10.Gearbox, Brake, Coupling

Hochschule Flensburg
University of Applied Sciences

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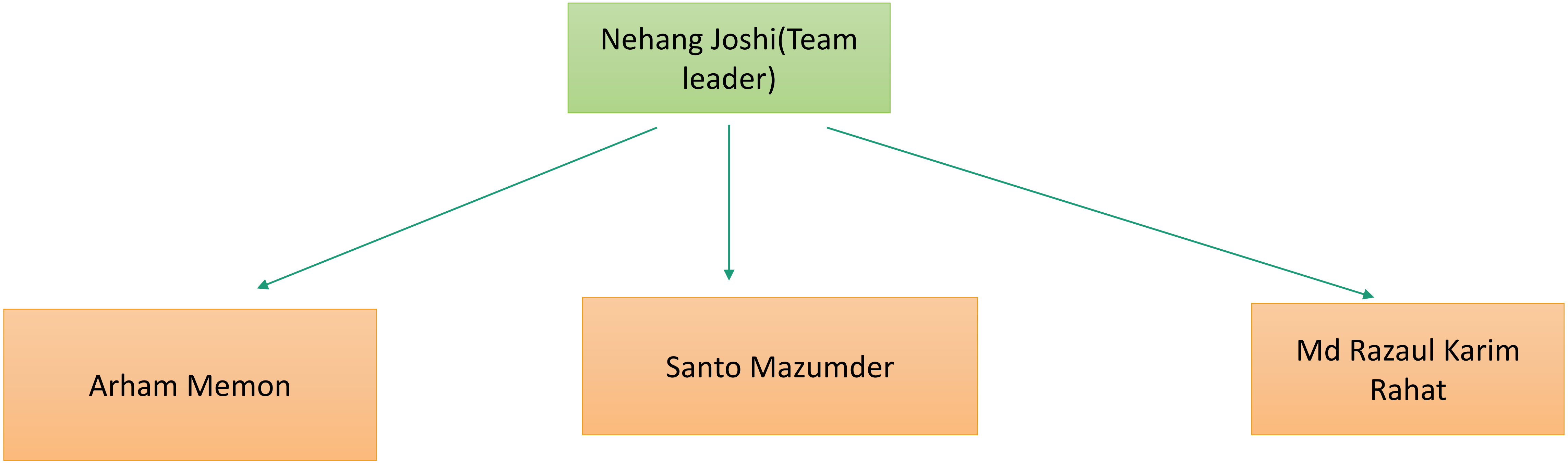
Agenda of the 2st week (27th July to 1st August)

- Study of last years documentation (in detail ………….)
- Research for appropriate mechanical drive train system and gearbox layout
- Research on relevant standards and guidelines
- Research on gearbox variants, mechanical brake systems and couplings (high speed side)
- Benchmark and definition of gearbox, brakes and coupling

- ***Research on possible suppliers suitable for delivering to Syria***

Study of last years documentation

- So basically we did research on previous year documentation and we came up with short ideas that how it should be work and how it could be done for this year as well for Syria project 2025-26.
- There are three parts for components we have to divided into three with four members as of now we all are working on same line like all the members including team leader are doing only research on this topic.



Update- Study of last years documentation (for 2nd week)

- **<u>So we noticed that many student did project in last many year for optimus which is describe below.</u>**

✓ Optimus 200XL

✓ Optimus 295

✓ Optimus 60E

✓ Optimus oceanus

✓ Optimus shakti

Optimus 200XL

- As part of the masters’ course “Wind Engineering” of the HS Flensburg, a wind turbine was designed with the aim to create the highest power output on the market. This turbine is called Optimus 200XL and has a nominal power of 12.5MW. The project is an upgrade of the Optimus 200 project, which was conducted by the students of the previous semester and created a turbine of 10MW.
- The contents of this report are the outcomes of the group that was responsible for parts of the mechanical drivetrain. These parts were the gearbox, gearbox housing, coupling, coupling housing, rotor brake and lock. All these components were designed by calculations and 3DCAD drawings, which is shown in the following chapters. Also, the learned lessons of each member of the team are stated. In the end, an outlook on still open tasks is given, as well as an evaluation of the team work within the group.
- Each whole chapter was written by the person that is stated in the name of the chapter independently from the other group members.

