Politecnico di Torino

Corso di Laurea Mechanical Engineering
A.a. 2020/2021
Sessione di Laurea Ottobre 2021

Design of a test bench for the flow ripple determination in positive-displacement hydraulic pumps

Annex Budget

Relatori:
Daniela Misul
Miquel Torrent Gelmà

Candidato:
Andrea Gallo

Contents

1 BUDGET 2
1.1 DIRECT COSTS 2
1.1.1 Designed test bench 2
1.1.2 Fluid Mechanics Department's test bench 5
1.1.3 Additional direct costs 5
1.2 INDIRECT COSTS 6
1.3 ECONOMIC VIABILITY 7

1 BUDGET

The master thesis has been developed over the course of five months and different typologies of costs should be taken in account. We have designed a test bench suitable for different positive-displacement pumps and we have installed one in the Department of Fluid Mechanics of our University. Therefore, we take in account two different budgets for the two test benches.
Finally, we can divide the costs into two main categories, direct and indirect.

1.1 DIRECT COSTS

Into the direct cost we include the cost of instrumentation, working staff, standard and documentation. For the cost of the personal, we include an average salary of € 30/h for the laboratory staff, €60/h for the director of the thesis and of € 12/h the junior engineer. Initially we focus our attention on the two test benches. Later we consider the remaining direct costs.

1.1.1 Designed test bench

For the cost of the designed test bench, we take in account

- Cost of the designed mechanical parts.
- Cost of the young engineer's work.
- Cost of the installation of the test bench.
- Cost of the components not designed but required for the standard ISO 10767:1-2015.

During the fabrication of the mechanical parts, different treatments must be taken in account. In the following table are present the types of mechanical treatments for each component and the respective time. Time and process are in common for the three Kits. It is remembered that a salary of € 30/h for the mechanical parts' production.

	Process	Time	Process' cost
Flange			
	Preparation	5 $minutes$	
	Cutting	10 $minutes$	
	Milling	20 $minutes$	
	Drilling	10 $minutes$	
			22.50€
Hydraulic pipes			
	Preparation	5 $minutes$	
	Cutting	5 $minutes$	
	Chamfering	5 $minutes$	
			7.50€
Mounting block 1			
	Preparation	10 $minutes$	
	Cutting	5 $minutes$	
	Milling	30 $minutes$	
	Drilling	10 $minutes$	

			27.50€
Mounting block 2	Preparation	$10\ minutes$	
	Cutting	$5\ minutes$	
	Milling	$30\ minutes$	
	Drilling	$10\ minutes$	
			27.50€

Table 1 Designed mechanical part's process and cost

In the following table, we consider the mechanical parts with their raw material cost, their fabrication time and so their overall cost. In addition, the table shows the drawing numbers of each component as a means of reference. The installation of each kit takes 90 minutes while the installation of the test bench takes 6 hours. Each kit is equipped with 4 hydraulic pipes. Therefore, each hydraulic pipe's price must be considered 4 times.

	Raw material cost	**Process' cost**	**Cost per part**
KIT A			
Flange TFM-A-20	**2.00€**	**22.50€**	**24.50€**
Hydraulic pipes TFM-A-21/23/25/26	**1.00€**	**7.50€**	**8.50€**
Mounting block 1 TFM-A-22	**2.00€**	**27.50€**	**29.50€**
Mounting block 2 TFM-A-24	**2.00€**	**27.50€**	**29.50€**
Installation of kit TFM-A-10		**45.00€**	
KIT B			
Flange TFM-B-20	**2.00€**	**22.50€**	**24.50€**
Hydraulic pipes TFM-B-21/23/25/26	**1.00€**	**7.50€**	**8.50€**
Mounting block 1 TFM-B-22	**2.00€**	**27.50€**	**29.50€**
Mounting block 2 TFM-B-24	**2.00€**	**27.50€**	**29.50€**
Installation of kit TFM-B-10		**45.00€**	
KIT C			
Flange TFM-C-20	**2.00€**	**22.50€**	**24.50€**
Hydraulic pipes TFM-C-21/23/25/26	**1.00€**	**7.50€**	**8.50€**
Mounting block 1 TFM-C-22	**2.00€**	**27.50€**	**29.50€**
Mounting block 2 TFM-C-24	**2.00€**	**27.50€**	**29.50€**
Installation of kit TFM-C-10		**45.00€**	
INSTALLATION OF TEST BENCH TFM-A/B/C-1		**180.00€**	
TOTAL COST	**30.00€**	**637.50€**	**667.50€**

Table 2 Designed mechanical parts' cost

For the mechanical parts' raw material, a total cost of 30€ is found while the labor cost is equal to 637.50€.
At these costs, we have to add also the cost of the remaining components which are necessary to our test bench. We take in account that the components such as electric motor, hydraulic pumps, and deposit are already present. Therefore, their cost is omitted.

