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ИНТЕРМЕТ INTERMET
ИНТЕРМЕТ ИНЖИНИРИНГ INTERMET ENGINEERING

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Assistance to the Societe Arabe du Fer et de L'Acier Mauritanie (SAFA) in management and products diversification in the Islamic Republic of Mauvritania

FINAL REPORT

Part I
Volume 1

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for the
La Societe Arabe du Fer et de L'Acier (SAFA)

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1. INTRODUCTION

The present work was carried out according the contract between Intermet Engineering and UNIDO (Contract No.91/151, UNIDO project No.US/MAU/89/178) for Mauritania. The project objectives are: to improve the operating and maintenance activities and quality of finished product at the SAFA steel plant and rolling mill; to reinforce SAFA management through the introduction of new management methods and systems.

In conformity with the contract a team of Intermet experts went to Mauritania in December of 1991 on the first field mission. The experts studied the steelmaking and rolling technologies practiced in the plant and the main problems facing the plant engineers. They also studied in details the current system of management and planning.

Within the framework of the first mission the experts analyzed the current technology offered technical advice on steelmaking, ingot casting and rolling procedures to improve productivity and quality of steel products. They also suggested measures to improve maintenance procedures in the plant. Diagnostic and management audit was also performed. New methods and systems necessary to improve planning and production were defined. The equipment specification required for quality control, maintenance procedures and computerizing was made.

During second field mission the following subsystem have been developed,installed, customized and put in to day-by-day operations:

Inventory control,

Material Requirement,

Production control (including row material and energy consumption for each product and department).

Input - Output Balance (including cost calculation for each product and department).

On-the-job training of SAFA personal was carried out by subcontractor team. It is recommended to set up SAFA's computer group, train or recruit one or two skilled system programmers to secure the systems operation and development.

Intermet team discussed Finding and Recommendation with SAFA's staff and managers.

Part I of Final Report includes:

Reinforce bars' production analysis on SAFA. Concept of project proposals on reinforcing equipment and technology of production on SAFA.

Reinforcing management system of SAFA.

Part II of Final Report includes:

Project proposals on converting preheating furnace from gas-oil to mazout fuel.

Project proposals on improvement of roll pass design. Project proposals on rolling mill and flaying shear synchronization.

Basic data on the technology of steelmaking and rolling in SAFA works, as well as the current system of planning, management and control are reported bellow. The report contains a preliminary analysis of the data and technological recommendations.

The Intermet team expresses acknowledgements to the SAFA engineers and managers for their help. The team is grateful to the Director General Yahya Ould Hademine and the Chief of Technical Department Mouhameddin Baba, as well as engineers Mouhtarash and Hasan for their collaboration.

2. REIFORCE BARS' PRODUCTION ANALYSIS ON SAFA

The SAFA Steelworks put into operation in 1979 isdesigned to meet the needs of the area in reinforcing steelbeing them in great demand due to an increased scope of housing and industrial construction in the country and thefact that import supplies of this product were limited.

The steelworks consists of two shops - a steelmaking shop and a rolling shop and employs 106 production staff with up to70 people working on a part-time basis. The table below shows the distribution of working staff according to the work done.

	full-time employees	Part-time employees
Management	26	4
Steelmaking shop	36	20
Rolling shop	23	36
Repair service	21	10
Total	106	70

Overall technological scheme is shown in Fig. 1.

The steelmaking shop incorporates scrap yard, scrappreparation section, remelting section, casting section and the ingot bay. Design capacity of the steelmaking shop is 15.000 t ingots annually.