Gearbox

- Design work 3.1.1 Description of process, issues, final solution and interfaces The process of designing the gearbox will be explained in this part. For the first step, different companies at the wind expo “WindEnergy Hamburg 2018” which produce gearboxes, have been analysed to see which concept is produced more than others by companies, which also shows the level of market friendliness of a product.
- After spending time and effort, it was decided to have a two-stage planetary gearbox with fixed ring gears to have the biggest ratio and to save money, because it was possible to use the ring gears as part of the gearbox housing. This concept doesn’t have a helical gear at the end and a hollow shaft goes directly to the generator.
- Two-stage planetary gearboxes also have some technical advantages compared to three stage ones, e.g. higher efficiencies even at partial loads because oil plunging occurs only in two stages instead of three.
- The material which has been chosen for the gearbox was 18 CrNiMo 6-7 which has 206000 N/mm2 of module of elasticity and a Poisson´s ratio of 0.3.
- One of the issues which have been recognized was the spreading of the forces and moments inside the gearbox because of the high ratio of the stages. The first idea was to have five planets in the first stage. However, there was a problem with the dimensions of the gearbox. It had to be very compact and there was not enough space for five planets with the desired ratio. Therefore, it was decided to have four planets in the first stage and three planets in the second stage

Rotor Brake

- The brake is not normally used to stop the plant in full operation. It is only used in order to achieve complete stoppage of the drive train after the plant has been stopped largely by the pitch of the blades. In small wind turbines, a mechanical rotor brake, which in cases of emergency prevents rotor runaway, has proved to be extraordinarily successful and widely used today [16]. With increasing turbine size as in Optimus 200XL with a rotor diameter of 200 m the rotor brake takes on almost unreasonable dimensions if it is to brake the rotor torque and power during full-load operation. For this reason, the task of the rotor brake in Optimus is restricted to the function of pure parking brake. The brake is designed and calculated according to the DNVGL [12] guideline, based on lecture notes by Prof. Quell and with the aid of SolidWorks software for 3D and 2D Design.