COMPONENT	COST
Hydraulic filter	9€[1]
Loading valve	42€[1]
Relief valve	42€[2]
Piezoelectric pressure sensor	2800€[3]
Piezoresistive pressure sensor	108€[1]
Hydraulic fittings	605€[1]
Inductive sensor	48€[4]
Temperature sensor	60.50€[5]
Hydraulic oil	132€[6]
Charge amplifier	149€[7]
Digital scope	3300€[8]
Power supply	7.80€[9]
SAE-A ROQUEL L22	180€[3]
SAE-B CASAPPA HDP30.43	510€[3]
LINDE HPR75	1380€[3]
TOTAL COST	12173.30€

Table 3 Circuit component's cost

A total cost of 12173.30€ should be taken in account for the remaining components.
Finally, we consider the cost of the junior engineer. Basically, his work comes from the design of mechanical parts.
In the following table we consider both the time of design and drafting.

	TOTAL TIME	COST PER HOUR	COST
KIT A			
Flange	75 *minutes*	12€/h	**15€**
Hydraulic pipes (4 units)	60 *minutes*	12€/h	**12€**
Mounting block 1	75 *minutes*	12€/h	**15€**
Mounting block 2	75 *minutes*	12€/h	**15€**
Kit A's assembly	180 *minutes*	12€/h	**36€**
KIT B		12€/h	
Flange	75 *minutes*	12€/h	**15€**
Hydraulic pipes (4 units)	60 *minutes*	12€/h	**12€**
Mounting block 1	75 *minutes*	12€/h	**15€**
Mounting block 2	75 *minutes*	12€/h	**15€**
Kit B's assembly	180 *minutes*	12€/h	**36€**
KIT C		12€/h	
Flange	75 *minutes*	12€/h	**15€**
Hydraulic pipes (4 units)	60 *minutes*	12€/h	**12€**
Mounting block 1	75 *minutes*	12€/h	**15€**
Mounting block 2	75 *minutes*	12€/h	**15€**
Kit C's assembly	180 *minutes*	12€/h	**36€**
TEST BENCH'S ASSEMBLY	125 *minutes*	12€/h	**25€**
TOTAL COST	**1520 *minutes***		**304€**

Table 4 Design cost

A total cost of 304.00€ should be taken in account for the junior engineer's work.

To sum up, for the design and the installation of the test bench suitable for different positive-displacement pumps an overall cost equal to 13144.80€.

	COST	FINAL COST
RAW MATERIAL	**30.00€**	
MECHANICAL PROCESS	**322.50€**	
DESIGN	**304.00€**	
ADDITIONAL COMPONENTS	**12173.30€**	
INSTALLATION	**315.00€**	
		13144.80€

Table 5 Summary of designed test bench cost

1.1.2 Fluid Mechanics Department's test bench

Now we focus our attention on the cost of the test bench installed in the Department of Fluid Mechanics of Our University. In the following table we consider the components used and their cost. In addition, we take in account the time spent by the laboratory staff for the installation of the test bench.

COMPONENT	COST
Electric motor	234€[10]
Hydraulic pump	110€[11]
Hydraulic filter	9€[1]
Loading valve	42€[1]
Relief valve	42€[2]
Piezoelectric pressure sensor	2800€[3]
Piezoresistive pressure sensor	108€[1]
Hydraulic fittings	605€[1]
Inductive senor	48€[4]
Temperature sensor	60.50€[5]
Hydraulic oil	132€[6]
Charge amplifier	149€[7]
Digital scope	3300€[8]
Power supply	7.80€[9]
Installation (16 hours)	480€
TOTAL COST	**10927.30€**

Table 6 Circuit's cost

A total cost of 10927.30€ is taken in account for the test bench useful to test the 10.6 cc/rev external gear pump. As it is possible to understand, many components are in common among the designed test bench and the one installed in our laboratory. In addition, the price of the two piezoelectric pressure sensors takes in account also the housing and the cables.