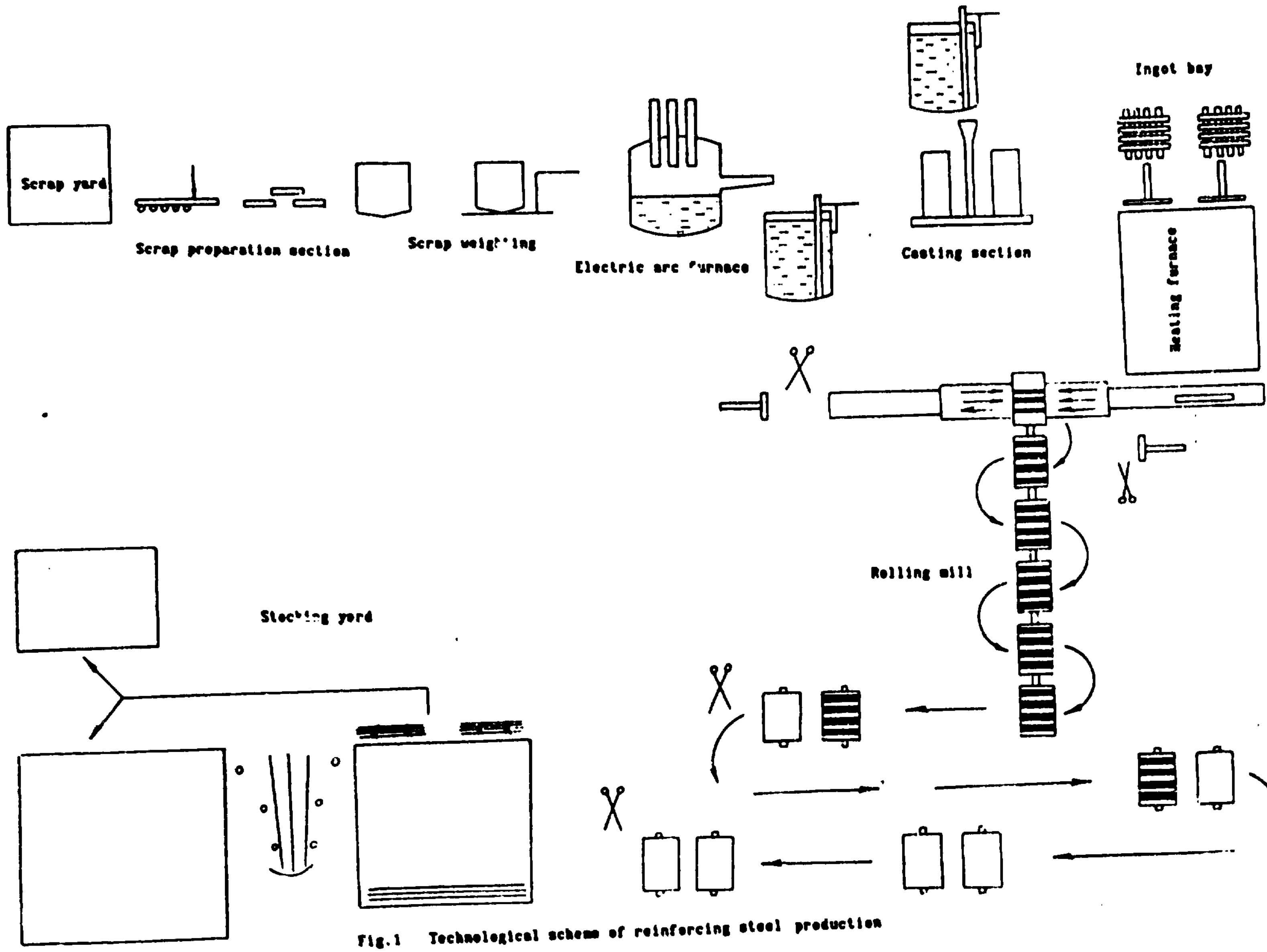

Fig.1 Technological scheme of reinforcing steel production

The rolling shop accommodates the heating furnaces section, breakdown train, finishing stands and the stocking yard. Theshop design capacity is 36.000 t reinforced bars per year. Reinforced bars are produced according to NORSNIM specifi-cations corresponding to the French AFNOR NF A35016 standard.The main figures for chemical composition and mechanicalproperties of the rolled product with respect to diameter arelisted in the tables below (tables 1,2).

The main geometric parameters of the finished product according to the design documents are given in Fig.2 and Table 3.

Table 1

Chemical composition of steel, %

C	Mn	Si	P	S
0.25-0.50	0.70-1.30	0.15-0.40	0.08	0.05

Table 2

Mechanical properties of the finished product

	ø < 20 mm	ø > 20 mm
Yield point	42 kg/mm^2	40 kg/mm^2
Breaking point	48.5 kg/mm^2	46 kg/mm^2
Relative elongation	14 %	14 %

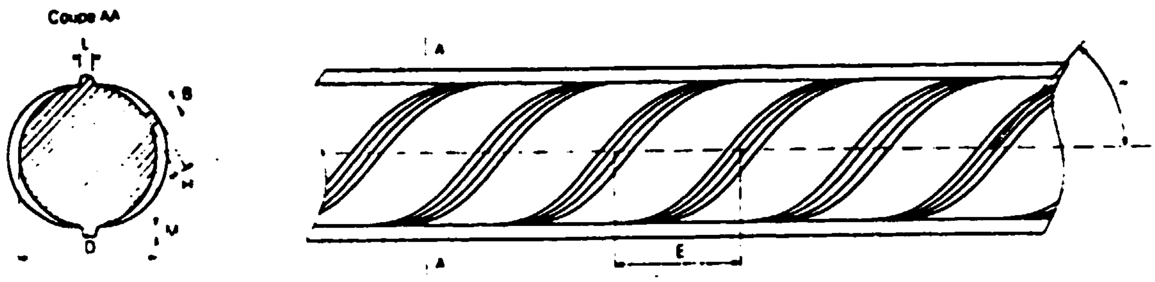

Fig.2

SAFA reinforcing bar

Table 3

Geometric parameters of the finished product

Nominal diameter ⌀, mm	6	8	10	12	14	16	20	25	32
Basic diameter ⌀, mm	5,8	7,6	9,6	11,5	13.4	15.4	19.4	24.3	31.2
Maximum diameter D + 2H	7.0	9.2	11.6	13.7	15.8	18.2	22.8	28.3	36.0
M.L.dimensions M L	 0.6 1.6	 0.8 2.0	 0.8 2.2	 0.8 2.4	 0.8 2.8	 0.8 3.2	 1.0 3.6	 1.2 4.0	 1.4 4.5
Additional characteristics H = B, mm E, mm α, °	 0.6 6 42	 0.8 7 42	 1.0 9 42	 1.1 10 45	 1.2 11.5 45	 1.4 12.5 45	 1.7 14.5 50	 2.0 17.5 50	 2.4 20 50

