For the collaboration between the

University of Applied Sciences Wildau, Germany

and

Dedan Kimathi University of Technology, Kenya

Project Report

Maintenance and revival of a francis-turbines governor

Author:	José Rolando Fredriksson Chaves
Student in:	Mechanical Engineering (MA)
Summer project thru:	20th July to 14th September 2016
Supervisors:	Dr. Jean Bosco
	Prof. Michael Herzog

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1.0 Summary of last report

The hydro-electric turbine located in the coffee farm at the Dedan Kimathi University was installed in 1980 by Gilbert Gilkes & Gordon Ltd (England). This turbine had mainly the purpose of producing electricity for lighting. After several years the project broke down and the turbine got out of use. The extended period of time of non-usage caused a deplorable state for the turbine. Today there is a project to revive this system that works with a francis turbine which had the following specifications:

Table 1: Specifications for the Francis turbine made in 1926

Power	12.5 KW
Voltage	240 V
Generator speed	1500 rpm

In the last report from March 2016 were three phases described to make this project work:

Phase 1: Was to determine the viability of the project and to dismantle the turbine system for inspection.

Phase 2: Servicing the main components of the system i.e. generator and the governor, assembling the turbine system and reworking the foundation for mounting the system.

Phase 3: To generate more power above the current 12.5 kW (in these case 100kW), ensure an optimal power generating system and ensure the system is sustainable.

Furthermore the results measured in phase 2 were considered as a clear indication that the revival of the system can be successful; see results in table 2.

Table 2: Measured parameters in phase 2

Runner speed	350 rpm
Generator speed	1150 rpm
Generator output	210 V

Values such as the head of the turbine and the necessary flow rate of water were calculated to determine the most suitable type of turbine to generate 100kW. After evaluating the possibilities of how to generate more power, the conclusion was to invest in a new type of turbine: a Cink Kaplan Turbine.

In conclusion the costs for the project were estimated and here shown in table 3.

Table 3 Cost of the Project [1]

Item	**Cost (Ksh.)**
Civil works	400,000
Cink Kaplan turbine	13, 000, 000
Generator	400,000
Miscellaneous	200,000
TOTAL	**14,000,000**

2.0 Introduction

This project is an extension of the water turbine project as a complement to the previous work on phase 2. Despite the proposal of investing in a new turbine for the farm, there is the intention of reviving the francis turbine for teaching purposes as a training rig for students. Figure 1 shows the turbine allocated at the farm.

Figure 1. Francis turbine at the coffee farm [photo, July 2016]

This hydropower system is composed basically of the turbine, the generator and the governing system. On the last phase of the project the focus was on the two first. The remaining component (the governor) has been examined, too, but not tested. Furthermore, the possible investment required for the revival of this part was not included in the budget presented above. Out of these criteria follows that the governing system will have the central role for the project.

3.0 Objectives

1. To analyze the working principle of the oil pressure governor and define the steps to reactivate its use.
2. To determine missing components and elaborate the technical drawings for machining.
3. To determine options of combining the old technology with current hydraulic or electric components.

4.0 Methodology

The content of the project will need the understanding from the old technology, which we find in the farms governor, to the new technologies that are currently applied in hydropower stations. In order to find the way of combining these two technologies, there will be a closer look into the practice.

1. The first practical look consists in visiting the site in the university where the turbine is located.
   - To understand the working mechanism in the generating system
   - To evaluate the components in their environment
     and
   - To transport the governor to ADMATC[1] for further inspection of the single components
2. Secondly, visiting the Sagana hydropower station of the Kenya Electricity Generating Company (KENGEN) will give us the opportunity to observe the types of governors implemented in their systems. Yet this examples deal with greater power production (around 1,5 MW).
3. At last, we make a few hydraulic exercises to understand the basic components of a hydraulic governor.

5.0 The Governor

The mechanic oil pressure governor of the farm was installed by the Gilkes Company. It has following product description: Oil pressure governor, Type A, Nr. 644 (see Figure 2).

Figure 2. Gilkes & Gordon Ltd., Oil pressure governor [photo, July 2016]

[1] ADMATC: Advanced Design and Manufacturing Training Center, Mechatronics Department, DeKUT

The primary purpose of a governor for a hydroelectric unit is to control the speed deviations and loading of the unit. It accomplishes this by controlling the flow of water through the turbine, which is defined by the opening position of the so called wicket gates. As we can see in Figure 3, the wicket gates are located one "ring" before the runner. The water will flow thru the scroll casing until it hits the wicket gates and then from the runner to the outlet. The reason why a governor system is needed, is to maintain the rotation of the shaft as constant as possible, otherwise the generator will not be able to produce "clean" electrical power.

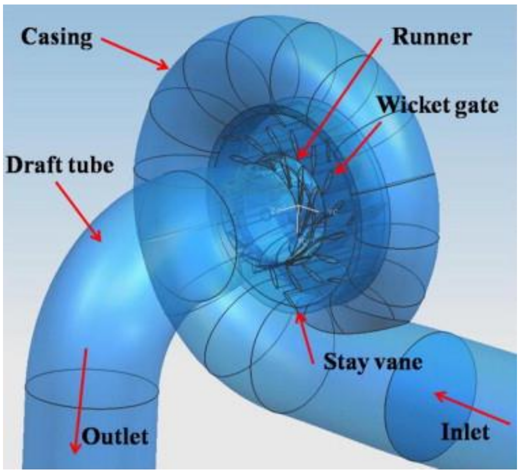


Figure 3 Francis turbine – Component overview [3]

From the last report we know about the farms governor, that some parts were missing. Including the hand wheel that was used to open the vanes manually, this was machined in the last phase. For other possible missing parts we contacted the Gilkes Company, to request for information about the assembly parts or datasheets, however with no success since the documents were unable to find. (See appendix nr. 1)

The challenge that follows out of it now, is the understanding of its working principle. This governor was built around 90 years ago, which means we will be dealing with an old mechanism. Without the information of the Company that produced it and limited sources in the internet about this specific governor, we will take as reference the working principle and components from other mechanical governors to describe the functioning system and determine the differences between the newer and the old technology.

5.1 General descriptions of a mechanical governor

There are numerous designs and configurations of mechanical governors, but generally, they have many of the same components. The main parts are a speed sensing device, usually a ball head, an oil pressure system, hydraulic valves to control oil flow, and one or more hydraulic servomotors to move the wicket gates. [6] Now an overview of the components:

The Oil Pressure System

The oil pressure system consists of an oil pump/s, oil accumulator tank/s, oil sump, and the necessary valves, piping, and filtering required

The Control System

The control system can be mechanical, analog, or digital depending on the type of governor. In the truest sense, the control system is the "governor". The purpose of all other components in a governor system is to carry out the instructions of the control system (governor). For mechanical governors, the control system consists of the flyball, linkages, compensating dashpot, and speed droop device.

Hydraulic System

The hydraulic system consists of an oil sump, one or two oil pumps, an air over oil accumulator tank, and piping to the servomotors. Typically, there are two pumps with lead and lag controls so that there is always a backup pump. Some systems will share two pumps between two units so that in an emergency one pump could be used for both units. The accumulator tank is usually sized so that in the event the pumps fail, the gates can still be closed.

Wicket Gate Position Feedback

The restoring mechanism is a “feedback” device that feeds back the current wicket gate position and the post movement command position to the control system. In a mechanical governor this is typically a pulley cable system.

These descriptions above apply to modern mechanisms of governors and in the background also for former governors, yet with not all of the components. We could find these aspects at the Sagana Falls Power Station of KENGEN. The power station is set for a capacity of 1,5 MW power production.

On their 4 Francis Turbine they had on two of them a hybrid of governors. One of them was an automatic/manual governor and the other one was purely manual, in case the first governor fails. The two governors are located next to each other on one side of the turbine. Both of them are connected to the regulating lever and rod to position the wicket gates.

Figure 4 Auto/ Manual Governor[photo, Sept. 2016]

Figure 5 Manual governor [photo, Sept. 2016]

On figure 4 we can see the ball head of the governor (the conic component). This is the flying ball mechanism that is directly driven by the shaft of the turbine.

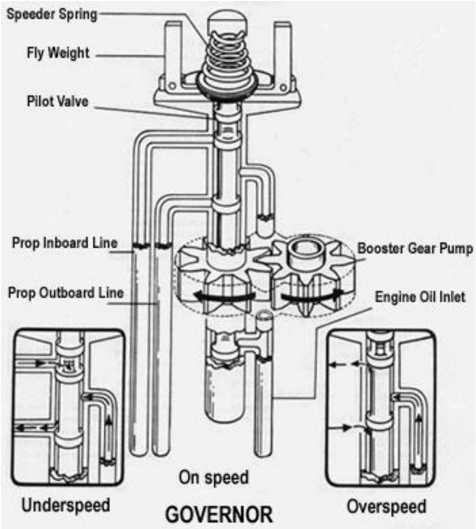


Figure 6 Position of rod at under- and over speed [8]

As the shaft rotates the fly weights will expand causing the vertical movement of a rod that varies the position of valves, allowing the oil to flow in different ways in the system. The pushrod is then counterbalanced by a spring. To clarify this, use Figure 6 as a reference to observe the oil flow in case of over- or under speed.

The auto/manual governor also has a servo mechanism that allows an accurate control of the pushrod. This mechanism is not used for the manual governor in figure 5.

Another type of governor we found is the hydraulic governor at the Mesco Hydro Station that produces around 0.43 MW. Here we found the most modern variation of a governor in our visit. This observation is important for the 3rd objective defined before. This governor has a sensitive system connected to the inlet. A 15 KW electromotor is in charge for the oil pumping in the governor. We found several types of directional control valves (DCV) that control the flow of oil and response to regulate the opening of the wicket gates.

In the library of content of the project, there are photography's contemplating the hydraulic circuit used in the hydraulic governor and also pictures of the other governors we could find at KENGEN.

5.2 Oil Pressure Governor, 1926

Having searched after the common parts in a governor, we want to determine the parts that contained the one in the farm. As a guidance we also used drawings of governors to find a similarity in the structure, nevertheless we point out they are not 100% alike.

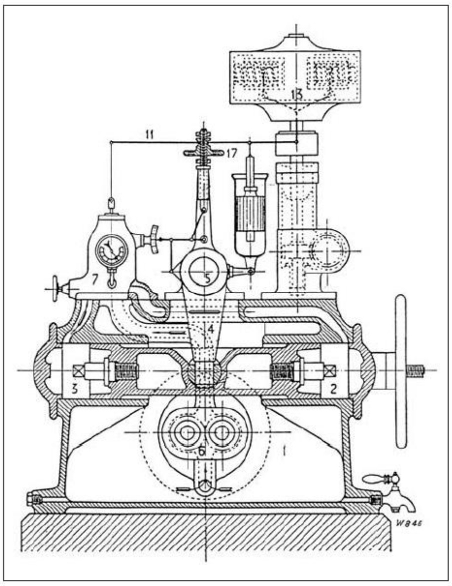


Figure 7 Universal governor of Escher Wyss (Zurich, 1906) [4]

On the first look, we consider the structure of the universal governor (Fig. 7) is the nearest to the one we are dealing with, at least the parts that are contained in it.

We find:

1) An oil sump on the lowest part, with two draining sections.
2) A booster gear pump *(5)* connected with a pipeline to the section *(7)* which conducts the oil to the front and the back of the governor *(5)**[2] and also measures the percentage of the wicket gates´ opening.

[2] The five meant here is the one on the left

3) A hand wheel (on the right) for manual adjustment.
4) A flying ball/weight mechanism *(13)*
5) A bar *(11)* with the effect of a “see-saw” according to the input speed between *(13)* and *(7).* Basically the responding/regulating bar of the input in the system.

Other types of mechanical governors are shown in Figures 9.1 and 9.2.

