SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

FACULTY OF CHEMICAL AND FOOD TECHNOLOGY

INSTITUTE OF CHMICAL AND ENVIRONMENTAL ENGINEERING

Curriculum and Laboratories for Faculty of Chemical Technology of KPU

REPORT ON TRAINING VISIT

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Prof. Shah Mohammad Besmel

SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

FACULTY OF CHEMICAL AND FOOD TECHNOLOGY

DEPARTMENT OF CHEMICAL AND BIOCHEMICAL ENGINEERING

REPORT

ON MY ACADEMIC AND SIENTIFIC ACTIVITIES IN TRAINING COURSE AT THE SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

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Preface

I am Shah Mohammad Besmel the professor and Dean of Chemical Technology faculty of Kabul Polytechnic University. I attended a two month training stay from 25.03.2011 to 01.06.2011 in the Slovak University of Technology in Bratislava, Slovakia. Main purpose of this training stay was familiarity with new pedagogic methods, preparing a new modern curriculum for faculty of chemical technology of KPU and preparing instructions for chemical engineering laboratories. Activities I've done during this training stay are listed below:

- Preparing of curriculum and syllabi for organic technology department

- Preparing of curriculum and syllabi for food technology department

- Preparing instructions for chemical engineering laboratories

- Visiting and being familiar with chemical engineering laboratories.

- Visiting and being familiar with inorganic chemistry & inorganic substances technology laboratories.

- Visiting microbiology laboratories.

- Participating in some lectures, seminars, and laboratorial works of bachelor, master & PHD classes of chemical engineering department.

- Visiting faculty bookstore and library.

- Participating in chemical engineering annual conference, the 38th International conference of Slovak Society of Chemical Engineering.

I want to appreciate and thank, doc. Ing. Juma Haydary, PhD., Prof. Jozef Markoš, DrSc. , and other teachers of the faculty of Chemical and Food Technology of the Slovak University of Technology in Bratislava for their excellent cooperation and collaboration.

Some parts of collected materials are inserted in continuation of this report.

With Respect

Prof. Shah Mohammad Besmel

Contents

Introduction

This training report contents the proposal of curriculum for two departments of faculty of chemical technology of Kabul polytechnic university. The curriculum is proposed for Bachelor degree of study at department of food technology and also for department of organic technology. Two versions of both curriculums were prepared. One for a 9 semester long of study, which is currently applied at KPU and another for 8 semester study program, which is suggested.

The Syllabi of basic subject of both study programs, specially for food technology program are included.

The second part of the report contents the design of a chemical engineering laboratory for faculty of chemical technology of KPU.

Chemical Engineering Laboratory completes the theoretical knowledge and computational skills of students providing them with practical experience. It thus contributes to better comprehension of the momentum, heat and mass transfer theories which represent the fundaments of chemical engineering. The students get acquainted with selected hydraulic, heat and diffusion processes in laboratory equipments and models of industrial apparatus. They get to know the construction of the equipments and apparatuses, their operation and reaction on various changes. Doing so, they use various measuring instruments; get acquainted with automatic data collection and stacking. Some processes, e.g. rectification, can be operated by a computer software and the collected data are then also processed that way.

Equipments and processes are selected so that they thematically follow the lectures and computational seminars in Chemical Engineering. The following table lists ten laboratories while three are devoted to hydrodynamics, two to heat transfer and five to mass transfer. There are more alternatives to these laboratories, while also the equipment’s configuration can be changed. Considering the costs of the Chemical Engineering Laboratory establishment, this number of laboratories is the minimum required in the study program in two semesters and in the planned extent.

Part 1: Curriculum development for departments of Food Technology and Organic Technology of KPU

Contents

Development of 9 semesters study program of Food Technology department

N^0	Subjects	Old curriculum				Proposed New curriculum				Recommended curriculum			
		Number semester	Number credits	Number of hrs	Number of exams	Number semester	Number credits	Number of hrs	Number of exams	Number semester	Number credits	Number of hrs	Number of exams
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Islamic culturs	1: 8	8	8	8E	1:8	25	34	8E	1:8	8	8	8E
2	Afghanistan history	1, 2	2	2	2E	-	-	-	-	1,2	2	2	2E
3	Sport	1,2	2	4	2E	-	-	-	-	1,2	2	4	2E
4	Mathematical	1,2,3	10	13	3E	1,2	13	18	2E	1,2	9	13	9E
5	General chemistry	1	4	5	1E	-	-	-	-	-	-	-	-
6	Geometrical Drowing	1	2	3	1E	-	-	-	-	1	2	3	1E
7	Technical drowing	1,2	4	8	2E	3	3	4	1E	1	2	4	1E
8	Foreign Language (english)	1,2,3	6	12	3E	1:6	7	14	1E	1:6	8	16	1E
9	Fundamental of	1,2	4	6	2E	1,2	2	3	1E	1,2	2	4	1E

	cumpoter (informatic)												
10	General and inorganic chemistry	2	4	5	1E	1	7	10	1E	1,2	7	10	2E
11	Physic	2,3,4	8	11	3E	2	6	7	1E	2,3	6	8	2E
12	Material balances	-	-	-	-	2	2	3	1E	2	2	3	1E
13	Biology	2	2	2	1E	4	3	4	1E	4	3	4	1E
14	Organic chemistry	4,5	5	7	2E	3	5	7	1E	3	5	7	1E
15	Physical chemistry	3,4	4	6	2E	3,4	11	16	2E	3,4	6	8	2E
16	Analytical chemistry	3,4	5	7	2E	3,4	9	14	2E	3,4	6	8	2E
17	Teoretical mechanic	3,4	4	6	2E	-	-	-	-	3,4	4	6	2E
18	Numerical mathematic (calculitic mathematic)	3,4	4	6	2E	-	-	-	-	3,4	4	6	2E
19	Technical thermodynamic	3,4	4	6	2E	-	-	-	-	3,4	3	4	2E
20	Energetic balances	-	-	-	-	4	2	3	1E	4	2	3	1E
21	Technical	5	2	3	1E	5	2	3	1E	5	2	3	1E

	elektrotechnic (general elektrotechnic)												
22	Food technology	5,6,7,8	13	17	4E	5	3	6	1E	5,6,7,8	8	11	4E
23	Microbiology	5,6	5	6	2E	5	3	5	1E	5	3	4	1E
24	Biochemistry	5	2	3	1E	5	3	5	1E	5	3	4	1E
25	Bacteriology	5,6	6	7	2E	-	-	-	-	5,6	6	8	2E
26	Chemical engineering (unit operation)	4,5,6	7	10	3E	6,7	14	23	2E	5,6	7	9	2E
27	Biochemical technology	-	-	-	-	6	3	3	1E	6	3	3	1E
28	Chemistry of food	-	-	-	-	6	2	3	1E	6	2	3	1E
29	Environmental protection	6	1	1	1E	-	-	-	-	6	1	1	1E
30	Summar practical experience (educational practic)	6	2	4	1E	6	2	-	1E	5	2	4	1E
31	Energetic engineering	-	-	-	-	7	4	5	1E	7	4	5	1E
32	Equipment for chemical and food technology	8	3	4	1E	4	3	4	1E	7,8	6	8	1E
33	Bioengineering	-	-	-	-	7,8	9	13	2E	7,8	6	9	2E

	and bioreactors												
34	Cost engineering (economy and management)	7,8	6	7	1E	8	2	3	1E	8	2	3	1E
35	Control and automatization	7,8	6	8	2E	8	5	7	1E	7,8	6	8	2E
36	Environmental engineering (sufety engineering)	7,8	6	6	2E	-	-	-	-	8	2	3	1E
37	Food analysis	-	-	-	-	8	4	6	1E	8	2	3	1E
38	Optional subjects: - marketing - quality control and analysis	8	2	2	1E	-	-	-	-	8	2	2	1E
39	Optional subjects: - management - fundamental of biotechnology	7	2	2	1E	-	-	-	-	7	2	2	1E
40	Diploma project	9	9	9	1E	9	20	30	1E	9	9	9	1E
41	Productional practic	9	5	5	1E	-	-	-	-	9	5	5	1E
42	Practic befor diploma	9	2	2	1E	-	-	-	-	9	2	2	1E

Final approved curriculum for department of Food Technology - 9 semesters curriculum

Food Technology						
1st semester	credits	L	S	LE	hrs	exam
Islamic culture	1	1	0	0	1	1
Afganistan history	1	1	0	0	1	1
Sport	1	0	2	0	2	1
Mathematics I	5	3	4	0	7	1
Geometry	2	1	2	0	3	1
Technical drawing	2	0	4	0	4	1
ENGLISH	2	0	4	0	4	1
Informatics I	1	0	0	2	2	1
General and Inorganic Chemistry	4	2	2	2	6	1
SUMMARY	**19**	**8**	**18**	**4**	**30**	**9**

Food Technology						
2nd semester	credits	L	S	LE	hrs	exam
Islamic culture	1	1	0	0	1	1
Afganistan history	1	1	0	0	1	1
Sport	1	0	2	0	2	1
Mathematics II	4	2	4	0	6	1
ENGLISH	1	0	2	0	2	1
Informatics II	1	0	0	2	2	1
General and Inorganic Chemistry	4	2	2	2	6	1
Physics I	3	2	2	0	4	1
Material balances	2	1	2	0	3	1
SUMMARY	**18**	**9**	**14**	**4**	**27**	**9**

Food Technology						
3rd semester	credits	L	S	LE	hrs	exam
Islamic culture	1	1	0	0	1	1

ENGLISH	1	0	2	0	2	1
Physics II	3	2	0	2	4	1
Organic chemistry	5	3	2	2	7	1
Physical chemistry I	3	2	2	0	4	1
Analytical chemistry I	3	2	2	0	4	1
Numerical mathematics	2	1	2	0	3	1
Technical thermodynamics	1	1	0	0	1	1
Theoretical mechanics	2	1	2	0	3	1
SUMMARY	**21**	**13**	**12**	**4**	**29**	**9**

Food Technology						
4th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
ENGLISH	1	0	2	0	2	1
Biology	3	2	0	2	4	1
Physical chemistry II	3	2	0	2	4	1
Analytical chemistry II	3	2	0	2	4	1
Numerical mathematics	2	1	2	0	3	1
Technical thermodynamics	2	1	2	0	3	1
Theoretical mechanics	2	1	2	0	3	1
Energetic balances	2	1	2	0	3	1
SUMMARY	**19**	**11**	**10**	**6**	**27**	**9**

Food Technology						
5th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
ENGLISH	1	0	2	0	2	1
Electrotechnic	2	1	2	0	3	1
Food technology	4	2	2	2	6	1
Microbiology I	3	2	0	2	4	1
Biochemistry	3	2	0	2	4	1
Chemical Engineering I	3	2	2	0	4	1

SUMMER Pratctical Experience	2	0	0	4	4	1
SUMMARY	**19**	**10**	**8**	**10**	**28**	**8**

Food Technology						
6th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
ENGLISH	2	0	4	0	4	1
Food technology	2	1	2	0	3	1
Microbiology II	3	2	0	2	4	1
Chemical Engineering II	4	3	2	0	5	1
Biochemical Technology	3	3	0	0	3	1
Chemistry of Food	2	1	2	0	3	1
Environmental Protection	1	1	0	0	1	1
SUMMARY	**18**	**12**	**10**	**2**	**24**	**8**

Food Technology						
7th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
Food technology	2	2	0	0	2	1
Energetical Engineering	3	2	2	0	4	1
Equipment for Chemical and Food Industry	3	2	2	0	4	1
Bioengineering and Bioreactors	3	2	2	0	4	1
Control and Automatization	3	2	2	0	4	1
Management	2	2	0	0	2	1
Fundamentals of Biotechnology						
SUMMARY	**17**	**13**	**8**	**0**	**21**	**7**

Food Technology						

8th semester	credits	L	S	LE	hrs	exam
Islamic culture	1	1	0	0	1	1
Equipment for Chemical and Food Industry	3	2	2	0	4	1
Bioengineering and Bioseparations	3	2	0	2	4	1
Cost Engineering	3	2	2	0	4	1
Control and Automatization	3	2	2	0	4	1
Environmental Engineering	2	2	0	0	2	1
Food Analysis	2	1	0	2	3	1
Marketing / Quality control and analysis	2	2	0	0	2	1
SUMMARY	**19**	**14**	**6**	**4**	**24**	**8**

Food Technology						
9th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Diploma project	9	9	0	0	9	1
Productional Practice	5	5	0	0	5	1
Practice before Diploma	2	2	0	0	2	1
SUMMARY	**16**	**16**	**0**	**0**	**16**	**3**

Food Technology	Credits	L	S	LE	Hrs	Exams
SUMMARY	**166**	**106**	**86**	**34**	**226**	**70**

Development of 9 semesters study program of Organic Technology department

N^0	Subjects	Old curriculum				Proposed New curriculum				Recommended curriculum			
		Number semester	Number credits	Number of hrs	Number of exams	Number semester	Number credits	Number of hrs	Number of exams	Number semester	Number credits	Number of hrs	Number of exams
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Islamic culturs	1: 8	8	8	E	1:8	25	32	E	1:8	8	8	E
2	Afghanistan history	1, 2	2	2	E	-	-	-	-	1,2	2	2	E
3	Sport	1,2	2	4	E	-	-	-	-	1,2	2	4	E
4	Mathematical	1,2,3	11	14	E	1,2	13	18	E	1,2	9	13	E
5	Inorganic chemistry	2	4	5	E	1	7	10	E	1,2	7	10	E
6	Informatics	2	2	3	E	1,2	2	3	E	1,2	2	4	E
7	English (foreign language)	1,2,3	6	12	E	1:6	7	14	E	1:6	8	14	E
8	Technical drowing	1,2	4	8	E	3,4	6	8	E	1	2	6	E
9	Geometrical drowing	1	2	3	E	-	-	-	-	1	2	3	E

10	General chemistry	1	4	5	E	-	-	-	-	?	?	?	?
11	Material balances	-	-	-	-	2	2	3	E	2	2	3	E
12	Energetic balances	-	-	-	-	4	2	3	E	4	2	3	E
13	Physics	2,3,4	8	11	E	2	6	7	E	2,3	6	8	E
14	Organic chemistry	3,4,5	8	11	E	3	5	7	E	3	5	7	E
15	Physical chemistry	5,6	7	9	E	3,4	11	16	E	3,4	6	8	E
16	Analytical chemistry	3,4	6	8	E	3,4	9	14	E	3,4	6	8	E
17	Numerical mathematics	3,4,5	6	9	E	-	-	-	-	3,4	4	6	E
18	Theoretical mechanics	3,4	4	6	E	-	-	-	-	3,4	4	6	E
19	Thermodynamics and heat transfer	3,4	4	6	E	-	-	-	-	3,4	3	4	E
20	Unit operation (chemical engineering)	4,5,6	10	12	E	6,7,8	19	32	E	5,6	8	11	E
21	General chemical technology (basic principals of chem.)	4,5	8	10	E	5	4	4	E	5	4	5	E

22	Racio material for OT	-	-	-	-	5	3	3	E	5	3	3	E
23	Technical elektrotechnics	5,6	4	6	E	5	2	3		5	2	3	E
24	Safety engineering	7,8	4	6	E	5	4	4	E	7,8	4	6	E
25	Chemical engineering problems with PC	-	-	-	-	5	2	4	E	6	2	4	E
26	Basic processes of OT	-	-	-	-	6	3	3	E	6	3	3	E
27	Petro chemistry	6,7,8	11	14	E	6	3	3	E	6,7,8	3	3	E
28	Summar practical experience	6	2		E	6	2			5	2		
29	Energetic engineering	-	-	-	-	7	4	5	E	7	3	4	E
	Energetic balances	-	-	-	-	4	-	3	E	4	2	3	E
30	Equipment for chemical technology	7,8	4	6	E	7	3	5	E	7,8	4	6	E
31	Environmental engineering	-	-	-	-	7	2	5	E	7	2	3	E
32	Gas and oil refining	6,7	8	10	E	-	-	-	-	7	5	7	E

	technology												
33	Control and automatization	7,8	6	8	E	8	5	7	E	7,8	6	8	E
34	Oil – chemical synthez technology	7,8	5	7	E	-	-	-	-	7,8	5	6	E
35	Cost engineering (economic organization and planning)	7,8	5	7	E	8	2	3	E	8	3	4	E
36	Sterilization of waters	7	1	2	E	-	-	-	-	7	1	2	E
37	Management principales	7	1	2	E	-	-	-	-	7	1	2	E
38	Chemical reactor engineering	-	-	-	-	8	5	6	E	8	3	4	E
39	Biochemistry	8	2	3	E	-	-	-	-	8	2	3	E
40	- calculation of burning material - calculation of oil	8	2	4	E	-	-	-	-	8	2	4	E
41	Safe enviroment	6	1	1	E	-	-	-	-	6	1	1	E
	Physical method in org. chemistry	6	2	3	E	-	-	-	-	6	2	2	E
42	Diploma project	9	9	9	E	9	20	30	E	9	9	9	E

43	Productional practic	9	5	5	E	-	-	-	-	9	5	5	E
44	Practic before diploma proj.	9	2	2	-	-	-	-	-	9	2	2	E

Final approved curriculum for department of Food Technology- 9 semesters curriculum

