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## Gearbox Project Evaluation Software Development for 'MCD' Course

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**Abstract:** Gearbox frequently called as transmission as it included a set of gear that arrange properly inside a housing. The calculation of gearbox is a common thing among mechanical engineer. Hence, Mechanical Engineering Program in Univeristi Tun Hussein Onn Malaysia (UTHM) provide exposure to mechanical student about design and calculation of a gearbox in a Mechanical Component Design (MCD) course. The report of MCD project is complex and some of lecturer had difficulty to check the analysis in a short period since it involves with a lot of calculation that related with each other. Previous software is only evaluating the gearbox analysis without considering performance and awarding marks. This study aims to develop an Excel-based gearbox project evaluation software that is able to automatically analyse and evaluate performance for project reports in a short period of time. The analysis of gearbox follows the standard from AGMA and ABMA standards and this software capable to evaluate maximum three set of gear. The method that been used to plan and execute the project refer to waterfall methodology where consist of four phases which are literature review, designing the software, implementation and testing. All of the processes have their relation and allow the objective to be achieved. The system is able to automatically generate result once the student form in Excel is filled out and submitted. It is much faster since the awarding marks is display directly where it is beneficial for the lecturer. Only one testing was managed to be made to validate the system results and the result show that this system is able to extract, reading, compare, analyse data and provide the scale rating same as previous results. Throughout the development, this system is successfully built-in user-friendly interface along with the standards that been followed.

**Keywords:** Mechanical Component Design (MCD), Microsoft Excel, Gearbox Analysis

## 1. Introduction

At UTHM, there is a program under FKMP that offers a degree in Mechanical and Manufacturing Engineering. Under this program, there is a course which is Mechanical Component Design (MCD) which studies, analyses and designs a spur gearbox. The analysis report from the MCD project is very complex and lecturer spend a long time to check all the analysis since several lecturers must handle two sections of class. Also, previous software created by Nur Kamil Adli is only evaluate gearbox analysis without grading the marks.

The analysis of the gearbox must contain of gears, shafts, bearings and fitting with maximum of three set of gear. Each component will be analysed using standards referenced with existing standards such as gear design and bearing selection. The governing body for gear standard in United States been using American Gear Manufacturers Association (AGMA). They have established specifications for both metric and inch gears. For inch pitch spur gearing, the current AGMA standard to be used when specifying a gear standard is AISI/AGMA 2015-1-A01[1]. This standard is comparable to ISO 1328-1:2013 for metric pitch. The ABMA (American Bearing Manufacturers Association) standard provides how to calculate and determine bearing life. The load versus life at constant reliability is addressed by various practical deterministic equations, and the catalogue rating as rating life is introduced [2]. All calculation should be implementing SI units and also all the result will provide with five scale rating (Very Good, Good, Intermediate, Weak & Very Weak) individually.

Although, the Excel based software takes time to build but in future the system might helpful and can be implement. The calculation for gearbox contains a lot of formula and apply Microsoft Excel would be easier as it generates the result in a short period. The Mechanical Component Design subject is among the challenging course that implement a numerous of formula especially in analysis the gearbox.

The program that successfully developed throughout this project that will be able to automatically analyse, evaluate and provide performance for project reports in a short period of time. The user-friendly interface in the software able to speed up all process and much faster compare to previous method. It can also help user during marking process since it gets more accurate results in much faster time.

## 2. Review of literatures

A literature review is a piece of research that demonstrates knowledge and grasp of the academic literature on a particular topic in context. It contains three case study of Excel programming software that related to MCD course. Throughout the study, three case studies have created an idea to implement a software consisting of a system that has been briefed through sub-chapters.

First case study was about innovation MCD Marking Scheme Using Microsoft Excel. An innovation from the previous MCD report marking scheme template has been made by using an Excel program where several formulas have been placed in the excel cell so that it can make calculations automatically when the user ticks the part of the provided rubric evaluation box. The marking process consist two section which are non-analysis and analysis. The non-analysis produced the theoretical and fact information while the analysis included the calculation. Both sections required user to mark manually. To tick manually in the box is to write 'a' to form a right tick while cross tick will be generated if write 'r'. These parts need to evaluate properly suitable with predetermined theme. The weightage value then will be multiplied with evaluation scale to obtain the marks. Figure 1 show the MCD report marking scheme.

