International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 11 Issue 9 September 2022 || PP 18-30

Analysis of Parameters Affecting Performance onRemanufactured Continuously Variable Transmission Using Performance Demonstration Test Bed

Sung-Yong Hong[1], Sang-jin Yoon[2*]
[1]*(Department of Mechanical Engineering/ NambuUniversity, Republic of Korea)*
[2*]*(Departmentof Mechanical Engineering/ Nambu University, Republic of Korea)*

ABSTRACT : *In this study, we attempted to develop a tool to check the performance of each function in the process of repairing or remanufacturing a continuously variable transmission. A test bed to verify the reproducibility of the CVT was developed during the research process, and performance tests were conducted in the stage of disassembling and assembling each part of the CVT.The gear ratio is an important factor in setting vehicle dynamics, and it is the active gear ratio that converts engine speed to vehicle speed and engine power to vehicle performance once the operating engine speed is determined. The change in diameter between the input crankshaft and the output accelerator or tire affects the gear ratio. Depending on the operating power band, the engine produced undesired levels of power output, sometimes gaining or losing that power at different speeds. Based on the developed tuning software, we confirmed the possibility of generating an accurate tuning profile.In future research, we plan to develop tuning software required for remanufacturing of continuously variable transmission for hybrid electric vehicles in conjunction with the results of this study, and to verify the reliability of various elements and functions.*

KEYWORDS –*Continuously Variable Transmission, CVT, Gear Ratio, Remanufacturing, Performance Demonstration Test Bed*

Date of Submission: 04-09-2022 Date of Acceptance: 19-09-2022

I. INTROD1UCTION

The continuously variable transmission (CVT) is a transmission in which the ratio of the rotational speeds of two shafts, as the input shaft and output shaft of a vehicle or other machine, can be varied continuously within a given range, providing an infinite number of possible ratios.A CVT is a transmission that continuously controls the transmission ratio. It has high power transmission efficiency, eliminates shift shock while driving, and automatically controls the transmission ratio to improve fuel efficiency and maintain optimal driving conditions. In addition, the structure is simple, compact and lightweight, so it is suitable for small cars.

There are a belt drive type using a belt or chain and a variable groove width pulley and a traction drive type that transmits power by contact between rolling elements, etc.

Transmissions in automobile powertrains are being developed in various ways around the world to improve fuel efficiency and ride comfort. Currently, in the automobile market, automatic transmission (Auto Transmission), DCT (Dual Clutch Transmission), and CVT (Continuously Variable Transmission) types are predominant. Each transmission has different performance according to its structural characteristics, and has distinct advantages and disadvantages [1].

Conventional transmissions use a gear set to increase vehicle speed while maintaining the engine's operating range. As the gear ratio increases, the rotational speed or angular speed of the output accelerator increases in relation to the angular speed of the engine crankshaft [2]. The mechanical components of the transmission include a torque converter with Electronically Controlled Capacity Clutch, a binary vane oil pump assembly, clutch assembly, reverse clutch assembly, direct/overdrive internal gear assembly, direct/overdrive carrier assembly, input internal and carrier assembly, re-action internal gear and reverse hub assembly, output carrier assembly, output shaft [3-4].

Transmissions in automobile powertrains are being developed in various ways around the world to improve fuel efficiency and ride comfort.

Currently, in the automobile market, interest in resource recycling is increasing due to various environmental pollution problems as the number of scrap vehicles is increasing due to the increase in vehicles [4].

Therefore, in this study, in connection with the economic effect of the introduction of the automobile parts remanufacturing market, a continuously variable transmission that can continuously output the transmission ratio among automobile parts was remanufactured. In addition, the effect of variables on the stable operation of the transmission was investigated as a result of the performance verification process.

II. EXPERIMENTAL METHOD

2.1 Algorithm of the Performance Demonstration Test Bed

Hardware and software developed in this study were used as simulators to verify the correlation between CVT performance and variables.