Organic technology						
1st semester	credits	L	S	LE	hrs	exam
Islamic culture	1	1	0	0	1	1
Afganistan history	1	1	0	0	1	1
Sport	1	0	2	0	2	1
ENGLISH	2	0	4	0	4	1
Mathematics I	5	3	4	0	7	1
General and Inorganic Chemistry	4	2	2	2	6	1
Informatics I	1	0	0	2	2	1
Technical drawing	2	0	4	0	4	1
Geometrical drawing	2	1	2	0	3	1
SUMMARY	**19**	**8**	**18**	**4**	**30**	**9**

Organic technology						
2nd semester	credits	L	S	LE	hrs	exam
Islamic culture	1	1	0	0	1	1
Afganistan history	1	1	0	0	1	1
Sport	1	0	2	0	2	1
ENGLISH	1	0	2	0	2	1
Mathematics II	4	2	4	0	6	1
Inorganic chemistry	4	2	2	2	6	1
Informatics II	1	0	0	2	2	1
Material balances	2	1	2	0	3	1
Physics II	3	2	2	0	4	1
SUMMARY	**18**	**9**	**14**	**4**	**27**	**9**

Organic technology						
3rd semester	credits	L	S	LE	hrs	exam
Islamic culture	1	1	0	0	1	1
ENGLISH	1	0	2	0	2	1

Physics II	3	2	0	2	4	1
Organic chemistry I	4	2	2	2	6	1
Physical Chemistry I	3	2	2	0	4	1
Analytical chemistry I	3	2	2	0	4	1
Numerical mathematics	2	1	2	0	3	1
Theoretical mechanics	2	1	2	0	3	1
Thermodynamics and Heat Transfer	1	1	0	0	1	1
SUMMARY	**20**	**12**	**12**	**4**	**28**	**9**

Organic technology						
4th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
ENGLISH	1	0	2	0	2	1
Energetic balances	2	1	2	0	3	1
Organic chemistry II	2	1	2	0	3	1
Physical Chemistry II	3	2	0	2	4	1
Analytical chemistry II	3	2	0	2	4	1
Numerical mathematics	2	1	2	0	3	1
Theoretical mechanics	2	1	2	0	3	1
Thermodynamics and Heat Transfer	2	1	2	0	3	1
SUMMARY	**18**	**10**	**12**	**4**	**26**	**9**

Organic technology						
5th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
ENGLISH	1	0	2	0	2	1
Chemical Engineering I	4	3	2	0	5	1
General Chemical Technology	4	3	2	0	5	1
Raw materials for OT	3	3	0	0	3	1
Electrotechnics	2	1	2	0	3	1

SUMMER Pratctical Experience	2	0	0	4	4	1
SUMMARY	**17**	**11**	**8**	**4**	**23**	**7**

Organic technology						
6th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
ENGLISH	2	0	4	0	4	1
Chemical Engineering II	4	2	2	2	6	1
Chem. Eng. Problems with PC	2	0	0	4	4	1
Petrochemistry	3	3	0	0	3	1
Gas and Oil Refining Technology	5	3	2	2	7	1
Environmental Protections	1	1	0	0	1	1
Physical Methods in Organic Chemistry	2	1	2	0	3	1
SUMMARY	**20**	**11**	**10**	**8**	**29**	**8**

Organic technology						
7th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
Safety Engineering	2	1	2	0	3	1
Energetic Engineering	3	2	2	0	4	1
Equipments for Chemical Technology	2	1	2	0	3	1
Environmental Engineering	2	1	2	0	3	1
Control and Authomatization	3	2	0	2	4	1
Chemistry and Technology	5	5	0	0	5	1
of Basic Organic Chemicals						
Water technology/Management	1	0	2	0	2	1
SUMMARY	**19**	**13**	**10**	**2**	**25**	**8**

Organic technology						
8th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**

Islamic culture	1	1	0	0	1	1
Safety Engineering	2	1	2	0	3	1
Equipments for Chemical Technology	2	1	2	0	3	1
Control and Authomatization	3	2	2	0	4	1
Fine chemicals technology	3	2	2	0	4	1
Cost Engineering	3	2	2	0	4	1
Chemical Reactor Engineering	3	2	2	0	4	1
Biochemistry	2	1	2	0	3	1
Fuel production calculations	2	0	4	0	4	1
Oils production calculations						
SUMMARY	**21**	**12**	**18**	**0**	**30**	**9**

Organic technology						
9th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Diploma project	9	9	0	0	9	1
Productional Practice	5	5	0	0	5	1
Practice before Diploma	2	2	0	0	2	1
SUMMARY	**16**	**16**	**0**	**0**	**16**	**3**

Organic technology	**Credits**	**L**	**S**	**LE**	**Hrs**	**Exams**
SUMMARY	**168**	**102**	**102**	**30**	**234**	**71**

Development of 8 semesters study program of Food Technology department

N^0	Subjects	Old curriculum				New curriculum				Recommended curriculum			
		Number semester	Number credits	Number of hrs	Number of exams	Number semester	Number credits	Number of hrs	Number of exams	Number semester	Number credits	Number of hrs	Number of exams
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Islamic culturs	1: 8	8	8	8E	1-8	25	33	8E	1:7	7	7	7E
2	Afghanistan history	1, 2	2	2	2E	-	-	-	-	1,2	2	2	2E
3	Sport	1,2	2	4	2E	-	-	-	-	1,2	2	4	2E
4	Mathematical	1,2,3	10	13	3E	1,2	12	18	2E	1,2	9	11	2E
5	General chemistry	1	4	5	1E	-	-	-	-	1	4	6	1E
6	Inorganic chemistry	2	4	5	1E	1	6	10	1E	2	4	6	1E
7	Geometrical drowing	1	2	3	1E	-	-	-	-	1	2	3	1E
8	Technical drowing	1,2	4	8	2E	-	-	-	-	1	2	4	1E
9	Forein language (english)	1,2,3	6	12	3E	1:6	7	14	1E	1:6	7	14	6E
10	Physics	2,3,4	8	11	3E	2	6	7	1E	2,3	6	8	2E
11	Informatic (fundamental of cumpoter)	1,2	4	6	2E	1,2	2	3	1E	1,2	2	4	2E
12	Material balances	-	-	-	-	1	2	3	1E	1	2	3	1E
13	Energetic balances	-	-	-	-	2	2	3	1E	2	2	4	1E
14	Biology	2	2	2	1E	2	3	4	1E	2	3	4	1E
15	Organic chemistry	4,5	5	7	2E	3	5	7	1E	3	3	4	1E
16	Physical chemistry	3,4	4	6	2E	3,4	11	16	2E	3,4	6	8	2E
17	Analytical chemistry	3,4	5	7	2E	3,4	9	15	2E	3,4	6	8	2E

18	Theoretical mechanics	3,4	4	6	2E	-	-	-	-	3,4	4	6	2E
19	Numerical mathematic (calculitic mathematic)	3,4	4	6	2E	-	-	-	-	3	2	3	1E
20	Technical thermodynamic	3,4	4	6	2E	-	-	-	-	4	4	5	1E
21	Technical electrotechnic	5	2	3	1E	-	-	-	-	5	2	3	1E
22	Food technologyT	5,6,7,8	13	17	4E	5	3	3	1E	5,6	6	9	2E
23	Microbiology	5,6	5	6	2E	3	3	4	1E	3	3	4	1E
24	Biochemistry	5	2	3	1E	4	5	4	1E	4	3	4	1E
25	Chemical engineering (unit operation)	4,5,6	7	10	3E	5,6	14	22	1E	5,6	6	8	2E
26	Equipment for food technology	8	3	4	1E	5	4	5	1E	5	4	5	1E
27	Bioengineering and bioreactors	-	-	-	-	6	4	6	1E	6	4	6	1E
28	Biochemical technology	-	-	-	-	6	3	3	1E	6	3	3	1E
29	Chemistry of food	-	-	-	-	5	2	2	1E	6	2	3	1E
30	Summar practical experience	6	2	4	1E	5	2	2	1E	5	2	2	1E
31	Environmental protaction	6	1	1	1E	-	-	-	-	6	1	1	1E
32	Energetic engineering	-	-	-	-	7	4	5	1E	7	3	4	1E
33	Cost engineering	7,8	6	7	2E	7	1	2	1E	7	3	4	1E
34	Control and automatization	7,8	6	8	2E	8	5	7	1E	6,7	6	8	2E
35	Food analysis	-	-	-	-	7	4	6	1E	7	2	3	1E
36	Bioengineering and bioseparation	-	-	-	-	7	3	3	1E	7	2	3	1E
37	Environmental engineering	7,8	6	6	2E	7	2	3	1E	7	3	3	1E
38	-management - fundamental of	7	2	2	1E	-	-	-	-	7	2	2	1E

	biotechnology												
39	-marketing - quality control and analysis	8	2	2	1E	-	-	-	-	7	2	2	1E
40	Productional practic	9	5	5	1E	-	-	-	-	8	5	5	1E
41	Practic before diploma	9	2	2	1E	-	-	-	-	8	2	2	1E
42	Diploma project	9	9	9	1E	8	22	18	1E	9	9	9	1E

Final approved curriculum for department of Food Technology- 8 semesters curriculum

Food Technology						
1st semester	credits	L	S	LE	hrs	exam
Islamic culture	1	1	0	0	1	1
Afganistan history	1	1	0	0	1	1
Sport	1	0	2	0	2	1
Mathematics I	5	4	2	0	6	1
Geometry	2	1	2	0	3	1
Technical drawing	2	0	4	0	4	1
ENGLISH	1	0	2	0	2	1
General and Inorganic Chemistry	4	2	2	2	6	1
Informatics I	1	0	0	2	2	1
Material balances	2	1	2	0	3	1
SUMMARY	**20**	**10**	**16**	**4**	**30**	**10**

Food Technology						
2nd semester	credits	L	S	LE	hrs	exam
Islamic culture	1	1	0	0	1	1
Afganistan history	1	1	0	0	1	1
Sport	1	0	2	0	2	1
Mathematics II	4	3	2	0	5	1
ENGLISH	1	0	2	0	2	1
General and Inorganic Chemistry	4	2	2	2	6	1
Physics I	3	2	2	0	4	1
Energetic balances	2	0	4	0	4	1
Informatics II	0	0	0	0	0	0
Biology	3	2	0	2	4	1
SUMMARY	**20**	**11**	**14**	**4**	**29**	**9**

Food Technology						
3rd semester	credits	L	S	LE	hrs	exam
Islamic culture	1	1	0	0	1	1
ENGLISH	1	0	2	0	2	1

Physics II	3	2	0	2	4	1
Organic chemistry	3	2	0	2	4	1
Physical chemistry I	3	2	2	0	4	1
Analytical chemistry I	3	2	2	0	4	1
Numerical mathematics	2	1	2	0	3	1
Technical thermodynamics	0	0	0	0	0	0
Theoretical mechanics	2	1	2	0	3	1
Microbilogy	3	2	0	2	4	1
SUMMARY	**21**	**13**	**10**	**6**	**29**	**9**

Food Technology						
4th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
ENGLISH	1	0	2	0	2	1
Physical chemistry II	3	2	0	2	4	1
Analytical chemistry II	3	2	0	2	4	1
Technical thermodynamics	4	3	2	0	5	1
Theoretical mechanics	2	1	2	0	3	1
Biochemistry	3	2	0	2	4	1
Informatics II	1	0	0	2	2	1
SUMMARY	**18**	**11**	**6**	**8**	**25**	**8**

Food Technology						
5th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
ENGLISH	1	0	2	0	2	1
Electrotechnic	2	1	2	0	3	1
Food technology	4	2	2	2	6	1
Equipment for food technology	4	3	2	0	5	1
Chemical Engineering I	4	3	2	0	5	1

SUMMER Pratctical Experience	2	0	0	4	4	1
SUMMARY	**18**	**10**	**10**	**6**	**26**	**7**

Food Technology						
6th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
ENGLISH	2	0	4	0	4	1
Food technology	2	1	2	0	3	1
Chemical Engineering II	2	1	0	2	3	1
Biochemical Technology	3	3	0	0	3	1
Chemistry of Food	2	1	2	0	3	1
Environmental Protection	1	1	0	0	1	1
Bioengineering and Bioreactors	4	3	3	0	6	1
Automatization and Control	3	2	0	2	4	1
SUMMARY	**20**	**13**	**11**	**4**	**28**	**9**

Food Technology						
7th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
Food Analysis	2	1	0	2	3	1
Energetical Engineering	3	2	2	0	4	1
Cost Engineering	3	2	2	0	4	1
Bioengineering and Bioseparations	2	1	2	0	3	1
Control and Automatization	3	2	2	0	4	1
Management/	2	2	0	0	2	1
Fundamentals of Biotechnology						
Environmental Engineering	3	3	0	0	3	1
Marketing	2	2	0	0	2	1
Qulity Control and Analysis						
SUMMARY	**21**	**16**	**8**	**2**	**26**	**9**

Food Technology						
8th semester	credits	L	S	LE	hrs	exam
Diploma project	9	0	0	9	9	1
Productional Practice	5	0	0	5	5	1
Practice before Diploma	2	0	0	2	2	1
SUMMARY	**16**	**0**	**0**	**16**	**16**	**3**

Food Technology	Credits	L	S	LE	Hrs	Exams
SUMMARY	**154**	**84**	**75**	**50**	**209**	**64**

Development of 8 semesters study program of Organic Technology department

N^0	Subjects	Old curriculum				New curriculum				Recommended curriculum			
		Number semester	Number credits	Number of hrs	Number of exams	Number semester	Number credits	Number of hrs	Number of exams	Number semester	Number credits	Number of hrs	Number of exams
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Islamic culturs	1: 8	8	8	8E	1:8	25	33	8E	1:7	7	7	7E
2	Afghanistan history	1, 2	2	2	2E	-	-	-	-	1,2	2	2	2E
3	Sport	1,2	2	4	2E	-	-	-	-	1,2	2	4	2E
4	Mathematical	1,2,3	11	14	3E	1,2	12	18	2E	1,2	9	13	2E
5	General chemistry	1	4	5	1E	-	-	-	-	1	4	6	1E
6	Inorganic chemistry	2	4	5	1E	1	6	10	1E	2	4	6	1E
7	Informatics	2	2	3	1E	1	1	1	1E	1,2	2	4	2E
8	Foreing language (english)	1,2,3	6	12	3E	1:6	7	14	6E	1:6	7	14	6E
9	Technical drowing	1,2	4	8	2E	-	-	-	-	1	2	4	1E
10	Geometrical drowing	1	2	3	1E	-	-	-	-	1	3	3	1E
11	Material balances	-	-	-	-	1	2	3	1E	1	2	3	1E
12	Energetic balances	-	-	-	-	2	2	3	1E	2	2	4	1E
13	Physics	2,3,4	8	11	3E	2	6	7	1E	2,3	6	8	2E
14	Organic chemistry	3,4,5	8	11	3E	3	5	7	1E	3,4	5	8	2E
15	Physical chemistry	5,6	7	9	2E	3,4	11	16	2E	3,4	6	8	2E
16	Analytical chemistry	3,4	6	8	2E	3,4	9	15	2E	3,4	6	8	2E
17	Numerical mathematics	3,4,5	6	9	3E	-	-	-	-	3,4	4	6	2E
18	Theoretical	3,4	4	6	2E	-	-	-	-	3,4	4	6	2E

	mechanics												
19	Technical thermodynamic	3,4	4	6	2E	-	-	-	-	3,4	3	4	2E
20	Chemical engineering (unit operation)	4,5,6	10	12	3E	5,6,7	19	31	1E	5,6	6	8	2E
21	Basic principales of chemical technology	4,5	8	10	2E	5	4	4	1E	5	4	5	1E
22	Raw material for OT	-	-	-	-	3	3	3	1E	3	2	2	1E
23	Technical electrotechnics	5,6	4	6	2E	-	-	-	-	5	2	3	1E
24	Chemical engineering problem with PC	-	-	-	-	2	2	4	1E	4	2	4	1E
25	Petrochemistry	-	-	-	-	4	3	3	1E	6	3	3	1E
26	Gas and oil refining technology (basic processes of OT)	6,7	8	10	2E	6	3	3	1E	5	5	7	1E
27	Equipment for chemical and food technology	7,8	4	6	2E	5	4	5	1E	6	4	5	1E
28	Safty engineering	7,8	4	6	2E	5	4	4	1E	7	2	3	1E
29	Summar practical experiences	6	2	2	1E	6	2	2	1E	5	2	2	1E
30	Chemical reactor engineering	-	-	-	-	6	5	6	1E	6	3	4	1E
31	Environmental protaction (safe environmental)	6	1	1	1E	-	-	-	-	6	1	1	1E
32	Physical method in organic chemistry	6	2	3	1E	-	-	-	-	5	2	3	1E
33	Chemistry and technology of basic organic chemical (oil	7,8	5	6	2E	-	-	-	-	6	3	3	1E

	chemical technology)												
34	Environmental engineering	-	-	-	-	7	2	3	1E	6	2	3	1E
35	Control and automatization	7,8	6	8	E	8	5	7	1E	6,7	4	6	2E
36	- water technology - management	7	1	2	1E	-	-	-	-	6	1	2	1E
37	Energetic engineering	-	-	-	-	7	4	5	1E	7	3	4	1E
38	Cost engineering (economic organization and planning)	7,8	5	7	2E	7	1	2	1E	7	3	4	1E
39	Biochemistry (chemotology)	8	2	3	1E	-	-	-	-	7	2	3	1E
40	Fine chemical technology	-	-	-	-	-	-	-	-	7	3	4	1E
41	- calculation of burning material - calculation of oil	8	2	4	1E	-	-	-	-	7	2	4	1E
	Physical method in org. chemistry	6	2	3	E	-	-	-	-	6	2	2	E
42	Productional practic	9	5	5	1E	-	-	-	-	8	5	5	1E
43	Practic before diploma	9	2	2	1E	-	-	-	-	8	2	2	1E
44	Bechlor project (diploma project)	9	9	9	1E	8	22	18	1E	8	9	9	1E