No.		Evaluate Item	Weightage	Evaluation Scale					Sub Marks	Marks
				5	4	3	2	1		
1	<b>Introduction (10%)</b>									
	1.1	Group Description	[ 0.4 ]		✓					1.6
	1.2	Product / Project Background	[ 0.6 ]							0.0
	1.3	Objective & Design Scope	[ 0.4 ]		✓					2.0
	1.4	Milestone / Planning Chart	[ 0.6 ]		✓					3.0
		<b>TOTAL (10%)</b>								<b>6.6</b>
2	<b>Design and Analysis (75%)</b>									
	2.1	<b>Concept Development [Sketching] (5%)</b>								
		✓ Addresses the entire system (global picture)	[ 0.2 ]							0.0
		✓ Shows how each component fits together	[ 0.2 ]							0.0
		✓ Labels components to identify key features and provides description	[ 0.2 ]							0.0
		✓ Shows approximate dimensions	[ 0.2 ]							0.0
		✓ Provides realistic visualization (3D sketching + shading)	[ 0.2 ]							0.0
	2.2	<b>Engineering Analysis (10%)</b>								
	2.2.1	<b>Fundamental Analysis (10%)</b>								
										0.0

Figure 1: MCD report marking scheme layout [3]

For second case study describe about the transformation Microsoft Excel with Visual Basic Application (VBA). An example case study on programming Excel with VBA can be referred to “Automated Gearbox Analysis software”. This software has been developed by Nur Kamil Adli which is former bachelor degree final year student in 2013. The main objectives to develop this software is to assist lecturer in MCD course to check and validate the student work in project report. The accuracy in calculation for previous software that been developed by Nur Kamil Adli is more than 96% in first version. Since the software has been validated and improved by Mohd Azwir several times, the accuracy of this software in calculation had been increase almost 100% for version 2.07. Figure 2 show the automated gearbox analysis software.

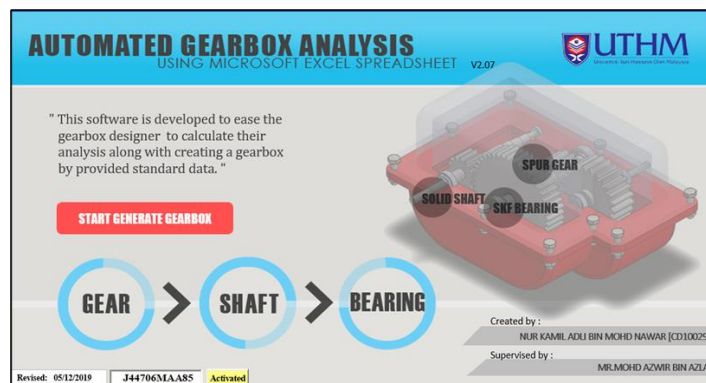


Figure 2: Automated Gearbox Analysis software [4]

Last case study was about integration of Google Form and Microsoft Excel in evaluation of ‘student test’. In UTHM, there are one example that used this Integration of Google Form and Microsoft Excel technique to evaluate the student performance. It has been used in all test of Mechanical Component Design Course from 2019 till 2022. In this case study, 1st test application Excel software in semester 1 session 2020/2021 has been selected as reference of study. In this software, there are four segments in handling the integral software which are collection of databases, data transfer, analysis of data and result. The collection of data included the prepare the set of answer and the student information in Microsoft Excel. However, data transfer mostly need to export the data from the declaration form and student answer in Google Form Spreadsheet to Microsoft Excel. Then, the analysis of data segment, the data were compared between student answer and a set of answer for acquire the marks. Finally, for the results segment, the total score will be displayed along with a detailed evaluation of each work step in one Excel as shown as Figure 3.