1.1.3 Additional direct costs

Now we consider the remaining direct costs. In this section we consider the total cost of the thesis. Thus, we take in account the meeting with the thesis's directors, the time spent to understand the standard and the software, to design the mechanical parts and the circuit's

schemes, to write the code and all the documents required. In the software familiarization are include Matlab, Excel, Solidworks and Autocad. In this table, we take in account only the theorical 300 hours of developing this master thesis.

	Time [h]	Price for hour [€]	Total price [€]
Theorical investigation			
Software familiarization	20	12	240€
Researching	40	12	480€
Standard ISO 10767:1-2015	–		140.80€
Documentation	–	–	*avalaible for free*
Reunion with the director	30	60	1800€
Tests			
Junior engineer's work	90	12	1080€
Documentation			
Report and annexes	30	12	360€
Drawings			
CAD	90	12	1080€
Total cost			5180.80€

Table 7 Studies' costs

To sum up, it is useful to resume the direct costs (we here take in account only the test bench installed in the laboratory of our university) with the following table:

	COST
TEST BENCH	**10447.30€**
TEST BENCH'S INSTALLATION	**480.00€**
STUDIES	**5180.80€**
TOTAL DIRECT COSTS	**16108.10€**

1.2 INDIRECT COSTS

Into this category are included mainly the utility costs such as electricity consumption, internet, water, etc. Additionally, due to the numerous variables that should be considered for this type of expense, it was decided to consider only of the cost deriving from the electricity consumption and to consider in the category "any other business" all the remaining expenses.
Considering that during the tests all the electrical equipment are used with the same frequency, under the item "test bench" are included the use of the electric motor, the digital scope, the power supply and the charge amplifier.

	kWh	Price[12]	
Test bench	128	12.80 €	
Personal computer[13]	84	8.40 €	
Any other business		4.24 €	
Total cost		25.44 €	

Table 8 Indirect costs

To sum up an overall cost of 16133.54€ should be taken in account for the realization of this master thesis. It is remembered that the overall cost for the designed test bench is given in the section 1.1.1 and installation of the test bench.

	COST
DIRECT	16108.10€
INDIRECT	25.44€
TOTAL	16133.54€

Table 9 Total cost of the master thesis (without considering the designed test bench)

1.3 ECONOMIC VIABILITY

It is important to state that almost the 70% of the hours spent for this master thesis are attributed to learn the methodology, writing the code and the installation of the test bench. In addition, most of the costs belongs to initial expenses of the instrumentation and in the labor cost. Therefore, once becoming familiar and having carried out the first tests, the cost of further positive displacement pump studies will be significantly lower.
For this reason, due to the importance of characterizing positive displacement pumps and to the fact that the cost could be amortized during the year the decision to implement this test in the laboratory of our university could be considered a feasible and sensible decision.

1 https://catalogo.rayflex.net/es/home.

2 https://rodavigo.net/es/p/valvula-limitadora-presion-ref-roquet-sgra06g11-t20/211SGRA06G11T20 [visited 20/06/2021]

3 Offer received by the seller

4 https://www.automation24.biz/inductive-sensor-ifm-electronic-ift200-ifb3007-bpkg-m-v4a-us-104-dps [visited 20/06/2021]

5 https://www.automation24.es/sensor-de-temperatura-con-tubo-de-cuello-titec-htfb3-muv-250 [visited 20/06/2021]

6 https://www.silmid.com/us/lubricants/hydraulic-fluids/Fuchs-Renolin-B-10-VG-32-Hydraulic-Oil-in-various-sizes/ [visited 20/06/2021]

7 https://www.ebay.es/itm/293067253389?chn=ps&mkevt=1&mkcid=28 [visited 20/06/2021]

8 https://www.ebay.com/p/1818874722 [visited 20/06/2021]

9 https://www.meanwell-web.com/en-gb/ac-dc-single-output-enclosed-power-supply-output-rs--50--24 [visited 20/06/2021]

10 https://adajusa.es/motores-electricos-trifasicos-3000-rpm-brida-b14-ie1-ie2-ie3-siemens/motor-trifasico-3kw-4cv-3000-rpm-brida-b14-ie2-siemens.html visited [20/06/2021]

12 For the price for kWh is considered the current price of 0.1 kWh in Spain.

13 For the personal computer is considered a consumption of 0.3 kWh and a total use of 280h.