Final approved curriculum for department of Organic Technology - 8 semesters curriculum

Organic technology						
1st semester	credits	L	S	LE	hrs	exam
Islamic culture	1	1	0	0	1	1
Afganistan history	1	1	0	0	1	1
Sport	1	0	2	0	2	1
ENGLISH	1	0	2	0	2	1
Mathematics I	5	3	4	0	7	1
General and Inorganic Chemistry	4	2	2	2	6	1
Technical drawing	2	0	4	0	4	1
Geometrical drawing	2	1	2	0	3	1
Material balances	2	1	2	0	3	1
SUMMARY	**19**	**9**	**18**	**2**	**29**	**9**

Organic technology						
2nd semester	credits	L	S	LE	hrs	exam
Islamic culture	1	1	0	0	1	1
Afganistan history	1	1	0	0	1	1
Sport	1	0	2	0	2	1
ENGLISH	1	0	2	0	2	1
Mathematics II	4	2	2	2	6	1
Inorganic chemistry	4	2	2	2	6	1
Informatics	2	0	0	4	4	1
Energetic Balances	2	0	4	0	4	1
Physics I	3	2	2	0	4	1
SUMMARY	**19**	**8**	**14**	**8**	**30**	**9**

Organic technology						
3rd semester	credits	L	S	LE	hrs	exam

Islamic culture	1	1	0	0	1	1
ENGLISH	1	0	2	0	2	1
Raw material for Organic Technology	2	2	0	0	2	1
Physics II	3	2	0	2	4	1
Organic chemistry I	3	1	2	2	5	1
Physical Chemistry I	3	2	2	0	4	1
Analytical chemistry I	3	2	2	0	4	1
Numerical mathematics	2	1	2	0	3	1
Theoretical mechanics	2	1	2	0	3	1
Thermodynamics and Heat Transfer	1	1	0	0	1	1
SUMMARY	**21**	**13**	**12**	**4**	**29**	**10**

Organic technology						
4th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
ENGLISH	1	0	2	0	2	1
Petrochemistry	3	3	0	0	3	1
Chemical Enginering Problems with PC	2	0	0	4	4	1
Organic chemistry II	2	1	2	0	3	1
Physical Chemistry II	3	2	0	2	4	1
Analytical chemistry II	3	2	0	2	4	1
Numerical mathematics	2	1	2	0	3	1
Theoretical mechanics	2	1	2	0	3	1
Thermodynamics and Heat Transfer	2	1	2	0	3	1
SUMMARY	**21**	**12**	**10**	**8**	**30**	**10**

Organic technology						
5th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
ENGLISH	1	0	2	0	2	1
Physical Methods in Organic Chemistry	2	1	2	0	3	1
Chemical Engineering I	4	3	2	0	5	1
General Chemical Technology	4	3	2	0	5	1
Gas and Oil Refining Technology	5	3	2	2	7	1
Electrotechnics	2	1	2	0	3	1

SUMMER Pratctical Experience	2	0	0	4	4	1
SUMMARY	**21**	**12**	**12**	**6**	**30**	**8**

Organic technology						
6th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
ENGLISH	2	0	4	0	4	1
Chemical Engineering II	2	1	0	2	3	1
Automatization and Control	2	1	2	0	3	1
Equipments for Chemical and Food technology	4	3	2	0	5	1
Chemical Reactor Engineering	3	2	2	0	4	1
Chemistry and Technology of Basic Organic Chemicals	3	3	0	0	3	1
Environmental Protections	1	1	0	0	1	1
Water Technology/Management	1	0	2	0	2	1
Environmental Engineering	2	1	2	0	3	1
SUMMARY	**21**	**13**	**14**	**2**	**29**	**10**

Organic technology						
7th semester	**credits**	**L**	**S**	**LE**	**hrs**	**exam**
Islamic culture	1	1	0	0	1	1
Safety Engineering	2	1	2	0	3	1
Cost Engineering	3	2	2	0	4	1
Energetic Engineering	3	2	2	0	4	1
Equipments for Chemical Technology	2	1	2	0	3	1
Biochemical Engineering	2	1	2	0	3	1
Control and Authomatization	2	1	0	2	3	1
Fine Chemicals Technology	3	2	2	0	4	1
Fuel production calculations	2	0	4	0	4	1
Oils production calculations						
SUMMARY	**20**	**11**	**16**	**2**	**29**	**9**

Organic technology						
8th semester	credits	L	S	LE	hrs	exam
Diploma project	9	0	0	9	9	1
Productional Practice	5	0	0	5	5	1
Practice before Diploma	2	0	0	2	2	1
SUMMARY	**16**	**0**	**0**	**16**	**16**	**3**

Organic technology	Credits	L	S	LE	Hrs	Exams
SUMMARY	**158**	**78**	**96**	**48**	**222**	**68**

Short Syllabi of selected subjects

Mathematics I

Themes:
- Mathematical analysis – function, definition region, extremes, limits, derivation, numerical derivation, integral, definite integral, numerical integration
- Linear algebra: matrix, vectors, operations with matrix, inversion matrix, determinant, solution of systems of linear equations (Gauss elimination, Inverse matrix,...)

Laboratory expeirences:
Using EXCEL (and MATLAB if avaliable) for numerical solution problems
- extreme of functions (Solver)
- numerical solution of integrals
- matrix operations
- solution of systems of linear equations

Mathematics II

Themes:
- roots of polynoms, roots of non linear equations, numerical solution of non linear equation, system of non linear equation, Jacobian, analytical derivations and numerical derivations for Jacobian
- differential equation, initial volume problem, boundary value problem, analytical solution, numerical solution: Euler method, Runge Kutt method,..
- system of differential equations, initial value problem, boundary value problem, analytical solution, numerical solution
- partial differential equations, numerical solution of PDE

Laboratory expeirences:
Using EXCEL (and MATLAB if avaliable) for numerical solution of problems related to the themes

Physics

Themes:
- Mechanics
- Optics
- Electricity and Magnetism

Laboratory experiences:

- measurements of some fysical properties, estimation of parameters, least square methods

Inorganic chemistry

Themes:

- structure of atoms, chemical bound, structure of molecules,
- solutions: solubility, crystallization, equilibrium, protolytic reactions and equilibria, pH, reaction kinetics, chemical equilibria
- Mendeleev´s Periodic sTable: basic properties, reactions and compounds of basic elements

Seminars:

- concentration, preparation of solutions, calculation of yield of crystallization, reaction, chemical calculations

Laboratory experiences:

- basic laboratory experiences
- basic reactions
- basic synthesis of anorganic chemistry

Informastics

Aim:

- give to students basic practice with PC, MS Windows and MS Office

Themes:

- MS Windows
- MS Word
- MS PowerPoint
- EndNote
- Internet
- Access to Databases (if available like ScienceDirect, Scopus, Web of Knowledge)

Material balances

Themes:

- flows and concentrations: mass units, molar units, transformation from molar to mass units and vice-versa, average molar mass of the flow
- flowsheet: nodes, flows, orientation of flows, parameters of flows
- material balance of system and node: total, for component
- system of equations ant their solution

- stoichiometry, conversion, extend of reaction, limiting component, key component, source of component, one reaction, complex reactions
- material balance of node with chemical reaction
- material balances of systems with chemical reaction

Energetic balances

Themes (with practical solution of examples and problems):

- enthalpy – reference state, specific molar heat capacity, temperature dependence, change of state – heat of vaporization, ...
- enthalpy of component, enthalpy of mixture,
- energy and enthalpy balance of systes without chemical reaction, heat losses
- reaction enthalpy, combustion heat
- energy and enthalpy balance of systems with chemical reaction

Chemical Engn. Problems with PC

Aim:
Practical solutions of problems from Material balances and Energy balances using EXCELL (or MATLAB) – system of linear and nonlinear systems of governing equations, extrapolation, interpolation, ...

Raw materials for Organic Technology

Themes:

- Coal: types of coal, properties, composition, resources, mining, primary treatment, carbonization
- Coke, tars, coal gas, gassification of coal
- Petroleum: properties, composition, resources, mining, primary treatment, transportation, atmospheric and vacuum distillation, desulphurisation, ...
- Natural gas: resources, properties, composition, mining, primary treatment, transportation, syngas, hydrogen production
- Biomass – sources, properties, composition, pyrolysis, gasification, alcoholic fermentation, anaerobic fermentation – biogas production

Petrochemistry

Themes:

- catalysis, catalytic cracking, ...
- pyrolysis, production of aromats,
- alkylation, izomerization,
- basic processes of hydrogenation/dehydrogenation – cyclohexane, styrene
- basic processes of oxidation – phenol, ethylene oxide, terephtalic acid,...
- basic processes of chlorination, fluorination – vinyl chloride, solvents, teflon,....
- production of monomers – ethylene, propylene, ...
- polymerization – polyethylene, polypropylene, poly esters, PVC, ...
- Fisher Tropsh synthesis, methanol, ...

Chemical Engnineering Problems with PC

Using EXCEL (if possible MATLAB)

- linear regression
- nonlinear regression
- estimation of parameters from laboratory data
- statistical elaboration of data
- optimization

Chemical Engineering I

Themes:

- hydrodynamic: equation of continuity, energy balance, Bernuli equation, fluid flow – laminar, turbulent, dissipation of energy, pipeline, valves, fitting, measurements of volumetric flow, pumps
- flow of fluid in packed beds, filtration, precipitation, mixing
- heat transfer, rate equation, steady state heat transfer, unsteady state heat transfer, heat exchange, design of heat exchangers, losses of heat, isolations
- evaporators

Chemical Engineering II

Themes:

- Vapour – liquid equilibrium, boiling point/condensation point of binary and multicomponent mixtures
- Distillation
- Stripping
- Rectification of binary mixtures – continuous, batch, design of columns
- Rectification of multicomponent mixtures
- Extraction, equilibrium, principles, batch extraction, multi step batch extraction, continuous counter-current extraction, equipments
- Absorption, mass transfer – two film theory, equilibrium, material balances, design of absorption column

Basic principles of chemical technology and inorganic technology

Themes:

- chemical concept, information sources,
- flow sheet diagrams,
- balances of large systems,
- sulphuric acid
- ammonia
- nitric acid, ammonium nitrate,
- phosphoric acid
- fertilizers production
- calcium oxide, cement, calcium hydrate, calcium carbid
- alluminium production
-

Equipments for chemical and food industry

Themes:

- materials, corrosion,
- pressurised systems
- storage systems
- pipe lines, valves, fittings
- pumps
- compressors, ventilators, vacuum pumps
- heat exchangers, dryers

- cooling system
- columns – packed beds, packages, stage columns, ...
- safety systems, measurements,
- ......

Chemical Reactor Engineering

Themes:

- stoichiometry, one reaction in the system, complex reaction scheme, conversion, selectivity, extend of reaction
- chemical equilibria
- thermal effect of chemical reaction
- kinetics of chemical reaction, reaction rate, rate equations, rate constant, Arrhenius equation,
- basic types of homogeneous reactors:
  - isothermal batch reactor, material balances, solution of equations, reaction time, time of period, optimisation of batch reactor
  - non isothermal batch reactor, enthalpy balance, adiabatic reactor, heat exchange,
  - isothermal plug flow reactor
  - non isothermal plug flow reactor
  - isothermal continuous stirred tank reactor
  - non isothermal CSTR, enthalpy balance, multiple steady states, dynamics of CSTR
  - tank in series system
- estimation of kinetic parameters
- basic principles of catalysis, reaction rate Langmuir – Hinshelwood, external heat and mass transport, reaction and diffusion in the catalytic particles, Thiele modulus, effectiveness factor
- basic types of heterogeneous catalytic reactors: fixed bed, moving bed, fluidized bed
- basic principles of non catalytic reactions fluid – solid, shell progressive mechanism
- basic types of non catalytic fluid – solid reactors: fixed bed, moving bed, fluidized bed
- gas – liquid reaction, two film theory, reaction and diffusion in liquid film, Hatta number, types of reactors

Basic processes of OT

Themes:

- basic technologies for production of
  - surface active chemicals

- colorants
- medicals
- chemicals for rubber industry
- chemicals for agriculture: herbicides

Chemical Engineering III

Themes:

- Adsorption
  - principles of adssorption, equilibrium at adsorption, adsorption isotherm, adsorption from gases, adsorption from liquids
  - industrial adsorbents, characterization of adsorbents
  - batch adsorption
  - multiple steps adsorption
  - fixed bed adsorptions,
  - moving bed adsorption
- Ion exchange separation
  - ion exchange resins, characterisation, properties, equilibrium
  - equipments, design, operations
- Membrane separation
  - types of membranes, mechanism of mass transport through membranes
  - types of proceses (microfiltration, nanofiltration, reverse osmosis, dialysis, electrodialysis, pervaporation, pertraction, membrane extraction
  - equipments, operations, design
- Crystalization
  - mechanism of crystalization, equilibrium, solubility,
  - crystals, grows of crystals, nucleation
  - equipments, operations, design
- Drying, air – water diagram, drying equilibrium, material balance, equipments
  - systems air – water, equilibrim, air – water enthalpy diagram,
  - drying, moisturizing of air, mixing of air, heating, cooling of air
  - cooling of water
  - equilibrium of drying, kinetics of drying
  - equipments, design

Syllabi of selected subjects for food Technology

Biology

Objective of the course:
The aim of the subject is to inform students about chemical building of living systems, molecular principles of life, genetics and evolution, basic classification of organisms, effect of enviroment on living organisms, practical application of microorganisms, animals and plant.

Week 1: Introduction. Object of biology and characterization of biological sciences. Characteristics and organisation of living systems. . Biology and society. Meaning of study of biology.
Week 2: Chemical building block of life - biopolymers. Prokaryotic cell structure. Classification of structural compartments of prokaryotic cells.
Week 3: Eukaryotic cell structure. Classification of structural compartments of eukaryotic cells (plasma, cytoskeleton, the endoplasmic reticulum, the Golgi apparatus. Lysosomes, microbody, vacuoles, nucleus – the cell informatic and control centre. Mitochondrions and chloroplasts: the cell energy centre – cellular respiration and photosynthesis).
Week 4: Bioenergetics. Catabolism of carbohydrates, lipids and proteins. Citric acid cycle and oxidative respiration.
Week 5: Photosynthesis. Genes. Translation, regulation of gene expression.
Week 6: Biomembranes: plasma membrane, cell transport of materials through membranes.
Week 7: Cell communication. Cell growth and cell division: mitosis, cell cycle, meiosis, gametogenesis and fertilization.
Week 8: Basic genetics concepts. The laws of heredity and viability: Mendel´s and Morgan´s laws. Chromosomes and genes: the cell interactions of genes, the sex chromosomes, the binding of genes, the mutation changes of genotype. Non nucleus heredity: plastide heredity, mitochondrial heredity, plasmic heredity.
Week 9: DNA – the genetic material, chromosomes organization of DNA, DNA replication. Gene activity: the gene expression, transcription and translation of genetic information. Mutations. The regulation of gene activity. Gene manipulations and biotechnology.
Week 10: The origin of life, evolution of living systems. Three life domains on the Earth, phylogenetic tree, basic classification of living things.
Week 11: Animal and plant tissue – the basic types and being, structure and function. Organes – structure, function and constitute.
Week 12: Anatomic building and function of seed plant. Enviromental concerns: physical, chemical and biological influences on the cell. Age and cell death. Practical and industrial application of organisms.
Week 13: Ecology, populations, societies, ekosystems (The human living enviroment – contamination and protection of the living enviroment).

Microbiology

Objective of the course:

The aim of the subject is to provide students with basic knowledge about bacterial cells, fungi, yeasts and provide them survey of microbial cytology, morphology, reproduction, nutrition and growth of microorganisms.

Week 1: The development, scope and perspectives of microbiology. The place of microorganisms in nature. Taxonomy. Terminology in microbiology.
Week 2: Definition of biosfera, occurrence of microorganisms. Methods of obtaining and storing microorganisms.
Week 3: Classification of microorganisms according to physiological properties. The basic structure of microorganisms.
Week 4: Basic structure of prokaryotic cells. Bacteria - size, shape, arrangement. The cell wall - composition and characteristics (G+ and G- bacteria). Structures internal to the cell wall: cytoplasmic membrane, cytoplasm, nuclear area, ribosomes, inclusions. Taxonomy, identification a bacteria systems.
Week 5: Bacterial division. Endospore forming bacteria, sporogenesis. Exotoxins. Endotoxins. Archaebacteria. Cyanobacteria. Actinomycetes. Mycobacteria: Rickettsias and chlamydias. Enterobacteriaceae. Life cycle of bacteria. Growth and reproduction of bacteria.
Week 6: The eukaryotic cells. Characteristics of filamentous fungi (moulds) and yeasts. The vegetative body. The cell wall - composition and characteristics. Growth and reproduction. Yeasts - morphology, cytology, reproduction. Taxonomic overview.
Week 7: Fungi - morphology, cytology, reproduction. Taxonomic overview. Mycotoxins. Algae. Protozoa.
Week 8: Viruses - bacterial, animal viruses, vegetable viruses. Viroids. Prions.
Week 9: Nutrition and growth of microorganism. Nutritional types. The physiology of growth. Bacterial growth in batch culture. Exponential growth and generation time. Physical and chemical requirements for growth. Measurement of microbial growth. Growth curve parameters.
Week 10: Metabolism of microorganisms. Energetic metabolism of chemolithotrophs, chemoorganotrophs and photolithotrophs bacteria. Nutrition and applicationnin industry.
Week 11: Biosynthesis of basic building elements.
Week 12: Microorganisms and environment. Effects of environmental factors on microorganisms.
Week 12:. Industrial and ecological important microorganisms. Microbial biotechnology (Bacteria, Yeasts, Filamentous fungi in industry).