some part of the performance demonstration algorithm developed in this study is shown below as an example.

```
/* Includes ------------------------------------------------------------------*/
#include "stm32f10x_lib.h"
#include "math.h"
void Decrement_TimingDelay(void);
GPIO_InitTypeDefGPIO_InitStructure;
ErrorStatusHSEStartUpStatus;
ADC_InitTypeDefADC_InitStructure;
TIM_TimeBaseInitTypeDefTIM_TimeBaseStructure;
TIM_OCInitTypeDefTIM_OCInitStructure;
typedefenum {FAILED = 0, PASSED = !FAILED} TestStatus;
#define TxBufferSize1   (countof(TxBuffer1) - 1)
#define RxBufferSize1   TxBufferSize1
#define ADC1_DR_Address    ((u32)0x4001244C)
#define StartAddr  ((u32)0x0803e000)
#define EndAddr   ((u32)0x0803e800)
#define FLASH_PAGE_SIZE    ((u16)0x800)
#define DAC_SDI_H      GPIO_SetBits(GPIOB, GPIO_Pin_15)
#define DAC_SDI_L      GPIO_ResetBits(GPIOB, GPIO_Pin_15)
#define DAC_SCK_H      GPIO_SetBits(GPIOB, GPIO_Pin_14)
#define DAC_SCK_L      GPIO_ResetBits(GPIOB, GPIO_Pin_14)
#define DA_SEL0_L        GPIO_ResetBits(GPIOB, GPIO_Pin_13)
#define DA_SEL0_H        GPIO_SetBits(GPIOB, GPIO_Pin_13)
#define DA_SEL1_L        GPIO_ResetBits(GPIOB, GPIO_Pin_12)
#define DA_SEL1_H        GPIO_SetBits(GPIOB, GPIO_Pin_12)
#define DA_SEL2_L        GPIO_ResetBits(GPIOB, GPIO_Pin_5)
#define DA_SEL2_H        GPIO_SetBits(GPIOB, GPIO_Pin_5)
#define DA_SEL3_L        GPIO_ResetBits(GPIOB, GPIO_Pin_6)
#define DA_SEL3_H        GPIO_SetBits(GPIOB, GPIO_Pin_6)
#define DA_SEL4_L        GPIO_ResetBits(GPIOB, GPIO_Pin_7)
#define DA_SEL4_H        GPIO_SetBits(GPIOB, GPIO_Pin_7)
#define DA_SEL5_L        GPIO_ResetBits(GPIOB, GPIO_Pin_8)
#define DA_SEL5_H        GPIO_SetBits(GPIOB, GPIO_Pin_8)
#define OIL_PUMP_ON               GPIO_ResetBits(GPIOB, GPIO_Pin_1)
#define OIL_PUMP_OFF              GPIO_SetBits(GPIOB, GPIO_Pin_1)
void set_polarity(TIM_TypeDef *tim,u16 ch,u16 polarity);
volatile u32 oldv=0,newv=0,width=0,period=0;
volatile u32 oldv4=0,newv4=0,width4=0,period4=0;
float f_Period,f_Duty;
float f_Period2,f_Duty2;
u16 _10msec_Cnt = 0;
u16 trmCnt = 0;
u8 ad_seq = 0;
u16 ad_val[9];
#define MAX_ADC_BUFF            100
u16 ADC_Buf[9][MAX_ADC_BUFF];
u16 ADCConvertedValue[9];
u16 ad_cnt[9] = {0};
```

```
u8 TX_Oper = 0;
u8 TX_Diect_On = 0;
volatile u8 force_on = 0;
u32 EraseCounter = 0x00, Address = 0x00;
vu32 NbrOfPage = 0x00;
volatile FLASH_StatusFLASHStatus;
volatile TestStatusMemoryProgramStatus;
u32 _DataRegister[93];
USART_InitTypeDefUSART_InitStructure;
DMA_InitTypeDefDMA_InitStructure;
//ADC_InitTypeDefADC_InitStructure;
u8 DATA_EEPROM[240];
u8 open[8] = {'0'};
u8 v_on[8] = {0};
u16 open_cnt[8] = {0};
u8 Rx0_Complete = 0;
u8 Tx0_pointer = 0;
u8 Tx0_Length = 0;
u8 Tx0_Enable_delay = 0;
u8 Tx0_Disable_delay = 0;
u8 Tx0_buf[200];
u8 Rx1_buf[50];
u8 Rx0_buf_Tmp[25];
u16 Req_Address;
u8 Blink=0;
u16 HB_Cnt = 0;
u8 OUT0_C_Cnt = 255;
u16 Reset_Cnt = 0;
u8 RDY = 0;
u8 TX_Len = 0;
vu16 TmrExtiCnt[3] = {0,0,0};
u16 SenCntData[3] = {0,0,0};
|
ButtonNum = ((Rx0_buf[1]-0x30) * 10) +(Rx0_buf[2]-0x30) ;
}
Opertime = ((Rx0_buf[3]-0x30) * 100) +((Rx0_buf[4]-0x30) * 10) +(Rx0_buf[5]-0x30) ;
DACSolData[0] = ((Rx0_buf[6]-0x30) * 100) +((Rx0_buf[7]-0x30) * 10) +(Rx0_buf[8]-0x30);
DACSolData[3] = ((Rx0_buf[9]-0x30) * 100) +((Rx0_buf[10]-0x30) * 10) +(Rx0_buf[11]-0x30);
DACSolData[4] = ((Rx0_buf[12]-0x30) * 100) +((Rx0_buf[13]-0x30) * 10) +(Rx0_buf[14]-0x30);
DACSolData[2] = ((Rx0_buf[15]-0x30) * 100) +((Rx0_buf[16]-0x30) * 10) +(Rx0_buf[17]-0x30);
DACSolData[5] = ((Rx0_buf[18]-0x30) * 100) +((Rx0_buf[19]-0x30) * 10) +(Rx0_buf[20]-0x30);
DACSolData[1] = ((Rx0_buf[21]-0x30) * 100) +((Rx0_buf[22]-0x30) * 10) +(Rx0_buf[23]-0x30);

TestMode = Rx0_buf[24]-0x30;
TestCommand = Rx0_buf[25];

if(TestMode == 2)
{
    RCC_LSICmd(ENABLE);
    while (RCC_GetFlagStatus(RCC_FLAG_LSIRDY) == RESET);
```

```
                                        IWDG_WriteAccessCmd(IWDG_WriteAccess_Enable);
                                        IWDG_SetPrescaler(IWDG_Prescaler_4); // 4, 8, 16 ...
256
                                        IWDG_SetReload(0x0FFF);
                                        IWDG_ReloadCounter();
                                        IWDG_Enable();
                                        while(1);
                                }
                        }
                        Rx0_ReceiveCnt=0;
                }
                else
                {
                        Rx0_buf[Rx0_ReceiveCnt++] = rev;
                }

                if(Rx0_ReceiveCnt >=30) Rx0_ReceiveCnt=0;

                USART_ClearITPendingBit(USART1, USART_IT_RXNE);
        }
}

void TIM8_CC_IRQHandler(void)
{

        if(TIM_GetITStatus(TIM8, TIM_IT_CC3) == SET)
        {
                TIM_ClearITPendingBit(TIM8, TIM_IT_CC3);
newv = TIM_GetCapture3(TIM8);
    if(GPIOC->IDR & GPIO_Pin_8)
                {
set_polarity(TIM8,3,TIM_ICPolarity_Falling);
      period = (newv>oldv)? (newv - oldv) : (0xffff + newv - oldv);
oldv = newv;
    }
                else
                {
set_polarity(TIM8,3,TIM_ICPolarity_Rising);
width  = (newv>oldv)? (newv - oldv) : (0xffff + newv - oldv);
                }
        }

        if(TIM_GetITStatus(TIM8, TIM_IT_CC4) == SET)
        {
                TIM_ClearITPendingBit(TIM8, TIM_IT_CC4);

    newv4 = TIM_GetCapture4(TIM8);
    if(GPIOC->IDR & GPIO_Pin_9)
                {
set_polarity(TIM8,4,TIM_ICPolarity_Falling);
      period4 = (newv4 > oldv4)? (newv4 - oldv4) : (0xffff + newv4 - oldv4);
      oldv4 = newv4;
    }
                else
                {
set_polarity(TIM8,4,TIM_ICPolarity_Rising);
      width4  = (newv4 > oldv4)? (newv4 - oldv4) : (0xffff + newv4 - oldv4);
```