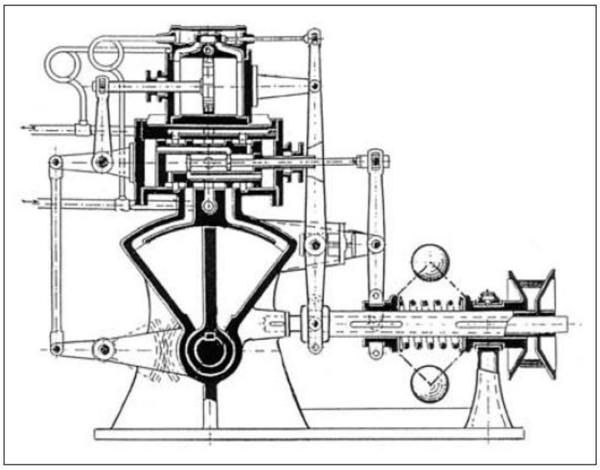


Figure 9 Sturgess governor (U.S.A, about 1900) [4]

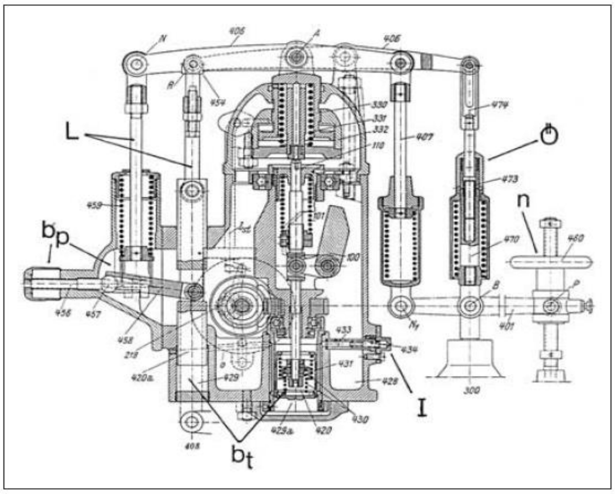


Figure 9 Pilot unit with integrated fly ball sensor (about 1935) [4]

With the hint we observed in this figures we could define the function of the parts in our governor.

5.2.1 Vision

The vision of the project again is to make the turbine work. Since KENGEN engeneers state the machine can run again, we put more concrete objectives, in order to fullfill the steps needed to make this governor work, such as.

- Define the missing parts to design and machine them.
- Propose a solution for the broken components

5.2.2 Current state

The governor which we are putting the focus on is not in a working condition and neither the conecting parts to the turbine, plus there are missing parts which will be designed and machined.

5.2.3 Actions

We took a closer look into the system, to define the missing parts and give maintenance to them.

For practical reasons the single components were meassured and then designed in a CAD-Software: Autodesk Inventor 2015 (See appendix 2; <u>*note:*</u> *the files can only be open with the 2015 version or a higher one; The pieces are contained also in the library of the project*).

Figure 10 Single components of the governor [photo, sept. 2016]

The whole governor was cleaned with an industrial cleaner to remove the old oil and dirt stored in it. Before reassembly all rackets were changed for new ones.

5.2.4 Test

The testing of the governor we define as an open milestone, since it can be tested properly when the missing parts are machined. In other words, the governor itself is ready to be tested, but is waiting for the new components to be attached.

5.3 Structure and Components

While we were reassembling the components, we noted and described the working principle of this governor, which is explained in the following points:

Note: for explaining we define the face of the governor with the hand-wheel as the front face. See appendix 4.

1) From the outside we find a machine with an input and an output. The input speed follows thru a transamition with a belt from the output shaft of the turbine to the input pulley of the governor. See Figure 11. The output is shown in Figure 12.

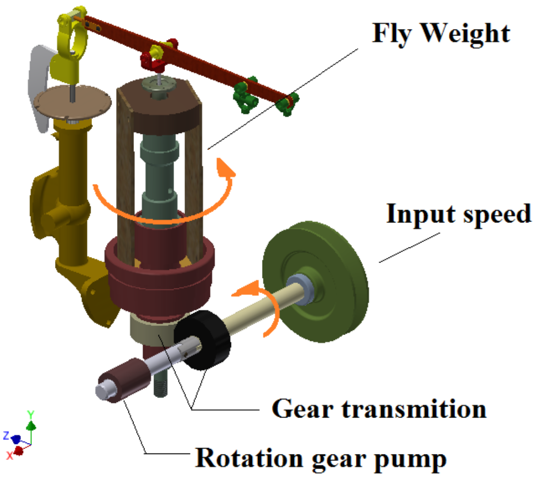


Figure 11 Components at the input

2) There is a booster gear pump also driven by the input shaft. The rotating gear can be apreciated in figure 11, which is coupled to another gear of the same size. *The location of it can be seen in figure 13.*
3) The housing itself is the oil sump, devided into the lower and the upper part.
4) The hand wheel is used to adjust the angle position of the outputting shaft (the manual adjusment).

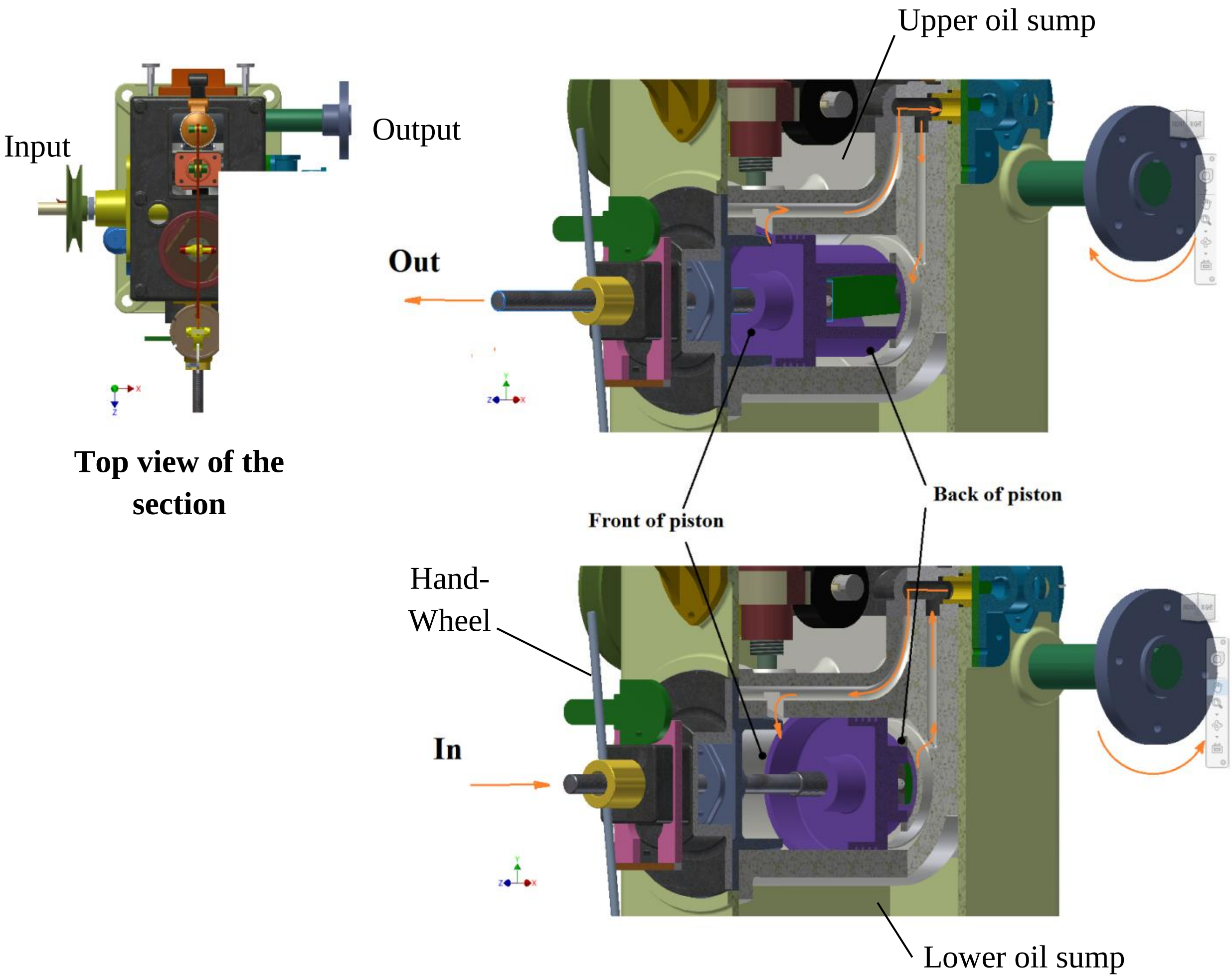


Figure 12 Governor from the inside: piston movement and oil flow

5) Figure 12 shows also the flow of oil, which helps the operator (the person) to move easily the piston back and forth with the hand wheel. As the hand wheel rotates, the angle position on the output shaft changes. This is coupled to the turbine thru the regulating rod and lever of the wicket gates, which finally regulates the water flow that goes into to the rotor.
6) On the left the oil meter is positioned direct to the lower oil sump and connected to the input shaft thru a 5 mm-pipe.
7) On the right we find a component directly connected to the lower oil sump with no connection parts. Comparing it to the universal governor, we conclude there is a missing pipe for oil flow that fits to it and to one of the entries of the gear pump. See the location in Figure 13.

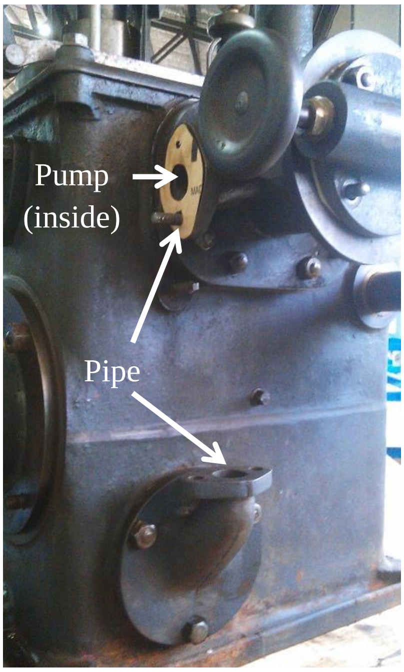


Figure 13 Missing Pipe [photo, Sept. 2016]

This governor is purely manual with a “primitive sensing system” in comparison to the current ones or rather without one, since it can not sense the flow rate variations. It gets the input directly from the output shaft of the turbine an cannot adjust by itsself the opening of the wicket gates. Nevertheless it fullfills its working porpuse by positioning the wicket gates to a define level by the operator.

6. State of components

6.1 At the governor

Missing components:

1. The oil flow pipe
2. Plugs for the openings at the pump section (see fig. 14)
3. Threaded bolts
4. Connecting component for the measuring stock attached to the dashpot cylinder

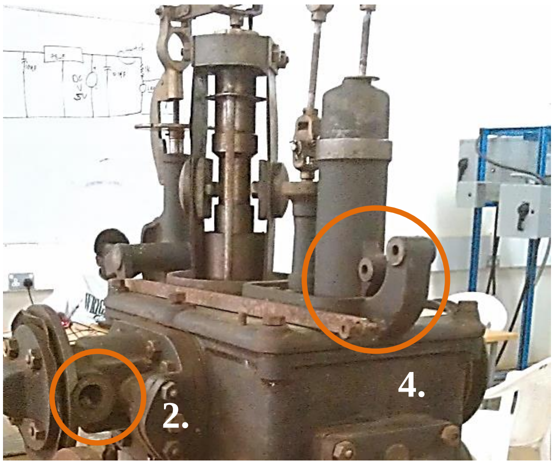


Figure 14 Missing parts

6.2 At the turbine

Missing components:

1. Rods for the guide valve ring (see Figure 14-ii).
2. Pins for the rods in 1. (see Figure 14-iii)

Damaged components:

1. Regulating lever (see Figure 14-i and Figure 15)

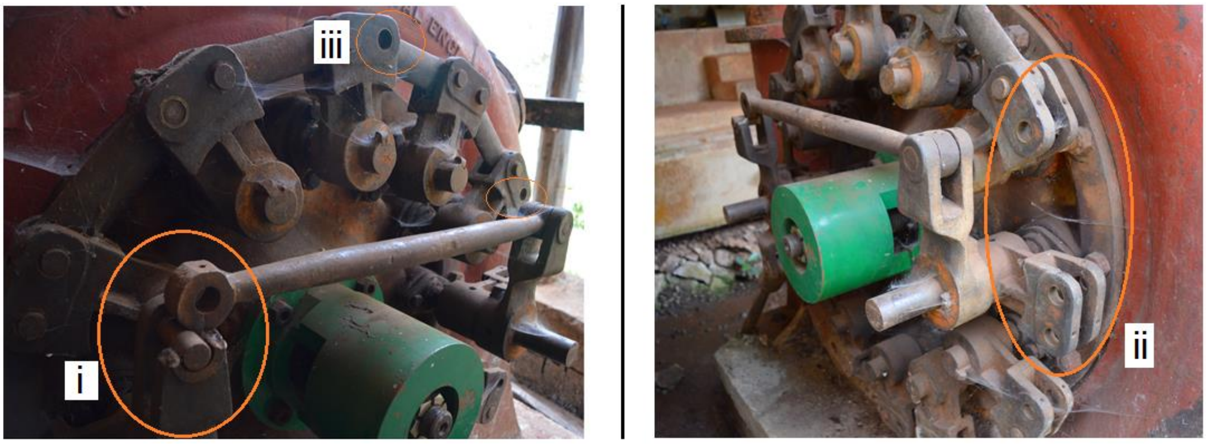


Figure 15 i-Damaged lever; ii-Missing Rods; iii-Missing pins

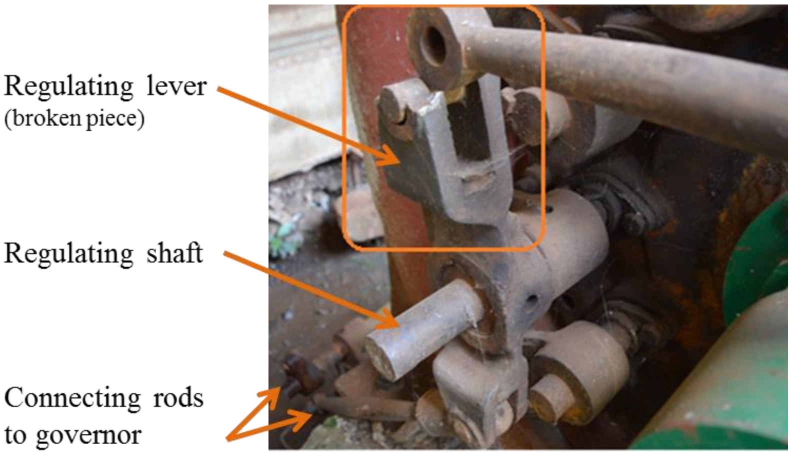


Figure 16 Closer look to the damaged lever

6.3 Construction measures

For the construction measures we took in count the financial aspect, for which we decided to present solutions that can be machined at the Machine Shop in ADMATC. Excluding the participation of an extern company would mean that the costs will rely on:

- Material costs
- Machine operation costs
- Personal costs

Furthermore we consulted the personal of the Machine Shop about the feasibility of the components and the compensation proposal that were presented.

The drawings and part lists can be found under appendix 5.

Note: *the drawings until this phase were ready-made but not controlled or proved by a second constructor. Yet the construction proposals were accepted by the machine shop personal.*

7. Summary and Project Results

The revival of the turbine will follow without the services of Gilkes, with the governor and without connection to the grid.

The Governor

The governor regulates the speed of the runner. This is done by controlling the volume of water hitting the runner. By opening the vanes in the turbine cavity more water flows into the runner there by increasing its speed. Consequently if the vanes are closed, the amount of water hitting the runner is reduced considerably and this reduces the speed of the runner shaft.

State

The governor which we are putting the focus on is not in a working condition and neither the conecting parts to the turbine, plus there are missing parts which will be designed and machined.

Actions

Cleaning and oiling of the governor components, changing the rackets, defining missing parts in the governor and at the turbine, designing of the governor in Inventor and elaborating the technical drawings of missing and damaged components for machining in ADMATC.

Perspective

The components missing can be machined in the Machine shop of the University. Once the components are machined, the governor can be tested. For it to be tested at the site of the turbine there should be maintenance works on the linkages to the turbine since they show a rusted surface. The components should be oiled, too.

Observation

For the objectives set at the beginning of the project, we could conclude a very important part for the governor's revival, which include:

- Describing its working principle
- Determining missing and broken parts
- Preparing of the material needed for machining or repairing relevant components

Since we put the focus on the construction, the objective of finding a way to combine the governor with an electric-hydraulic circuit remains open.

Information Sources

[1] COD, Mechatronic Engineering (3rd May, 2016): “Project proposal for hydro turbine, phase 3”; Nyeri, Kenya; Dedan Kimathi University of Technology; 19 pag.

[2] Ueli Meter (1985): “Local experience with micro-hydro technology ”; St. Gallen, Switzerland ; SKAT, Swiss Center, ISBN 3 908001 02 1

[3] Website: sciencedirect.com; Difference between Kaplan and Francis-turbine (09.09.2016)

[4] Karl Heinz Fasol, IEEE Control Systems Magazine, (August 2002): “A Short History of Hydropower Control”; University of Michigan Library; 9 pag.

[5] William Duncan, Jr. and Roger Cline (July 2002), “Mechanical governors for hydroelectric units; facilities, instruction and standards”; Bureau of Reclamation Denver Federal Center, Denver; 43. pag.

[6] Mesa Associate, Inc. and Oak Ridge, National Laboratory Tennessee (December 2011): “Best Practice Catalog; Governor”, Tennessee; 22 pag.

[7] Martin's Marine Engineering; „Basic electronic speed governor“; MAN B&W Diesel Aktiengesellschaft, Augsburg; presentation, 38 slides.

Appendix

[1] Gilkes e-mail response about the information request:

Jess Lawrence <j.lawrence@gilkes.com> 10:40 (hace 3 horas)
para mí

inglés > español Traducir mensaje Desactivar para: inglés

Dear José,

Thank you for your email and interest in Gilkes. We have had a look for the original drawing but unfortunately we have been unable to find it, or any relating documents. Without this we are unable to help with your project.

We apologise that we are unable to provide you any help. We wish you well with your project.

Kind regards
Jess Lawrence
Marketing & Sales Administrator

GILKES

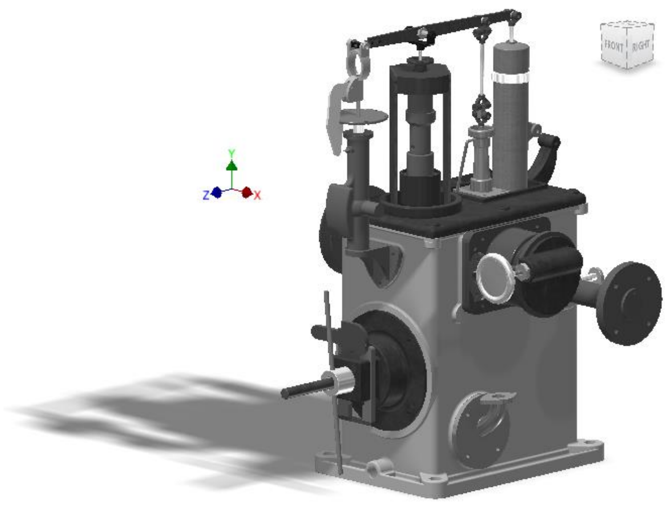
Direct: +44 (0) 1539 790045
Tel: +44 (0) 1539 720028
Fax: +44 (0) 1539 732110
Web: www.gilkes.com

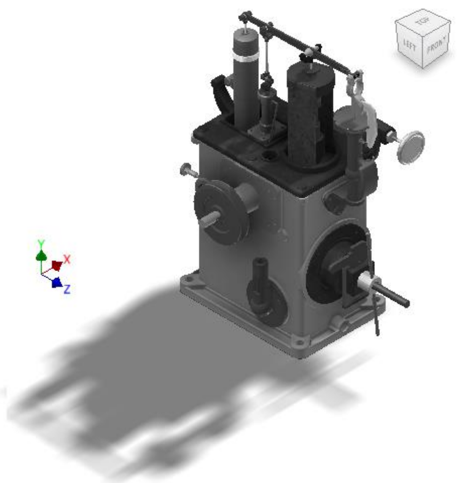
Registered Office: Gilbert Gilkes & Gordon Ltd. Kendal, Cumbria, England, LA9 7BZ
Registration No: 173768 England & Wales

[2] Overview of the CAD-Model

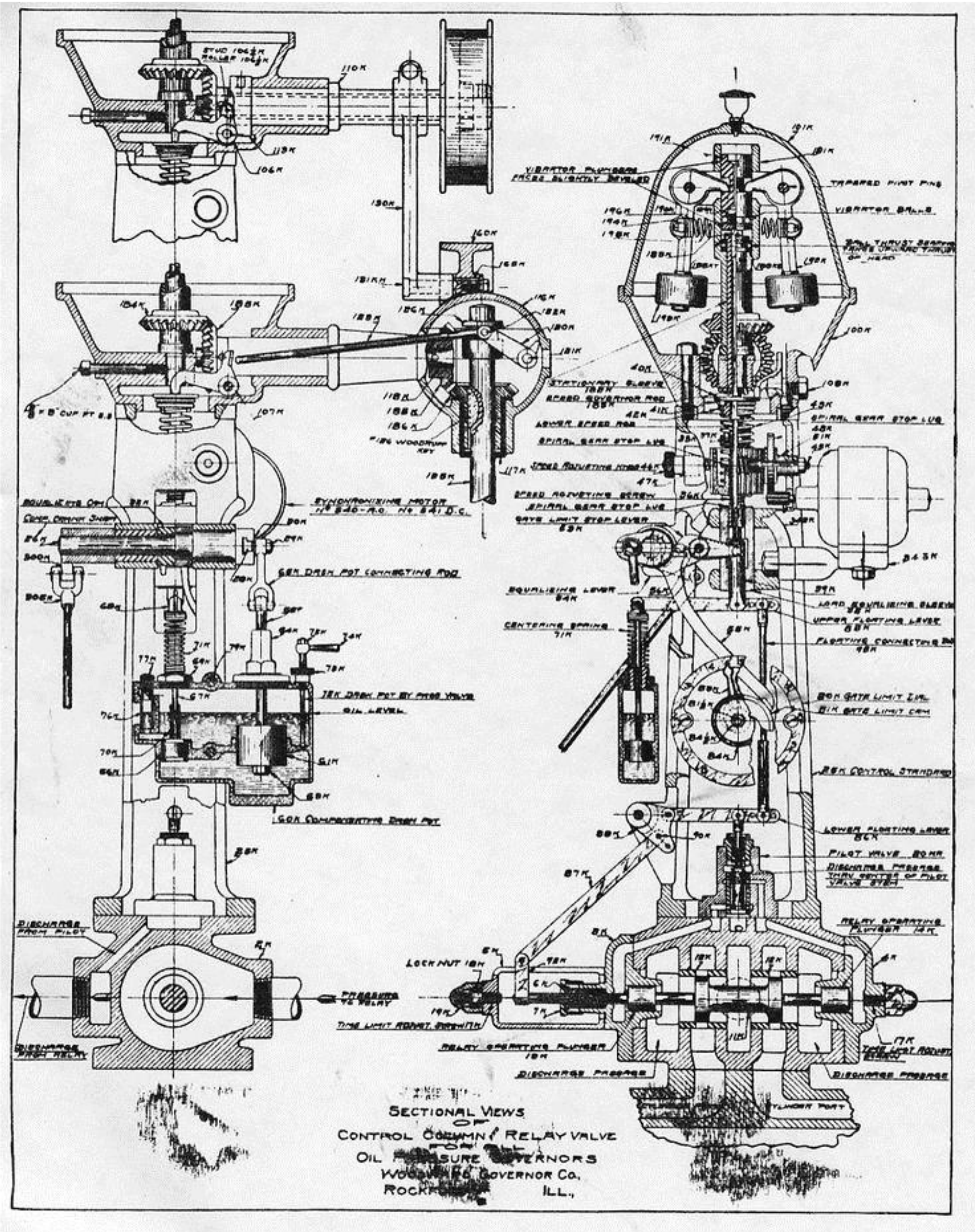
Oil pressure Governor (1926)
Typ: A
Nr.: 466
Gilbert Gilkes & Gordon Ltd. (Kendal, London)