Biochemistry

Objective of the course:
The course provides information about cell constituents, structure and function of biopolymers, e.g. amino acids, proteins, saccharides, lipids and nucleic acids, and the basics of energetic metabolism. Further, structure of biomembranes, types of membrane transport are explained and basic principles of enzyme catalysis are introduced. Next, methods of isolation and characterization of biopolymers are introduced and some applications including enzyme engineering and genetic engineering are discussed.

Week 1: Chemical composition of living organisms. Ions, trace elements, occurrence and function, role of water. Buffers. Energetics of living organisms. Equilibrium and noni-equilibrium processes. Chemical equilibria. Coupling of endergonic and exergonic reactions. High-energy bond.
Week 2: Cellular compartments. Amino acids - composition and structure, peptides, proteins. (Peptide bond. Proteins and polypeptides, their properties and structure. Methods of protein structure study. Proteosynthesis).
Week 3: Methods of isolation, purification and separation of proteins. Functional roles of proteins.
Week 4: Carbohydrates - monosaccharides, polysaccharides, glycoproteins. (Monosaccharides. Stereochemistry. Biologically important monosaccharides, their derivatives, oligosaccharides and polysaccharides. Glycoside bond).
Week 5: Lipids - structure and classification. Triglycerides, phospholipids. Isoprenoids.
Week 6: Biomembranes – structure and function. Membrane transport.
Week 7: Enzymology, enzyme catalysis. Substrate specificity. Cofactors. Enzyme kinetics. Inhibitors. Regulation of enzyme activity.
Week 8: Metabolic pathways. Termodynamic relationships and energy-rich components.
Week 9: Anaerobic and aerobic catabolism of glucose. Gluconeogenesis. Citric acid cycle. Anaplerotic reactions. Glyoxylate cycle. Pentose cycle. Oxidative phosphorylation. Respiratory chain.
Week 10: Transport of reducing equivalents, substrates and products of phosphorylarion. Utilization of fatty acids. Enzymologic, energetic, transport, and regulatory aspects. Photosynthetic phosphorylation and carbon fixation. Dark-reactions of photosynthesis. Fixation of CO2 in C3 and C4 plants. Photorespiration. Calvin cycle.
Week 11: Nucleic acids - structure and function. DNA, RNA.
Week 12: Nucleic acids – functions in organisms, genetic code.
Week 13: Applide biochemistry - modern biotechnology, genetic engineering.

Food technology

Objective of the course:

The aim of the subject is to provide students with basic knowledge about food technology.
Basic conceptions in food technologies are introduced. Classical and modern approached in food technologies (technology of sugar and cereals, technology of milk, meat and oils) are discussed.

Week 1: Food industry in our country. Assignation of raw materials for food industry. Characterisation of raw materials.
Week 2: Basic conceptions in food technologies. Technology of sugar and cereals. Technology of sugar production.
Week 3: Technology of cereals processing. Bakery technology. Technology processing of cocoa beans. Production of chocolate and chocolate candies.
Week 4: Technology production of biscuits, crackers and snack products, pasta production. Technology of starch and starch products.
Week 5: Technology of plant based foods. Basics of food preservation. Processed fruits and vegetables. Soft drinks.
Week 6: Technology of animal based foods. Meat technology. Poultry technology. Eggs processing. Processing of venison. Fish processing.
Week 7: Technology of milk, milk products and oils. Properties of milk, milk treatment. Pasteurisation of milk, Cheese, butter and cream production. Biological methods for prolongation durability of milk.
Week 8: Production of butter. Production of cream. Biological methods for extending shelf life of milk.
Week 9: Technology of oils, fats, detergents and cosmetics. Raw materials. Acquisition of oils, fats, refining and modification of oils and fats.
Week 10: Fermentation technologies. Principles. Raw materials.
Week 11: Viticulture.
Week 12: Brewery industry. Beer production.
Week 13: Distillery industry. Yeast production. Vinegar production.

Biochemical technology

Objective of the course:

The aim of the subject is to provide students with basic knowledge about biochemical technology. History of biotechnology, biotechnological procedures, substrates and equipments are discussed. Next, chemical, food, pharmaceutical and enviromental biotechnologies are introduced.

Week 1: History of biotechnology. Classic and modern biotechnology. The development, scope and perspectives of biotechnology. Mainly products in biotechnology.

Week 2: Microorganisms in biotechnology. Industrial microbiology. (Classification of microorganisms according to physiological properties. The basic characteritics of microorganisms. Methods isolation, mutation and storage industrial important microorganisms).

Week 3: Substrates for Biotechnology.

Week 4: Processes and equipments in industrial biotechnology. Bioreactors.

Week 5: Isolation and purification of biotechnological products. (Isolation and purification of biomolecules, isolation of proteins, denaturation, aggregation, homogenization, membrane processes,..).

Week 6: Food biotechnology I. (Brewing yeasts and fermentation, wine production, production of spirits)

Week 7: Food biotechnology II (other food technologies (milk, meat,...), genetically modified food).

Week 8: Chemical biotechnology I (enzymes, production of primary and secondary metabolites – organic acids, amino acids, lipids, proteins, ...).

Week 9: Chemical biotechnology II (continue previous lecture: production of vitamins, nucleotides, polysaccharides, solvents,...). The current status of their production in the world.

Week 10: Pharmaceutical biotechnology I.(Production of antibiotics, monoclonal antibodies, vaccines, immunosuppressive agents).

Week 11: Pharmaceutical biotechnology II. (Enzymes inhibitors, therapeutical agents for human and veterinary medicines).

Week 12: Environmental biotechnology I. (Agricultural biotechnology, fodder crops, pesticides, insecticides, silage,...)

Week 13: Environmental biotechnology II.(Biodegradation, bioremediation, phytoremediation, biopesticides).

<u>Laboratory Practice in Biology</u>

Objective of the course:

The laboratory practices include basic techniques in biology: Practical verification of properties of the microscope. Chemical composition of living cells. Cell and Environment. Basic methods of treatment of biological material before microscopy. Methods cell research. Observation of microscopic specimens of plants and animals.

Week 1: Lab overview: guidelines, safety, and report. Introduction of lab facility.Description of the microscope, the principle of the microscope, sample preparation for the microscope.

Week 2: Observation capitals, hair in different optical planes, diatoms and other unicellular organisms.

Week 3: Chemical composition of living matter. Methods of research cells (fixation, maceration, cutting, coloring). Proof of starch grains in cells of potato tubers. Proof of DNA in the cell nucleus.

Week 4: The proof of calcium in onion cells, the proof of cellulose in cellulose wadding, the proof of fat in cells of Sudan III and the proof of DNA.

Week 5: Vegetable dyes (types, function, location) and microscopic observation. Observation of chloroplasts in leafs cells and plant cell vacuoles .

Week 6: Observation of chloroplasts and plant dyes in the cells of peppers, carrots, tomatoes, apples and other fruits and vegetables. Natural pH indicators in the cell. Exam 1.

Week 7: Construction of the plant body, plant tissues, fruits and seeds.

Week 8: Observing the surface of plant leaf, tissue leaf stems, roots for the longitudinal and transverse section, observation and plotting fruits and seeds of maize, beans, wheat, rice, soy, starch grain morphology of seed storage starch.

Week 9: Animal tissues.

Week 10: Observation of permanent preparations of epithelial tissue, connective tissue - ligaments, cartilage, bone, muscle building - smooth muscle, skeletal muscle, heart muscle.

Week 11: Cell and Environment (osmosis, mitosis). Plasmolysis in plant cells.

Week 12: Osmotic value of cells. Observation of mitotic cell division. Exam 2.

Week 13: Granting credits or repair test.

Laboratory Practice in Microbiology

Objective of the course:
The laboratory practices include basic techniques in microbiology: preparation of culture media, cultivation of microorganisms, isolation of pure culture, identification of microorganisms based on macroscopic, microscopic and biochemical characteristics. Principles for the establishment of micro-organisms in food, water and environment. Growth and inhibition of microorganisms.

Week 1: Introduction to principles and laboratory methods in microbiology. Lab overview: guidelines, safety, and report. Introduction of lab facility.

Week 2: Aseptic Technique. Culture vessels, sterilization, disinfection. Preparation of nutrient media (liquid, solid, agar plates, agar slopes).

Week 3: Microorganisms in the environment. Aseptic collection and transmission of microorganisms. Isolation of pure cultures of microorganisms. Inoculation and cultivation of microorganisms.

Week 4: Introduction to microscopy. Preparation of native cell preparates, observation of living microorganisms.

Week 5: Fixation and staining microorganisms. Negative staining. Gram staining technique Microscopy of bacteria. Diagnostic staining bacteria. Gram stain. Staining of bacterial endospores.

Week 6: Microscopy of yeast. Morphology, reproduction, vegetative elements and sexual reproduction. Nature of yeast growth in liquid medium. **Exam 1.**

Week 7: Microscopy of fungi. Slide preparation. Microscopic morphological characters, types of mycelium. Morphology of reproductive structures and spores. Comprehend the diversity in structure between bacteria, yeasts and fungi.

Week 8: Methods for determining the growth of microorganisms. Enumeration of microorganism. Direct microscopic counts in counting clambers. Viable plate counts - colony forming units (CFU).

Week 9: Effect of temperature, effect of UV light and other factor on growth of microorganisms.

week 10: Metabolic activity of bacteria, biochemical tests and tests used for microbial sensitivity to antibiotics.

Week 11: Mutation. Mutagens.

Week 12: Transformation of cells *Escherichia coli* with plasmid DNA. Exam 2.

Week 13: Granting credits or repair test.

Laboratory Practice in Biochemistry

Objective of the course:
The laboratory practices include basic biochemical methods for identification and determination of various biologically important molecules. Determination of protein, carbohydrates, lipids and certain vitamins. Isolation of enzymes and determination of enzyme activity.

Week 1: Introduction to principles and laboratory methods in biochemistry. Lab overview: guidelines, safety, and report.

Themes of lab for Biochemistry
1. Spectrophotometric methods in biochemistry
1.1. Determination of carbohydrates several different methods and their comparison
1.2. Determination of proteins by various methods and their comparison
1.3. Isolation and determination of leaf colors

2. Using the properties of biologically important molecules in their assessment
2.1. Determination of L-ascorbic acid (vitamin C)

3. Enzymes
3.1. Isolation, purification and determination of alpha-amylase activity of malt
3.2. Isolation, purification and determination of catalase activity of beef liver. Effect of substrate concentration on activity enzyme.
3.3. Determination of kinetic parameters of glucose 6-phosphate dehydrogenase

4. Lab for Biochemistry – second part
4.1. Isolation of protein from milk and their identification by electrophoresis in polyacrylamide gel
4.2. Isolation of plasmid pTZ57R / T alkaline lysis of the bacteria E. coli DH5 alpha.
4.3. Working with cells and isolated cell organelles. Preparation of chloroplasts and observation of the Hill reaction.

Laboratory Practice in Food Analysis

Objective of the course:
The aim of the laboratory exercises is to gain practical experience and knowledge in methods of determining nutrients, contaminants in foodstuffs and methods of sensory analysis.

Week 1: Introduction to principles and laboratory methods in food analysis. Specific methods used in food analysis, collection and processing of samples.

Themes of lab for Food Analysis

Physical methods of water determination, determination of water activity.
Chemical methods of water determination.
Determination of proteins.
Determination of digestible protein, analysis of individual protein species.
Determination of amino acid composition of proteins - sample preparation.
Analysis of free amino acids.
Specific methods for the determination of amino acids, the use of enzymatic methods.
Determination of saccharides – processing of samples, physical methods of saccharides determination.
Chemical methods of reducing sugars determination - stoichiometric and non-stoichiometric reactions.
Enzymatic methods of sugars determination.
Determination of polysaccharides.
Determination of pulp and other carbohydrates.
Isolation and determination of total lipids - comparison of different methods.
Determination of phospholipids.
Determination of total sterols, analysis of cholesterol and other sterols.
Determination of the representation of fatty acids in lipids.
Determination of indicators of lipids yellowing.
Determination of stability against auto-oxidation of fats.
Determination of vitamins (B1, B2)
Determination of vitamins – vitamin PP, B3, B5, B6, H, B12
Determination of ascorbic acid – using of spectrophotometric, chromatographic and electrochemical methods and by titration.
Determination of vitamines – A, D, E, K.
Treatment of samples for determination of minerals and trace elements.
Classification of methods for determination of minerals and trace elements.
Determination of K, Na, Ca and Mg.
Determination of S, P, Cl.
Determination of Fe, Zn, Cu.
Determination of Pb, As, Se, Hg, Cd.
Determination of macroelements.
Methods od identification and quantification of senzoric active compounds.
Determination of tannins.
Determination of natural dyes (anthocyanins, carotenoids, chlorophyll).
Determination of preservatives.

Determination of antioxidants, sweeteners, synthetic dyes.
Determination of mycotoxins and nitrosamines.
Basic steps for determining pesticide residues.
Basic steps for determining polychlorinated biphenyls residues.
Senzoric analysis.

Part 2: Chemical Engineering Laboratory

Contents

Item	Apparatus	Description	Specification
	Momentum Transport		
1	Fluid Friction Measurements	Friction head losses in straight pipes of different sizes can be investigated over a range of Reynolds' numbers from 10^3 to nearly 10^5, thereby covering the laminar, transitional and turbulent flow regimes in smooth pipes and in an artificially roughened pipe. In addition a wide range of accessories are standard including pipe fittings and control valves, a Venturi tube, an orifice plate assembly and a Pitot tube. An arrangement of six pipes provides facilities for testing the different fittings. The Fluid Friction Measurements unit provides facilities for the detailed study of fluid friction head losses which occur when an incompressible fluid flows through pipes, fittings and flow metering devices. Enhancing understanding of the hydraulic principles is involved through the use of complementary computer software.	C6MKII Fluid Friction Measurements The unit is designed for use with the F1-10 Hydraulics bench
2	Multi-Pump Test Rig	The rig demonstrates the operating characteristics (head-flow curves and efficiency) of a series of different types of pumps - centrifugal, gear, axial, plunger. Up to four pumps can be accommodated within the rig simultaneously for use within a single laboratory period, and each can be run without disconnecting any pipework or connections.	C3 MKII Multi-Pump Test Rig
3	Filtration Unit	The unit demonstrates the principles of batch filtration using a fully functional plate and frame filter system with both constant pressure and constant flow operating modes. The experimental data allow mass balancing and determining important criteria for scale-up.	UOP12 Filtration Unit

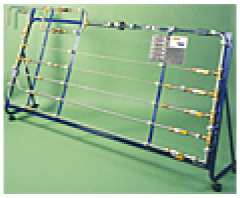
	Heat Transport		
4	Computer Controlled Heat Exchanger Service Module	A range of small scale heat exchangers, designed to illustrate the principles and techniques of indirect heat transfer between fluid streams. Different types of small scale heat exchanger can be mounted on a common bench-top service unit. The equipment is controlled by personal computer, which serves as the operator interface. Full data logging, control and educational software is supplied with the equipment. In addition, the equipment has been fitted with failsafe systems, including a watchdog circuit, which allows for safe operation from a remote computer. The service unit provides two fluid streams to the heat exchanger, a hot water stream and a cold water stream. The hot water stream is heated in a vessel fitted with an electric heater. The pump speed and direction are under software control, allowing for co-current and counter-current investigations over a wide range of flow rates. The cold water stream is generated from a mains water supply. Conditioning circuits for up to 10 K-type thermocouples are included. The instrumentation also includes flowmeters to measure the flow rates of the two fluid streams.	HT30XC Computer Controlled Heat Exchanger Service Module
4a	Shell and Tube Heat Exchanger	Heat is transferred between one fluid flowing through the tubes and another fluid flowing through the cylindrical shell around the tubes. A miniature shell and tube heat exchanger for use with an Armfield Heat Exchanger Service Unit comprises an outer shell and 7 internal tubes. There are two transverse baffles inside the shell. Four temperature sensors are supplied in tappings at fluid inlets and outlets.	HT33 Shell & Tube Heat Exchanger