2.1. Production equipment and technology in steel shop

In SAFA steel is produced in an electric arc furnace of nominal capacity 5 t. Since oxygen blowing is not practiced at present it was possible to reduce the hearth thickness thus increasing the furnace capacity to 7.0-7.5 t, its diameter being 2.40 m.

Power capacity of the transformer is 2.4 KVA and is regulated in the semi-automatic regime designed for 8 degrees of capacity. The furnace is lined with magnesite contained of small amount of SiO_2-Al_2O_3-MgO. Refractory lining of the furnace roof is made of fire clay brick. Lining life is: for the roof - 200-300 heats, for the side walls - 200-230 heats, for the bottom - about 2.000 heats. To increase refractory lifethe furnace is repaired with dolomite at certain intervals after 40-45 heats.

The electrode diameter in the electric furnace is 250 mm. Scrap, both imported and of Mauritania's own, is stored in the charge yard. The equipment installed in the plant makes it possible to cut long stock into pieces of up to 600 mm.

Metal charge is fed to the furnace from two baskets with the help of a crane fitted by with a lifting magnet. It is possible to weigh the scrap to be charged into the furnace on the special scales.

The 3 bottom-tap ladles available in the shop are lined with fire-clay. Lining life being 110-120 heats. Nozzle and stopper are replaced after every heat. Special equipment for drying and pre-heating of ladles is available. The ladle heating takes 8-12 hours. The slag from the furnace is delivered into a slag pot. Steel is casted into a number of moulds each designed for 4 ingots of cross section 110x110 mm and a height under 1.500 mm. The uphill-casting scheme is used in the shop. The moulds prepared on the bottom plate. Each plate carries 16 moulds, filled from the central runner. The plate can accommodate a full heat.

The ingots are shipped with the help of a hydraulic-driven device which removes the ingots that got stuck to the mould. After removal the ingots are marked and placed in the ingot bay.

As was mentioned above steel is mostly produced from the scrap supplied by SNIM company. This scrap consists of rails and wheels from the railroad. The rails supplied by SNIM are cut into length of 600 mm in the preparation section while wheels can be used without any preliminary treatment. The charge contains up to 30 % of scrap produced by the steelworks as the waste product of rolling which is also pre-cut into lengths of 600 mm.

The metal charge is supplied to the furnace in two subsequent buckets, the second is discharged after melting the content of the first one. Normally the charge contains up to 30 % of railway wheels and 40 % of rails, the remaining 30 % being the waste product of the plant. The charge composition is designed so that after complete melting of the metal carbon content in the metal should exceed the required carbon content in the steel by 0.1 %. The melting period is 40-50 min. Limestone is used as a slag-forming material in steelmaking.

After complete melting of the charge temperature is measured by immersing a thermocouple into the melt and samples are taken to define carbon content. As for other components of the melt their content is not registered. Carbon concentration is determined chemically. The analysis takes about 10 min. In case carbon content is greater than 0.3 % rolling scale is added to the furnace to oxidize the excessive carbon. The oxidation period lasts approximately 30-35 min.

With carbon content less than 0.1 % electrode waste is supplied to the furnace to carbonize the charge.

When it is necessary temperature measurements and sample taking are repeated several times.

At 1660°C and carbon content reaching 0.2-0.3 % the metal is tapped into the bottom-tap ladle by tilting the furnace.

The metal is reduced by ferromanganese (Mn content - 75 %), 70 kg per heat, added to the furnace - 5 minutes before teeming, and by ferrosilicon (silicon content - 75 %), 25-30 kg per heat, added to the ladle immediately before teeming.

The metal is bottom-cast into ingots of weight up to 124 kg. The liquid metal is not weighted up. The required number of moulds is estimated by the operators visually as their experience shows them. In case of necessity a couple of moulds can be removed. If the amount of the metal seemed exceeds the expectations, the remaining part of the metal is delivered to the slag pit together with the slag, which leads to heavy metal losses.

The casting facilities are provided with 2 bottom plates with ingots placed simultaneously. Considering the total heat time in the electric furnace 2 plates are sufficient for casting of the metal.

On complete solidification of the metal ingots are removed from the moulds.Standard sample is taken from the runner.

Each heat is registered in the steelmaking section log where the data on composition and amount of the charge used are included. The results of temperature and carbon content probes are entered in the log in the chronological order, as well as the amount and kind of additions and other technological features of the heat. Special forms also include the data on the number of cast ingots, length and characters of idle periods, of which the main are caused by inadequate operation of the mechanical and electrical equipment. Some idle time is due to lack of power supplies by the SONELEC. The forms also contain information on maintenance and repairs.