DD180065		Name : SOO JUN CHUN		Agreement sign:	
25.5/30		IC/Passport No : 980725015549		8:26:03 PM	
		Section : 2		Submitted time:	
		Lecturer : Hj Mohd Azwir bin Azlan		10:18:30 PM	

Q1 (a)	FBD	FBD4	✓	1.0
	Critical location	Point '1'	✓	1.0
Q1 (b)	Element	Sketch 3	✓	1.0
	$\sigma_{x1 \text{ axis}}$ (MPa)	84	✓	1.0
	$\sigma_{x1 \text{ bending}}$ (MPa)	98.6	✓	1.0
	$\sigma_{x1 \text{ total}}$ (MPa)	182.6	✓	1.0
	$\tau_{xy}$ (MPa)	105.9	✓	1.0
Q1 (c)	$\sigma_1$ (MPa)	231.2	✓	1.0
	$\sigma_2$ (MPa)	-48.5	✓	1.0
	Material	Ductile	✓	0.5
	Suitable Theory	Maximum Shear Stress (MSS) Theory	✓	0.5
	$\tau_{max}$ (MPa)	139.9	✓	1.0
	FOS	1.02	✓	1.0
	Conclusion	Critical	✗	0.0
Q1 (d)	Safety Diagram	A	✓	1.0
	"X" (MPa)	231.2	✓	0.5
	"Y" (MPa)	-48.5	✓	0.5

Q2 (a)	Critical location	Point B - Because this point has stress concentration and smaller diameter size	✓	1.0
Q2 (b)	$S_{ut}$ (MPa)	400	✓	0.5
	$S_{u'}$ (MPa)	200	✓	0.5
	$k_a$	0.922	✓	0.5
	$k_b$	0.961	✗	0.0
	$k_c$	0.85	✓	0.5
	$k_d$	1	✓	0.5
	$k_e$	0.814	✓	0.5
	$k_f$	1	✓	0.5
	$S_e$ (MPa)	122.5	✗	0.0
Q2 (c)	$q$	0.70	✓	1.0
	$K_r$	2.40	✓	1.0
	$K_f$	1.98	✓	1.0
Q2 (d)	$\sigma_{e,a}$ (MPa)	0	✓	0.5
	$\sigma_{e,b}$ (MPa)	79.2	✓	0.5
	$\sigma_{e,c}$ (MPa)	0	✓	0.5
	$\sigma_z$ (MPa)	156.9	✓	0.5
	$a$	1057.8	✗	0.0
	$b$	-0.156	✗	0.0
	Life, $N$ (cycles)	205,737	✗	0.0
	$x = f_{s,u}$ (MPa)	360	✓	0.5
	$y = \sigma_1$ (MPa)	156.9	✓	0.5
	Conclusion	It will not achieve targeted life	✓	1.0

Figure 3: Result of student detail evaluation [5]

### 3. Methods of approach

Methodology is essentially the process of using the research to build a project. By using techniques like flowcharts and implementation rules, the methodology employs the project design process. Referring Eric in 2011, the waterfall model is a linear approach to application development that makes use of set phases that don't overlap. Figure 4 below show the Waterfall model.