Drawing by José Fredriksson
Autodesk Inventor 2015

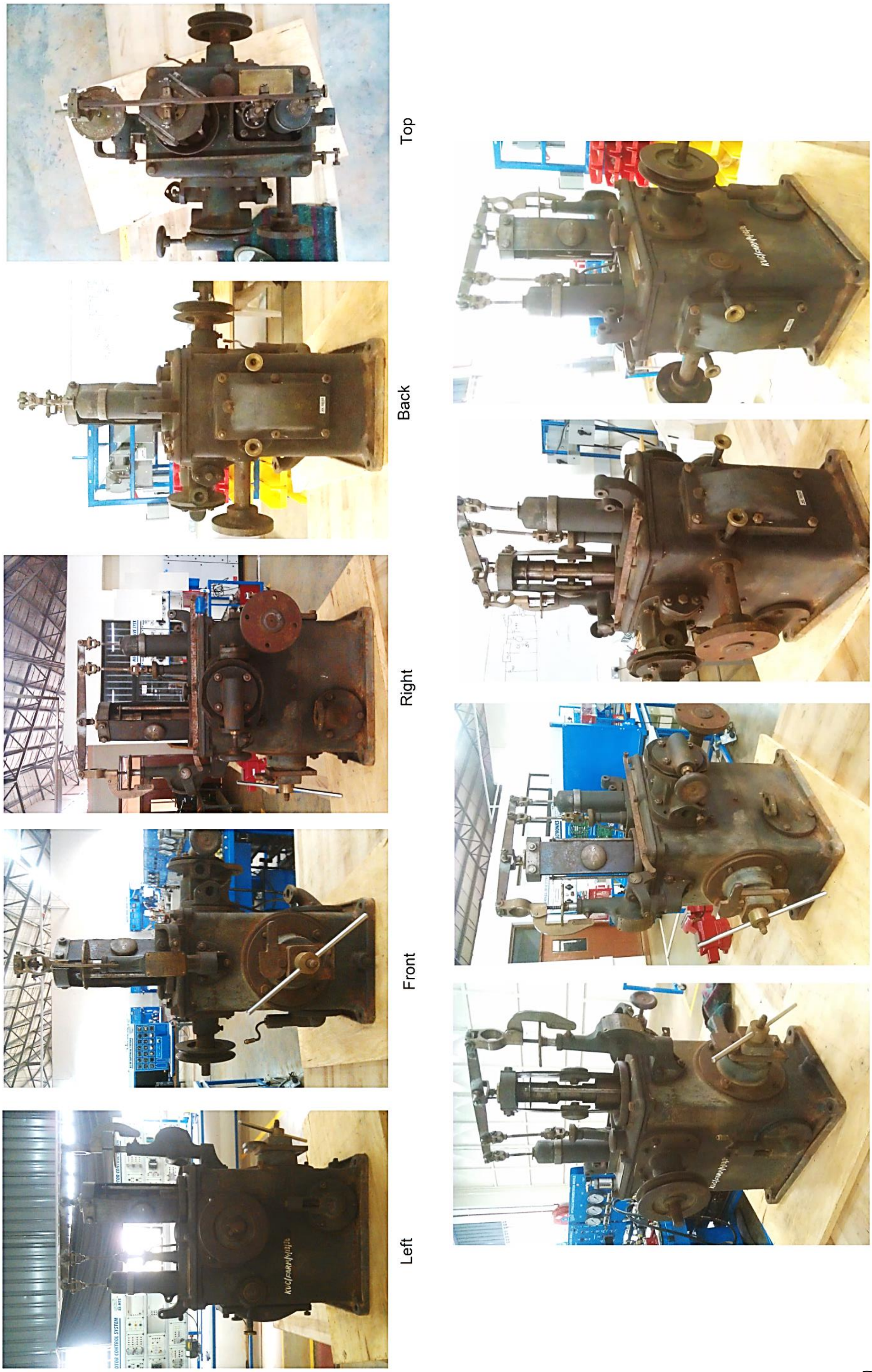




[3] Sectional view of a control/ relay valve for an oil pressure governor



[4] Governor faces, taken before maintenance and cleaning [Photography, July 2016]



C

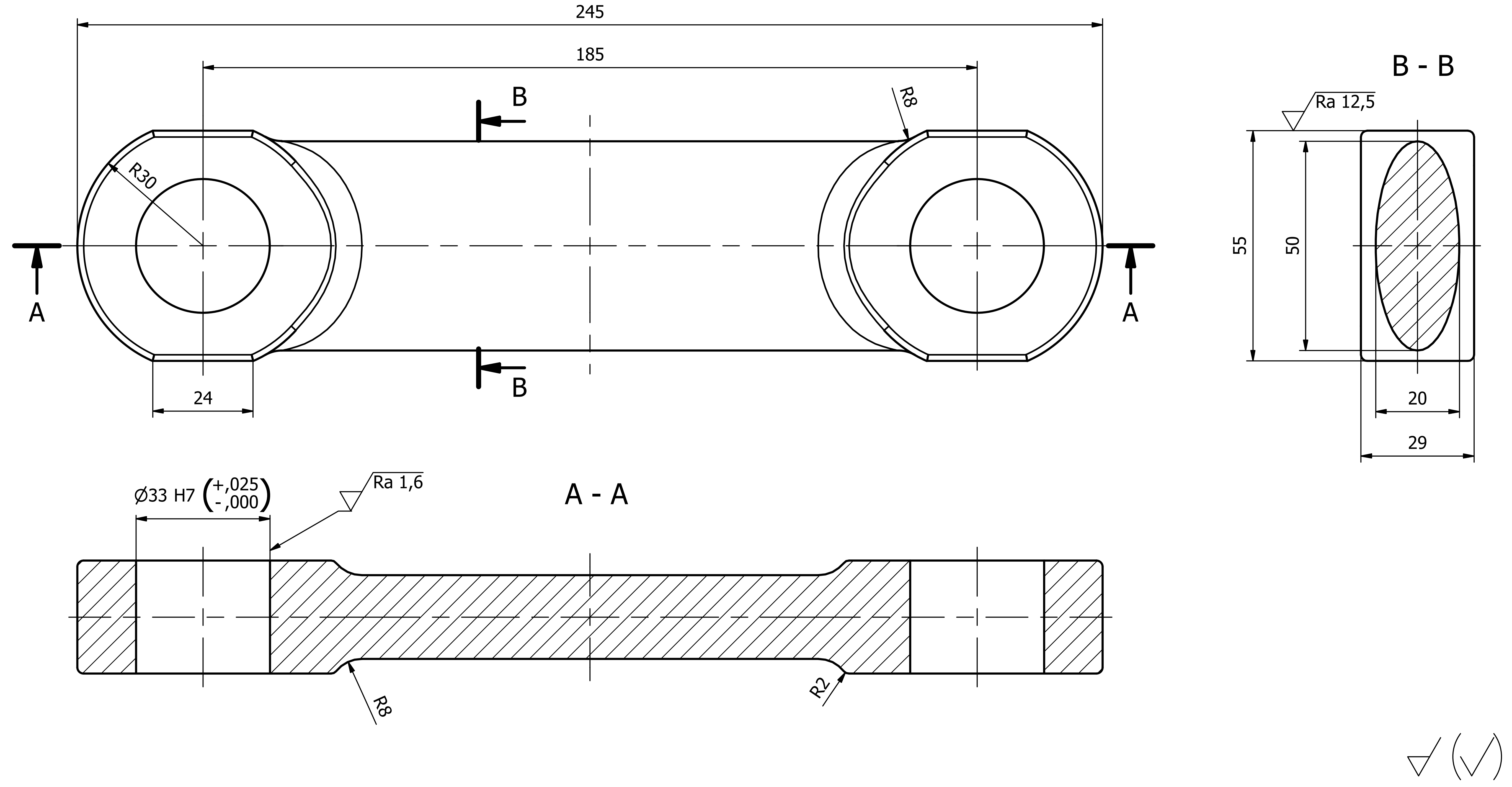
[5] Table of Technical Drawings

Nr.	Drawing Number	Designation
1	K00.2016.00	Guide Valve Rod
2	K00.2016.01	Guide Valve rod, ass.
3	K00.2016.02	Bush
4	K02.2016.00	Fork attachment
5	K02.2016.03	Block
6	K02.2016.10	Fork Reparation
7	K03.2016.00	Pipeline Welding **//
8	K03.2016.01	Pipeline Connection
9	K03.2016.02	1 inch pipe **
10	K03.2016.03	Plug
11	K04.2016.00	Bolt M9x50
12	K04.2016.01	Bolt M9x40

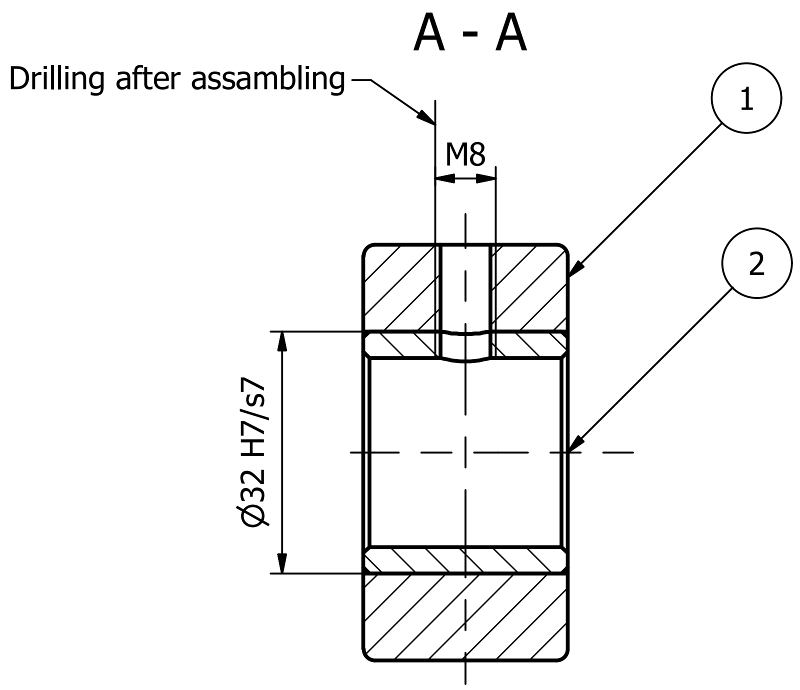
**Construction was changed on the papers as sketches. They are not to be machined after the drawings presented.

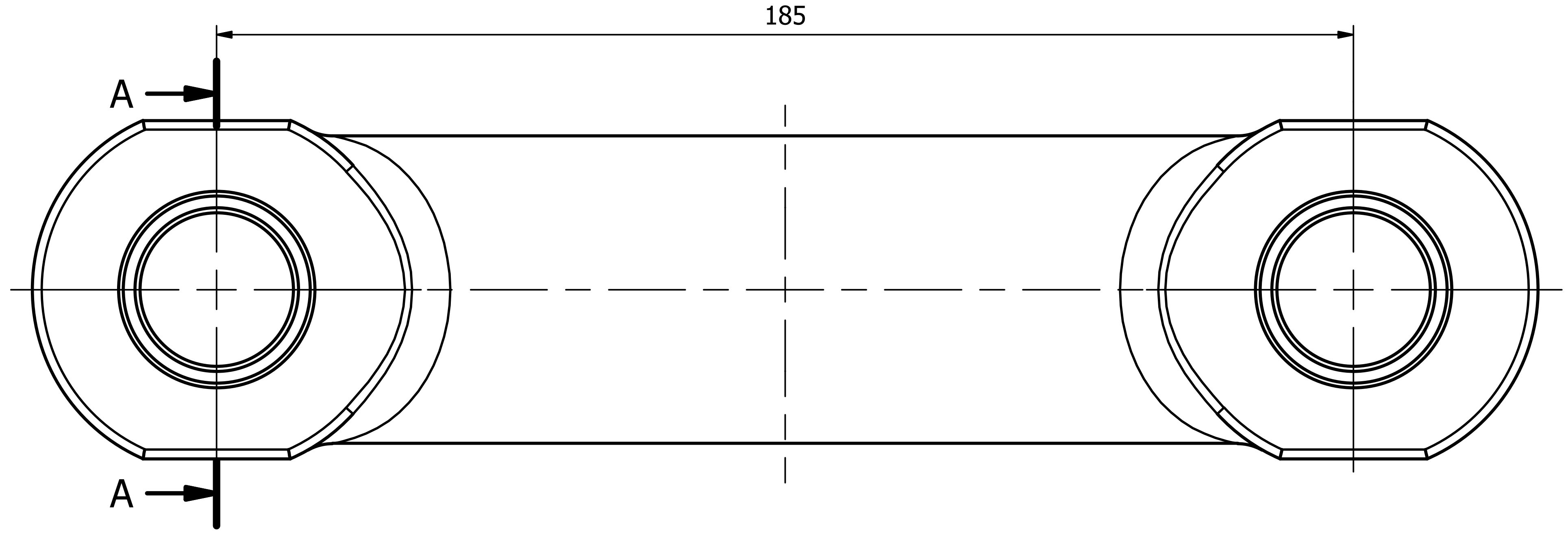
//Distance between the two openings is correct. The shape of the pipeline should be fitted.