2.2. Analysis and recommendations on construction steel production efficiency

While speaking about the technology of steelmaking in SAFA works it should be noted in the first place, that with respect to raw materials the plant is in most favorable conditions. The scrap in use - rails and wheels of railway carriages as well as hot waste of the rolling shop - has a contrast chemical composition and low content of harmful impurities. Due to that the refining stage in the steelmaking process in the arc furnace is avoided and producing steel in the plant is in fact confined to remelting. The task facing the steelmakers in these conditions is to ensure the required carbon content and attain the necessary temperature. Nevertheless, analyzing the documentation for 1991 we can see that precise estimation of weight of scrap of different types is missing. As a result it is impossible to calculate the steel composition after remelting which results in the necessity of multiple probes for carbon content. It is also noteworthy that average carbon content for 1991 being 0.26 % up to 30 % of melts exhibit a carbon content lower than the grade one (see Table 1), i.e. less than 0.25 %, while sometimes 15 % of melts carbon content does not reach 0.20 % (in 1990 about 7 % of melts showed carbon content less than 0.25 % and about 10 % of melts - lighter than 0.50 %). As was mentioned above, probe analysis for silicon and manganese content is not performed. Before and while teeming the metal from the furnace up to 25-30 kg of ferrosilicon and ferromanganese are added to the steel for the purpose of reduction and alloying. As the calculation show, however, the maximum possible silicon and manganese contents in the steel (provided 80 % of ferroalloys are assimilated) do not exceed 0.3- 0.5 % respectively.

Thus, comparing the account data for 1990-1991 years with the standard requirements we can see that the NORSNIM requirements for chemical composition are not met. The consumers, though, as follows from a general review of the situation, do not come out with strict requirements concerning those parameters and there are no reclamations.

Analysis of the account data for the steelmaking shop makes it possible to state that in a great number of cases the shop personal overheat the melts. This trend having increased in 1991. In some cases the metal temperature reached 1675°C. As is generally known, overheating the metal in an arc furnace brings about a number of negative consequences - the lining service life is reduced, while electric power consumption is increased, as well as metal waste. All the above mentioned factors adversely affect the quality of the metal and ingots produced.

Analyzing the steelmaking technology in SAFA steelworks one cannot miss the fact that the amount of ingots varies greatly from heat to heat. The average number being 60-64 ingots per heat in some cases this value goes down to 26-39 ingots (heats #10164, 10244, 10474 in 1990). It is the result of an inadequate casting technology: in some cases the metal breaks through the runner set in group casting, or, to true contrary, the runners are clogged up. In case when it is impossible to continue the casting of metal, the steel is delivered back to the furnace. If there were no accidents during the casting of metal but the number of moulds is not enough to accommodate the steel melted, the remaining steel goes to the slag pot together with the slag. Thus, inadequate casting leads to reducing the yield of ingots, increasing the consumption coefficient and remelting expenditure.

One of most important factors determining the efficiency of technological equipment is idle time. As was mentioned above, all periods of idle time are registered in SAFA works. For example, during the two recent campaigns, idle time for 33 days (1772 hours) and 23 days (1552 hours), was 185 hours (23,4 %) and 120 hours (21.7 %), respectively. The main reason for that is concerned with inadequate technology - 17.5 % and 12 %, respectively, and inadequate operation of electrical equipment - the latter accounts for 4 and 9 % of idle time, respectively.

Analyses of technology shows that steelmaking plant has some reserves. It makes it possibly to improve effectiveness of production and to decrees expenses at this section of SAFA's work.

The following activities are recommended for further improvement of production quality and effectiveness in the steel plant.

To install the express analysis of the chemical composition of the metal.

The temperature regime of heats in the electric furnace should be optimized; the tapping temperature of the metal should not exceed 1630-1650°C.

2.3. Production equipment and technology in the rolling mill

The 300 SAFA rolling mill designed and constructed by the Italian company AVAC is to produce annually 32.000 tof light sections: round sections of diameter 8 to 32 mm, reinforcing steel of the same dimensions, shapes of angle, channel and the like types, as well as wire rod 6 mm in diameter.

At present the mill rolls reinforcing steel of 8, 10, 12, 14 and 16 mm diameter from carbon steel (see Table 1) meeting technical requirements to mechanical properties according to AFNOR NF 35016 specifications (Tables 2,3).

Rolling billet is an ingot of mass 124 kg, of height 1.5 m. The pencil-billet has a bottom section of 110×110 mm and a top section of 94-96 mm. The ingot mass, its length and top section vary depending on the degree the mould was filled.

With respect to function the rolling mill can be subdivided into four parts:

- heating furnace;
- rolling stands;
- cooling and removal facilities;
- stocking yard.

2-zoned continuous pusher-type heating furnace incorporates 4 front end burners and uses liquid fuel of the gas-oil type.

Layout of the rolling mill equipment is shown in Fig.3.