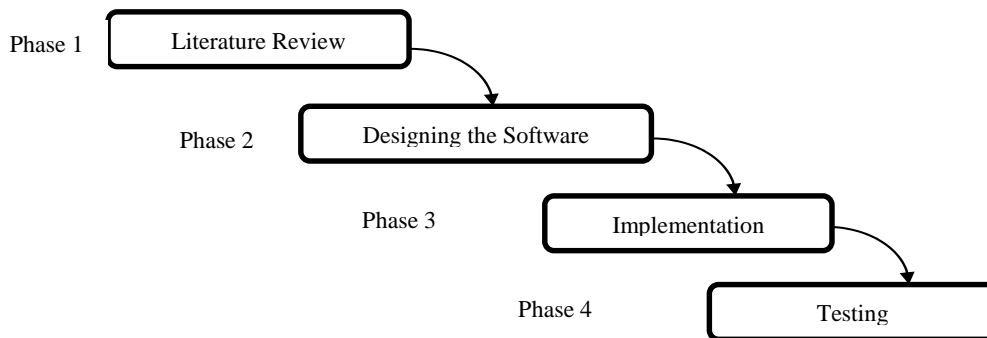
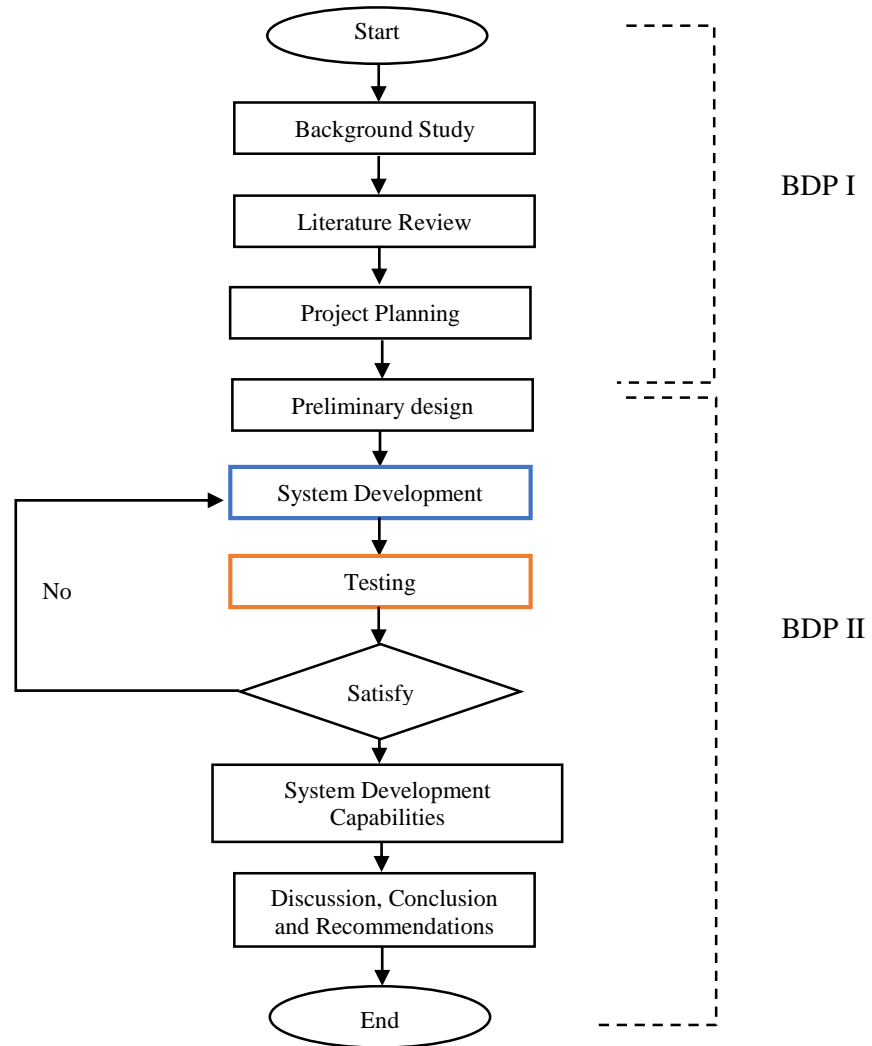


Figure 4: Waterfall model [6]

In Bachelor Degree Project (BDP) I, it starts with a background study stage, where the results should be presented in a sequential order to highlight developments in the subject and gaps that must be filled. The background should be written as an explanatory description of past research and the aim of the investigation. The main source of literature review is the study of the Excel software itself where it helps in understanding a system and the method of developing a software using Microsoft Excel. This project planning was drafted as discipline that addresses how to accomplish a project within a specific timeline, typically with defined stages and resources.

In BDP II, preliminary design stage provides the interface of the software as a beginning step for designing the software. In order to create the interface software, a creativity and knowledge from literature review should be implement. The software development is the most crucial section where a lot of time requires as to develop a command in MCD Project Report Evaluation Software. The software development capabilities will describe the limitation of the software and the general information in detail. The discussion, conclusion and recommendation stage conclude the

relevance of a research project's findings as interpreted by the researcher, together with suggestions for further study.



**Figure 5: Project implementation flowchart**

#### 4. Software development and testing

##### 4.1 Preliminary design

As mention in literature review, the Google form is a platform to create the student forms. There have several reasons on why the Google form not the best option to create the student form. First of all, it requires a lot of formula and pictures to insert as it not convenient wasting a lot of time and energy. Next, the forms will become longer and not suitable for packs information. Finally, it cannot insert some tables as it has to write it one by one for each information.

The best option in order to create a neat form is by using Microsoft Excel where the capabilities to encounter the weakness of Google forms as well. This project carried two types of Microsoft Excel such as student form and MCD software. In student form, there have divided into many parts such as group information, fundamental analysis, gear fundamental analysis, gear failure analysis, shaft failure analysis, bearing analysis and housing analysis as shown in Figure 6.