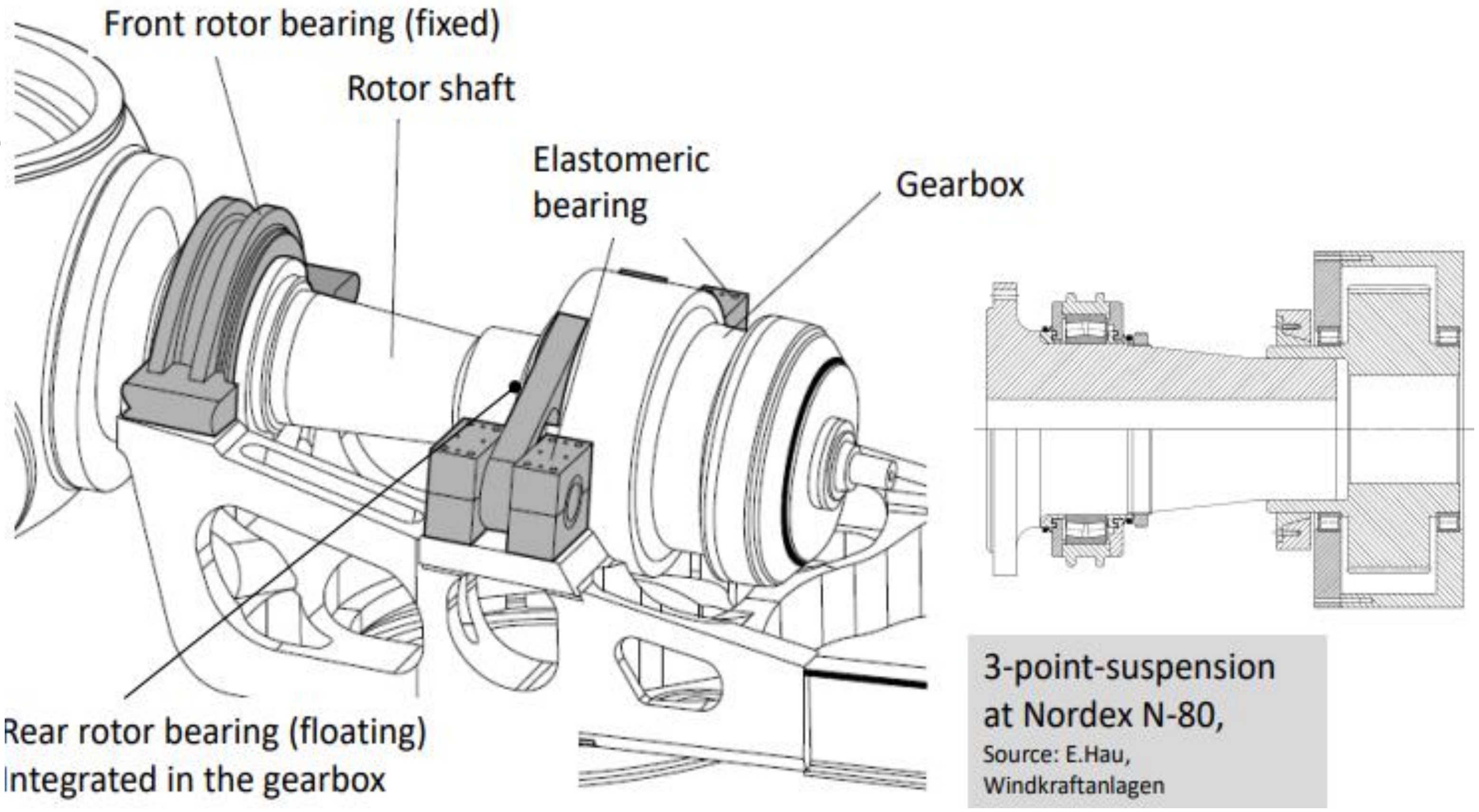
Coupling

- There are many different concepts concerning couplings in wind turbines available. The drivetrain concept of Optimus 200XL was a rather unusual one, seen from the design itself and the amount of forces it experiences. This meant, that not all coupling concepts could be used in it. Research has been done online and on the WindEnergy fair 2018 in Hamburg, where many major suppliers were exhibiting their technology.
- Because the drivetrain concept of Optimus 200XL was inspired by the designs of the Adwen AD 8-180 and the Vestas V164, it was also tried to gather information about the couplings used in these turbines. Furthermore, other promising concepts were investigated, like the Geislinger Compowind

Optimus 295

Gearbox Data

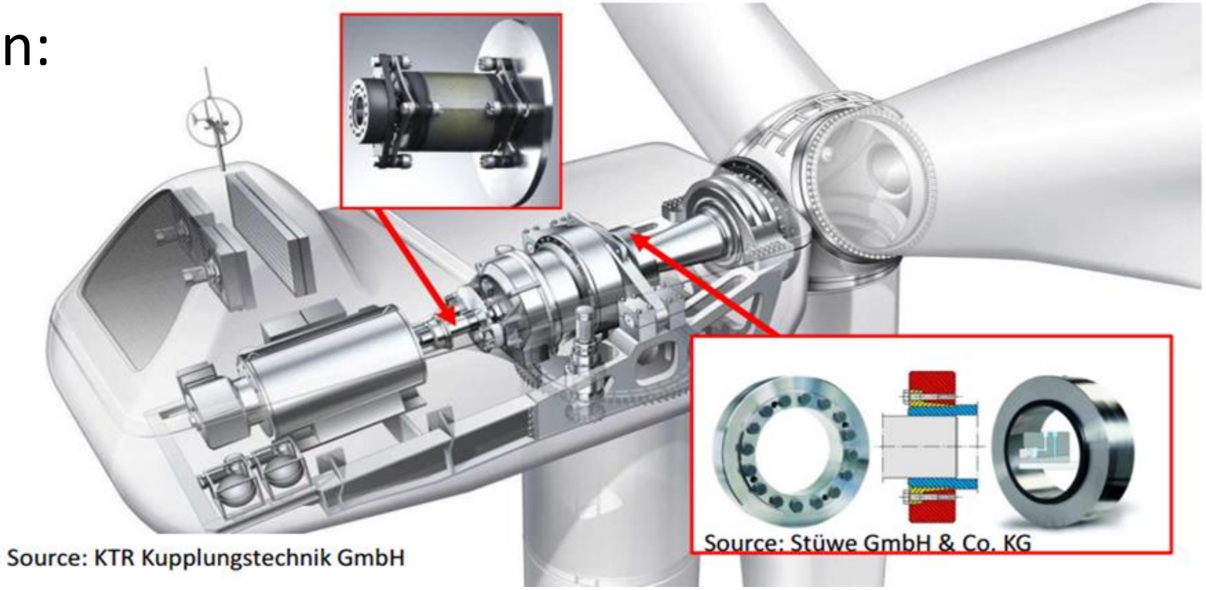
- Target ratio of 70 - 80
- 3 stages of planetary gears
- 18CrNiMo 6-7, cast Iron for the housing
- Fixed ring



Couplings

In general, the coupling is the connection between:

- Rotor shaft and gearbox (LSS)
- Gearbox and generator (HSS)



Main Objectives:

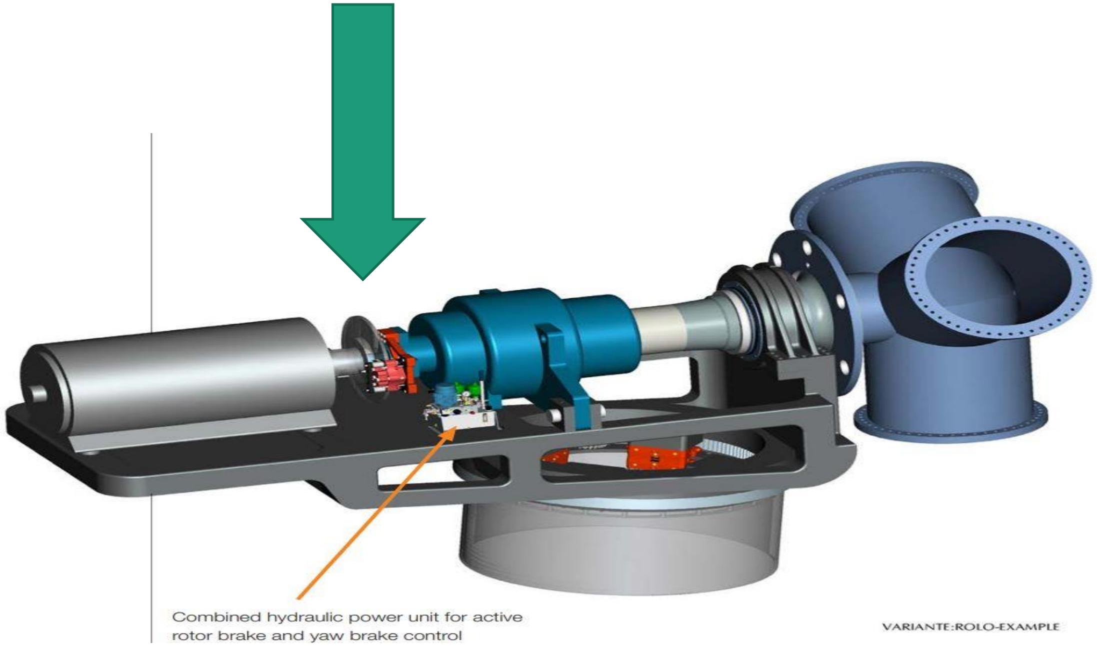
- To handle high torque, Minimize shock loads, and compensate misalignments between the rotor shaft and the gear box