Ingots from the ingot yard located in the parallel steelmaking bay are placed by crane on the ingot receiving table of the heating furnace and pushed along uncooled bottom hearth guides. The hearth dimensions are 15 by 5 m. The heating temperature is measured with the help of the roof thermocouple and registered by the potentiometer. The heating time depends on the rate of ingot removal from the furnace and varies in a substantial range. The ingots are front pushed out of the front end window onto the table. It is possible to push the ingot manually from the table to the guides placed along the longitudinal axis of the furnace for a second heating in case of an accidental stop or improper heating.

After the turn-table where the ingot is directed smaller section-on it goes to the 350 6-stand breakdown train. The first three high cogging stand is fitted with front tilting boards and a back tilting table. The ingot is first rolled in coupled box passes with tilting on the front side and then in the system of breakdown oval and square passes. 8 passes in all are performed in the first stand. After 6 and 7 passes the front and back ends of the piece are cut with shears installed at the back end of the feed tables on both sides of the stand. The piece is fed from the first stand to the other 5 stands of the train via repeaters with a pneumatically opened groove for loop release.

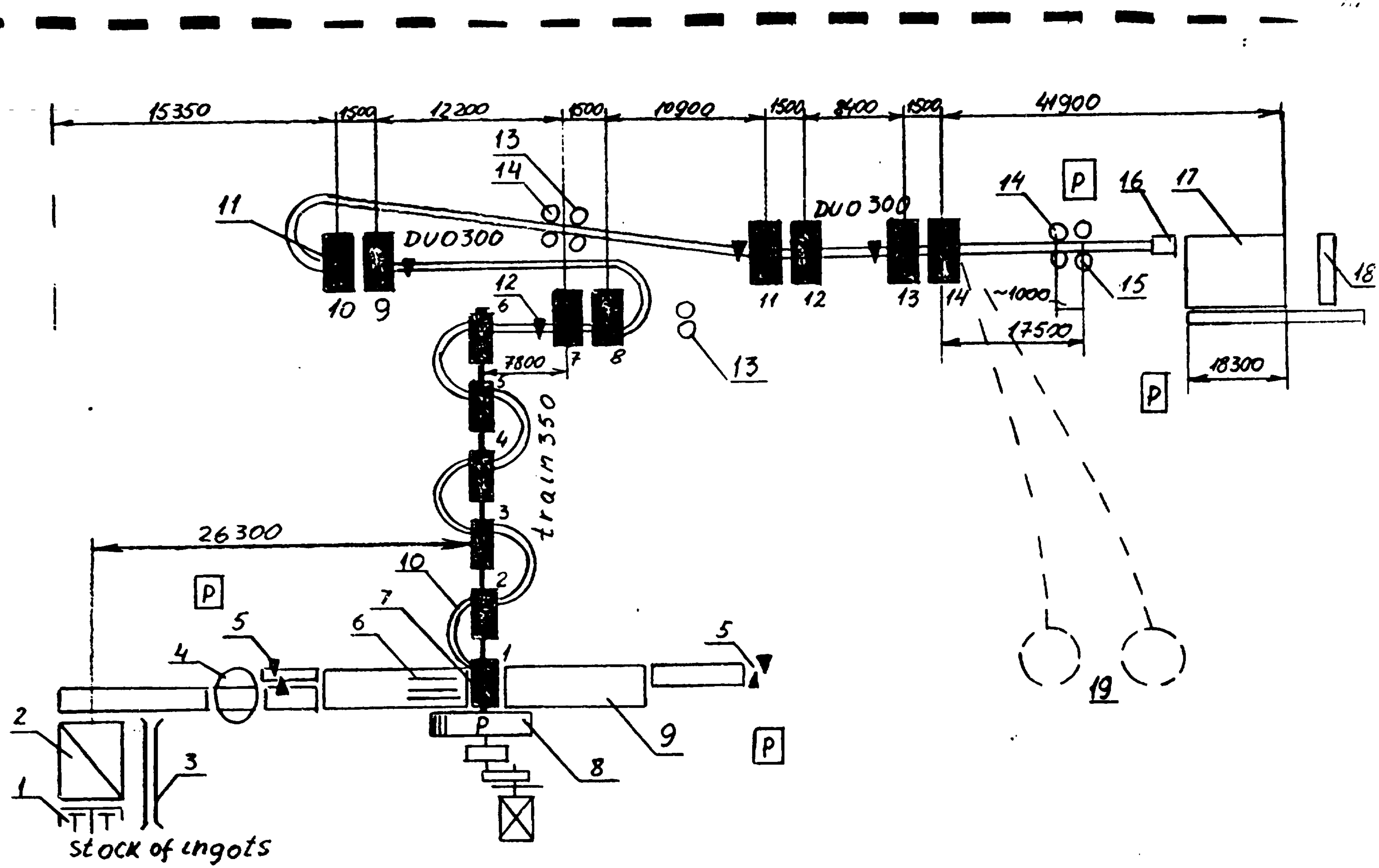

Fig.3

Layout of the rolling mill equipment

Then the stock is rolled in a straight-away 8 stand mill with continuous groups of 2 stands each the feeding direction being changed with the help of repeaters after 8 or 10 stands. Before each group of stands emergency shears are installed, 8 and 10 stands are followed by rotation shears with carryover pinch rolls between 8 and 11 stands. Depending on the section size rolled groups of 13 and 14 stands (⌀ 8), 11 and 12 stands (⌀ 10), 7 and 8 stands (⌀ 16) can serve as finishing and leader stands. The metal from the finishing stand goes to the flying shears to be cut into 12-meter rods. After the brake block the metal is fed to the cooling bed where the cooled rods are packed.