**Group Information**

Group Name : Technovators  
 Group Code : S1K03  
 Section : 1  
 Lecturer : En Azwir  
 Semester / Session : Semester 1 2019/2020  
 Project Name : Sugarcane Crusher Gearbox  
 Course Code : BDA 31203  
 Team member with matric number :  
 1) Yasmin Syalliana bt Roslan (DD170018)  
 2) Mohammad Badrol Hiyam b Mohammad Rohi (DD170066)  
 3) Muhammad Kamarul Ezwan b Mohd Azmi (DD170008)  
 4) Nurul Widad bt Mohd Zaid (DD170054)  
 5) Nur Syazana bt Ruslan (DD170036)  
 Submitted Date : 28/6/2023

**Requirement**

Power ( $P_{require}$ ) : 0.72 kW  
 Torque ( $T_{require}$ ) : 240 Nm  
 Speed ( $n_{require}$ ) : 28.65 rpm  
 Efficiency : 85%

**Motor selection**

Power ( $P_{motor}$ ) : 1.5 kW  
 Torque ( $T_{motor}$ ) : 15.4 Nm  
 Speed ( $n_{motor}$ ) : 930 rpm

**Overall gear ratio required**

Speed ( $M_{G,O\_speed}$ ) : 32.46  
 Torque ( $M_{G,O\_torque}$ ) : 7.8

**Selected gear ratio**

Overall : 30  
 Set 1 : 6  
 Set 2 : 5  
 Set 3 :

**Validation**

Speed ( $n_{final}$ ) : 31 rpm  
 Torque ( $T_{final}$ ) : 462 Nm

**Material selection**

	Pinion	Gear
Material	Through-hardened Grade 1	Through-hardened Grade 1
Brinell Hardness	340	300
Face width (mm)	20	20
Allowable bending strength, $S_b$ (MPa)	269.52	248.2
Allowable contact strength, $S_c$ (MPa)	954.8	866

**Preliminary shaft design (shaft 1)**

Material selection : 1045 CD  
 Surface finish : Machine or cold drawn  
 Stress concentration factors : Shoulder fillet - well rounded ( $r/d = 0.1$ )  
 $S_u$  (MPa) : 630  
 $S_y$  (MPa) : 530

**Shaft sketching (shaft 1)**

Shaft effective length (mm) : 90  
 Pinion 1 left position (mm) : 62.5  
 Minimum safety factor : 1.5  
 Minimum shaft diameter  $P_{1, D_{min}}$  (mm) : 13.46  
 Maximum shaft diameter  $P_{1, D_{max}}$  (mm) : 24.2

**Bearing specification (shaft 1)**

Design (Bearing A) : Deep groove, single row, unsealed  
 Design (Bearing B) : Deep groove, single row, unsealed  
 Reliability (%) : 90  
 Life cycle ( $kWh$ ) : 17.52  
 Application factor : 1.2

**Calculated parameter (shaft 1)**

$F_D$  (Bearing A) (kN) : 0.25  
 $F_D$  (Bearing B) (kN) : 0.569  
 $n_b$  : 930  
 $C_{10}$  (Bearing A) (kN) : 2.98  
 $C_{10}$  (Bearing B) (kN) : 6.78

Shaft 1  
 Bearing A (left side)      Bearing B (right side)

Figure 6: All sheet part in student form layout.

## 4.2 Innovation of MCD software

All student must fill in the student form before all the data will be extract using 'VLOOKUP' and transfer to MCD software. Student answer been located at input sheet layout. All data in MCD software had been link to the input sheet and evaluate in analysis sheet layout based on 23 criteria in MCD report marking scheme. Figure 7 display the input sheet layout and analysis sheet layout.