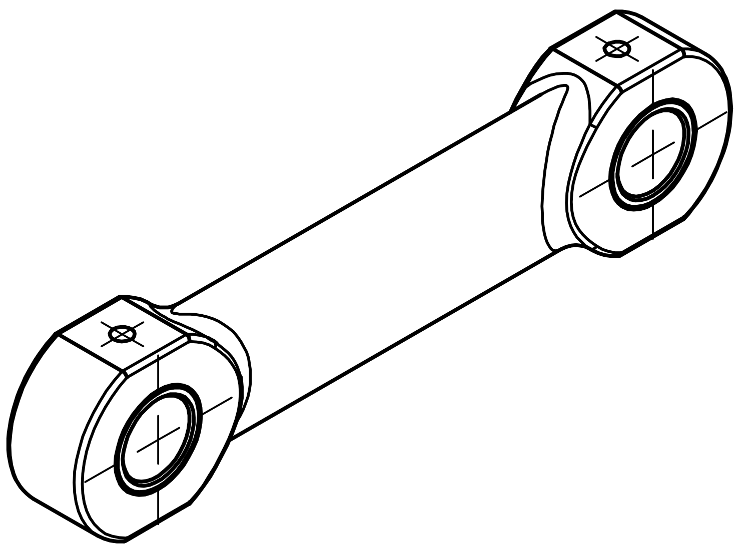
Parent Drawing	K00.2016.01	Turbine



DRAWN Jose Fredriksson	25.08.2016		FOR Dedan Kimathi Universty of Technology; PROJECT Revival Francis Turbine
CHECKED		TITLE Guide valve rod — Francis Turbine	
QA			
MFG			
APPROVED		SIZE A3	DWG NO K00.2016.00 — REV
TOL.: ISO 2768-1 f		SCALE 1 : 1	SHEET 1 OF 1



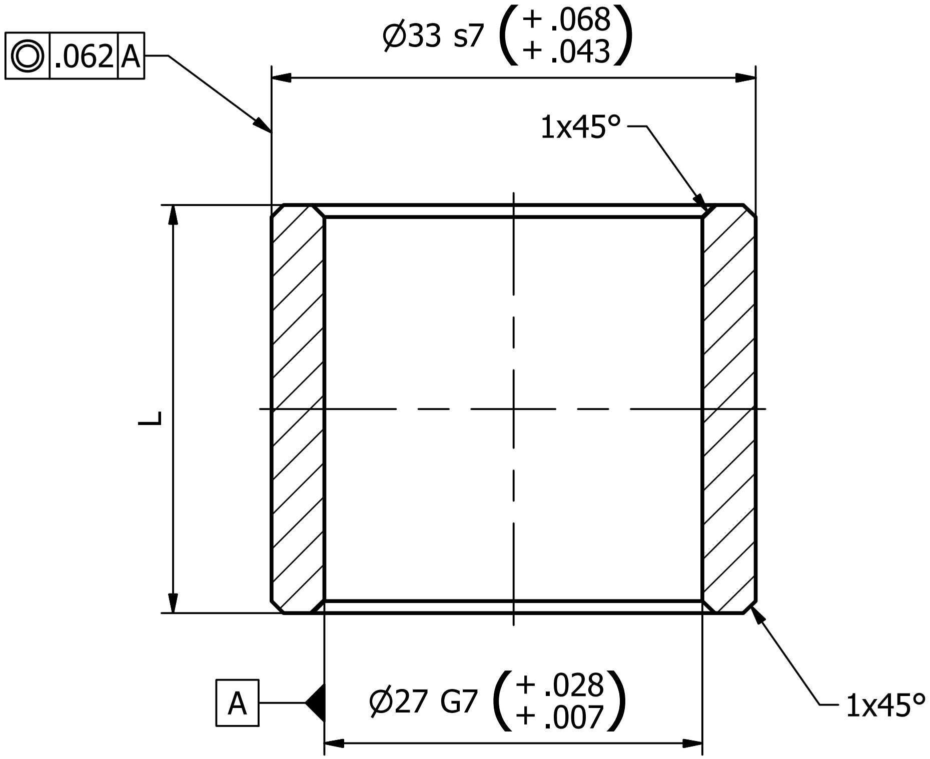




POS.	QTY	PART NUMBER	DESCRIPTION	MASS
1	1	K00.2016.00	Guide valve rod	2,196 kg
2	2	K00.2016.02 - Pos. 1	Bush D=33, d=25, l=29	0,074 kg

DRAWN Jose Fredriksson	26.08.2016	FOR Dedan Kimathi Universty of Technology
CHECKED		PROJECT Revival Francis Turbine
QA		TITLE **Guide valve rod, ass.** Francis Turbine
MFG		
APPROVED		
TOL.: ISO 2768-1 f		SIZE A3 — DWG NO K00.2016.01 — REV
		SCALE 1 : 1 — SHEET 1 OF 1

Pos. 1	Parent Drawing	K01.2016.01	Turbine
Pos. 2	Parent Drawing	K02.2016.10	Turbine

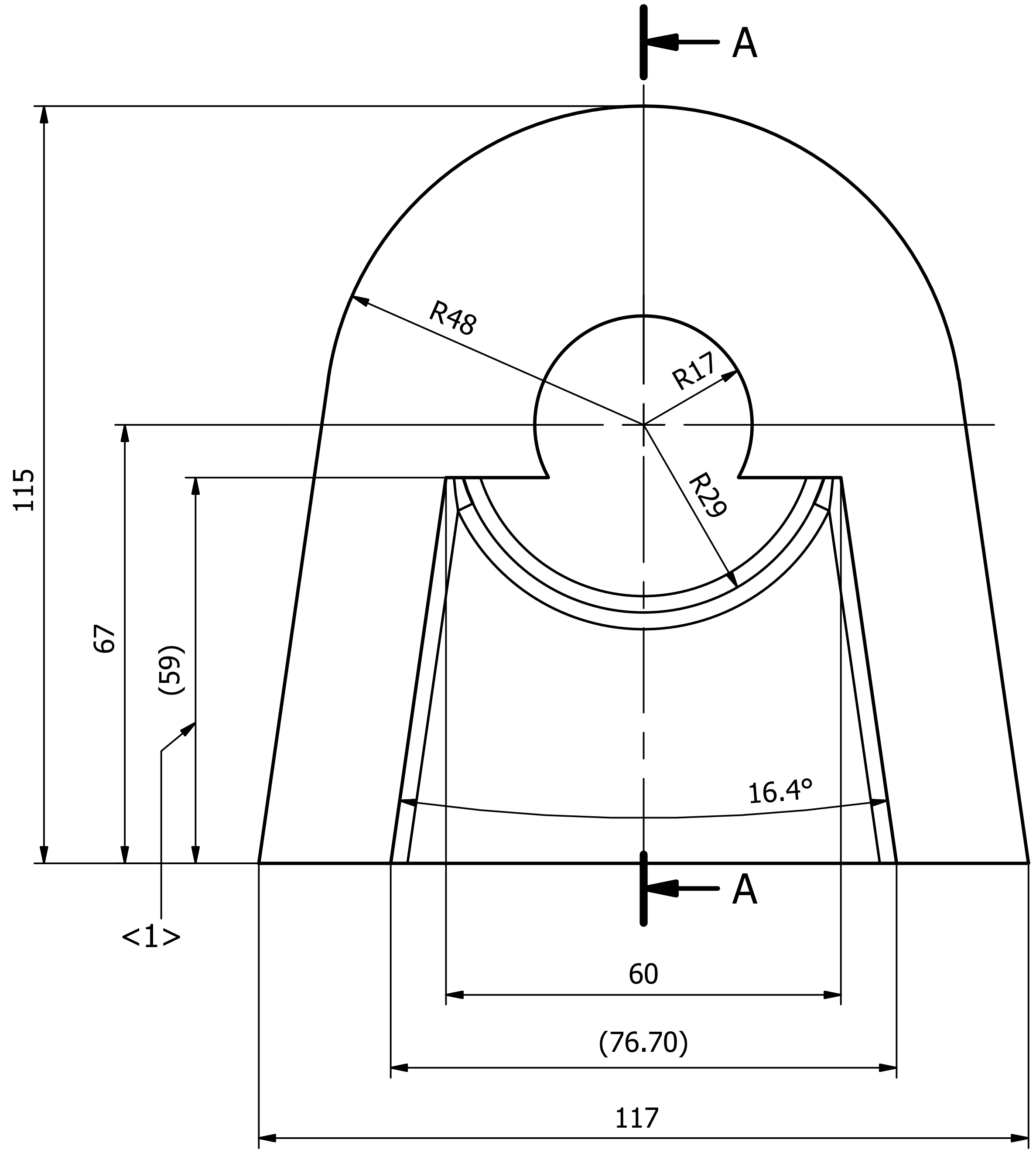


Ra 1,6

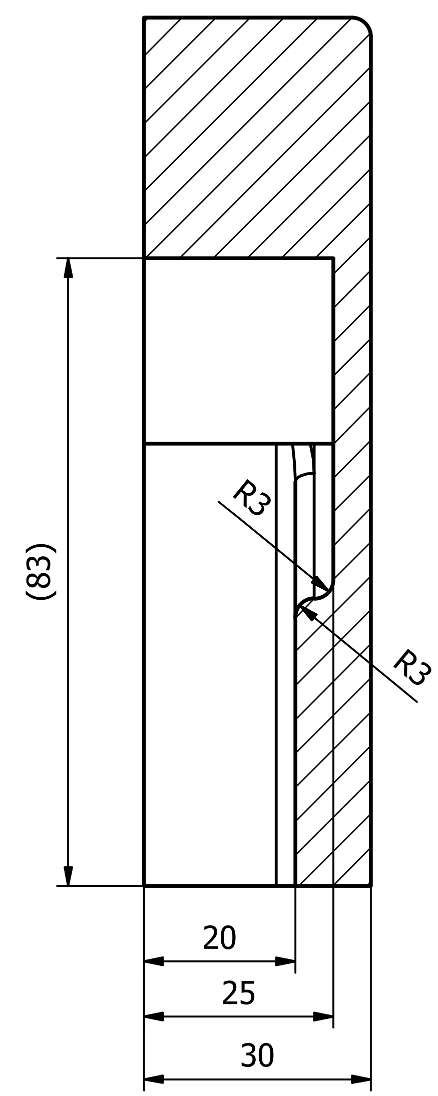
Pos.	L [Value]	Material	Mass
1	29	Brass	0,069 kg
2	25	Brass	0,061 kg

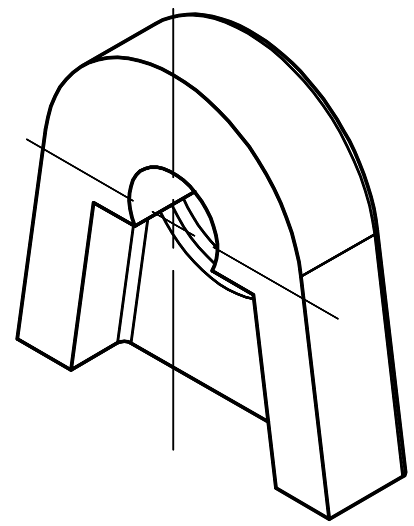
DRAWN Jose Fredriksson	29.08.2016	FOR Dedan Kimathi Universty of Technology
CHECKED		PROJECT Revival Francis Turbine
QA		TITLE
MFG		**Bush**
APPROVED		Francis Turbine
TOL.: ISO 2768-1 m		SIZE A4 — DWG NO K00.2016.02 — REV
		SCALE 2 : 1 — SHEET 1 OF 1