The pack is then jack-knifed in a special device to be transformed by crane to the stocking yard.

Technical features of rolls and drivers are listed in the Table 4. Stand housing in the roughing train are of the open-top roll type while all other stands have close-top roll housings. The main line of roughing stands 350 includes an asynchronous motor, gearbox, fly-wheel and a pinion stand. The coupling spindle between the pinion stand and the first working stand has 5 sleeves with bronze inserts. The other spindles of roughing stands are of the wobbler type. Each stand-300 is fitted with an individual drive. The motor mounted over the pinion stand transmits the torque through a wedge-belt drive with rotation

Table 4

Parameters of rolls and main drive motors (SAFA mill 300)

Stand	Rolls						Motor			
	Barrel		Neck		Material	Hardness	Type	Power	RPM	Gear ratio
	D, mm	L, mm	d, mm	l, mm		SHR		kW		
1	360	1100	210	220	Steel	22(*)				
2	350	800	195	220	Iron	60/65				
3	350	800	195	220	Iron	68/72	AC	810	990	5.43
4	350	800	195	220	Iron	68/72				
5	350	800	195	220	Iron	68/72				
6	350	800	195	220	Iron	68/72				
7	300	600	160	135	Iron	68/72	AC	132	980	3.65
8	300	600	160	135	Iron	68/72	AC	132	980	2.92
9	300	600	160	135	Iron	68/72	AC	132	980	2.70
10	300	600	160	135	Iron	68/72	AC	132	1480	3.20
11	300	600	160	135	Iron	68/72	AC	132	1480	3.25
12	300	600	160	135	Iron	68/72	AC	132	1480	2.68
13	300	600	160	135	Iron	71/74	DC	220	1850	1.93
14	300	600	160	135	Iron	71/74	DC	220	1850	1.60

(*) - The allowed bending stress

speed decreased. The mill is to be equipped with two coilers of the "Garret" type to roll steel in coils practically out of use today.

Roll pass design in all stands beginning with the second stand of the roughing train makes use of the oval-square series. Leader pass for rolling reinforcing steel is flat oval. Pass dimensions and parameters are listed in Table 5,6, corresponding figures showing the designations (Fig.4).

Under the given technology samples are taken from the pack in the stocking yard to measure the actual section size, test mechanical properties and provide visual control of section and surface quality.

The rolling mill is operated from 5 pulpits (see Fig.3).

Table 5

SAFA mill 300 pass dimentions

Stand	Pass	Pass shape	Hк mm	Bк mm	R1 mm	R2 mm	Bd mm	S mm	Fк mm2
	1	box	88.0	130.0	3.0	15.0	125.0	5.0	10027.5
	2	box	62.0	130.0	3.0	15.0	125.0	5.0	6720.1
	3	box	90.0	68.0	3.0	12.0	62.0	5.0	5261.0
	4	box	65.0	68.0	3.0	12.0	62.0	5.0	3640.5
1	5	box	45.5	74.0	1.5	10.0	63.0	5.0	2634.0
	6	fl.oval	30.0	84.0	0.0	35.0	30.4	5.0	1690.9
	7	square	49.2	49.9	6.0	0.0	.0	5.0	1208.2
	8	fl.oval	21.0	58.0	0.0	30.0	17.2	5.0	723.5
2	9	square	34.4	34.2	4.0	0.0	.0	4.0	568.2
3	10	oval	17.7	43.5	81.0	0.0	.0	5.0	472.9
4	11	square	26.5	26.4	3.0	0.0	.0	3.0	338.2
5	12	oval	13.1	31.9	55.7	0.0	.0	3.0	277.2
6	13	square	19.2	20.0	3.0	0.0	.0	2.0	192.3
7	14	oval	9.3	25.7	55.7	0.0	.0	3.0	137.5
8	15	square	14.5	15.7	3.0	0.0	.0	1.5	117.2
9	16	oval	7.1	21.0	45.5	0.0	.0	2.0	90.8
10	17	square	12.0	12.8	2.0	0.0	.0	1.0	79.0
11	18	oval	7.5	15.7	22.3	0.0	.0	2.0	72.8
12	19	square	8.7	10.0	2.0	0.0	.0	0.5	47.3
			Reinforcing rod of diam. 8 mm						
13	20	fl.oval	5.5	14.4	0.0	3.6	7.9	1.5	50.2
14	21	reinforc	7.8	8.2	4.1	0.0	.0	0.6	44.6
			Reinforcing rod of diam. 10 mm						
11	18	fl.oval	7.0	18.0	0.0	4.5	9.9	2.0	78.5
12	19	reinforc	9.8	10.2	5.1	0.0	.0	1.0	67.9
			Reinforcing rod of diam. 12 mm						
9	16	fl.oval	8.4	21.6	0.0	5.4	11.9	2.4	113.0
10	17	reinforc	11.7	12.3	6.1	0.0	.0	1.0	98.7
			Reinforcing rod of diam. 14 mm						
7	14	fl.oval	9.8	25.2	0.0	6.3	13.9	2.8	153.9
8	15	reinforc	13.7	14.3	7.2	0.0	.0	1.0	138.4
			Reinforcing rod of diam. 16 mm						
6	13	square	21.8	22.1	3.0	0.0	.0	2.5	236.2
7	14	fl.oval	11.2	28.8	0.0	7.2	15.9	3.2	201.0
8	15	reinforc	15.7	16.4	8.2	0.0	.0	1.0	183.4