**(a) Input sheet layout in MCD software**

Select group to check

Group Code	Group Name	Section	Lecturer	Session	Project Name	Course Code	Date
2	S1K03	Technovators	1	En Azwir	Semester 1 2019/2020	Sugarcane Crusher Gearbox	BDA 31203 28/6/2023

**(b) Analysis sheet layout**

**Number of gear teeth are determine properly**

	Set 1	Set 2	Set 3	
Gear ratio	6	5		0
<b>Minimum teeth</b>	<b>Software</b>	<b>Student</b>		<b>Marks</b>
Pinion1	16	16		1
Pinion 2	16	16		1
Pinion 3	6	0		0
<b>Selected teeth (pinion)</b>		<b>Student</b>		<b>Marks</b>
Pinion1		20		1
Pinion 2		20		1
Pinion 3		0		0
<b>Selected teeth (gear)</b>	<b>Software</b>	<b>Student</b>		<b>Marks</b>
Gear 1	120	120		1
Gear 2	100	100		1
Gear 3		0		0
				100.0%

Figure 7: (a) Input sheet layout in MCD software, (b) Analysis sheet layout

The analysis sheet layout was a placed to compare student answer with MCD software answer. Then, all marks in all criteria in analysis sheet will be link into evaluation form sheet

and automatically been evaluate by rating scale as shown in Figure 8.

<b>2.2.2 Gear Fundamental Analysis (10%)</b>								<b>10.0</b>
✓ Number of gear teeth are determine properly	[ 0.4 ]	100.0%	✓					2.0
✓ Torque and RPM are calculate properly	[ 0.6 ]	100.0%	✓					3.0
✓ Module selection are reasonable	[ 0.2 ]	100.0%	✓					1.0
✓ Contact ratio analysis are also included	[ 0.4 ]	100.0%	✓					2.0
✓ Acting load at each gear are been calculated correctly	[ 0.4 ]	100.0%	✓					2.0
<b>2.2.3 Gear Failure Analysis (15%)</b>								<b>15.0</b>
✓ Material selection has been discuss properly	[ 0.4 ]	100.0%	✓					2.0
✓ Determination of face width and Qv are reasonable	[ 0.2 ]	100.0%	✓					1.0
✓ Correct procedure used to calculate AGMA bending and pitting stress	[ 1.5 ]	97.1%	✓					7.5
✓ Bending and contact stress correctly calculated	[ 0.2 ]	100%	✓					1.0
✓ Used proper justification and assumption	[ 0.3 ]	100.0%	✓					1.5
✓ Bending and pitting safety factor are in acceptable range	[ 0.4 ]	100.0%	✓					2.0

Figure 8: Evaluation form sheet

### 4.3 System testing

There are several tested been conducted by using high score, medium score and low score for project report. By using high score project from Technovators group, similar result was obtained from system with manual marking scheme. The accuracy for high score project report was 99.50%. The only difference was at ‘Determination of face width and Qv are reasonable’ criteria due to slightly error in decimals point.

HM FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING UNIVERSITI TUN HUSSEIN ONN MALAYSIA		System marking						
- DESIGN PROJECT REPORT -		GROUP NAME :- Technovators - S1K03						
eria, [5]- Very Good, [4]- Good, [3]- Intermediate, [2]- Weak, [1]- Very Weak)		95.0% 75.0% 50.0% 30.0% 0.0%						
Evaluate Item	Weightage	Evaluation Scale					Sub Marks	Marks
		5	4	3	2	1		
<b>2.2.2 Gear Fundamental Analysis (10%)</b>								<b>10.0</b>
✓ Number of gear teeth are determine properly	[ 0.4 ]	100.0%	✓					2.0
✓ Torque and RPM are calculate properly	[ 0.6 ]	100.0%	✓					3.0
✓ Module selection are reasonable	[ 0.2 ]	100.0%	✓					1.0
✓ Contact ratio analysis are also included	[ 0.4 ]	100.0%	✓					2.0
✓ Acting load at each gear are been calculated correctly	[ 0.4 ]	100.0%	✓					2.0
<b>2.2.3 Gear Failure Analysis (15%)</b>								<b>15.0</b>
✓ Material selection has been discuss properly	[ 0.4 ]	100.0%	✓					2.0
✓ Determination of face width and Qv are reasonable	[ 0.2 ]	100.0%	✓					1.0
✓ Correct procedure used to calculate AGMA bending and pitting stress	[ 1.5 ]	97.1%	✓					7.5
✓ Bending and contact stress correctly calculated	[ 0.2 ]	100.0%	✓					1.0
✓ Used proper justification and assumption	[ 0.3 ]	100.0%	✓					1.5
✓ Bending and pitting safety factor are in acceptable range	[ 0.4 ]	100.0%	✓					2.0
<b>2.2.4 Shaft Analysis (15%)</b>								<b>14.6</b>
✓ Correct resolve forces at the shaft free body diagram	[ 0.6 ]	100.0%	✓					3.0
✓ Calculate bending load with proper bending moment diagram	[ 0.6 ]	100.0%	✓					3.0
✓ Shaft material selection is also been discussed	[ 0.2 ]	100.0%	✓					1.0
✓ Include with proper stress concentration factor analysis	[ 0.4 ]	100.0%	✓					2.0
✓ Calculated minimum diameter required at each gear	[ 0.4 ]	97.2%	✓					2.0
✓ Fatigue and yield factors of safety are met	[ 0.4 ]	97.5%	✓					2.0
✓ Included with tolerances and fitting analysis at each shaft	[ 0.4 ]	82.1%	✓					1.6
<b>2.2.5 Bearing Analysis (5%)</b>								<b>5.0</b>
✓ Bearing forces have been correct resolved	[ 0.4 ]	300.0%	✓					2.0
✓ Correct procedures used to determine bearing load rating	[ 0.4 ]	100.0%	✓					2.0
✓ Suitable bearing size have been selected	[ 0.2 ]	100.0%	✓					1.0