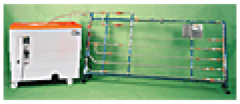
		The heat exchanger is constructed from stainless steel tube and clear acrylic outer annulus, end caps and baffles.	
4b	Reconfigurable Plate Heat Exchanger	The HT32 has a single heating section configured for multi-pass operation with passes in series. It comprises seven individual plates, which can be reassembled to the heat exchanger with only three plates to demonstrate a single pass. HT37 - Extended Reconfigurable Plate Heat Exchanger is designed to be reconfigurable by the student, and can accommodate up to four sections of heating	HT32/HT37 Plate Heat Exchangers
5	Vapour-Compression Refrigeration Unit	A PC controlled system with automatic recording of process variables. Compressor speed nad torque can be logged continuously. Condenser and evaporator use plate heat exchangers with water as the heat transfer medium allowing complete energy balance	RA1 Vapour-Compression Refrigeration Unit
	Mass Transport		
6	Batch Distillation Column	Self-contained sieve plate distillation column unit including reboiler, condenser and reflux tank. Temperatures on each and every sieve plate are monitored and displayed as well as the power supplied to the reboiler heater and reflux ratio settings between 0 and 100%. The 50mm diameter sieve plate column may be readily interchanged with a packed column supplied as an alternative. Experimental capabilities: pressure drop across the column as a function of boil-up rate, column efficiency as a function of boil-up rate, at total reflux, distillation at constant reflux ratio: variation of top product composition with time	UOP3BM Batch Distillation Column (Manual)
7	Liquid/Liquid Extraction Unit	The equipment consists of a glass liquid/liquid extraction column packed with Raschig rings	UOP5 Liquid/Liquid Extraction Unit

		together with an integral distillation column for solvent recovery. Sensing electrodes and a solenoid valve control the level of the water/solvent interface at the top or bottom of the column as required. Demonstration capabilities: > hydrodynamics of liquid/liquid systems > continuous or semi-continuous > operation with organic or aqueous phase as the continuous phase > evaluation of test mixtures for industrial study > mass balances	
8	Gas Absorption Column	The packed absorption clear acrylic column of 75mm diameter is filled with 10mm x 10mm glass Raschig rings which are representative of the type of packing used in gas absorption. A centrifugal pump is used to deliver the liquid to the top of the column. The gas to be absorbed is normally carbon dioxide. This gas passes through a calibrated variable area flow meter and is mixed with an air stream also of known flow rate from a rotary compressor positioned in the framework. Carbon dioxide content of the gas samples is determined using a Hempl apparatus. Demonstration capabilities: Production of mass balances for a packed absorption column, method of transferring units, including calculation of NTU and HTU, determination of the Mass Transfer Coefficient, study of the hydrodynamic characteristics of a packed column, determination of loading and flooding points	UOP7 Gas Absorption Column
9	Water Cooling Tower	Water Cooling Tower includes both the simulated heating load and the circulating pump. Supplied with one standard packed column, dimensions 150mm x 150mm x 600mm, comprising 10 plates.. Experimental capabilities: Observation of water flow pattern and distribution with various water and air flow rates, performance and flow measurements, use of psychrometric charts, application of the	UOP6 Basic Water Cooling Tower

		steady flow equation, energy balances, investigation of performance for different loads and different temperatures.	
10	Tray Drier	This small scale tray drier dries solids by passing a stream of hot air over trays of wet material in the compartment measuring 300x300x400mm. Controls mounted on a panel at the fan end of the tunnel permit variation of air speed and heater power to vary temperature through the drier. Capabilities include: demonstration of drying rate regimes, effect of temperature and air flow rate on drying rate, mass and energy balancing and the use of psychrometric charts.	UOP8 Tray Drier

1. C6MKII Fluid Friction Measurements - Issue 1





The Armfield Fluid Friction Measurements unit provides facilities for the detailed study of fluid friction head losses which occur when an incompressible fluid flows through pipes, fittings and flow metering devices. The unit is designed for use with the Armfield F1-10 Hydraulics bench.

Pipe friction is one of the classic laboratory experiments and has always found a place in the practical teaching of fluid mechanics.

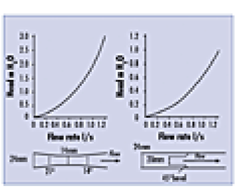
With this unit friction head losses in straight pipes of very different sizes can be investigated over a range of Reynolds' numbers from 103 to nearly 105, thereby covering the laminar, transitional and turbulent flow regimes in smooth pipes.In addition an artificially roughened pipe is supplied which, at the higher Reynolds' numbers, shows a clear departure from the typical smooth bore pipe characteristics.

In addition to the equipment for the study of losses in straight pipes, a wide range of accessories are standard including pipe fittings and control valves, a Venturi tube, an orifice plate assembly and a Pitot tube.

An arrangement of six pipes provides facilities for testing the following:

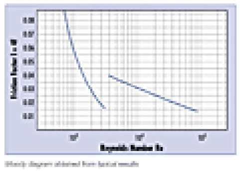
> 4 smooth-bore pipes of different diameters
> artificially roughened pipe
> 90° bends (large & small radii)
> 90° elbow
> 90° mitre
> 45° elbow
> 45° Y
> 90° T
> sudden enlargement
> sudden contraction
> gate valve
> globe valve
> ball valve
> inline strainer
> Perspex Venturi
> Perspex orifice meter
> Perspex pipe section with a Pitot tube & static tapping

test and published results comparison



Examples of typical results obtained by comparing test data with published results

Moody diagram obtained from typical results



Short samples of each size test pipe are provided loose so that the students can measure the exact diameter and determine the nature of the internal finish. The ratio of the pipe diameter to the distance of the pressure tappings from the ends of each pipe has been selected to minimise end and entry effects. A system of isolating valves is provided whereby the pipe to be tested can be selected without disconnecting or draining the system. The arrangement allows tests to be conducted on parallel pipe configurations.

An optional floor standing hydraulics bench incorporates a sump tank and volumetric flow measurement facility. Rapid and accurate flow measurement is possible over the full working range of the apparatus. The level rise in the measuring tank is determined by an independent sight gauge. A 250ml capacity glass measuring cylinder is supplied for measuring the flow rate under laminar conditions (very low flows).

Each pressure tapping is fitted with quick action self-sealing connections. Probe attachments with an adequate quantity of translucent polythene tubing are provided so that any pair of pressure tapings can be rapidly connected.

SPECIFICATION

> A unit for the detailed study of fluid friction head losses which occur when an incompressible fluid flows through pipes, fittings and flow metering devices.

> A substantial floor standing tubular steel frame supports test circuits comprising:

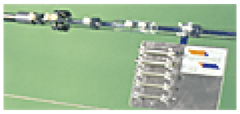
- 4 smooth-bore pipes of different diameters ranging from
4.5mm I.D. to 17.2mm I.D.
- artificially roughened pipe
- 90° bends (large & small radii)
- 90° elbow
- 90° mitre
- 45° elbow, 45° Y, 90° T
- sudden enlargement
- sudden contraction
- gate valve
- globe valve
- ball valve
- inline strainer
- perspex Venturi
- perspex orifice meter
- perspex pipe section with a Pitot tube & static tapping
- 38 tapping points

> Suitable for studying Reynolds' numbers from 10^3 to nearly 10^5
> A system of isolating valves, quick release manometer connection valves and self-sealing pressure tappings ensure fast accurate results
> Data logging accessory available
> Computer aided learning program available
> A user instruction manual provides installation, commissioning and maintenance data, together with student exercises.
> The unit is designed for use with the F1-10 Hydraulics bench

Technical details

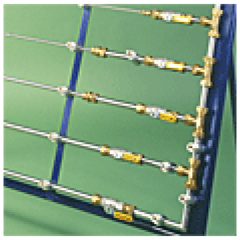
Test pipes:

Clear acrylic pipe section and test pipe samples



Diameter:
1. 19.1mm O.D. x 17.2mm I.D.
2. 12.7mm O.D. x 10.9mm I.D.
3. 9.5mm O.D. x 7.7mm I.D.
4. 6.4mm O.D. x 4.5mm I.D.
5. 19.1mm O.D. x 15.2mm I.D. (Roughened)

Control valves and pressure tapings



Distance between tappings: 1m
Number of tapping points: 38

Ordering Options

C6MKII-10: Basic Fluid Friction Measurements

This comprises the framework containing the pipes and fittings. It requires an Armfield F1-10 Hydraulics bench plus an instrumentation system (see below).

C6MKII: Fluid Friction Measurements

This comprises the C6MkII-10 described above, plus a hydraulics bench.
An instrumentation option is required (see below).

Instrumentation options

Manual Data Acquisition

In order to complete the full range of experiments possible with the C6MkII, it is necessary to measure pressures over a greater range than a single instrument can provide. Armfield recommend the use of a water manometer for the low pressure measurements and an electronic pressure meter for the high pressure measurements.

Order codes:

H12-2: One metre pressurised water manometer
H12-8: Hand held digital pressure meter

Also available for use with manual data acquisition instruments is a software package which performs all the necessary calculations from readings entered manually.

Order code:C6-301: Educational software (manual data entry)

Instructional Capabilities

A wide range of measurements, demonstrations and training exercises are possible with the equipment:

> confirming the relationship between head loss due to fluid friction and velocity for flow of water
> determining the head loss associated with flow through a variety of standard pipe fittings
> determining the relationship between pipe friction coefficients and Reynolds' number for flow through a pipe with roughened bore
> demonstrating the application of differential head devices in the measurement of flow rate and velocity
> providing practical training of pressure measurement techniques
> enhancing understanding of the hydraulic principles involved through the use of complementary computer software

Recommended Instruments

Stop watch
Vernier calliper

Optional Accessories

F1-10: Hydraulics bench
H12-8: Digital pressure meter
H12-2: 1m pressurised water

Shipping specification

C6-MkII-10
Gross weight 165kg
Volume 1.4m^3

C6-MkII
Gross weight 325kg
Volume 2.9m^3

Overall dimensions

C6-MkII-10
Height: 1.10m
Width: 2.25m
Depth: 0.43m

2. C3 MKII Multi-Pump Test Rig

The Armfield Multi-Pump Test Rig demonstrates the operating characteristics (head-flow curves and efficiency) of different types of pumps, each having a broadly similar input power.
The rig can accommodate both rotodynamic and positive displacement pumps up to four devices within the rig simultaneously for use within a single laboratory period, and each can be run without disconnecting any pipework or connections.

The equipment comprises a water reservoir, and five pump positions, (four active). Each pump position uses pipework and sensors optimised to the type of pumps it is intended for.
Positions (from right to left) 1, 2a and 2b are optimised for high flows at low heads, such as the rotodynamic pumps whereas positions (3) and (4) are suitable for lower flows but higher pressures, as obtained from the positive displacement pumps.
To switch between any of the four installed active pumps, (or series/parallel configuration) is simple, requiring only isolating valve changes and control panel selection.
A PLC control panel is used to allow the correct combination of suction, head, flow, pump speed and torque to be unambiguously displayed for the selected pump test.

Specification

• A self contained multi-pump test rig, containing all the services and instrumentation for determining the characteristic curves of different pumps at different speeds
• Series/parallel pump demonstations can be performed with the second centrifugal pump option
• Control valve incorporated upstream of each pump (except axial pump) to demonstrate the effect of suction loss on performance
• Electronic torque measurement using a state of the art sensorless vector drive
• Electronic measurement of flow, pressure head and suction
• Optional volumetric flow measurement system for reciprocating pumps
• Optional data logging and educational software.

Technical details

C3-MkII-20 Centrifugal Pump

A brass bodied Centrifugal pump with plastic Impellor and Stainless steel shaft. Maximum flow 145 l/min and maximum head 11 m.

?C3-MkII-20SP Second Centrifugal Pump

A second Centrifugal pump, identical to C3-20, and including the additional valves required to perform a Series/Parallel pump demonstration.

C3-MkII-21 Gear Pump

A corrosion resistant bronze bodied gear pump, with stainless steel shafts and bronze helical gears for quiet operation.Maximum flow 16 l/min and maximum head 70 m.

?C3-MkII-22 Axial Flow Pump

A purpose designed axial flow pump, housed in a clear acrylic casing.
Maximum flow 75 l/min and maximum head 1.2 m.

C3-MkII-26 Plunger Pump
(also requires C3-MkII-40 volumetric measurement system)

A plunger pump with stainless steel wetted parts, with a bore of 34mm (1 3/8 inch) and a stroke of 25 mm (1 in).Maximum flow 5.3 l/min at maximum head of 80 m.

Each pump accessory comes on its own baseplate, assembled complete with all pipes, valves and fittings to allow it to be easily fitted to the C3-MkII. Different types of fitting are used for different positions in order to help prevent incorrect fitting.

C3-MkII-40 Volumetric Measurement System

The reciprocating pump (C3-MkII-26) is not suitable for electronic flow measurement due to the pulsating nature of the flow. To accurately measure the flow rate from these pumps requires a Volumetric Measurement System, where the volume of water flowing over a period of time can be measured. The C3-MkII-40 is a water column of 8 litres capacity, with a vertical scale. The bottom of this column is connected to the input of the reciprocating pump, and the time taken for the water level to change between 2 points is measured.

C3-MkII-304IFD Data Logger and Educational Software

The data logger and education software option allows the results to be logged to a Windows PC (not supplied) via a USB port. A wide range of data logging, data display and graph plotting options are available.

Demonstration Capabilities

> Determining the performance of different types of pumps at constant speed by producing a set of characteristic curves

For rotodynamic pumps:

• Pressure head v flow

• Power absorbed v flow

• Pump efficiency v flow

For positive displacement pumps:

• Flow v pressure head

• Power absorbed v pressure head

• Volumetric efficiency v pressure head

> Determining the effect of speed on the performance of pumps

> Understanding the difference between rotodynamic pumps and positive displacementpumps

> Understanding the effect of system resistance

> Investigating the effect of suction losses on a centrifugal pump

> Demonstration of the effect of running two centrifugal pumps in series andparallel (Requires C3-MkII-20SP)

> Understanding the characteristics of a reciprocating pump

Requirements

Electrical Supply:

C3-MKII-A 220-240V, 50Hz, 10 Amps

C3-MKII-B 110-120V, 60Hz. 20 Amps

C3-MKII-G 220-240V, 60Hz, 10 Amps

Water:

Clean water: 100 litres (initial fill only, no permanent connection required)

Shipping specification

Volume 3.4m^3

Gross weight: 550kg

Overall dimensions

Length: 2.10m

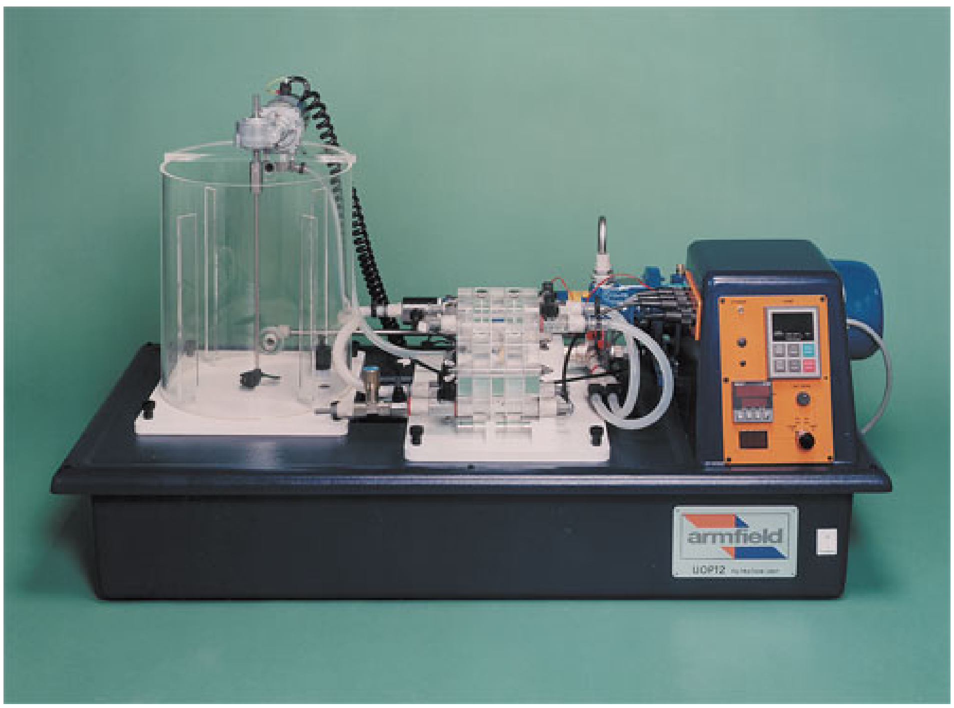
Height: 1.48m

Depth: 0.75m

3. *UOP12 Filtration Unit*

BATCH FILTRATION WITH THE PLATE AND FRAME FILTER UNIT

Filtration is an extremely important unit operation being used by industries such as chemical, food and water treatment.
The filtration unit demonstrates the principles of batch filtration using a fully functional plate and frame filter system. A continuous, tangential flow microfiltration unit using a hollow fibre filtration cartridge (a membrane technology application) is available as an option. Both types of filter are widely used in the commercial world.
The practical training exercises are appropriate to chemical and all other process related engineering courses, including technician training. An economic investigation allows the student to take experimental data and to use it to help make decisions on the size and the operation of a filtration plant in order to meet economic and output targets.



UOP12 is a bench top unit designed to introduce students to the fundamentals of solid/liquid filtration. The apparatus consists of an acrylic feed tank connecting to a progressing cavity pump which feeds a slurry to the acrylic plate and frame filter press. A pressure sensor on the output of the pump measures the filtration pressure.
The filter press consists of 2 end plates, 2 frame plates and a wash plate. The plate and frame filter unit uses nylon as the filter medium. The unit is constructed in clear acrylic which enables the entire filtration process to be observed. The filtrate passes through an optical sensor which determines the efficiency of the filtration process. Filtrate temperature is also measured. The second inlet to the filter is for mains water for filter cake washing. A second pressure sensor and a needle valve control the water pressure during the washing cycle. A 3-way valve allows filtrate to be returned to the feed tank or to a filtrate vessel/drain.