Table 6

Parameters of roll pass design for reinforcing rod of diam. 8 mm (SAFA mill 300)

Stand	Pass	Pass shape	Pass dimensions				Dimensions of metal stock				Parameters of deformation				Rolling speed	RPM of rolls	Rolling torque	Temperature	Rolling force
			Height 2hp mm	Width B mm	Side A mm	Gap S mm	Side A mm	Height H mm	Width B mm	Cross-section F mm2	Abs. reduction dH mm	Spread dB mm	Elongation coefficient	Angle of bite deg	m/s		kNm	oC	kN
								103.0	103.0	10365.0									
	1	box	93.0	130.0		5.0		88.0	105.5	9277.8	15.0	2.5	1.117	19.0	2.69	182.5	16	1230.0	330
	2	box	57.0	130.0		5.0		62.0	116.4	7171.3	26.0	10.9	1.294	24.3	2.97	182.5	36	1223.2	567
	3	box	85.0	68.0		5.0		90.0	67.3	5597.9	26.4	5.3	1.281	29.8	2.74	182.5	22	1217.2	331
	4	box	60.0	68.0		5.0		65.0	72.5	3998.5	25.0	5.2	1.400	31.5	3.03	182.5	21	1210.5	340
1	5	box	40.5	74.0		5.0		45.5	73.1	2996.4	22.5	8.1	1.328	21.6	3.20	182.5	18	1202.1	337
	6	fl.oval	25.0	84.0		5.0		32.0	85.0	2182.4	13.5	11.9	1.373	17.2	3.43	182.5	19	1190.6	377
	7	square	44.2	49.9	38.6	5.0	38.6	47.2	47.4	1247.3	39.3	15.4	1.750	31.0	3.34	182.5	43	1175.2	525
	8	fl.oval	16.0	58.0		5.0		23.0	47.7	1006.1	12.6	12.1	1.240	17.6	3.48	182.5	16	1159.5	295
2	9	square	30.4	34.2	26.9	4.0	27.5	35.4	32.9	705.4	12.3	9.9	1.426	22.9	3.30	182.5	17	1125.9	253
3	10	oval	12.7	43.5		5.0		17.5	35.2	565.2	9.4	8.3	1.248	14.2	3.38	182.5	8	1120.0	194
4	11	square	23.5	26.4	20.6	3.0	21.0	27.0	25.3	411.2	8.2	7.8	1.374	19.5	3.33	182.5	11	1106.4	183
5	12	oval	10.1	31.9		3.0		13.0	27.5	322.3	7.5	7.0	1.276	12.8	3.41	182.5	6	1096.7	149
6	13	square	17.2	20.0	15.4	2.0	16.0	20.0	19.3	237.6	7.5	6.3	1.356	16.8	3.32	182.5	7	1079.9	139
7	14	oval	6.3	25.7		8.0		9.8	21.4	192.9	5.9	5.7	1.232	11.8	4.10	254.3	4	1044.5	120
8	15	square	13.0	15.7	12.1	1.5	13.0	15.8	14.6	150.6	5.6	4.8	1.281	15.7	5.24	337.3	5	1036.1	109
9	16	oval	5.1	21.0		2.0		8.0	17.3	127.6	4.6	4.7	1.181	10.3	6.19	385.9	3	1019.1	100
10	17	square	11.0	12.8	9.7	1.0	11.0	13.8	11.9	106.8	3.5	3.9	1.195	13.7	7.41	478.1	4	1014.1	92
11	18	oval	5.5	15.7		2.0		8.0	13.8	99.3	2.6	3.2	1.075	8.0	7.97	502.8	2	1002.6	71
12	19	square	8.2	10.0	7.4	0.5	8.7	10.6	11.6	73.9	3.2	3.6	1.344	13.1	10.70	680.4	3	996.5	84
13	20	fl.oval	4.0	14.4		1.5		5.6	12.1	65.6	3.2	3.3	1.087	8.4	12.05	757.3	2	1002.9	72
14	21	reinforc	7.2	8.2	8.2	.6	8.0	8.0	8.2	51.1	4.1	2.6	1.285	12.7	15.47	1003.7	2	1000.4	63

Torque exceeds the allowed value: 15 17 19 passes.
Overfilling of passes: 4 6 19 passes.
Angle of bite exceeds the allowed value: 3 4 7 passes.