Parent Drawing	K02.2016.10	Turbine



A - A





<1> = Distance defined by broken fork
(part to be repaired) on each side

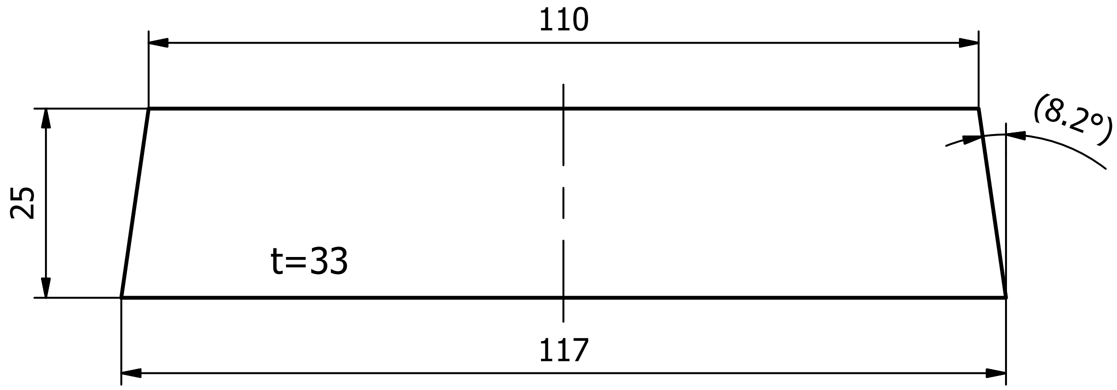
Semis	Material	Mass
30x115x117	Cast Iron	1,591 kg

DRAWN: Jose Fredriksson	01.09.2016	FOR: Dedan Kimathi Universty of Technology
CHECKED		PROJECT: Revival Francis Turbine
QA		TITLE: Fork attachment — Francis Turbine
MFG		
APPROVED		
TOL.: ISO 2768-1 f		SIZE: A3 — DWG NO: K02.2016.00 — REV
		SCALE: 1 : 1 — SHEET 1 OF 1

Fork attachment

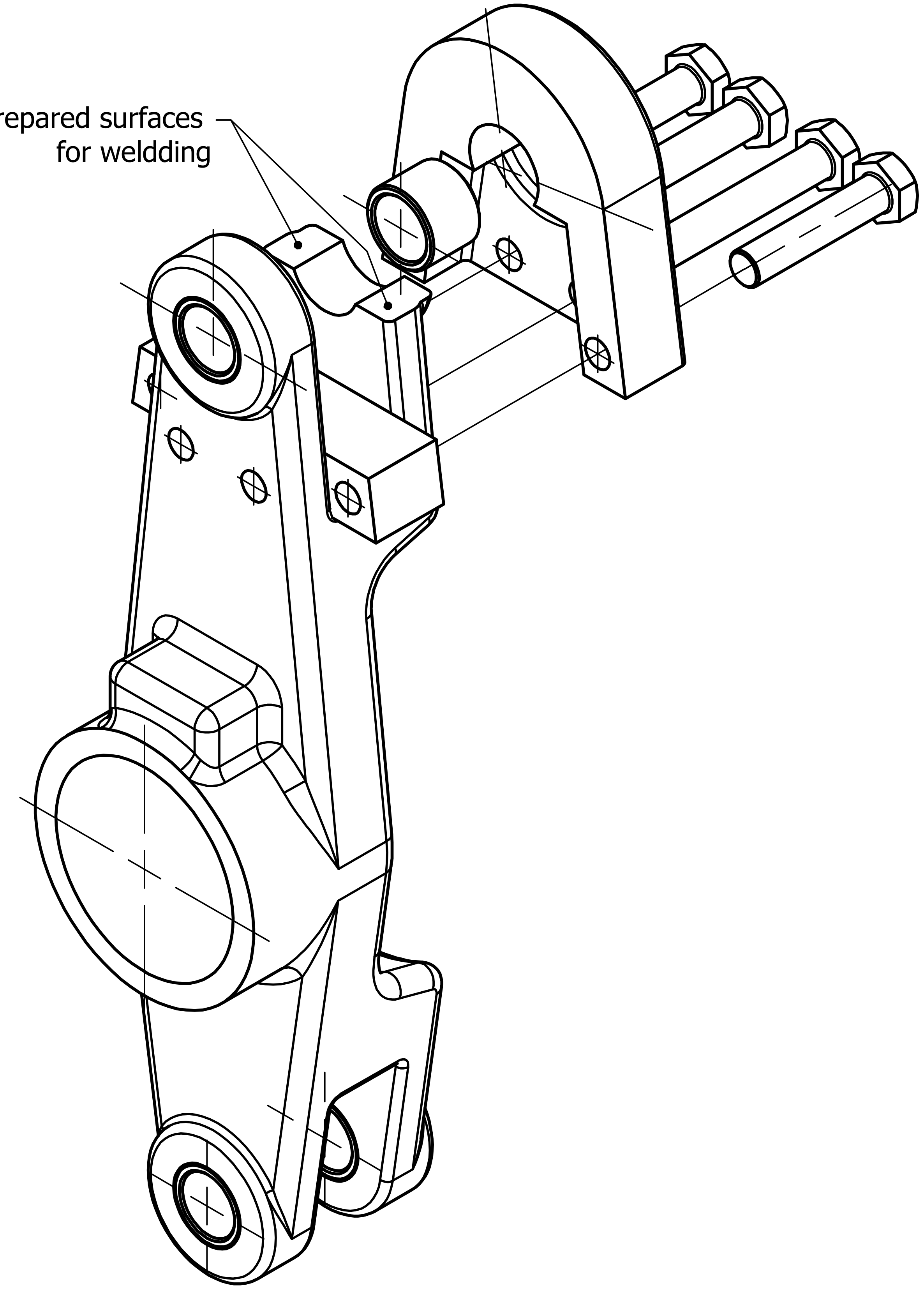
Francis Turbine

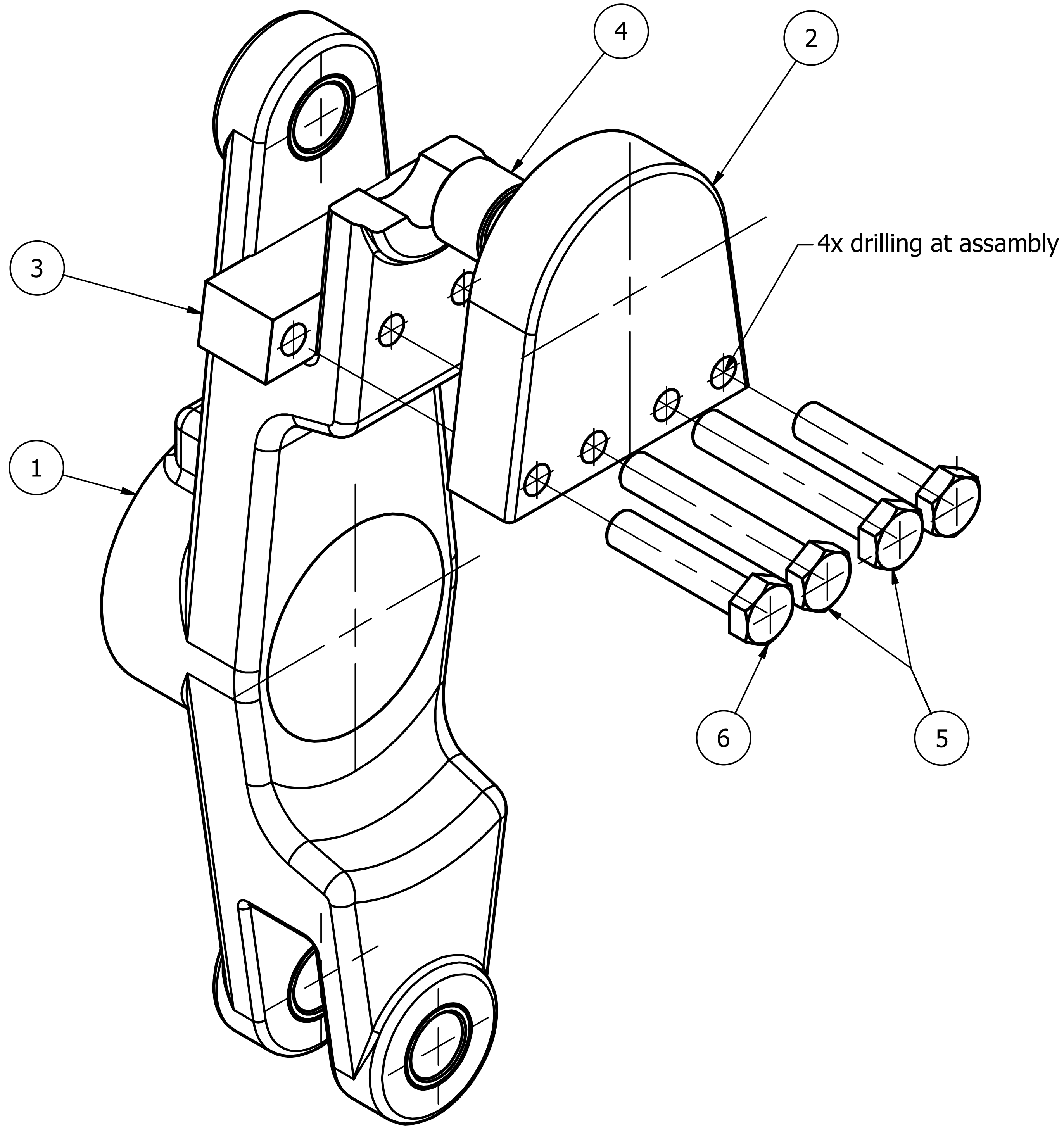
Parent Drawing	K02.2016.10	Turbine



Semis	Material	Mass
33x25x117	Cast Iron	0,659 kg

DRAWN Jose Fredriksson	02.09.2016	
CHECKED		FOR Dedan Kimathi Universty of Technology
QA		PROJECT Revival Francis Turbine
MFG		TITLE Block Francis Turbine
APPROVED		
TOL.: ISO 2768-1 m		SIZE A4
		DWG NO K02.2016.03
		REV
		SCALE 1 : 1
		SHEET 1 OF 1





POS.	QTY	PART NUMBER	DESCRIPTION	MATERIAL	MASS
1	1	-	Borken Piece at turbine	Iron, Cast	1,312 kg
2	1	K02.2016.00	Fork attachment	Iron, Cast	1,591 kg
3	1	K02.2016.01	Block	Iron, Cast	0,659 kg
4	1	K00.2016.02 - Pos. 2	Bush D=33, d=27, L=25	Brass	0,061 kg
5	2	DIN 931 - M14x90 - 8.8	Hex bolt	St A2	0,131 kg
6	2	DIN 931 - M14x65 - 8.8	Hex bolt	St A2	0,106 kg
7	1	Welding	Bevel seam- L= 82 mm	*	