2.2 Performance Measurement of Remanufactured CVT through Test Bed

T

he performance demonstration is shown in Fig. It was performed jointly with PMK (Korea) while changing the parameters using the same test bed equipment as in Fig. 1.

Figure 1. Performance demonstration test bedfor manufactured CVT

The remanufacturing process of JHXX is shown in Fig. 2.The CVT remanufacturing process includes the steps of CVT fault inspection, disassembly, primary inspection, and secondary inspection.

CVT fault check	Engine check lamp is on
CVT malfunction check by test bed (1st inspection)	Gear box, oil level, Noise according to the number of gears
CVT disassembly	Check the first inspection result
Inspection of CVT internal parts	Check the malfunctioning part in detail
Inspection by part	Speed sensor, oil pressure sensor, solenoid parts
Parts cleaning	Housing, drive pulley, driven pulley
Repair and adjustment	Parts exchange, adjustment
Assembly of CVT	
2nd inspection by test bed	Commissioning operation, check the driving status of the CVT by stage

Figure 2. Schematic diagram of the remanufacturing process CVT

A performance experiment was conducted by developing a test bed and a program capable of expressing a performance curve to check whether normal operation is possible after remanufacturing the damaged CVT transmission.

The function of Transmission Control Solenoid Valve and Scan Tool Parameter is shown in Table 1.

When the TCM(transmission control module) detects an electrical circuit malfunction or overcurrent, the TCM cuts off the power-side driver for the corresponding solenoid and generates a fault code. The power-side driver resets when the circuit fault is corrected and the ignition switch cycle is complete.

Table 1. Function of Transmission Control Solenoid Valve and Scan Tool Parameter

Solenoid		Function	Scan Tool Parameter
Transmission Control Solenoid Valve 1	2ND FULLY SOL 1	Secondary Pulley	Secondary Pulley Pressure Command
Transmission Control Solenoid Valve 2	1ST FULLY SOL 2	Primary Pulley	Primary Pulley Pressure Command
Transmission Control Solenoid Valve 3	LINE PRESSURE SOL 3	Line Pressure	Calculated Line Pressure
Transmission Control Solenoid Valve 4	FOR, BACKARD SOL 4	Drive/Reverse Clutch	Clutch Pressure Command
Transmission Control Solenoid Valve 5	LOCKUP SOL 5	Torque Converter Clutch	Torque Converter Clutch Pressure Command
Transmission Control Solenoid Valve 6	OIL PUMP SOL 6	Binary Pump Control	Transmission Fluid Pump Mode

Fig. 3 shows the CVT mounted on the test bed for the performance test.

