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MAE 434W

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**Research Question: What is the optimal design option for a dual clutch transmission when considering the long terms effects of vibrations on the contact surfaces?**

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|  | **Source #1** |
| **Citation** | A. Senatore, "Advances in the Automotive Systems: An Overview of Dual-Clutch  Transmissions," *Recent Patents on Mechanical Engineering,* vol. 2, pp. 93-101, 2009. |
| **Purpose** | * Demonstrate advantages of AMT’s & DCT’s * Provide some chronological information about the advances in AMT & DCT technology through the years * Explain various techniques that may be utilized in the near future to refine these clutch designs |
| **Why is the study necessary?** | * DCT’s and AMT’s increase fuel efficiency and may soon be the technology of choice * Future carbon emission laws could force automakers to implement these designs in more vehicles * As the technology improves, sales of these designs continue to increase * Future research has potential to yield considerable results as assorted control system designs are utilized |
| **Methods** | * Compare/contrast DCT/AMT technology to more commonly used designs * Description of the potential for future exploration in this area of study * Description of historical designs/patents that have led up to the current models |
| **Results** | * Efficiency of DCT/AMT technology will improve with further breakthroughs in this field * Sales of the technology have increased over the years and will continue to do so * Future DCT/AMT technologies will improve significantly as this is an area with considerable ongoing research and development |
| **Discussion/Conclusion** | * DCT/AMT technology can improve the performance of an automobile * As more research is done on the control systems the benefits of using a DCT or an AMT will increase |
| **How can this help my senior project?** | * This article showed me a considerable amount of detailed information about how these technologies work that will prove vital when we begin to attempt to construct a DCT of our own. Every article we find that provides a detailed description of how a DCT works is potentially one more piece of the puzzle. * The article justifies the use of an AMT or DCT and explains the advantages of using each * The article contained several excellently rendered diagrams that showed how a DCT and AMT are put together. Great visual aids |

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|  | **Source #2** |
| **Citation** | S. Bickerstaffe, "A step change [dual-clutch transmission]," *Automotive Engineer,* vol. 38, p. 37, November 2013. |
| **Purpose** | * An informative article discussing the trend towards dual-clutch transmissions * To examine the possibilities for hybrid transmissions in the near future * To discuss the effect DCT technology has had on research done on new transmissions, specifically that they will force other technologies to improve in order to remain competitive in the market |
| **Why is the study necessary?** | * Research in this area is on the verge of a major breakthrough * The potential for legislative bodies to force the hands of automobile manufacturer’s to do whatever it takes to increase fuel efficiency and reduce carbon footprints * There is a need, from the perspective of the manufacturer, to determine how much of a market there will be for DCT’s in the future and to see if they will ever be as or more popular than automatic transmissions |
| **Methods** | * Discuss how much money (billions) has been spent on research and construction of manufacturing apparatus for other , similar technologies and whether or not the auto makers will be willing to throw that away * Examine whether or not fuel economy is the only driving force at play here * Discuss whether or not the luxury vehicles would ever move away from automatic transmissions |
| **Results** | * Some companies have focused their assets on intensifying their range of front wheel drive products * New designs have additional gear components, added torque, and are considerable smaller * Research in these areas have produced innovative designs |
| **Discussion/Conclusion** | * Automatic transmissions will be hard pressed to remain competitive if DCT technology continues to improve at the current rate * Many manufacturers are making gear boxes with more gears than ever before * Hybridization will serve to increase the popularity of DCT technology because it will improve the overall design and increase efficiency |
| **How can this help my senior project?** | * This article contained a wealth of information about why there has been a shift towards research and design on DCT’s. Any paper we write as a group or as individuals for the formula team requiring some justification for why we’re doing the project would be greatly enhanced using the information and persuasive arguments contained in this article. * The article also included significant technical details about how these transmissions function and the design process utilized by some manufacturers in creating their own DCT prototypes |

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|  | **Source #3** |
| **Citation** | S. Bickerstatfe, "Change strategy [dual-clutch transmission]," *Automotive Engineer,* vol. 36, pp. 20-21, November 2011. |
| **Purpose** | * Informative article detailing the complexities involved in designing a DCT with very specific specifications * Conveys useful information about how one company optimized their DCT by examining ways to make individual parts lighter, all while keeping the price tag as low as possible |
| **Why is the study necessary?** | * This case study is necessary because it’s important to be able to compare the different techniques and ideas used by different teams of engineers when they went through the process of building their own DCT’s * It’s important to see how one team of designers took an existing idea and found some ways to creatively improve on the original design. These people made some excellent breakthroughs and it’s important for people to be able to understand their methodologies so that they can follow up and improve on their work. |
| **Methods** | * In order to reduce the size & weight of their product the engineering team went through the design component by component in an effort to find any way to shrink their final result. * Every piece was examined to determine if it was actually necessary for the operation of the transmission and also if it could be constructed out of any lighter weight materials without sacrificing overall product quality * Computerized models of the different design options were tested out before a final decision was made |
| **Results** | * Their team was very successful, the overall weight of the transmission was reduced by 10 kg * Despite that drastic reduction, the overall cost of the transmission did not increase significantly * They developed an entirely new control system called a precog, which transmits a signal to the transmission as soon as you begin to shift. The device then executes some of the tasks essential to changing gears before you’ve actually even made the change. |
| **Discussion/Conclusion** | * The final product they came up with is easier to drive than almost any other vehicle on the road. This goes to show how research in this area will revolutionize the driving experience. * The entire process these designers went through will have to be repeated for electric engines sometime here in the future. |
| **How can this help my senior project?** | * The idea that you can significantly improve the performance of a DCT by making each piece as lightweight and small as possible is one that we should keep in mind throughout our work this spring & summer. It is also noteworthy that we should pay close attention to the material we use on each section of the car. Although this article was focused on the DCT, keeping weight as low as possible on the entire car should be a recipe for a higher top speed and an overall higher quality final product. |