Diagram of flow path through the plate and frame filter

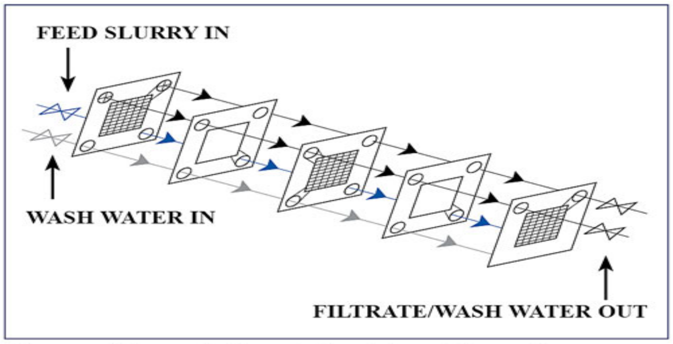


Diagram of flow path through the plate and frame filter.

Specification

• A bench top unit comprising a vacuum formed ABS plastic plinth with integral electrical console on to which is mounted the filtration system.
• A plate and frame batch filter (separation area 230 cm^2) is supplied as standard. Both constant flow rate and constant pressure operation are possible.
• A controller enables constant pressure operation by controlling the speed of the feed pump.
• The progressing cavity feed pump enables constant feed rate operation.
• An optional tangential flow hollow fibre microfiltration cartridge (plus pre-filter and shell and tube heat exchanger) can be fitted. The hollow fibre cartridge has a separation area of 110 cm^2 and a cut-off of 0.2 µ-m.
• Feed flow rate can be varied between 0 and 130 litres/hour.
• The console contains a pump motor control and display panel.
• A separate controller displays the filter inlet pressure and is used to control the pump speed. Another digital meter displays, via a selector switch, either outlet pressure, permeate pressure, temperature or optical absorbence.
• An optical absorbence sensor is provided for on-line and off-line monitoring of the filtration process. It is also used to monitor the efficiency of filter cake washing operations.
• All electrical sensors: pressure, optical absorbence, temperature and the feed pump flow rate can be logged using a PC (optional teaching software available).
• An optional interface device and educational software package is available.
• Water and calcium carbonate are the recommended working materials for reasons of safety and ease of use.
• A comprehensive instruction manual is included with a range of fully detailed laboratory teaching exercises.

Capabilities

> Demonstrating filtration through membrane technology
> Understanding the principles of batch filtration using both constant pressure and constant flow operating modes
> Mass balancing
> Demonstration of precoat filtration
> Optimisation of filtration performance using body aid
> Demonstration of Darcy's Law
> Determination of medium and cake resistances
> Effect of body aid on medium and cake resistances
> Filter cake washing and dewatering
> Determining important criteria for scale-up
> Economic optimisation of filtration operations

Optional Accessories

UOP12-10 - Tangential flow filter accessory

UOP12-304IFD - Educational Software and data logging accessory

(requires a Windows computer with a USB port).

Requirements

Single phase mains electrical supply:

UOP12-A: 220/240V/1ph/50 Hz @ 10A
UOP12-B: 120V/1ph/60Hz @ 15A
UOP12-G: 220V/1ph/60Hz @ 10A

Optional mains water supply:

3 litres/min @ 2 bar,

Optional pressurised air supply:

@ 2 bar.

Shipping specification

Volume: $0.50m^3$
Gross weight: 50kg

Overall dimensions

Height: 600mm
Width: 1.1m
Depth: 500mm

4. HT30XC Computer Controlled Heat Exchanger Service Module - Issue 2

A range of small scale heat exchangers, designed to illustrate the principles and techniques of indirect heat transfer between fluid streams. Different types of heat exchanger can be mounted on a common bench-top service unit. Small scale versions of commonly used industrial heat exchangers are available (including plate, tubular and 'shell and tube') for analysis and comparison. The equipment is controlled by a user supplied personal computer, which serves as the operator interface. Full data logging, control and educational software is supplied with the equipment. In addition, the equipment has been fitted with failsafe systems, including a watchdog circuit, which allows for safe operation from a remote computer.

Key Features

> Small scale, bench top equipment
> Fast response times allow in depth investigations in a short time
> Representative of industrial heat exchangers
> Multiple, industrially representative heat exchangers available
> All functions computer controlled, including reversing of one of the fluid streams for co-current and counter-current investigations
> Standard USB interface
> Safety functions implemented to allow for remote operation by computer
> Full educational software with data logging, control, graph plotting, and detailed 'Help'
> Suitable for project work. The service bench provides facilities for evaluating in-house heat exchanger designs

Description HT30XC Service Unit

The HT30XC is a service unit, to allow the operation of one of the Armfield range of small scale heat exchanger systems. It provides controlled cold water flow, bi-directional hot water flow and the instrumentation required to do a series of in-depth investigations into heat exchanger performance. The individual heat exchangers can be quickly changed over, to allow comparisons between different types of heat exchanger to be made.

The HT30XC requires a user supplied personal computer for the operator interface. The interface to this computer is USB, allowing for simple interfacing and setting up. Once the appropriate heat exchanger has been installed and set up, all other functions can be performed under computer control. Appropriate measures have been implemented so that in the case of a computer failure or communications breakdown, the system shuts itself down in a safe manner.

Hardware Description

The service unit provides two fluid streams to the heat exchanger, a hot water stream and a cold water stream. The hot water stream is heated in a vessel fitted with an electric heater. The heater is switched on and off by a solid state relay (SSR) which is under software control. A thermostat limits the maximum water temperature to 85°C for operator safety. A gear pump circulates water from the vessel, through the heat exchanger and back into the heater vessel. Both the pump speed and direction are under software control, allowing for co-current and counter-current investigations over a wide range of flow rates.

The cold water stream is generated from a mains water supply. The flow through the heat exchanger is adjusted by a variable flow valve, again under software control. A manually adjustable pressure regulator is used to minimise the effect of mains pressure fluctuations.

Conditioning circuits for up to 10 K-type thermocouples are included, (the thermocouples themselves are supplied with the heat exchangers). The instrumentation also includes flowmeters to measure the flow rates of the two fluid streams.

Switching on the unit puts it into ‘Standby’ mode. From this mode it is necessary for a regular series of pulses to be received from the software (via the built in USB interface) to fully power up the unit. This ensures that unless the control software is running, the heaters, the pump and the cold water control valve cannot be switched on. The unit also includes an emergency stop switch. All electrical circuits are located in a bench mounted ABS supporting base, and protected by a Residual Current Device for operator safety. The ABS base includes a drip tray and drain tap in case of water spillage or leakage.

Software Description

Full educational software is provided with the HT30XC for all the Armfield heat exchangers. Separate programs are provided for each exchanger, and each program contains a selection of separate exercises that can be performed. The actual details are exercise specific, but typically the following interfaces are available:

- All the temperatures and flow rates are displayed on a diagrammatic representation of the equipment.
- A software ‘button’ switches the equipment from ‘standby’ mode to fully on.
- The cold water flow control valve is operated by using up/down arrows or typing in a value between 0 and 100%. The actual flow rate can be read directly in L/min.
- The hot water flow rate is set by entering a required set point into a PID control function. This use of PID control ensures the flow is stable despite changes in the viscosity of the water due to heating.
- The heater is again controlled in a PID loop, by setting a required temperature set point.
- Data from the sensors is logged into a spreadsheet format, under operator control.
- Sophisticated graph plotting facilities are provided. Comparisons between data taken on different runs can be displayed.
- Student questions and answers, including a layered ‘Hint’ facility.
- Processing of measured values to obtain calculated values (this can be linked to the questions and answers to ensure student understanding).
- The data samples (measured and calculated) can be saved, or exported directly in Microsoft Excel format.
- Data from the sensors can be displayed independently from the data logging. This can be in bar graph format, or a recent history graphical display (useful to check for temperature stability prior to taking a sample).
- Presentation screens are available, giving an overview of the software, the equipment, the procedure and the associated theory. This is backed up by a detailed ‘Help’ facility giving in-depth guidance and background information.

User Defined Software and/or Remote Operation

Included separately on the software CD are the ‘drivers’ required to allow other software applications to communicate with the HT30XC via the USB interface. This allows users to write their own software instead of using the Armfield provided software. This software can be written in many different systems. Typically LabView, MatLab, ‘C’, ‘C++’, Visual Basic, Delphi, and any other software environment which allows calls to external drivers can be used.

In this way the user can write software to suit their specific requirements, in an environment which they are fully familiar with and which is compatible with their other equipment.

An extension of this methodology allows the equipment to be operated remotely, such as over a Local Area Network (LAN) or even over the internet. The HT30XC is ideal for this remote operation as it has been designed to ensure that the unit shuts down safely in the event of a communications failure. It has also been designed so that once the heat exchanger has been installed and configured, all the controls to perform a series of investigations are under software control, and so the student does not need to be present with the equipment.

In a typical installation, the HT30XC would be connected to a local PC via the USB bus. The local PC would be connected to the users’ PC’s via the LAN. The operator interface software would be run on the remote (users) PC and communicate to the control software on the local PC. (Armfield do not provide the software to implement this type of system).

For remote use, the appropriate heat exchanger would be installed onto the service unit, and the cold water pressure regulator adjusted to match the heat exchanger to the cold water supply. The unit is then switched on and remains in ‘Standby’ mode until appropriate software is run requesting the unit to power up fully. With the HT31, HT32 and HT33, Heat Exchangers, all functions can then be operated remotely. The HT34, HT36 and HT37 Heat Exchangers can be configured in different ways, and so the required configuration has to be manually implemented locally. However once this has beendone, a full set of investigations can be performed for that configuration, including co-current and counter-current flows.

Specification

• Bench top service unit, designed to accommodate a range of different small scale heat exchangers.

• Comprises hot water vessel, hot water recirculation pump, cold water control system, computer interface and all necessary instrumentation.

• The hot water vessel is made from clear acrylic (for visibility) and includes a 2kW heater with thermostatic over-temperature cut-out and low water level detection.

• The hot water pump is bi-directional (to allow co-current and counter- current investigations without re-configuring the hardware) and the flow rate is under computer control.

• The cold water system includes a manually adjustable pressure regulator and a flow control valve which is under computer control.

• Flow rates for both fluid streams in excess of 5L/min are achievable, but this may be restricted by some designs of heat exchanger (e.g. HT32 & HT36 Plate Heat Exchangers).

• Up to 10 temperatures (K-type thermocouples) can be monitored using the service unit. Operating range, 0-75°C, resolution 0.1°C.

• Two flow meters are included, operating range 0.2 to 9 L/min resolution 0.1L/min

• All data is available to a (user supplied) Windows PC, via a USB interface. This computer is also used to control the flow rates, hot water temperature, and hot water direction.

• Full software for educational use is included.

• A comprehensive instruction manual is included.

Heat Exchanger Options

A wide selection of heat exchanger options are available for use with the HT30XC, ranging from simple exchangers to demonstrate co-current and counter-current flow, to reconfigurable systems with interim temperature measurements, capable of being used for in-depth heat exchanger analysis. The heat exchangers are easily interchanged, with quick release fittings on the flexible interconnecting tubes, and a simple location system using thumbscews to secure the exchangers onto the service unit.

Instructional Capability

Training exercises which are common to each of the heat exchangers when used with the HT30XC:

- Demonstration of indirect heating/ cooling by transfer of heat from one fluid stream to another when separated by a solid wall.
- Energy balance determination (heat balance) and calculation of efficiencies by measuring the flow rates and temperature changes in the hot and cold fluid streams.
- Introduction to different styles of heat exchanger and comparison of the differences in operation and performance.
- Using the Logarithmic Mean Temperature Difference (LMTD) in heat transfer calculations.
- Definition and measurement of Overall Heat Transfer Coefficient (U).
- Demonstration of the differences between counter-current and co-current operation, (not relevant for

some HT34 configurations).
- Demonstration of the transition from linear to turbulent flow.
- Effect of hot and cold fluid flow rate on the heat transfer coefficient.
- Effect of driving force (temperature differential) on the heat transfer coefficient.
- Investigation of heat loss and reduction in heat transfer coefficient due to fouling of the heat transfer surfaces (suitable student project using user induced. fouling).

Additional training exercises using the HT36 Extended Tubular Heat Exchanger:

- Demonstration of temperature overlaps between fluid streams in countercurrent operation.
- Temperature profiles along the effective length of the heat exchanger in both counter-current and co-current operation
- Comparing the effect of different heat transfer areas.

Additional training exercises using the HT37 Extended Reconfigurable Plate Heat Exchanger:

- Temperature profiles along the effective length of the heat exchanger in both counter-current and co-current operation.
- Demonstration of temperature overlaps between fluid streams in counter-current operation.
- Use of LMTD correction factor when calculating the Overall Heat Transfer Coefficient.
- Comparing the effect of different heat transfer areas.
- The use of a regeneration stage for energy efficiency, when heating and subsequently cooling a product stream.
- Project work to implement a wide variety of plate configurations, giving series, parallel and combined fluid passes.

Additional training exercises using the HT34 Jacketed Vessel:

- Introduction to heat exchange in a batch or continuously fed stirred vessel and comparison of the differences in operation and performance when using a heating jacket or heating coil.

- Effects of stirring and vessel contents (volume) on the heat transfer characteristics.

Additional training exercises using a user provided heat exchanger:

- Any of the above exercises can be performed, where appropriate, using a user provided heat exchanger having appropriate characteristics, dimensions and fittings. The service unit will support evaluation of experimental heat exchangers constructed as design exercises by students.

Essential/Optional Equipment

The user must have access to a PC with a free USB port, running Windows 98, or later.

At least one heat exchanger module is required, additional heat exchangers are optional.

Requirements

Single phase mains electricity supply:

HT30XC-A: 230V, 50Hz, 10Amp
HT30XC-B: 115V, 60Hz, 20Amp
HT30XC-G: 230V, 60Hz, 10Amp

Cold water supply and drain:

5 Litres/minute at 1bar Gauge (Min)

Shipping Specification

Volume: $0.33m^3$

Gross weight: 33kg

Overall dimensions

Height: 0.45m (service unit only)
Width: 1.0m
Depth: 0.5m

4a. HT33 Shell & Tube Heat Exchanger - Issue 1

The shell and tube heat exchanger is commonly used in the food and chemical process industries. This type of exchanger consists of a number of tubes in parallel enclosed in a cylindrical shell. Heat is transferred between one fluid flowing through the tubes and another fluid flowing through the cylindrical shell around the tubes.

The miniature exchanger supplied is designed to demonstrate liquid to liquid heat transfer in a 1-7 shell and tube heat exchanger (one shell and 7 tubes with two transverse baffles in the shell).

Specification

• A miniature shell and tube heat exchanger for use with an Armfield Heat Exchanger Service Unit.
• Comprises an outer shell and 7 internal tubes. There are two transverse baffles inside the shell.
• Four temperature sensors are supplied in tapings at fluid inlets and outlets.
• The heat exchanger is constructed from stainless steel tube and clear acrylic. It is mounted on a PVC baseplate which is designed to be installed on the plinth of the Heat Exchanger Service Unit without the need for tools.
• The stainless steel tubes can be removed from the heat exchanger for cleaning.
• A comprehensive instruction manual is included.

Technical Details

The accessory consists of a miniature shell and tube heat exchanger with the following features:

- Hot fluid in the inner tubes and cold fluid in outer shell to minimise heat loss from the exchanger without the need for additional insulation.
- Seven stainless steel tubes, 6.35mm OD.
- The outer annulus, end caps and baffles constructed from clear acrylic to allow visualisation of the heat exchanger construction and minimise thermal losses.
- Nominal combined heat transfer area of 20,000mm2, (equivalent to that of the HT31 Tubular Heat Exchanger for direct comparison).
- Cold fluid (cold water) enters one end of the shell at the bottom and exits at the opposite end at the top having flowed over and under two transverse baffles inside the shell.

- Thermocouples are installed at the following 4 locations:
• Hot fluid
• Hot fluid outlet
• Cold fluid inlet
• Cold fluid

Essential Armfield Accessories

HT30XC or HT30X Heat Exchanger Service Unit

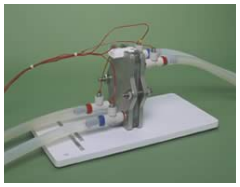
Shipping Specification

Volume: 0.06 m^3
Gross Weight 5 kg

Overall dimensions

Height 0.19m
Width 0.43m
Depth 0.39m

4b. HT32/HT37 Plate Heat Exchangers - Issue 1



HT32 - Plate Heat Exchanger

HT37 - Extended Reconfigurable Plate Heat Exchanger

The plate heat exchanger is extremely versatile and commonly used in the food and chemical processing industries where different combinations of plates and gaskets can be arranged to suit a particular application. The miniature exchanger supplied consists of a pack of plates with sealing gaskets held together in a frame between end plates. Hot and cold fluids flow between channels on alternate sides of the plates to promote heat transfer.

HT32 - Plate Heat Exchanger

The HT37 is designed to be reconfigurable by the student, and can accommodate up to four sections of heating, each section providing an additional temperature measurement point for each fluid stream. In order to make the unit easy to reconfigure, these sections are supplied as pre-assembled groups of plates complete with an intermediate plate (containing the temperature measurement points). Using the four heating sections provided, students can compare heat exchangers of different heat transfer area and different numbers of passes. A quick release clamp system allows the different arrangements to be changed quickly and easily without using tools.