Figure 9: Testing result for Technovators group

There was another testing result that were summarised in Table 1.

Table 1: The summary for testing result

Group name	Manual marking	System marking	Accuracy (%)
Technovators	45.9	46.1	99.50
Alpha	35.4	35.8	98.90
Alt+A4	21.4	19.3	90.20

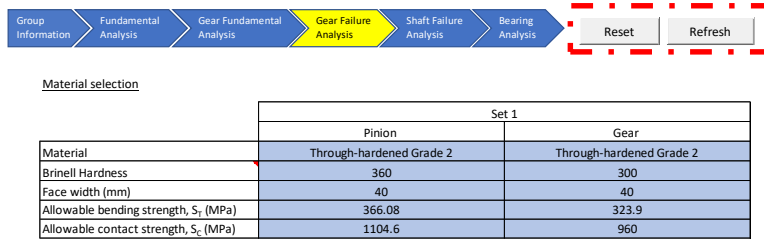
By using medium project report scores from Alpha group, there was a bit different due to the condition for the criteria changed. Also, the module set up with condition that may affect the value in safety factor of gearbox. Hence, the accuracy affected was calculated around 98.90%.

By using low project report scores from Alt+A4 group, there was slightly different due to the condition for the criteria changed. Also, the module set up with condition that affected the safety factor of gearbox. Hence, the accuracy affected was calculated around 90.20%.

### 4.4 System capabilities and specification

The system has their capabilities that capable to achieved the specification. There are a several system capabilities where have their limitation as shown in below.

- a) Analysis can be use between one to three set of gear.  
The system can be analysis the gearbox between one to three set of gear.
- b) Refresh and reset button at certain pages for activated VBA command.  
The refresh and reset button be implement in student form at gear failure analysis, shaft failure analysis and bearing analysis. The refresh button function for activated the gear set depended on number of gear set been used. While, the reset button used for show all rows that were hidden previously in activated page. Figure 10 show the example of refresh and reset button in student form.



**Figure 10: Example of refresh and reset button in student form**

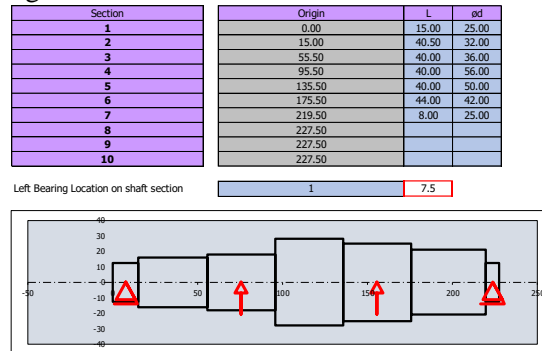
- c) The position of pinion and gear at the same shaft can be changeable.  
The position of pinion and gear at the same shaft can be adjustable since the equation been made complied with the criterion or conditions. Figure 11 illustrated the example of equation for moment at center that can be alter depended on situation.

$$=IF(D167<D168,"Moment at center pinion P2","Moment at center gear G1")$$

Moment at center pinion P2	:	33.79
Moment at center gear G1	:	54.176

**Figure 11: The example of equation for moment at center that can adjustable**

- d) Proper shaft layout can be obtained.  
The shaft layout can be generated once the student form filled out as shown in Figure 12.