Installation methods

Before the generator

Pros
- Control and Safety
- Reduced Gearbox Stress

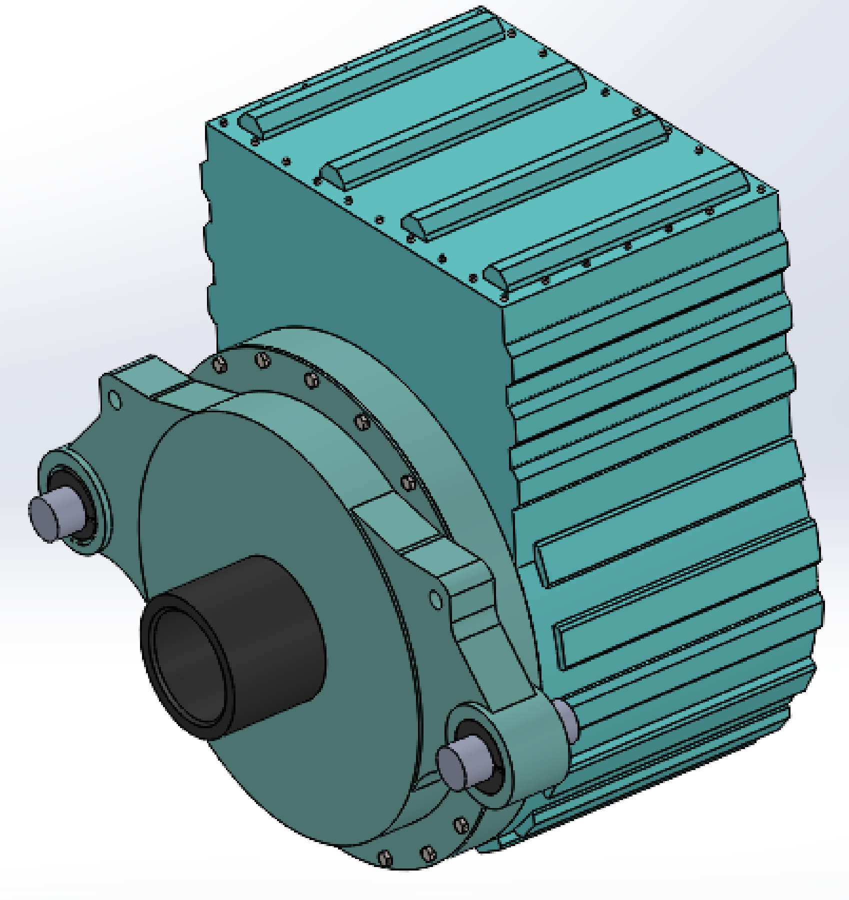
Cons
- Energy Loss
- High Cost



Source: https://www.svendborg-brakes.com/

Optimus 60E

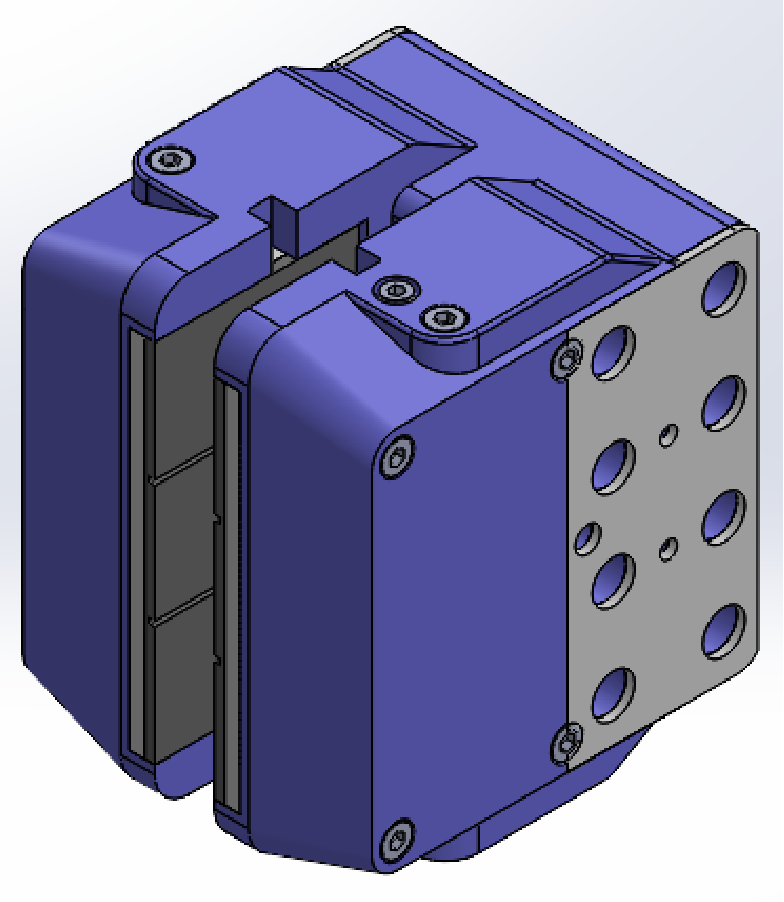
Gearbox



Specifications	
Total Ratio	58.91
Type	1- Planetary 2- Spur
Input Speed (min^{-1})	25.46 rpm
Output Speed (min^{-1})	1500 rpm
Length (mm)	1564 mm
Width (mm)	1980 mm
Weight (Kg)	7354 kg
CO_2 Footprint (Kg CO_2)	7338.91 kg

Optimus 60E

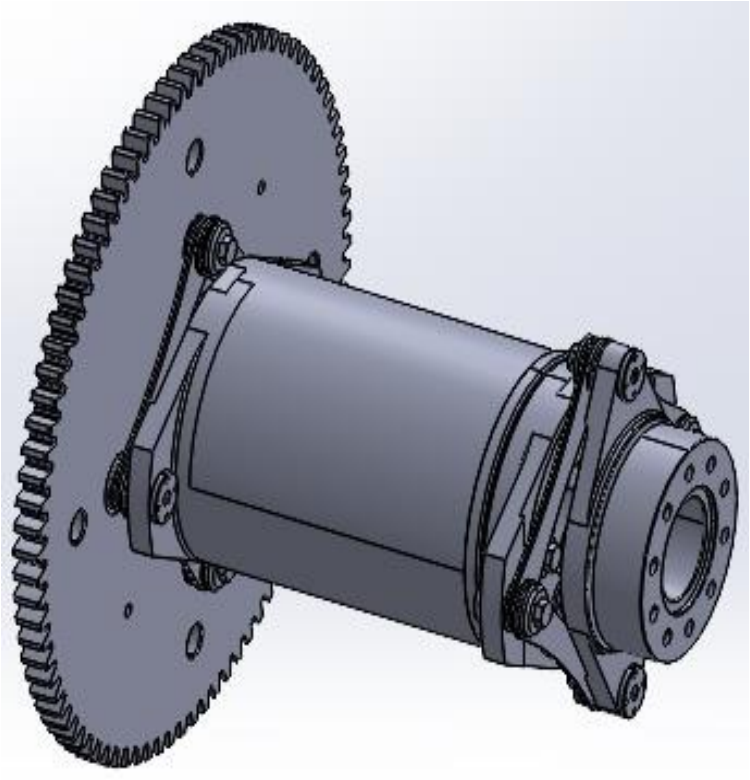
Brake Caliper



Brake Specification	
Type - Svendborg	45-X-104
Length (mm)	220
Width (mm)	167
Height (mm)	175
Weight (kg)	40
CO_2 Footprint (Kg CO_2)	30.4