Also supplied is a pre-assembled regeneration section to demonstrate this important energy efficient method of heating. The regeneration section can be used in conjunction with one, two or three of the standard heating sections in different configurations.

Plate heat exchangers can be implemented in a wide variety of configurations, with parallel passes, serial passes, or combinations of both. For more advanced investigations into these effects, (e.g. for project work) a further twelve loose plates are supplied with the HT37. These can be used in conjunction with the plates from the pre-assembled modules to investigate these other configurations.

HT37 - Extended Reconfigurable Plate Heat Exchanger

The HT32 has a single heating section configured for multi-pass operation with passes in series. It comprises seven individual plates, which are clamped together using two stainless steel threaded bars and nuts. It is possible to dismantle and reassemble the heat exchanger using only three plates to demonstrate a single pass.

Specification

• A small scale plate heat exchanger system for use with an Armfield Heat Exchange Service Unit to teach the fundamental concepts of heat exchangers.

• Comprises a number of stainless steel plates, each with a pressed chevron pattern and a food grade silicon rubber sealing gasket, mounted in a frame.

• Easily dismantled for cleaning.

• A comprehensive instruction manual is included.

Technical Details

The plates used in these heat exchangers have been specifically developed by Armfield for use in miniature heat exchanger systems. They are fabricated from 316 stainless steel, with a pressed chevron pattern to promote turbulence and provide multiple support points. Silicone rubber gaskets are used on each plate to seal the adjacent flow channels from each other.

Plate details:

Plate overall dimensions: 75mm x 115mm
Effective diameter: 3.0mm
Plate thickness: 0.5mm
Wetted perimeter: 153.0mm
Projected heat transmission area:0.008m2 per plate

The plates are mounted in a frame incorporating fixed and moving end plates with connections for hot and cold fluids. The exchangers are easily dismantled for inspection of the heat transfer surfaces.

HT32 HT37
Number of plates: 7 (5 effective plates) Reconfigurable up to 20 plates
(12 effective plates)
Heat transfer area: 0.04m2 0.096m2 max.
Heat exhanger configuration: Single heating stage Configurable sections, with a separate regeneration section
Temperature measurement points: 4 off:
• Hot fluid inlet
• Hot fluid outlet
• Cold fluid inlet
• Cold fluid outlet Up to 10 off:
• Hot fluid inlet
• Hot fluid interim positions (3)
• Hot fluid outlet
• Cold fluid inlet
• Cold fluid interim positions (3)
• Cold fluid outlet
Clamping mechanism: Dual screw threads with nuts Quick release, hand operated, no tools required
Project work: 12 additional plates (supplied loose) give the option of exploring many different configurations

Essential Armfield Accessories

HT37 requires the Armfield HT30XC, Computer Controlled Heat Exchanger Service Unit.

HT32 can be used with either the HT30XC or the HT30X Heat Exchanger Service Unit.

Shipping Specification

HT32:

Volume: 0.03m3
Gross weight: 6 kg

HT37:

Volume: 0.03m3
Gross Weight: 9.5kg

Overall dimensions

HT32:

Height 0.17m
Width 0.18m
Depth 0.39m

HT37:

Height: 0.17m

Width: 0.18m

Depth: 0.39m

5. RA1 Vapour-Compression Refrigeration Unit

The vapour-compression refrigeration system is the most common refrigeration system used today. RA1 is a computer controlled vapour-compression refrigeration system with automatic recording of appropriate process variables using an integral USB interface device. This allows the student to gain a thorough understanding of the refrigeration process by changing the operation of different parts of the process and recording the response of the complete system.

The compressor is driven by a three phase electric motor with an inverter drive that allows operation at different operating speeds. The inverter incorporates Torque Vector Control and allows the speed and torque of the motor to be measured and logged by the controlling PC. Temperatures throughout the system and pressure on both sides of the compressor are measured and logged. The refrigerant flow rate is also measured by a variable area flowmeter.
The condenser and evaporator both consist of a brazed plate heat exchanger. The water cooled condenser and water heated evaporator utilize a large reservoir of water to minimize changes in water pressure or temperature during operation.
The use of water as the heat transfer medium in the condenser and evaporator allows a complete energy balance to be carried out and performance to be measured accurately.
The use of a reservoir to recirculate the same water continuously also eliminates the need for a permanent mains water connection or water flowing continuously to drain. The flow of water through each heat exchanger is independently varied by a variable speed gear pump. The speed of both pumps is set by the operator using the PC.
The unit is totally self-contained, only requiring connection to an electrical supply and a suitable PC (not supplied). The unit is supplied with the necessary software and incorporates a USB computer interface device for connection directly to a PC.
The process components are mounted on a metal support frame that is designed to stand on top of the water reservoir. The water reservoir is designed to stand on the floor. Self-sealing quick release connectors and flexible tubing connect the reservoir to the refrigeration unit.

Specification

• Complete refrigeration system allowing demonstration of the vapour-compression refrigeration cycle with remote control, on-line monitoring and logging of results using a suitable PC
• Fully instrumented to allow complete analysis of the processes involved and calculation of the changes in performance with operating conditions
• Compressor speed can be varied and torque measured via an inverter allowing changes in performance to be evaluated – speed and torque can be logged continuously
• Condenser and evaporator use plate heat exchangers with water as the heat transfer medium allowing complete energy balance to be carried out and conditions in the condenser and evaporator to be varied accurately and independently using variable speed
• Computer controlled system with automatic recording of process variables using an integral USB interface device
• Measurement sensors include:
– 9x Thermistor sensors measuring temperatures throughout the system
– 2x Electronic flowmeters measuring flow of water through the condenser and evaporator
– 2x Electronic sensors and 2x Bourdon type refrigerant gauges measuring pressures before and after the compressor
– 1x Variable area flowmeter measuring refrigerant flowrate
allowing all of these parameters to be logged continuously
• Large reservoir supplies water at stable temperature and pressure to the condenser and evaporator eliminating fluctuations
• Expansion valve setting can be varied to change the operating point (superheat setting)
• Comprehensive instruction manual supplied

Demonstration Capabilities

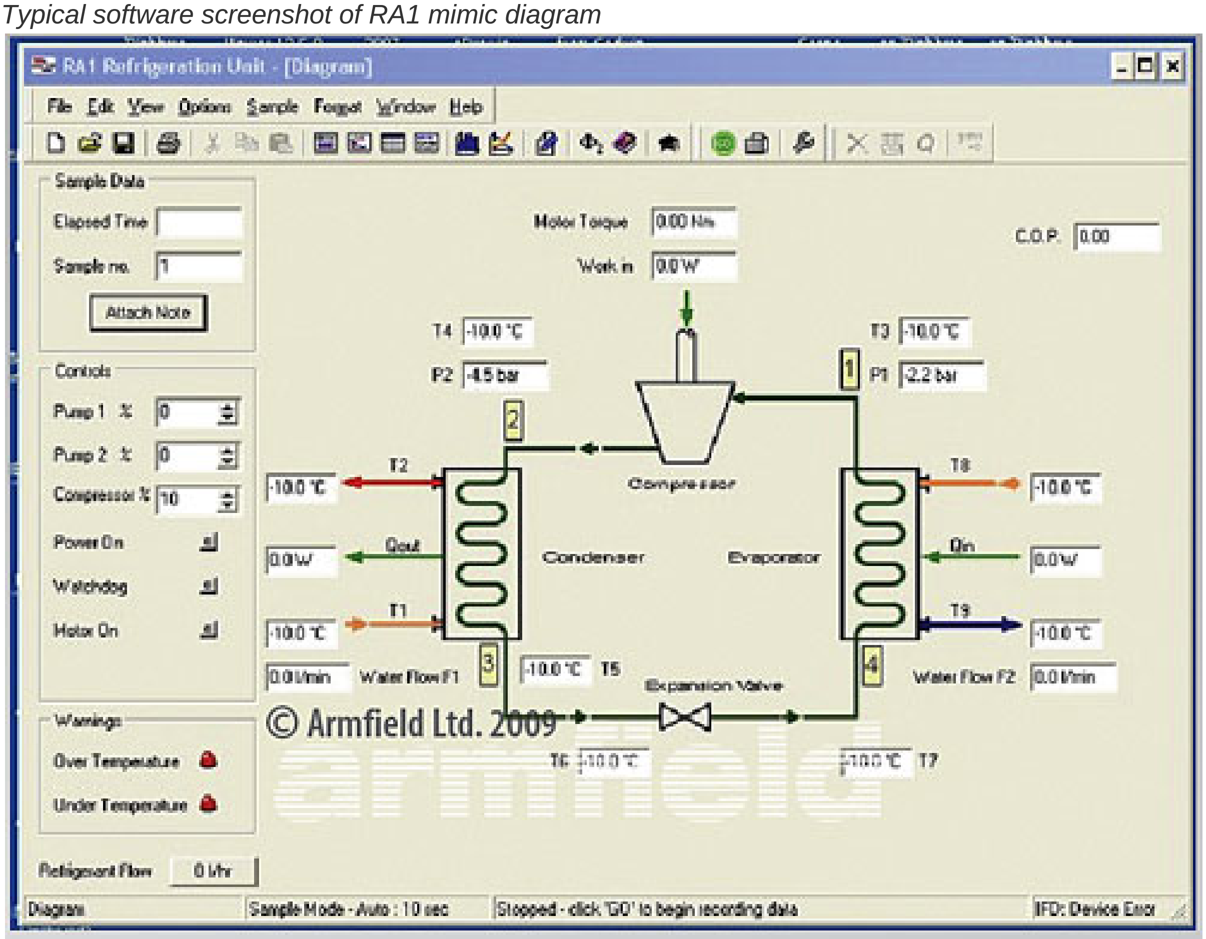
> Demonstration of the important features and operation of a vapour-compression refrigeration system, involving the combined processes of compression, condensation, expansion and evaporation
> Analysis of the heat transfer processes in the condenser and evaporator heat exchangers involving phase changes in the refrigerant stream
> Adjustment of the expansion valve to vary the operating point (superheat setting) to optimise the refrigeration process for different cooling loads
> Investigation of the effect of the following system changes on the Coefficient of Performance:
– Cooling water flowrate through the condenser
– Heating water flowrate through the evaporator (system load)
– The effect of adjusting the setting of the expansion valve
– Compressor speed (refrigerant flow rate)
> Modelling the system thermodynamically by plotting T-s and P-h diagrams using the properties for R134a refrigerant
> Performing an energy balance across the system
> The use of water as the heat transfer medium in the condenser and evaporator allows a complete energy balance to be carried out and performance to be measured accurately.

Software details

The software includes a range of functions and capabilities designed to make the operation of the equipment and processing of the results more straightforward, and also to enhance student understanding of the subjects being covered. It includes:

– Diagrammatic representation of the equipment, complete with continuous real time display of the various sensor outputs and instantaneous Coefficient of Performance
– Automatic data logging of sensor values into spreadsheet format
– Allows operator control of compressor speed (motor speed), condenser cooling water flowrate (pump speed) and evaporator heating water flowrate (pump speed)
– Incorporates maximum and minimum temperature limits to protect the equipment against misuse
– Additional USB driver is included that allows the outputs to be read in other software programs such as Labview™

Typical software screenshot of RA1 mimic diagram



Typical RA1 mimic diagram

Technical details

Refrigeration system
Vapour-compression type using R134a refrigerant85

Compressor speed range
200 to 1050 RPM

Motor output power
0.37 kW

Condenser & evaporator
Brazed plate heat exchangers using water as heat transfer medium

Water reservoir
Working capacity 400 litres

Temperature sensors
Thermistor type, range -10 to 60ºC

Refrigerant flowmeter
Variable area type, range 9 -38 l/hr

Ordering details

RA1-A/B/G
Vapour-Compression refrigeration unit complete with separate floor standing water reservoir and connections

Essential accessories

The system is designed to be used with a personal computer (not supplied). The computer must have a USB connection available and run Windows 98 or above.

Requirements

Electrical Supply:

Single phase electrical supply:
RA1-A: 230V/ 1ph / 50Hz @ 13 Amps
RA1-B :110V / 1ph / 60Hz @ 25 Amps
RA1-G: 220V / 1ph / 60Hz @ 13 Amps

Water Supply:

Supply of cold water to fill reservoir (working capacity 400 litres), permanent connection to water supply or drain is not required

Shipping specification

Volume: $1.1m^3$
Gross weight: 125kg

Overall dimensions

Refrigeration unit (process)
Length: 0.95m
Width: 0.52m
Height: 0.50m

Water reservoir
Length: 1.2m
Width: 0.6m
Height: 0.84m

note: Refrigeration unit is located ot top of water reservoir when installed

6. UOP3 Distillation Columns- Issue 6

Considerable advances in the instrumentation and control of distillation columns have been made in recent years, prompted by the advent of computer-linked systems supported by software packages for handling plant operating data. To reflect these advances, Armfield has developed two new state-of-the-art laboratory-based distillation columns that allow safe hands-on practical training for student engineers and plant operators:-

• A batch-only operated version (model reference UOP3BM) manually controlled, permits comprehensive study of the basic principles of distillation.

The unit is a self-contained and fully instrumented distillation facility, suitable for practical laboratory work relevant to the teaching of unit operations.
The equipment employs galvanically isolated intrinsically safe circuits and flameproof devices as appropriate, to allow safe distillation of standard test mixtures such as methylcyclohexane-toluene, methyl alcohol-water etc.
The equipment consists of two interconnected units: a floor standing process unit and a bench-mounted control console.

SPECIFICATION UOP3BM:

Batch Distillation Column (manual):

• Self-contained sieve plate distillation column unit including reboiler, condenser and reflux tank, suitable for use with flammable solvents and fully instrumented for batch operation.
• Temperatures throughout the process including those on each and every sieve plate are monitored and displayed on a bench mounted control console, via a selector switch. The console also houses controls for the power supplied to the reboiler heater and for reflux ratio settings between 0 and 100%.
• The console front panel connections allow the use of standard laboratory recorders and data loggers and of industry-standard PID and PLC controllers (not supplied).
• A U-tube manometer is incorporated to measure pressure drop over the distillation column.
• The 50mm diameter sieve plate column may be readily interchanged with a packed column supplied as an alternative.
• A vacuum system allows operation at reduced pressures down to 200mbar(abs).
• The unit is supplied completely assembled including lagging, and a comprehensive instruction manual describes commissioning, maintenance and instructional assignments.

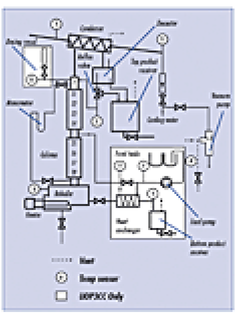
Technical Details

UOP3BM Process Unit

> a 50mm diameter plate distillation column containing 8 sieve plates and downcomers. Every plate includes a temperature sensor positioned to measure accurately the temperature of the liquid on each

plate. The sheaths of each plate temperature sensor are not more than 1.5mm diameter, to ensure rapid dynamic response.
> a 50mm packed column supplied as a separate item, but readily interchangeable with the plate column by the user, for comparative studies of the two types of distillation column.
> electrically heated reboiler of sufficient capacity for 1-2 hours of batch operation. The reboiler heater is protected against overheating and by a low level alarm.
> an overhead condenser with cooling water flow measurement and adjustment.
> a condensate collecting vessel, equipped with double overflow weirs and exit pipes to allow separation of immiscible liquids.
> a reflux return valve, solenoid operated, to provide for 0%-100% reflux, adjustable by electrical signal.
> a differential manometer connected to the top and bottom of the column, to monitor column pressure drop.
> a vacuum system with gauge to allow distillation studies at reduced pressures down to 200mbar(abs).

Schematic diagram of Armfield distillation columns



> sampling points throughout the system for composition analyses.
> materials of construction for surfaces in contact with the process fluids are; glass, stainless steel, PTFE or similar solvent-resistant materials.
> overall height of the process unit does not exceed 2.5 metres (8.2ft).
> lagging is provided, although it is possible to see at least one plate in operation with distillation in progress.
> maximum operating temperature inside the column operation is at least 130°C.

UOP3BM Control Console

> monitoring and selectable display of at least 13 system temperatures, including those of the liquid on each tray, the reboiler and across the condenser.
> monitoring, display and manual adjustment of:
i) the electrical power to the reboiler heater.
ii) the reflux ratio setting.

> front panel connections to allow the user to connect 0-5 Volt industry-standard analog or programmable logic controllers, to provide on-line control of the boil-up rate or reflux ratio from chosen column temperature measurements. The connection points also allow for the use of standard laboratory chart recorders and data-loggers. (Up to two temperature measurements simultaneously).

> mains power connection (single phase 3kW max. supply) protected by Residual Current Device. No-volt protection safety circuits to prevent unintentional start-up.

> individual circuits protected against excess current with resetable circuit breakers. Description

Experimental Capabilities

For Batch Distillation Column UOP3BM - under manual control:

> pressure drop across the column as a function of boil-up rate
> column efficiency as a function of boil-up rate, at total reflux
> plate-to-plate temperature profiles along the column
> McCabe-Thiele construction of operating line
> distillation at constant reflux ratio: variation of top product composition with time
> mass balance across the system
> manual control of reflux ratio, for example to achieve a top product of specified composition
> comparison of packed column with sieve plate column performance

Essential Accessories

Analytical equipment, suitable for composition analyses of any particular liquid mixture selected by the user (e.g. refractometer).