The process of setting the CVT on the test bed basically includes the steps of CVT mounting, control wiring connection, and transmission oil level check. Primary pulley, secondary pulley, oil pressure, and SPHE oil circulation port connection is also performed.

The transmission input shaft speed sensor is a Hall effect sensor mounted inside the transmission under the valve body and detects the speed of the transmission input shaft. The target wheel detects the battery clutch housing and has 60 teeth.

The Transmission Input Shaft Speed Sensor is used to control a combination of solenoid valves for accurate line pressure, gear ratio and torque converter clutch operation. Also, the intermediate speed sensor is a Hall effect sensor mounted on the outer housing of the transmission.

Figure 3. Remanufactured CVT mounting on the Performance demonstration test bed

III. RESULTS AND DISCUSSION

3.1 Acquisition data description through the test bed

Fig. 4 is an example of a performance change graph for each part according to time change.

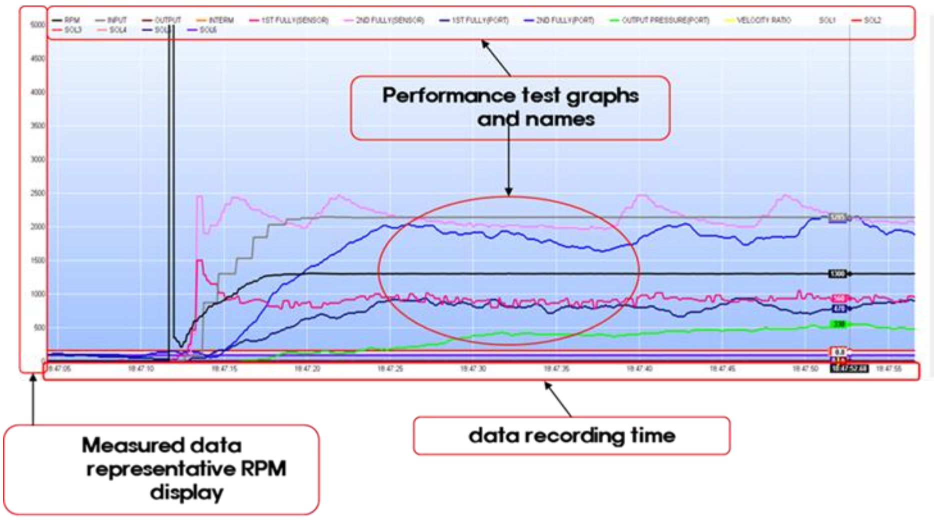


Figure 4. Example of graph description of performance change according to time change of each part

Fig. 4 explains the symbols for the test bed output results to explain the performance demonstration results, which will be discussed in the next section.

The solenoid valve is an actuator that controls the hydraulic pressure for shifting in the automatic transmission according to the output signal of the TCU, and the hydraulic pressure is transmitted to the clutch and brake connected to the planetary gear, and accordingly the transmission shows the gear ratio suitable for the driving conditions [5].

The VFS type solenoid valve is suitable for the purpose requiring high pressure control and low leakage to improve fuel efficiency.

The output shaft speed sensor played the role of driving the differential drive gear while the in-put shaft was driving the drive pulley through V-chain belts in the drive pulley [6].

The input shaft speed sensor uses the output energy from the car engine to rotate the input shaft with the power of the torque converter, and the shaft of the input shaft has the function of detecting the housing of the forward clutch installed.

The drumreluctor of forward clutch consists of 60 slots, and when the shaft rotates, the forward clutch-drum reluctor rotates at the same time. Input shaft speed sensor detected the rotating forward clutch-drum reluctor. The rotation of the forward clutch-drum reluctor is due to the rotation of the drive pulley.

The input shaft speed sensor is integrated and mounted inside the CVT, and the current changes according to the magnetic change using a current-type hall sensor. The circuit of the input shaft speed sensor is composed of 2 pins and serves as a reference function for the resistance to metal. It has a function of sending power from the PCM, passing through the parts, and controlling the PCM [7].

3.2 Abnormal performance results of CVT in test bed

Fig. 5 shows the driving test results when the shifting lever position is fixed to D-1 in driving mode. It was found from the experimental results that the output decreased in the auxiliary pump ON section.