**Figure 12: The example of proper shaft layout in student form**

- e) All analysis were carried out in metric unit only.  
All parameter of system established in metric unit only.
- f) The bearing database are referred to the Solidworks data.  
List of bearing that been used in system was available in Solidworks toolbox which make easier for user to draw 3D modelling of the selected bearing later.
- g) Preview in print  
The system cannot skip the information in print preview option due to the limitation of pages. Since the information consume a lot of pages, the system can skip the information only in same pages as shown in Figure 13. The information from other pages cannot moves to above



pages as the system only function in same pages.

The figure displays 12 screenshots of a software interface, arranged in a 3x4 grid. Each screenshot shows a table of engineering parameters for Pinion and Gear components across three different sets (Set 1, Set 2, Set 3). The parameters include:

- Bending stress and contact stress:** Values for Pinion and Gear in MPa.
- Strength correction factor:** Parameters like  $Y_A$ ,  $Y_B$ ,  $Y_C$ ,  $Y_D$ ,  $Y_E$ ,  $Y_F$ ,  $Y_G$ ,  $Y_H$ ,  $Y_I$ ,  $Y_J$ ,  $Y_K$ ,  $Y_L$ ,  $Y_M$ ,  $Y_N$ ,  $Y_O$ ,  $Y_P$ ,  $Y_Q$ ,  $Y_R$ ,  $Y_S$ ,  $Y_T$ ,  $Y_U$ ,  $Y_V$ ,  $Y_W$ ,  $Y_X$ ,  $Y_Y$ ,  $Y_Z$ .
- Stress cycle factor,  $F_{sc}$**
- Types of cycle factor**
- Stress cycle life factor,  $Z_N$**
- Temperature factor,  $K_T$**
- Reliability factor,  $K_R$**
- Hardness ratio factor,  $C_H$**
- Gear safety factor**
- Bending safety factor,  $S_b$**
- Contact safety factor,  $S_H$**
- Contact safety factor,  $S_{Hc}$**
- Throat:** Wear status.

Figure 13: The example of print preview

- h) One option needs to choose manually in Shaft ‘2’  
 The power out for Gear need to choose manually depending on the direction of gear in shaft as shown in Figure 14. This section should highlight as it affected the value of results in MCD marking scheme.

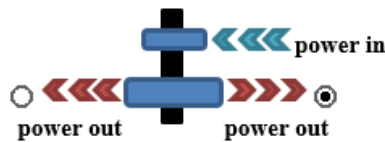


Figure 14: The power out of Gear at Shaft 2

## 5. Conclusion and recommendation

As a conclusion, the objectives of this project were achieved successfully within the time given. For this project, the MCD scheme report project was taken as guidelines of marking process. There were numerous equations has been learned in analysis sheet layout during software development. The macro section been used in student form in order to hide and unhide the unnecessary part depend on the number of gear set. Moreover, a critical thinking been built during analyse the data in analysis sheet layout where all parameter should evaluate differently regard of requirement of criteria.

However, the student forms not tested with one and three gear set where difficult to find student that did the project using one and three set of gear. The development of student forms in Excel just evaluates for two sets of gear only where it is the minimum requirement for analysis the project. There was one test had been done and the result provide the same scale rating as previous results.

From the developed of student forms and MCD software, there are a few recommendations that should be make in up-coming future. One of the recommendations is the software should be test using one and three set of gear in order to check the evaluation meet the requirement. The data for one and three set of gear were difficult to find due to the requirement of project need at least two set of gear. The option in shaft 2 sheet in MCD software require to choose manually to determine the direction of power out for gear. The result may affect the shaft analysis and bearing analysis. All data related to shaft 2 will be affect. Since, the power out for shaft have to be select manually depend on direction of gear output, hence next developer can consider to modify and link the power out automatically without choosing an option. In addition, the next developer can also consider adding detailed results in the MCD software. This may be beneficial for lecturers to detect any errors on each criterion in the project report. Next, student form should put the expired date as it can unable the form and detect the season and semester. All the information above is suggested to improve the software's capabilities and also the accuracy of the analysis.

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