DRAWN Jose Fredriksson	02.09.2016
CHECKED	
QA	
MFG	
APPROVED	
TOL.: ISO 2768-1 m	

FOR Dedan Kimathi Universty of Technology

PROJECT Revival Francis Turbine

TITLE

Fork Reparation

Francis Turbine

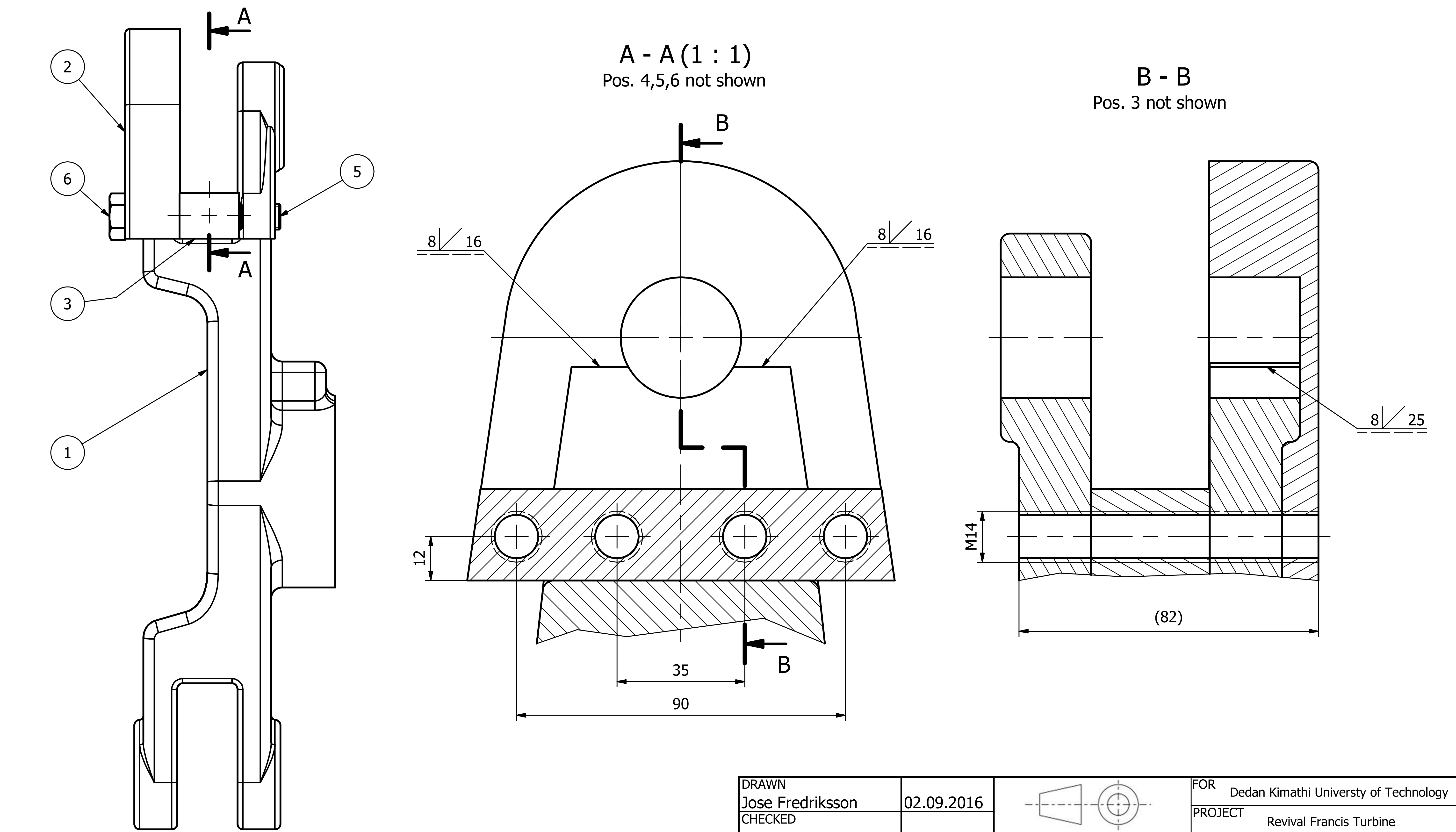
SIZE A3

DWG NO K02.2016.10

REV

SCALE 1 : 2

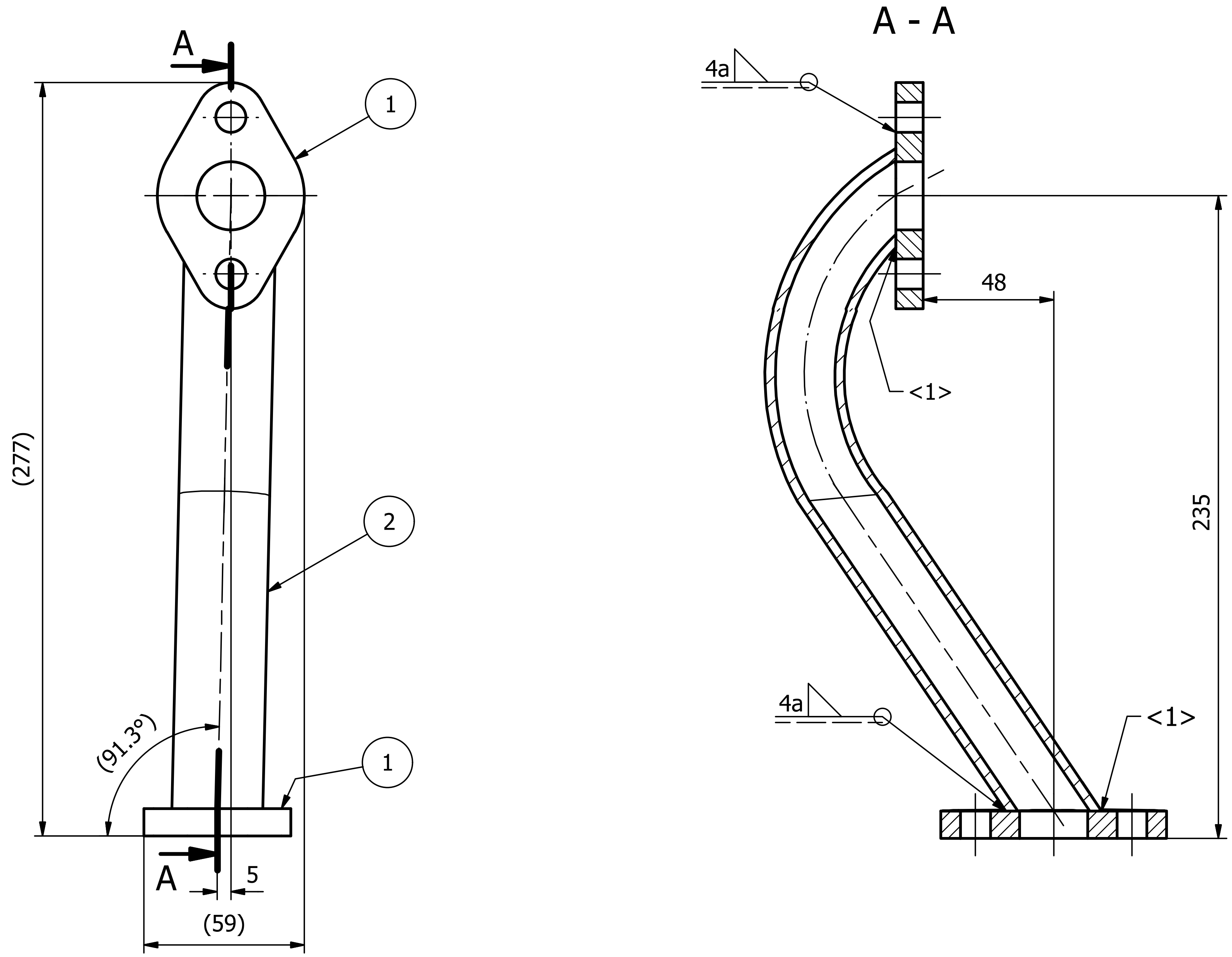
SHEET 1 OF 2



POS.	QTY	PART NUMBER	DESCRIPTION	MATERIAL	MASS
1	1	-	Borken Piece at turbine	Iron, Cast	1,312 kg
2	1	K02.2016.00	Fork attachment	Iron, Cast	1,591 kg
3	1	K02.2016.01	Block	Iron, Cast	0,659 kg
4	1	K00.2016.02 - Pos. 2	Bush D=33, d=27, L=25	Brass	0,061 kg
5	2	DIN 931 - M14x90 - 8.8	Hex bolt	St A2	0,131 kg
6	2	DIN 931 - M14x65 - 8.8	Hex bolt	St A2	0,106 kg
7	1	Welding	Bevel seam- L= 82 mm	*	

DRAWN Jose Fredriksson	02.09.2016	FOR Dedan Kimathi Universty of Technology
CHECKED		PROJECT Revival Francis Turbine
QA		TITLE Fork Reparation Francis Turbine
MFG		
APPROVED		
TOL.: ISO 2768-1 f		SIZE A3 — DWG NO K02.2016.10 — REV
		SCALE 1 : 2 — SHEET 2 OF 2

Parent Drawing	-	Turbine



<1> = -prepare pipe weldding surfaces
-use Pos.1 as reference

POS.	QTY	PART NUMBER	DESCRIPTION	MATERIAL	MASS
1	2	K03.2016.01	Pipeline Conection	Steel	0,189 kg
2	1	K03.2016.02	Pipe D= 1 in	Steel, Galvanized	0,830 kg
3	2	Weldding	Kehlnaht 4a	**	0,000 kg