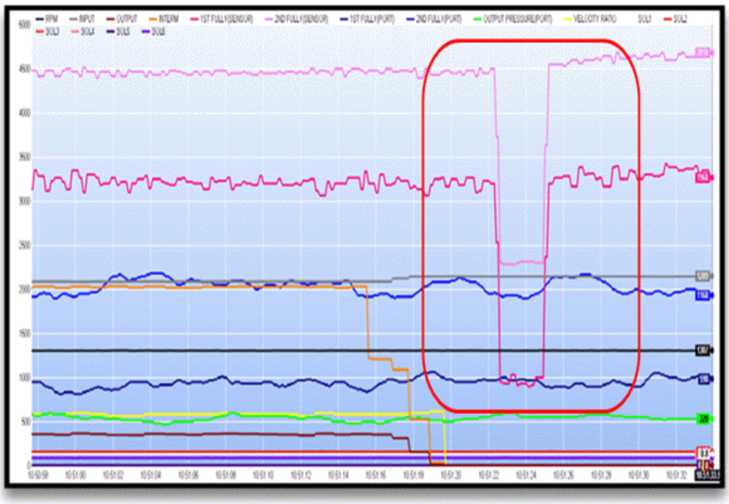


Figure 5. Abnormal output of the CVT in the driving test

Hydraulically controlled oil pumps account for a significant portion of the drive loss. Since the driving loss of the oil pump is mainly caused by the discharge flow rate and the hydraulic pressure required for control, it was necessary to minimize the oil pump driving loss by optimally designing the oil pump discharge flow rate and the hydraulic area required for control [8].

CVT can be shifted by adjusting the pulley ratio by changing the positions of the drive pulley and the driven pulley according to the geometric relationship. Therefore, the position of the drive pulley and the driven pulley needed to be controlled by the CVTF(Continuously Variable Transmission Fluid) amount and hydraulic pressure in the oil pressure chamber inside the pulley. Also, the size and control pressure of the pulley chamber were determined by the clamping force and the transmission ratio supporting the belt.

Based on these conditions, the remanufactured CVT required a review of the discharge amount to fill the CVTF (Continuously Variable Transmission Fluid) of the Oil Pressure Chamber using a high-spec oil pump.

Meanwhile, in order to normalize the abnormal CVT function, a control pressure suitable for the clamping force of the oil pressure chamber was created, and the flow rate and hydraulic pressure to control the pulley were determined by the specifications of the pulley [9].

Figure 6. The experimental graph of the gear ratio change according to the change of the primary and secondary pulleys

It can be seen in Figure 6 that the gear ratio drops and then rises again after shifting according to the change of the primary and secondary pulleys.The gear ratio due to the change of the primary and secondary pulleys is abnormal, indicating a state in which the high-speed gear ratio cannot be maintained even after shifting.

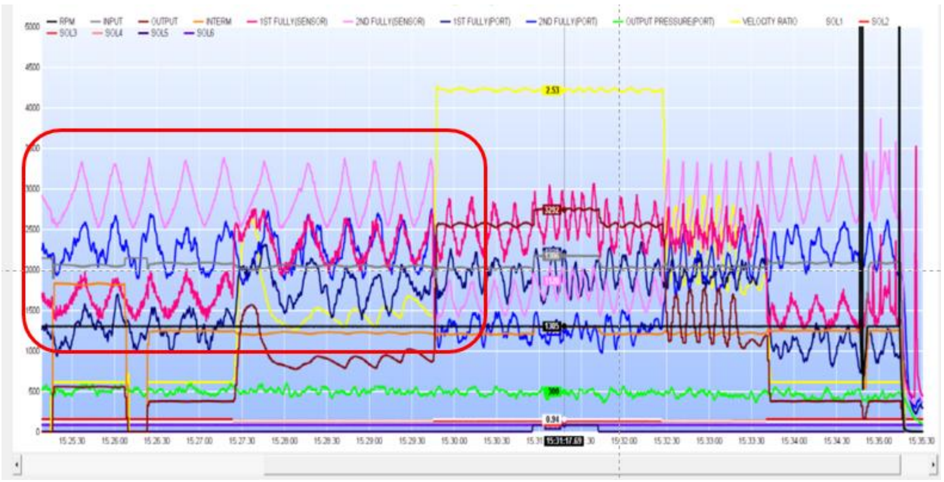


Figure 7. Abnormal condition due to poor transmission oil leveling

Fig. 7 shows a state in which the primary and secondary pulleys and pressure sensor values fluctuate severely due to oil leveling failure due to O-ring deformation and damage of the oil level control valve.

Fig. 8 shows the CVT shift curve and gear ratio instability over time.

The aux pump stops the torque converter (TCC) to the engine stop section according to the brake signal for some time during stop, and separately generates hydraulic pressure to maintain the pressure of the drive pulley and driven pulley. The aux pump did not work either because hydraulic pressure was generated to maintain the drive pulley and driven pulley, which are the vehicle power transmission devices, or a temporary phenomenon occurred due to a faulty connection of the power supply connector in the aux pump in the faulty part [10]. At the starting point of the vehicle's re-running due to poor maintenance of hydraulic pressure, a decrease in output occurred in the starting section. In addition, it was confirmed that the starting delay shape occurred intermittently in the engine restart section.