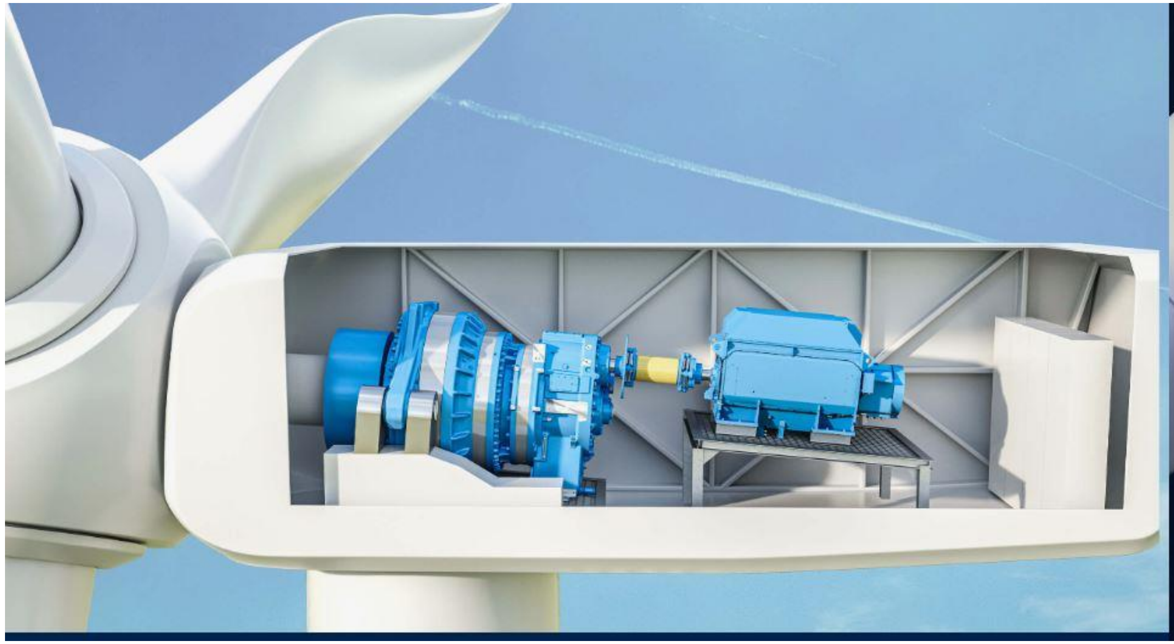
Optimus 60E

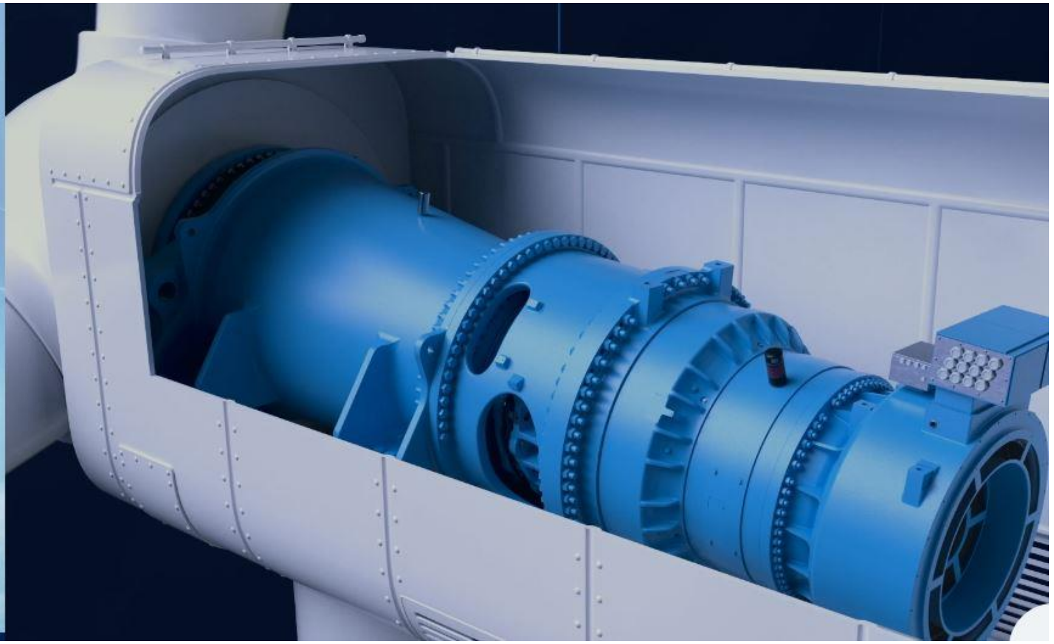
Coupling



Specification	
Type - KTR	Radex-N NANA 4
Length (mm)	679
Brake disc(mm)	∅700 x 30
Weight (kg)	164.29
CO_2 Footprint (Kg CO_2)	124.83
$M_{N,LSS}$ (KNm)	5.50
$n_{N,LSS}$ (min^{-1})	25.46
$n_{N,HSS}$ (min^{-1})	1500