Requirements

Installation Requirements

Solvent resistant level floor.
Either a flame-proofed room or in an area where a 2 metre clear and uninterrupted space on each and every side and above the unit can be maintained and into which no potentially spark producing equipment should be allowed to enter.

Electrical supply:

UOP3BM-A: 220-240V/1ph/50Hz @ 13A
UOP3BM-B: 120V/1ph/60Hz @ 25A
UOP3BM-G: 120V/1ph/60Hz @ 13A
Water

Cold water supply: 15 litres/min at 2.0bar pressure (min.)

Venting

Exhaust line to fume cupboard or to safe
discharge area outside of laboratory.

NB The distillation unit is floor mounted and is supplied already connected to the bench- mounting control console by sufficient armoured cable to allow the 2m clear space to be maintained around the column.

Shipping specification

UOP3BM

Volume: 3.4m3

Gross weight: 425kg

Overall dimensions

UOP3BM	Process unit	Console
Height:	2.25m	0.30m
Width:	0.85m	0.52m
Depth:	0.80m	0.40m

7. UOP5 Liquid/Liquid Extraction Unit

Liquid/liquid extraction is a valuable process in chemical engineering where the separation of one or more of the components from a liquid mixture is required. The Armfield UOP5 unit demonstrates this process in the laboratory so that students may gain a thorough understanding of this industrial technique.

Meaningful experiments may be conducted within a two hour laboratory period and students benefit from visual observation of the process.

The equipment, mounted in a floor standing, welded steel framework, consists of a glass liquid/liquid extraction column packed with Raschig rings together with an integral distillation column for solvent recovery. Water for the extraction column is pumped from a supply tank via a flow control valve and flowmeter to an injector in the base of the column and flows from an outlet pipe at the top to a collection tank.

Solvent from a stainless steel feed tank is pumped via a metering pump to the top of the column and flows counter-current to the water supply. Solvent drains under gravity to a stainless steel receiver vessel from where it may be directed into the feed tank or to the distillation column boiler. Provision of interface height control allows either the lighter or the heavier phase to be the continuous phase with the counterflow being discontinuous (droplets). Distillate is condensed and collected in a third stainless steel tank. Condensed solvent may also be returned to the feed tank for recirculation. Sensing electrodes and a solenoid valve control the level of the water/solvent interface at the top or bottom of the column as required.

Control of the equipment is simple. A panel displays the complete solvent/water flow system with controls at the appropriate points on the diagram.

The instruction manual included contains experiments, using non-flammable solvents for safety, providing a thorough grounding in the operation of solvent extraction systems in the context of unit operations for chemical engineering students.

Specification

• A glass liquid/liquid extraction column, length 1.2m, diameter 50mm.

• Water feed pump with flow control valve, range 0-800ml/min with 30 litre supply and collection tanks. • A metering pump, range 0-250ml/min, is used to feed solvent from the14 litre stainless steel tank.

• A stainless steel distillation column comprising four sieve plates in a glass section, a water cooled condenser, a 1kW 5 litre electrically heated boiler and a stainless steel condensate collection tank, is used for solvent recovery.

• All items are mounted in a floor standing welded steel framework.

• The unit is controlled from a panel with diagramatic display of the process with controls at appropriate points on the diagram.

• A comprehensive instruction manual is included.

Demonstration Capabilities

> hydrodynamics of liquid/liquid systems

> continuous or semi-continuous

> operation with organic or aqueous phase as the continuous phase

> evaluation of test mixtures for industrial study

> mass balances

Requirements

Electrical supply:
UOP5-A: 220-240V/1ph/50Hz
UOP5-B: 120V/1ph/60Hz
UOP5-G: 220V/1ph/60Hz

Cold water supply:

mains pressure

Vapour extraction system

Shipping specification

Volume: 3.3m^3
Gross weight: 380kg

Overall dimensions

Height: 2.5m

Length: 1.30m

Depth: 0.75m

8. UOP7 Gas Absorption Column - Issue 11

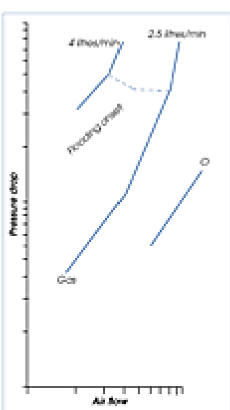
The Armfield Gas Absorption Column has been designed to demonstrate the principles of gas absorption and to provide practical training in the operation of gas absorption plant.

The packed absorption column is made up of two 75mm diameter clear acrylic sections joined end to end and installed vertically on a mild steel floor standing framework. The column is filled with 10mm x 10mm glass Raschig rings, which are representative of the type of packing used in gas absorption. Liquid for the process is stored in a 50.0 litre rectangular feed tank and a centrifugal pump is used to deliver the liquid to the top of the column where it falls through the packing and returns to the tank. A variable area flow meter in the recirculation line gives a direct reading of flow rate.

The gas to be absorbed is normally carbon dioxide and would be taken from a pressure cylinder (not supplied), standing adjacent to the column. This gas passes through a calibrated variable area flow meter and is mixed with an air stream also of known flow rate from a rotary compressor positioned in the framework. The ratio of gas to air in the mixture entering the column is therefore known and is easily varied. Entering at the base of the column, the gas mixture rises up through the packed bed and is counter-currently contracted with the liquid flowing down the column.

Pressure tappings at the base, centre and top of the column are provided to allow indication of pressure drop in the column using manometers. These tappings also provide a means of extracting samples of gas from the column. Carbon dioxide content of the gas samples is determined using a Hempl apparatus. Flow meters, manometers and gas analysis equipment are all mounted on a vertical backboard at a convenient height for operation.

Pressure drop versus air flow



Pressure drop versus air flow for different flow rates

SPECIFICATION

> Floor mounted packed column gas absorption unit using a 75mm diameter, 1.4m long clear acrylic column. The column contains 7 litres of 10 x 10mm glass Raschig rings and is mounted in a steel frame.

> Pressure sensing and gas sampling points are sited at the top, centre and base of the column.

> Two manometers are included to measure pressure.

> A Hempl type gas analysis apparatus is included.

> Three variable area flow meters are included to measure the flow of gas, air and liquid.

> A rotary compressor is used to pump air into the column.

> Water (solvent) is circulated using a centrifugal pump, using a 50 litre capacity feed tank.

> A comprehensive instruction manual is supplied which details the necessary installation, commissioning and maintenance procedures.

> The instruction manual also includes detailed experimental protocols for studying:

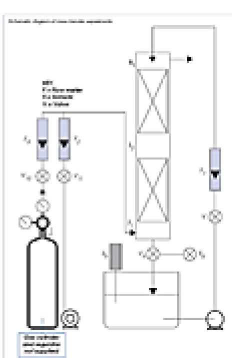
• Principles of gas absorption into a liquid using a packed column.
• Methods of gas and liquid quantitative analysis.
• Mass balancing over a packed absorption column.
• Method of transferring units, including calculation of NTU and HTU
• Determination of the mass transfer coefficient.
• Hydrodynamic characteristics of a packed column.
• Determination of loading and flooding points.

Demonstration Capabilities

> Study of the basic principles of the absorption of a gas into a liquid using a packed column
> Demonstration of methods of gas and liquid quantitative analysis
> Production of mass balances for a packed absorption column
> Method of transferring units, including calculation of NTU and HTU
> Determination of the Mass Transfer Coefficient
> Study of the hydrodynamic characteristics of a packed column
> Determination of loading and flooding points

Technical Details

Mass transfer experiments schematic



Feed tank capacity: 50.0 litres
Internal diameter of column: 80mm
Volume of packing: 7.0 litres

Height of absorption column: 1.4m
Type of packing: Raschig rings 10x10mm
Air compressor capacity: 0.15m3/min@0.3bar

Column feed pump capacity:
Air flow meter range: 20-180 l/min
Gas flow meter range: 1.0-22.0 l/min
Water flow meter range: 1.0-10.0 l/min

Ancillary Equipment

Essential Ancillary Equipment

> CO_2 Cylinder with pressure regulator

Recommended Ancillary Equipment

> Vent piping to outside laboratory
> Titration glassware for liquid analysis
> Separate drain tank for treatment of effluent

Requirements

Electrical supply:

UOP7-A: 220-240V/1ph/50Hz
UOP7-B: 120V/1ph/60Hz
UOP7-G: 220-240V/1ph/60Hz

Initial water fill

Shipping specification

Volume: 2.0m^3
Gross weight: 220kg

Overall dimensions

Height: 2.53m
Width: 0.90m
Depth: 0.65m

9. UOP6 Basic Water Cooling Tower

The Armfield Basic Water Cooling Tower can give students an appreciation of the construction, design and operational characteristics of a modern evaporative cooling system. The unit is also an example of an 'open system' through which two streams of fluid flow (water and air) and in which there is a mass transfer from one stream to the other.

Convincing energy and mass balances are obtained and students can quickly investigate the effects of air flow rate, water flow rate, water temperature, cooling load and packing density on the performance of a cooling tower.

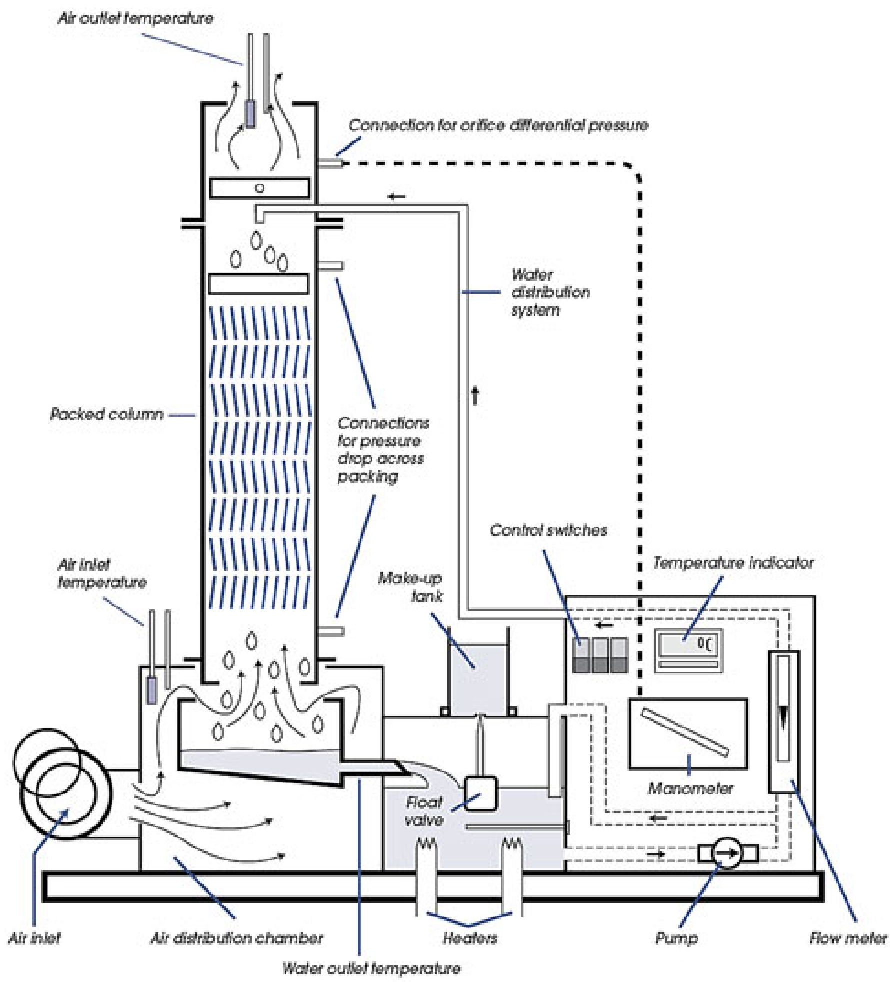
The Armfield Basic Water Cooling Tower is completely self-contained and includes both the simulated heating load and the circulating pump. It has much the same configuration as a full size force draught cooling tower, has the same characteristics and stabilises quickly.

In this unit a fan is placed at the base of the tower to drive air upwards through the packing. Natural buoyancy assists the fan and helps dissipate the humid air from the top of the tower.

The packing in the cooling tower breaks the water into thin films or droplets which present a large surface area to the air stream and thereby assist the cooling process. The water is cooled largely by evaporation and, to a small extent, by direct contact cooling. Due to the evaporation of some of the water into the air stream, a continuous supply of fresh water must be added to the system. This 'make-up' is normally less

than 5% of the cooling water flow rate. A float valve is provided to allow accurate measurement of 'make-up'. When the cooled water falls to the load tank it is reheated before circulation.
Three packed columns, having different surface/area volume ratios are available and can be quickly interchanged without using tools.
All the structural components are made from clear PVC or blue GRP, allowing students to observe the water flow through some parts of the system. Instrumentation is supplied.

UOP6: Basic water cooling tower flow diagram



Specification

> Bench top unit to demonstrate operation of a forced draught cooling tower, comprising tower base with air circulation, water reservoir with heater and make-up tank, and a control console with recirculation pump and instrumentation

> Centrifugal fan, maximum air flow: $0.06 kg/s^{-1}$
> Supplied with one standard packed column, dimensions 150mm x 150mm x 600mm, comprising 10 plates giving $110 m^2/m^3$
> Three additional columns are available as options for comparison (bare column, 7 plates and 18 plates)
> The columns are manufactured from clear plastic to allow viewing of water flow through the system
> The columns are easily interchangeable without the use of tools
> Maximum working temperature: 50°C

> Instrumentation includes:
- Thermocouple with digital readout for measuring terminal water temperature and wet and dry bulb temperatures
- Variable area flow meter 0 - $50 g/s^{-1}$ with control valve for water flow rate to packings
- Inclined tube manometer 0 - 40mm H_2O to measure orifice differential pressure or packing resistance

Capabilities

- Observation of water flow pattern and distribution with different packing arrangements and with various water and air flow rates
- Investigation of performance at:
    a range of process cooling loads
    a range of inlet temperatures

- measurement of all 'end states' and the rate of flow of air, water and 'make-up'
- plotting of 'end states' on a psychrometric chart and the application of the steady flow equation to draw up energy balances
- Investigation of effect of packing surface area/volume ratio on:
    approach to wet bulb temperature at inlet
    pressure drop across packing

Ordering Options

UOP6-10:

Basic Water Cooling Tower with 10 plate column giving $110 m^2/m^3$

Additional Columns:

UOP6-20: 7 plate column giving $77 m^2/m^3$

UOP6-21: 18 plate column giving $200 m^2/m^3$

UOP6-22: Bare column only

UOP6-23: Packing characteristics column

Requirements

Electrical supply:

UOP6-10-A: 220-240V/1ph/50Hz
UOP6-10-B: 120V/1ph/60Hz

Water supply:

2 L/hr distilled or demineralised water (in containers)

Shipping specification

Volume:0.7m^3

Gross weight: 130kg

Overall dimensions

Height: 1.20m

Width: 0.95m

Depth: 0.60m

10. UOP8 Tray Drier - Issue 8

This small scale tray drier dries solids by passing a stream of hot air over trays of wet material, a method commonly used in industry.

The unit is applicable to the Unit Operations laboratory of educational establishments and also to Food Technology education and research.

The unit consists of a floor standing tunnel in one end of which is mounted an axial flow fan. Downstream of the fan a bank of electrically heated elements heat the air flowing to the drying chamber. The chamber with transparent access door, contains a rack of trays suspended from a balance mounted on top of the drier. The total capacity of the trays is approximately 3kg of solids.

Ducting upstream and downstream of the drier is designed to provide a uniform airflow over the trays.

Controls mounted on a panel at the fan end of the tunnel permit variation of air speed and heater power to vary temperature through the drier.

Measurements of temperature and humidity (with an aspirated wet and dry bulb psychrometer) may be made before and after the drier chamber.

The heating elements are fully protected against overheating by the use of bi-metal thermostats and the heating circuits may only be switched on when the fan is running. The fan minimum speed is preset.

Operator safety is provided by means of a residual current device (RCD).

Operating parameters may be varied to provide data demonstrating theoretical and practical aspects of industrial drying practice and an instruction manual is included with exercise sheets for student experiments.

NOTE: Sample material is not included in the supply.

SPECIFICATION

> A floor standing tray drier with tunnel, axial fan and heating elements providing hot air to a compartment measuring 300x300x400mm.

> Fan adjustable to give air velocities of 0.3-1.8m/s.

> Four sample trays with a capacity of approx 3kg wet solids are suspended from a digital balance mounted on the drier top.

> Heater power adjustable up to 3kW.

> An anemometer and aspirated psychrometer permit measurement of air speed and humidity.

> Capabilities include: demonstration of drying rate regimes, effect of temperature and air flow rate on drying rate. Mass and energy balancing and the use of psychrometric charts.

Demonstration Capabilities

> demonstration of drying rate regimes
> heat and mass transfer analogies
> drying tests on solids for industrial use
> effect of temperature and air velocity on drying rate
> use of psychrometric charts
> mass balances (water)

Recommended Accessories

Stop clock

Requirements

Electrical supply:

UOP8-A: 220-240V/1ph/50Hz
UOP8-B: 120V/1ph/60Hz
UOP8-G: 220V/1ph/60Hz

Shipping specification

Volume: 1.42m^3
Gross weight: 220kg

Overall dimensions

Height: 1.40m
Length: 2.95m
Depth: 0.73m