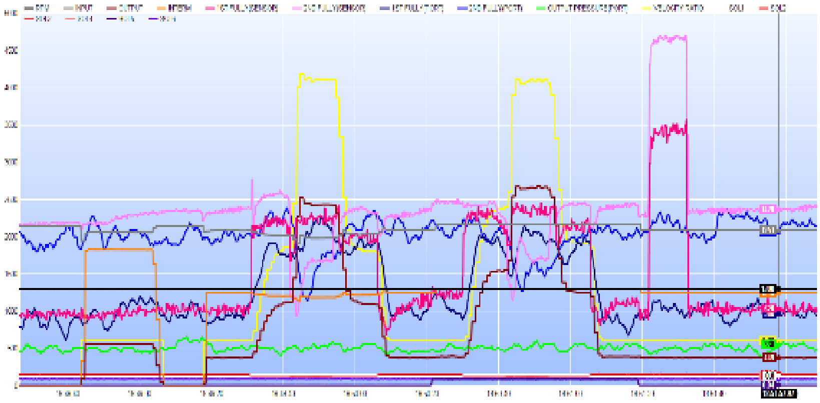


Figure 8. Unstable CVT shift curve and gear ratio over time

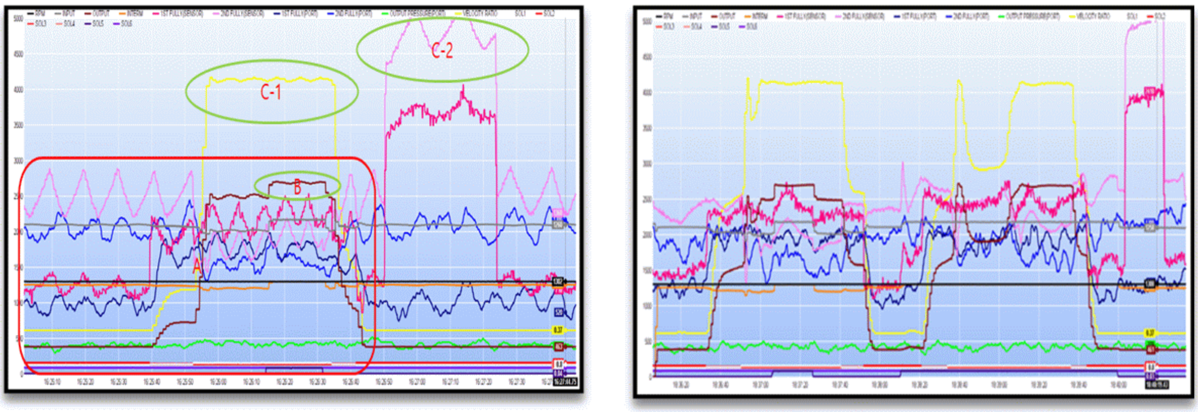
Fig. 9 is the performance test result data when the shifting lever position is fixed to D-5 in the driving mode.It displays the state where the solenoid abnormal condition occurred in the driving section.

It was possible to check the incomplete output state of the solenoid due to the rise in TCM line pressure.

It was confirmed that the incomplete output occurred due to the malfunction of the TCM line pressure solenoid due to the clogging of the oil filter.It shows that shift shock occurs intermittently due to abnormal driving.

In the section of graph-A, pulsation occurred in the entire waveform. It seems that the line pressure solenoid works to compensate for the under-pressure in order to prevent insufficient oil flow due to clogging of the oil filter. Precise control is not possible due to clogging of the oil filter, and as shown in the waveform, the waveform is throbbing [11].

It can be seen that the oil pressure rises in the solenoid operation waveform of graph C-1 (velocity ratio) and C-2 (driven pulley sensor). It can be seen that the CVT oil maintains the normal amount. Also, looking at graph B, it can be seen that the input and output rise.



(a) abnormalstate in the TCM

(b) Normal state in the TCM

Figure 9. Line pressure solenoid operation status graph of Transmission Control Module(TCM)

3.3 Normal performance results of CVT in driving tests after remanufacturing

Fig.10 shows the CVT output status under stable conditions such as RPM and speed ratio over time.As a result of the performance test after repair, the conditions for normal operation are as follows.

1) RPM: Test bed drive motor RPM measurement RPM: 1,304 RPM.

2) Input: A drive pulley according to the slip ratio of the torque gun butter, the detection unit is a tone wheel, and the number of detections is 60. The RPM of the drive pulley indicates 1,249 RPM.

3) Output: It is the power RPM transmitted to the differential gear through the drive pulley and driven pulley. The number of gears consists of 53, and the measured RPM is 447 RPM.

4) Interm.: The rotation speed of the driven pulley is detected, the number of teeth is 45, and the measured RPM is 1,244 RPM.

The sensor of the drive pulley and the driven pulley operates the transmission control solenoid valve to extract the RPM of the velocity ratio according to the positions of the drive pulley and the secondary driven pulley.

The Velocity Ratio calculation method is as follows.

- OUTPUT RPM ÷ INTERM RPM = VELOCITY RATIO
- 447 RPM ÷ 1,244 RPM = 0.3593 : 1 REV.