Optimus Oceanus





Research for appropriate mechanical drive train system and gearbox layout

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- <u>High speed drivetrains (3-4 </u>gears)
  (Ref.Optimus Shakti)
- Gearbox: • Complex design requirements due to many gears:

o Many components (gears, bearings, shaft-hub-connections,..)

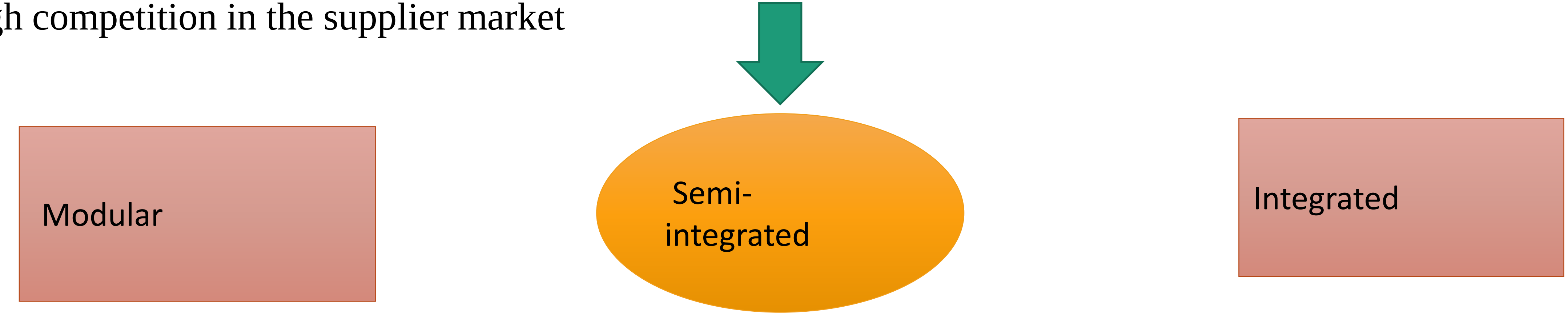
o Complex dynamics (many excitation frequencies, ‚soft‘ toothing,..)

• Critical to noise

• Just one lubricant despite unequal conditions in the different gears - In general very cost competitive due to high competition in the supplier market

Recommendation for project

1. Modular
2. **Semi-integrated (BEST Value provider)**
3. Integrated



Semi-integrated design (so-called 3-point-suspension)

- According to pervious year report (ref.optimus Shakti) they chosen semi-integrated drive train concept.

Why ?

rotor bearing system is partly integrated in the gearbox.

❖ The fixed bearing is connected to the machine bed, the floating bearing is part of the gearbox.

❖ rotor loads (forces and moments) are transferred through the housing of the gearbox into the machine bed.

❖ separated 2nd bearing housing is not required anymore(as per our decision this is the main advantage of this drive train system using for Syria project 2025-26 (But still needs to research)……………………

Research on relevant standards and guidelines (AS per pervious year)

IEC 61400-1:2019, Wind energy generation systems —Part 1: Design requirements

• IEC 61400-4:2012, Wind turbines —Part 4: Design requirements for wind turbine gearboxes

• ISO 6336-2:2019, Calculation of load capacity of spur and helical gears —Part 2: Calculation of surface durability (pitting)

• ISO 6336-3:2019, Calculation of load capacity of spur and helical gears —Part 3: Calculation of tooth bending strength

• ISO/TS 6336-4:2019, Calculation of load capacity of spur and helical gears —Part 4: Calculation of tooth flank fracture load capacity

• VDMA Specification 23903, Basic design requirements for plain bearings in main gearboxes of wind turbines

• VDMA Specification 23904, Reliability assessment for wind energy gearboxes

Research on possible suppliers suitable for delivering to Syria

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- Got some idea about from the internet and some website that is **Winenergy** group of company which origin of the German possible to provide in Syria because they have large production of gearbox which can gives good amount of work output and higher generation rates.
- Enercon company is also leading for supplies in Syrian region.
- ZF wind power Antwerpen also who is responsible to provide in this country
- ZF wind power and giants company like Siemens and flander 40-50% stockholder for this project for suppliers.