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|  | **Source #4** |
| **Citation** | Walker et al, "Investigation of synchronizer engagement in dual clutch  transmission equipped powertrains," *Journal of Sound and Vibration,* vol. 331, pp. 1398-1412, 2012. |
| **Purpose** | * To compare how a DCT powertrains react when connected to synchronizers in two different scenarios, with the harmonic engine vibrations taken into consideration and with those vibrations ignored * To investigate the intensity of the vibrations transmitted from the powertrain to the synchronizers * To create a model for the non-linear torques produced with synchronizers * To pinpoint the rate and damping relationships of harmonic engine vibrations in DCT’s * To investigate how using different engine models will impact these vibrations and torques in DCT’s |
| **Why is the study necessary?** | * Because DCT’s, unlike regular manual transmissions, are still connected to the engine when synchronization is initialized, vibrations are transmitted that can cause damage or even possibly failure * There have been very few previous studies on this subject, but as DCT’s become more prevalent it is important to understand how they handle these vibrations so that designs can be improved |
| **Methods** | * Two different simulations were used here, one which used the average torque values as a mathematical model and a second evaluation using harmonic torque * Analyze the relevant vibrations in an setting with no damping whatsoever |
| **Results** | * Comparing the results from the two test simulations, it can be seen that from the average torque model that the synchronizer connects nonlinearly * When harmonic torques were introduced while the apparatus was connected, it created larger vibrations * These vibrations can sometimes prevent the actuation or engagement of the synchronizer altogether * A new model for the investigation of these vibrational issues in DCT’s was developed by the researchers |
| **Discussion/Conclusion** | * The effect of the increased vibrations is significant in that they can have a tremendous impact on the frictions produced where the chamfer surfaces come in contact * Three different methods were found to be effective utilizing the mean torque simulation technique * This is the first study to thoroughly examine this topic using a two inertia representation as a function of shift and shaft acceleration |
| **How can this help my senior project?** | * This article contained a treasure trove of data about the effects of vibrations on DCT’s * The formula team now has three proven solutions for controlling vibrations in synchronizers. If we decide that the vibrations are too strong in our project and need to be controlled, we have a detailed analysis that will provide us with several options and show us what steps need to be taken to rectify the issue. |

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|  | **Source #5** |
| **Citation** | K. Van Berkel, "Fast and smooth clutch engagement control for dual-clutch transmissions," *Control Engineering Practice,* vol. 22, pp. 57-68, January 2014. |
| **Purpose** | * To attempt to use control commands to separate the dual tasks of a DCT into different phases in order to improve its overall functionality * To implement control solutions at a minimum of cost by doing offline computations based on testing data |
| **Why is the study necessary?** | * Present control models do not take into consideration the dynamics of the actuator or transitory effects that develop from the initial environment * Generally when the speed of the clutch is improved, you sacrifice smoothness, and vice versa. By separating the control commands of the DCT, you can find an optimum middle ground. |
| **Methods** | * Simulations were performed before the new controller was tested in real live conditions * Experiments were performed to test out the newly programmed controller in various scenarios * By fluctuating the initial parameters, the researchers showed that the ambiguity in the actuator time is the primary influence on the clutch performance |
| **Results** | * The results from the simulations and the experiments using test vehicles were compared and they were qualitatively very close to each other * Even with a very basic design, the experiment was a success and the goal of splitting the tasks using phases was obtained * The shifts between the stages are selected such that the preferred slip acceleration is realized precisely when the clutch engages * A significant contributing factor to the overall effectiveness of the controller was what time constant they programmed in as the time required for the clutch to engage. It was discovered that programming an underestimated time for the clutch to engage had significant benefits in the overall smoothness of the clutch. Overestimating the time required for engagement served no useful purpose; the only result was an obvious one that the clutch took longer to engage. |
| **Discussion/Conclusion** | * When the actuator timing was highly uncertain, smooth clutch engagement was achieved, but this caused the clutch to perform a little more slowly * Tests on experimental vehicles demonstrated that not only does this new 2 phase controller work, but that it holds up in real scenarios with unknowns added in as variables |
| **How can this help my senior project?** | * This article will be very useful when it comes to programming our PLC for our DCT. It is of great significance that the findings of this study indicate that the solution to this problem is easy as well as inexpensive, seeing as how we are not going to have unlimited funding at our disposal. * It detailed the best possible programming tactics to use for our PLC, ideas which we will surely try to make use of * This article contained an excellent schematic of a DCT, which is a useful reference for when we are making ours |