DRAWN Jose Fredriksson	01.09.2016
CHECKED	
QA	
MFG	
APPROVED	
TOL.: ISO 2768-1 f	

FOR Dedan Kimathi Universty of Technology

PROJECT Revival Francis Turbine

TITLE

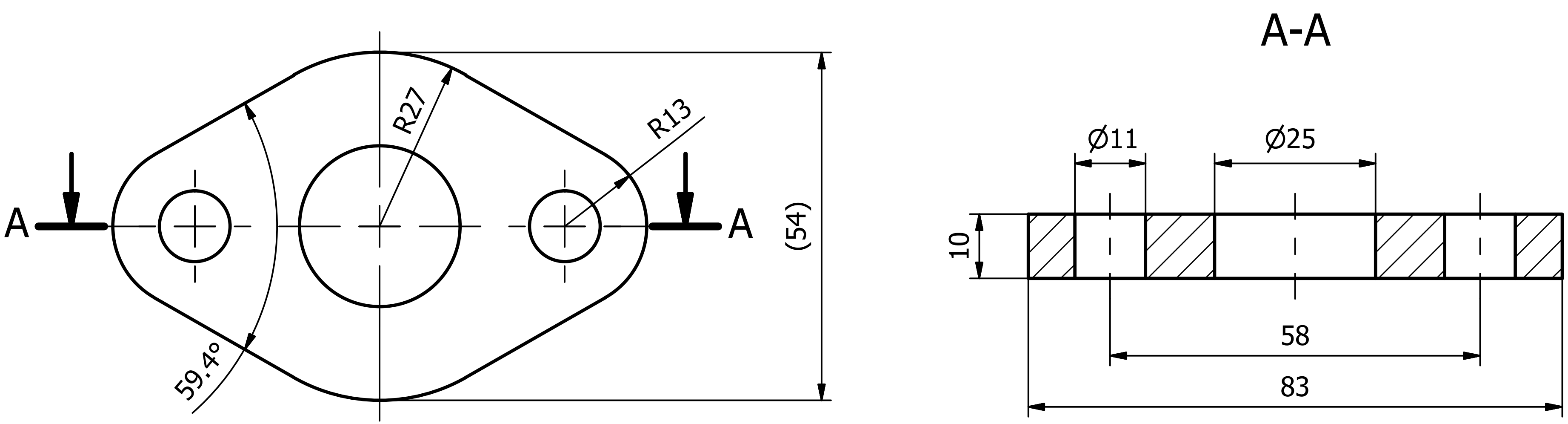
Pipeline weldding

Governor

SIZE	DWG NO	REV
A3	K03.2016.00	

SCALE 1 : 1 SHEET 1 OF 1

Pos. 1	Parent Drawing	K03.2016.00	Turbine



*Material can differ after weldders opinion

QTY	Semis	Material	Mass
2	10x54x83	*S235JR	0,189 kg

DRAWN Jose Fredriksson	12.09.2016
CHECKED	
QA	
MFG	
APPROVED	
TOL.: ISO 2768-1 m	

FOR Dedan Kimathi Universty of Technology

PROJECT Revival Francis Turbine

TITLE

Pipeline conection

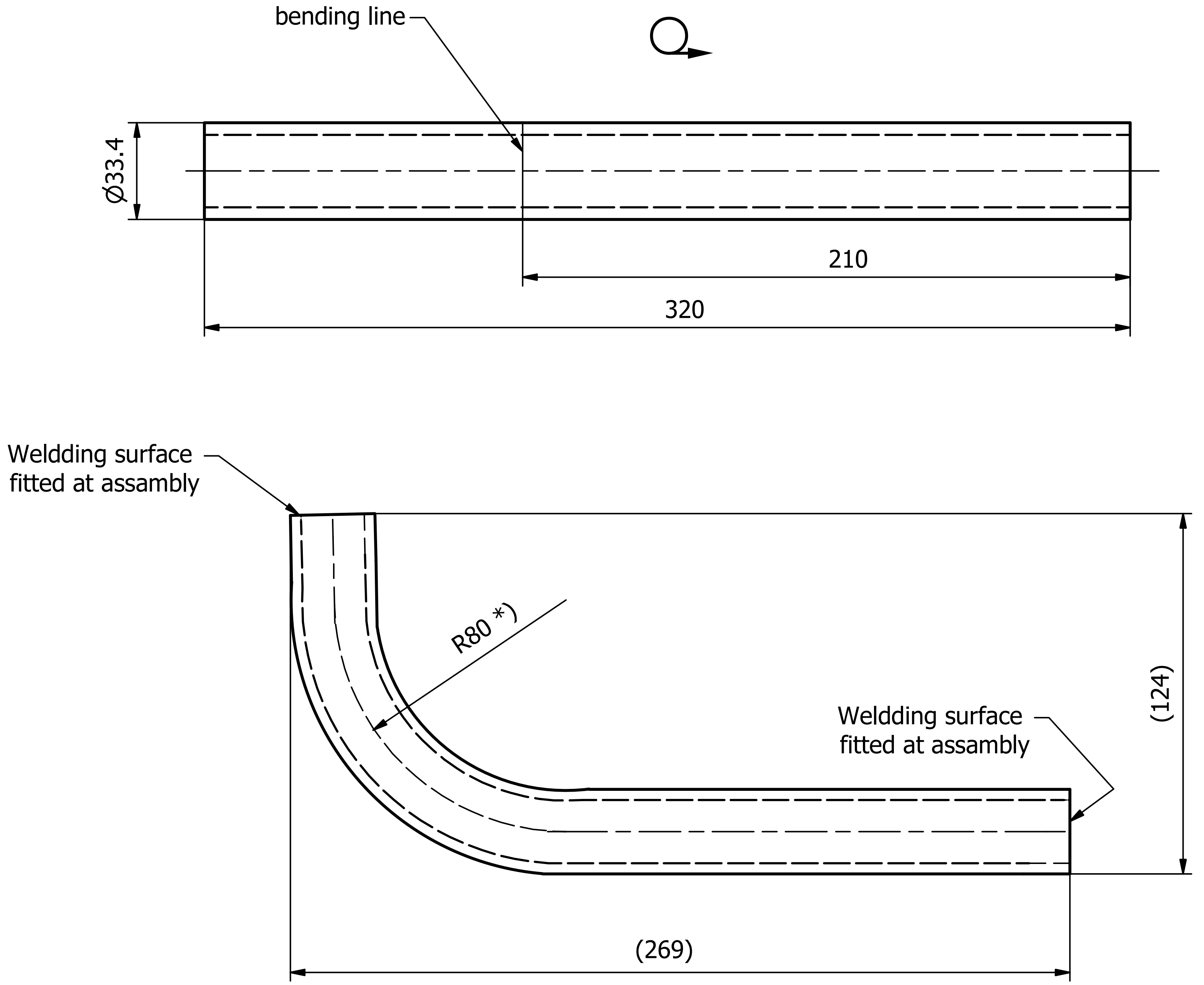
Governor

SIZE	DWG NO	REV
A4	K03.2016.01	

SCALE 1 : 1

SHEET 1 OF 1

Pos. 2	Parent Drawing	K03.2016.00	Turbine



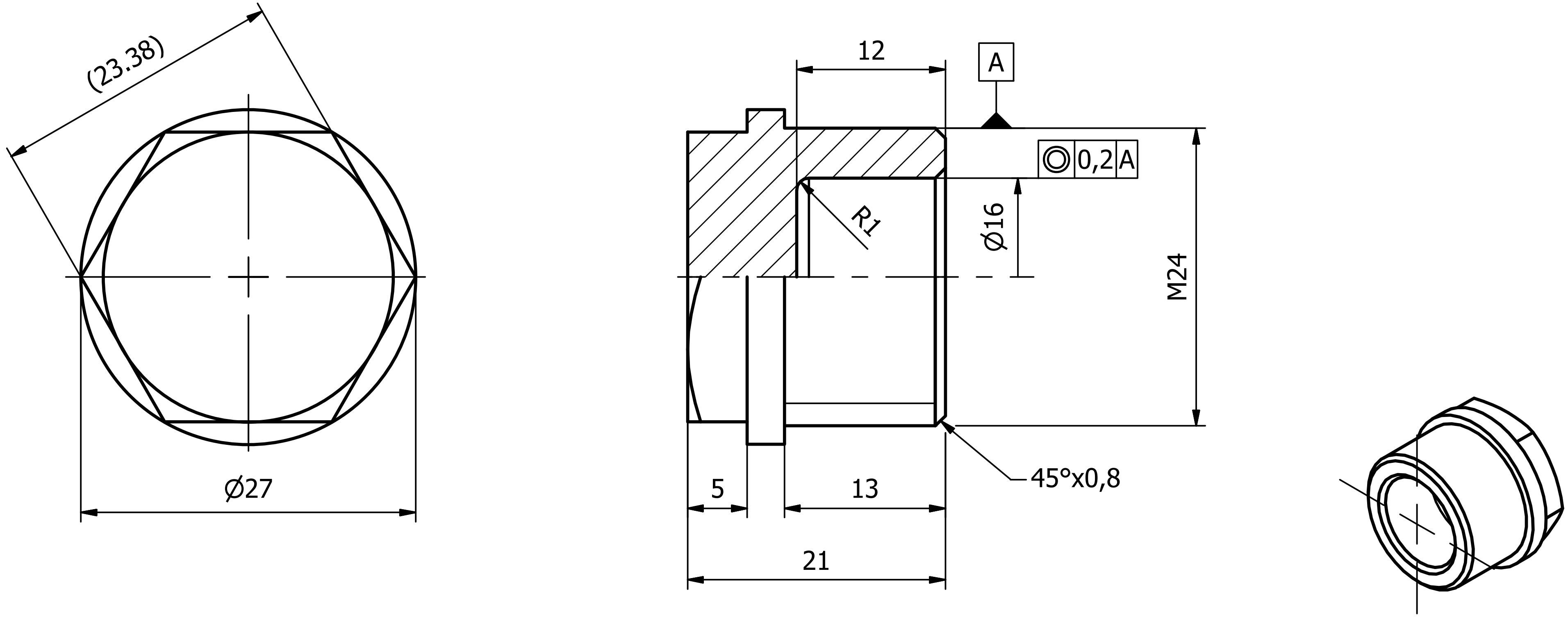
*) Radius depens on bending tool

QTY.	Semis	Material	Mass
1	Rd 33,40x332; s=4,2	galvanized, Steel	1,004 kg

DRAWN Jose Fredriksson	01.09.2016	FOR	Dedan Kimathi Universty of Technology
CHECKED		PROJECT	Revival Francis Turbine
QA		TITLE	1 inch Pipe Governor
MFG			
APPROVED			
TOL.: ISO 2768-1 f		SIZE A3	DWG NO K03.2016.02 · REV
		SCALE 1 : 1	SHEET 1 OF 1

TH WILDAU

-	Parent Drawing	-	Turbine



QTY	Semis	Material	Mass
2	10x54x83	Brass	0.063 kg

DRAWN Jose Fredriksson	12.09.2016	
CHECKED		
QA		
MFG		
APPROVED		
TOL.: ISO 2768-1 m		

FOR Dedan Kimathi Universty of Technology

PROJECT Revival Francis Turbine

TITLE

Plug

Governor

SIZE A4

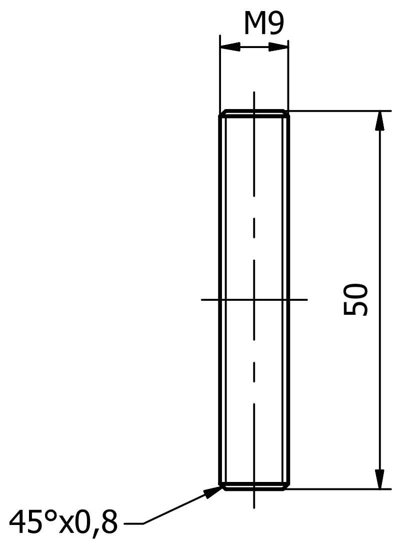
DWG NO K03.2016.03

REV

SCALE 2 : 1

SHEET 1 OF 1

-	Parent Drawing	-	Turbine



QTY	Semis	Material	Mass
1	9x50	1.4031	0.025 kg

DRAWN Jose Fredriksson	12.09.2016
CHECKED	
QA	
MFG	
APPROVED	
TOL.: ISO 2768-1 m	

FOR Dedan Kimathi Universty of Technology

PROJECT Revival Francis Turbine

TITLE

Bolt M9x50

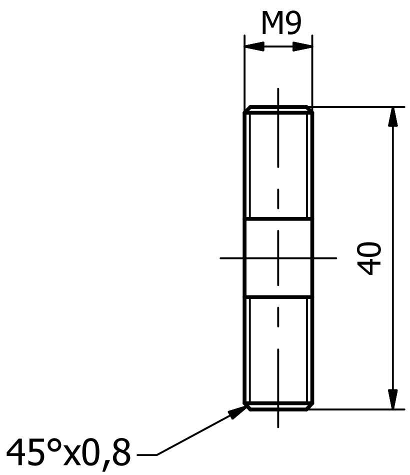
Governor

SIZE	DWG NO	REV
A4	K04.2016.00	

SCALE 1 : 1

SHEET 1 OF 1

-	Parent Drawing	-	Turbine



QTY	Semis	Material	Mass
2	9x40	1.4031	0.025 kg

DRAWN Jose Fredriksson	12.09.2016	FOR Dedan Kimathi Universty of Technology
CHECKED		PROJECT Revival Francis Turbine
QA		TITLE **Bolt M9x40** Governor
MFG		
APPROVED		
TOL.: ISO 2768-1 m		SIZE A4 / DWG NO K04.2016.01 / REV
		SCALE 1 : 1 / SHEET 1 OF 1

Overview of activities during the summer project:	
Week 1 (Th., Fr.)	
Orientation days	International Office, Public Relations, Dean of Students…
Week 2	
Introduction at the Mechatronics Department,	Staff, Lab and Project Supervisor and Dean, School of Engineering: Dr. Jean Bosco
Hydraulics at ADMATC (Advanced Manufacturing and Design Training Center)	Basic hydraulics LAP (Learning Activity Packet) on the AMATROL 850 Series hydraulic trainer: LAP1 Hydraulic power systems LAP2 Basic hydraulic circuits LAP3 Principles of hydraulic pressure LAP4 Hydraulic speed control
Visit to University farm	This is the location of the francis turbine and governor.
Week 3	
Transportation of the governor	From the farm to ADMATC
Dismantling the governor	Opening of the governor to understand its working principle
	Introduction to Prof. Muchiri, Director of the University in Nairobi Campus
Week 4	
Hydraulics at ADMATC	Basic hydraulics LAP: LAP 5 Pressure control circuits
Hydraulics at ADMATC	Intermediate hydraulics LAP: LAP 1 hydraulics DCV applications
Visit to KenGen (Kenya Electricity Generating Company)	Sagana Falls Power Station, 1,5MW Mesco Hydro Station, 0.43MW
Week 5	
Analysis PU Circuit	Describing and understanding the hydraulic circuit applied for the governing system at the Mesco Hydro Station
Governor 3D - Modeling	Measurement and Design of the single Components
Week 6	
Farm	Measurement of broken components at the turbine site
Governor 3D - Modeling	Elaboration of technical drawings
Week 7	
Construction	Reparation of the casting component in the turbine
Week 8	
Maintenance of the Governor	-Cleaning and oiling of the single components, -Changing of rackets -Reassembly of the machine
Final phase:	Handover of the: Report, technical drawings and 3D-Model

Vocabulary

English	Deutsch	Español
bar	Balken	travesanio
bolt	Bolzen	Clavija/Cerrojo
booster gear	Gesteigerte Getriebe	engranaje de refuerzo
bushing	Buchse	casquillo
crank	Kurbel	manivela
detent	Rast	fijador
gasket	Dichtung	Empaquetadura
guide vane	Leitschaufel	guia de paletas
handle	Griff	manija
lever	Hebel	palanca
lint free	fusselfrei	sin pelusas
load	Belastung	Carga
oil sump	Ölwanne	contenedor de aceite
plunger	Ventilkolben	destapador
Pulley	Rolle/ Flaschenzug	polea
rag	Lappen	trapo
rod	Stange	barra
spool	Spule	carrete
tensile	Zug	De tension
throttle	Drosselklappe	acelerador/ valvula reguladora
thus	so	así
wicket	Gatter	Palo/ postigo