(Above companies are located **in European region** mostly are capable enough)

- Goldwind and Dongfang is also could become leading for suppliers of gearbox,brake,coupling (**Asian region** and these companies located in china)

- **Remarks-** possibility for some other companies can do still research and proof required for supply chain

Semi-integrated design (so-called 3-point-suspension)

- Company in Germany which is using this kind of concept.

a. Senvion

b. Vestas

c. Siemens

d. Nordex

e. GE

(Task and aim is to do research that is they are also provider in Syria)?..................................

Manufacturer

coupling	Gearbox
• Geislinger • Flender • ESM	• ZF • DVS • Eickhoff • Winergy • NGC • Brauer • Multigear • Convent • Eno • SKF

Gearbox

Suppliers in the market:

Suppliers

GEISLINGER®
COUPLINGS AND DAMPERS. BUILT TO LAST.

FLENDER
winergy

JAURE®

VOITH

Geislinger

COMPOWIND Coupling

An innovative concept of fatigue-resistant and maintenance-free fiber composite membranes. With more than 90% reduction of rotor non-torque loads.

- Fatigue-resistant
- Maintenance-free
- No aging, no wear, resistant to heat, frost, and saltwater
- Diameters up to 3.5 m
- Weight-saving design
- Long life cycle

Source: https://www.geislinger.com/en/products/product/compowind-coupling/

Flender

ARPEX GIGA wind coupling

- This coupling can transmit torques of up to 12 MNm.
  - maintenance-free
  - compensate for axial, angular and radial misalignments.
  - A lot of Mechanical components

Source: https://www.flender.com/Produkte/Kupplungen/ARPEX-Windkupplungen/p/ATN09001

Jaure

JHC couplings

- Jaure hydraulic shrink coupling
  - Easier installation
  - Can withstand high shock loads
  - Leakage risk
  - High pressure oil pump system is needed

Source: https://www.regalrexnord.com/brands/jaure/wind-power-drives

COMPOWIND Coupling General View

Source: https://www.geislinger.com/en/products/product/compowind-coupling/

Brake system

Suppliers in the market:

- **ICP WIND**
- **Svendborg Brakes**
- **KTR**
- **Stuwe**

Summary work of our group this week (27^{th} July to 1st August)

- <u>Research on previous year documents and got information about gearbox,brake,coupling</u>
- **<u>Remarks</u>**- Fully research is still pending due to taking decision for appropriate because in every project they used different drive train concept as per area of the country ***(80% completed and 20% remain)***

- <u>Research on appropriate drive train concept and gearbox</u>
- **<u>Remarks-</u>** Got mostly idea about which is most relevant concept for wind turbine in Syria region but still need conformation about the variants of the drive train and gearbox just because of Syrian region is located in middle east and its very different location than western European countries so it would like to more critical than previous year project to choose drive train and its needs to required mentor guidance. (***80% work done and 20% still remain***)

- <u>Research on brake system and coupling for wind turbine</u>
- **<u>Remarks-</u>** Got idea about various kind of brake system and coupling which is use for most advance developments and which is most suitable for turbine but still needs to be use other medium to get more information about it (like research paper, YouTube, company documentation.
- We are able to find that which kind of company can still provide in the Syria region and it should be cost effective as per aim of the project so we are still trying to find and try from next week would be possible to find for new or cost cutting design.
- (***60 % work done and 40% pending***)

Research on standards and guild line and benchmarks for gearbox,brake,coupling

Remarks- Mostly aware and filmier with standards but still required to few ***(80% done and 20% pending)***

- Research on Syrian market and know about suppliers

Remarks- Research on possible suppliers suitable for delivering to Syria is still remain just because lack of knowledge and new country for project which is quite far from wind turbine market. ***(30% done and 70% pending) cost and value maybe play major role.***

Work load and media used for this week.

- **10 hours / This week**

- **<u>Media used</u>**

(Google chrome , YouTube , WhatsApp, research paper, companies pdf and documents)

- **<u>Medium of compunction with team mates</u>**

(WhatsApp group) **Remarks- will try to improve for offline as well as online meeting (zoom, WebEx)**

Next week plan in advance description (4th August to 8th august) 3rd week

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- Complete pervious week work better to do fully…………………
- Software installation (Solidworks, Anysys,Dlubal) still pending will do soon………………
- YouTube videos gearbox design , brake, coupling tutorial learning
- Get some idea about calculation……………..
- Get more information or gathering from companies website , articles and generals…………
- Familiar with wind turbine data trough research paper…………
- **Practice and try to improve data and information about topic.**
-

In sum up we are still trying to improve our method for work balance sure that we will do before 20th August…………

- **10 hours / This week**
- **Media used**

(Google chrome, YouTube, WhatsApp, research paper, company's pdf and documents)

- **Medium of compunction with team mates**

(WhatsApp group) **Remarks- will try to improve for offline as well as online meeting (zoom, WebEx)**