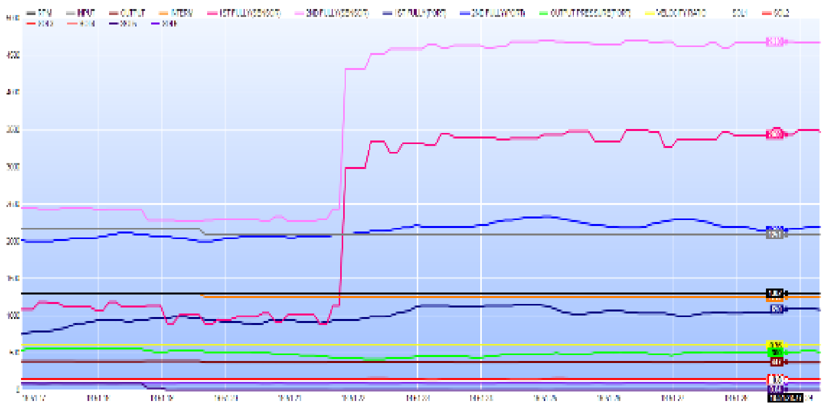


Figure 10. Stable state such as RPM and speed ratio over time

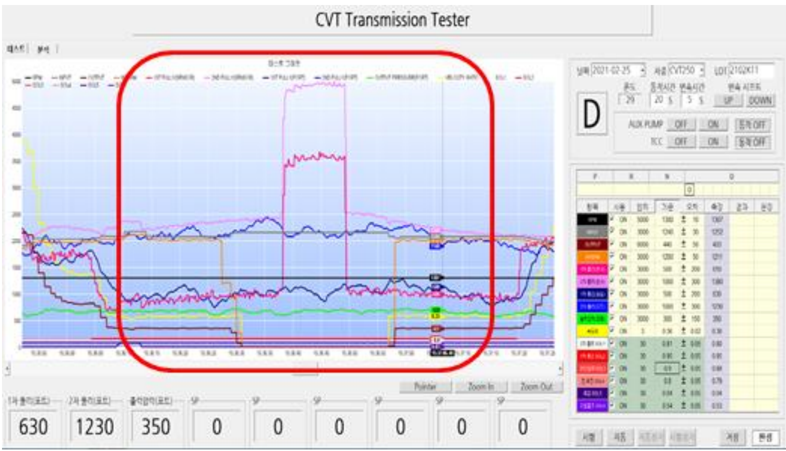


Figure 11. Normal output graph with repaired aux pump power supply connector

In this tuning software, the systems and stages include the components that activate the engine, transmission gearing with auxiliary chain reduction, and gear changes for each stage of operation. Once the desired engine performance and range of available gear ratios are established, these components are formulaically combined to create a relationship between vehicle performance and engine operation. Finally, it is possible to calculate the coordination of the CVT's regulatory components that enable gear changes and dynamics. Based on a limited number of field observations and simulations, it was possible to create a tune with a new dynamic target, assuming the dynamic characteristics of the vehicle [12]. This paper presented a feasible quantitative method to evaluate carbon emissions of the remanufacturing process of a used vehicle CVT(Continuously Variable Transmission) gearbox. The carbon emission evaluation method is proposed, which is combined with the Hierarchical Relevance Analysis (HRA) theory and the Emission Factor Approach (EFA). In this research, the characteristics of the carbon emissions of remanufacturing process for a used vehicle CVT gearbox are analyzed, various carbon sources on the remanufacturing system are classified and analyzed to define the boundaries of the remanufacturing system, and the correlation matrices among the hierarchical essential factors of carbon emissions are established. Then it combined with EFA to calculate the carbon emissions of each carbon source for the used vehicle CVT remanufacturing process. Finally, the proposed method is experimentally verified by using laser repairing of a used CVT wheel, and the feasibility of new quantitative evaluation method for carbon emissions on the remanufacturing processes is presented. The results show that the carbon emissions of the equipment/device are main contributors of the total carbon emissions of the remanufacturing system. Furthermore, scanning speed of the laser has a significant influence on the carbon emissions of the device and overall carbon emissions of the remanufacturing system.

3.4 Performance demonstration of remanufacturing CVT from an economic point of view

Cost-benefit analysis is a method of deriving the best alternative after comparing and evaluating the cost and benefit of each alternative among various business alternatives. Through economic comparison analysis, when the net benefits from each alternative project are greater than the total cost of the project, it is economically reasonable and the project is considered to be economically efficient.

As criteria or indicators for judging the analysis results, there are the cost-benefit ratio (B/C ratio), net present value (NPV), and internal rate of return (IRR).

As for the cost-benefit ratio, the higher the calculated ratio, the more economically efficient the project. When the net present value is zero or more, the business is evaluated as economical.

In addition, the internal rate of return is the expected rate of return that is expected if the project proceeds smoothly. In this study, the utility of the continuously variable transmission was derived by citing the NPV(net present value) equation(1), which is a universal economic analysis method.

$$\text{NPV(net present value)} = \sum_{t=0}^{n} \left[\frac{B_t - C_t}{(1+r)^2}\right] \quad (1)$$

Where,B_t ; benefit at time t, C_t ; cost at time t, r ; social discount rate, n ; Business period

As a result of evaluating the economic feasibility of the remanufacturing demonstration test bed by introducing NPV, this software seems to be able to contribute to inferring the remanufacturing performance target as well as providing the calculations necessary to install proper tuning based on reliability.

