce the inertia. Also, the heat generated due to the friction must be sufficiently removed to ensure and smooth tightening. At this time, a large external force is not required and balance should be maintained.

Equations (2-1) to (2-4) are clutch design formulas, where M is the bending moment, Z is the section modulus of the face, τ_{max} is the maximum shear stress, and σ_a is the allowable bending stress. Fig. 2 is the side surface shape and configuration of the clutch, P is the side pressure acting on the teeth face, H is the height of the teeth, D_1 and D_2 are the inner and outer diameters of the clutch [2].

$$M = PH \quad (2\text{-}1)$$

$$Z = \frac{1}{6} \times \frac{D_2 \times D_1}{2} \times \left(\frac{\pi \times (D_2 - D_1)}{4 \times n}\right)^2 \quad (2\text{-}2)$$

$$\sigma_b = \frac{M}{Z} \leq \sigma_a \quad (2\text{-}3)$$

$$\tau_{max} = \sqrt{\left(\frac{\sigma_b}{2}\right)^2 + \tau} \leq \sigma_a \quad (2\text{-}4)$$

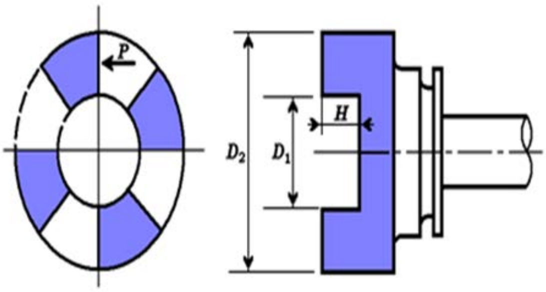

Fig. 2. Side shape and Composition of Claw clutch

2.3 Calculate of force acting on the teeth

The joint module considered in this paper will be designed based on the function of the claw clutch.

Table 1 shows the calculation results of the bending stress calculation using the clutch formula described in Section 2.2. The inside diameter of the joint module is the length from the center of the fastening device to the blade.

According to the KEPIC MNZ Appendix III design yield strength and allowable stress, bending stress should not exceed 90% of the yield strength of the material. In addition, it shall be 2/3 of the specified minimum yield strength at room temperature, which is the standard for setting the maximum design stress intensity of the non-ferrous metal material. Thus, the design stress intensity is set at 184 Mpa, which is 2/3 of 276 Mpa at 25 ° of Aluminum 6061- T6.

Using the formulas, the force acting on the teeth and the section modulus (Z) are used to obtain the bending stress of 0.182Mpa. This result satisfies the pre-design requirement because the bending stress acting on the teeth is less than the allowable bending stress, which is the yield strength. As shown in Table 2, the irradiation time and number of joint produces 144,000 with 40 years of operation life. Also, applying Fig. 3 the S-N curve of aluminum, it guarantees safety against repeated crash.

However, this result shows the bending stress on the teeth after full joint, which can predict the preliminary design requirements and stability for the joint module, but it cannot be applied to various crash scenarios at joint.

As a consequence, various impact conditions should be selected to create a scenario and the Joint module should be evaluated through the FEM analysis. After that, the actual Joint module should be manufactured and the performance evaluation and mechanical problems should be evaluated through the verification test.

Table 1: Allowable stress on craw at Full joint

	Calculation result	Unit
Outside diameter(d_o)	159	m
Inside diameter(d_i)	0.08	m
Number of Claw(n)	8	
Claw height(h)	0.015	m
Force acting on Claw	44.074	N
Bending moment	0.661	N*m
Section modulus(z)	3.624E-06	m^3
Bending Stress(σ_b)	0.18	Mpa
Allowable Bending Stress(σ_a)	184	Mpa

Table 2: Irradiation time and number of joint in HANARO

	Variable	Unit
Irradiation time	2~5	Hour
Operation time	300	Day
Design life	40	Year
Number of joint	12(1 day)	Cycle
Total cycle	144,000	Cycle

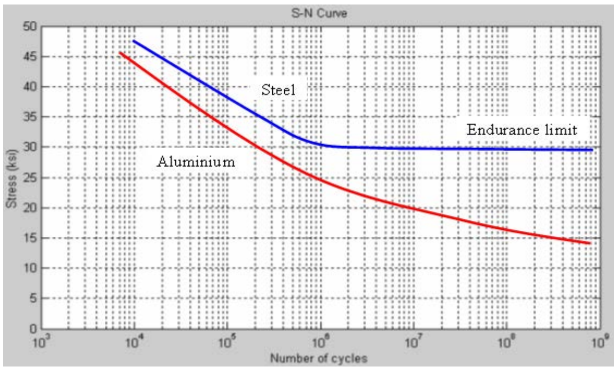

Fig. 3. Initial manufacture of Joint Module

3. Conclusions

In this paper, a joint module to be installed in the newly proposed NTD hydraulic rotation system was designed. The design direction was based on the function of the claw clutch.

The results of this paper are summarized as follows.

① KEPIC MNZ Appendix III design stress intensity set at 184Mpa, which is 2/3 of 276Mpa for Aluminum 6061-T6 at 25° according to the design stress intensity and allowable stress.

② The bending stress acting on the teeth is 0.182Mpa using the clutch formula. This is less than the design stress intensity and meets the pre-design requirements. Applying Fig. 3 the S-N curve of aluminum, it has faith in safety against repeated crash.

③ The calculation result is the calculated value of the stress acting on the teeth after full joint. After constructing various hypothetical scenarios when actually tightening, the joint module is evaluated through FEM analysis.

④ The mechanical problems and performance will be investigated through the verification test. After that additional complementary designs will be made in the future.

ACKNOWLEDGEMENT

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