IV. CONCLUSION

As a result of analyzing the degree of influence of variables on the transmission output according to the output band for the remanufactured CVT to exhibit stable performance during operation, an efficient belt shape must have a lightweight design and a variable ratio structure to maximize engine operating efficiency.

By predicting in advance the cause of the imperfect power region from the simulator results, the gear ratio is an important factor in setting the vehicle dynamics, and when the operating engine speed is determined, it is the active gear ratio that converts the engine speed to the vehicle speed and the engine power to the vehicle performance.

It is considered that it is possible to contribute to the diagnostic field by developing and verifying a performance demonstration test bed to overcome the problem of being discarded and not regenerated despite the high price when a problem occurs in some parts of the continuously variable transmission.

At this stage, only some CVT manufactured items have been demonstrated, but it seems possible to expand to other manufacturers' continuously variable transmission.

In a future study, we intend to add a function that can include the deceleration of the motor when switching to the regenerative braking charging mode and the function that the power does not go through the transmission when driving in reverse.

REFERENCES

[1]. Q. Wang, Z. Huang, J. HuandZ. Liu, A carbon emission evaluation method for remanufacturing process of a used vehicle CVT gearbox, *IEEE Access, 8*, 2020, 193257-193267. DOI: 10.1109/ACCESS.2020.3027709

[2]. L. Kong and R. G. Parker, Steady mechanics of layered, multi-band belt drives used in continuously variable transmissions (CVT),*Mechanism and Machine Theory, 43(2)*, 2008, 171-185. DOI: 10.1016/j.mechmachtheory.2007.02.003

[3]. E. S. Mohamed and S. A. Albatlan, Experimental investigation and theoretical model approach on transmission efficiency of the vehicle continuously variable transmission,*American Journal of Vehicle Design, 2(1)*, 2014, 43-52. DOI: :10.12691/ajvd-2-1-6.

[4]. N. Shabrov, Y. Ispolov and S. Orlov, Simulations of continuously variable transmission dynamics,*ZAMM‐ Journal of Applied Mathematics and Mechanics/ZeitschriftfürAngewandteMathematik und Mechanik, 94(11)*, 2014, 917-922. DOI: 0.1002/zamm.201300249

[5]. J. Kim, Launching performance analysis of a continuously variable transmission vehicle with different torsional couplings, *J. Mech. Des., 127(2)*, 2005, 295-301. DOI: 10.1115/1.1814387

[6]. A.Yildizab, A.Piccininnia, F.Bottiglionea, G.Carbonea, Modeling chain continuously variable transmission for direct implementation in transmission control, *Mechanism and Machine Theory 105*, 2016, 428-440, DOI: 10.1016/j.mechmachtheory.2016.07.015

[7]. Q. Daohai, L. Wei, L. Yunfeng, F. Bing, Z. Yunshan, Z. Feitie, Simulation and experimental study on the pump efficiency improvement of continuously variable transmission, *Mechanism and Machine Theory 131*, 2019, 137-151. DOI: 10.1016/j.mechmachtheory.2018.09.014

[8]. X. Yu and D. Sun, Characteristic analysis on a new hydro-mechanical continuously variable transmission system,*Mechanism and Machine Theory 126*, 2018, 457-467. DOI: 10.1016/j.mechmachtheory.2018.03.006

[9]. C. A. Fahdzyana, M. Salazar and T. Hofman, Integrated plant and control design of a continuously variable transmission, *IEEE Transactions on Vehicular Technology 70(5)*, 2021, 4212-4224. DOI:10.1109/TVT.2021.3068844

[10]. H. Liu, L. Han and Y. Cao, Improving transmission efficiency and reducing energy consumption with automotive continuously variable transmission: A model prediction comprehensive optimization approach, *Applied Energy 274(15)*, 2020, 115303. DOI: 10.1016/j.apenergy.2020.115303

[11]. MAC. Fernandes, Fuzzy controller applied to electric vehicles with continuously variable transmission, *Neurocomputing 214(19)*, 2016, 684-691. DOI: /10.1016/j.neucom.2016.06.051

[12]. W.Shabbir, SA.Evangelou,Efficiency analysis of a continuously variable transmission with linear control for a series hybrid electric vehicle, *IFAC Proceedings, 47(3)*, 2014, 6264-6269. DOI: 10.3182/20140824-6-ZA-1003.01770

Sung-Yong Hong, et. al. "Analysis of Parameters Affecting Performance onRemanufactured Continuously Variable Transmission Using Performance Demonstration Test Bed." *International Journal of Engineering Science Invention (IJESI)*, Vol. 11(09), 2022, PP 18-30. Journal DOI- 10.35629/6734