Specific power consumption: 65.0 kWh/t.

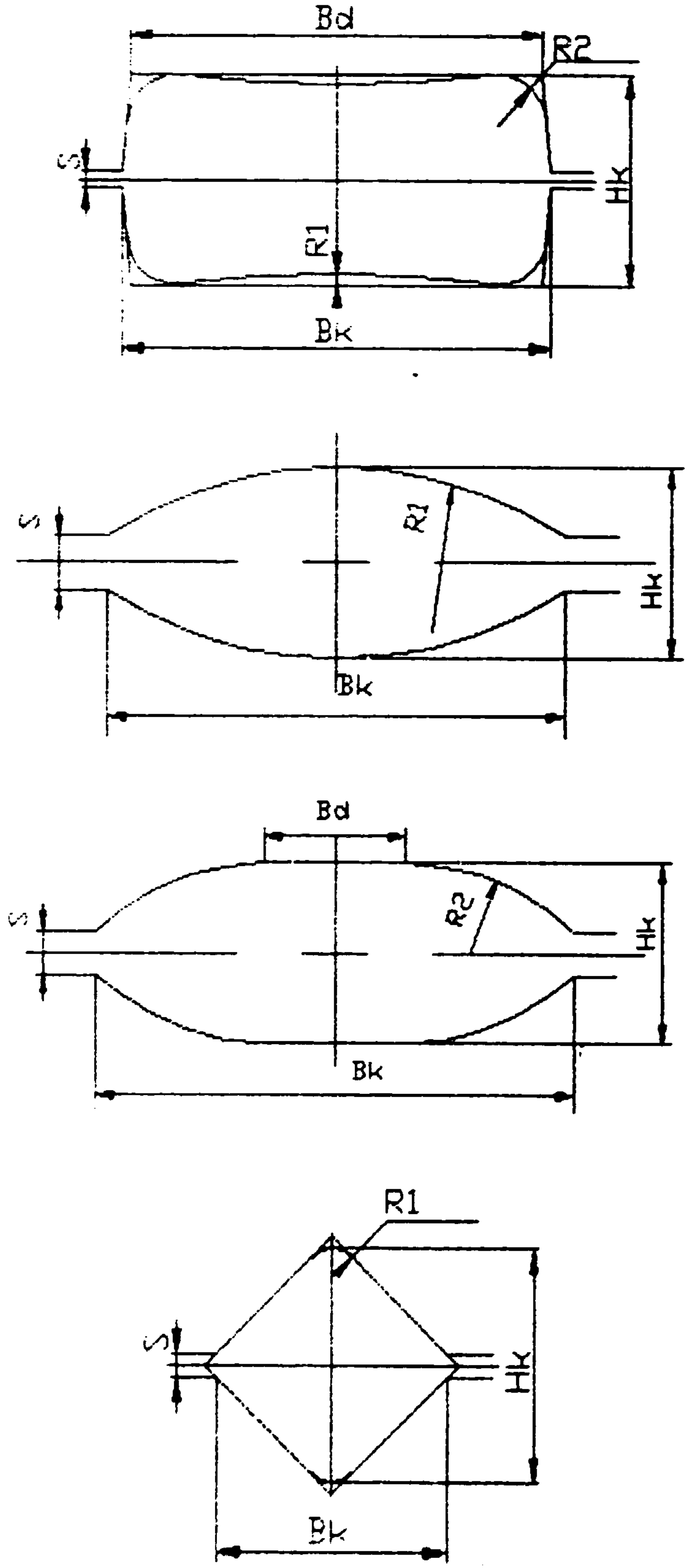

Fig. 4 Pass designations

2.4. Analysis and recommendations on improving reinforce bars production

The main reasons for a low efficiency of the rolling production in the SAFA plant are as follows:

- long period of shot down time for the rolling mill;
- relatively high losses of metal in the production process;
- high consumption of fuel, electric power and other materials per ton of yield.

In most cases the equipment is standing idle due to stops in the technological process caused by the failure to bite and stock breaking away from the rolling line (the so-called cobbling) unfinished sections or hot waste as a result of such accidents constitute the main losses of metal and amount to 9.58 % in 1990 and 8.87 % in 1991 of the total yield. The unfinished sections are cut into pieces and go to the steelmaking shop for remelting thus enormously increasing the expenditure. A certain amount of metal is wasted while a substantial part of the metal heated in the furnace (8.67 % according to the account data from 11/03/91 to 17/12/91) is transferred back for reheating due to a breakage of the rolling mill or improper heating.

Study and analysis of the current technological process and operation of equipment enabled us to define the following drawbacks.

Concerning the rolling process:

1. As was stated above deficiency of the rolling mill is caused by breaks in the technological process of rolling, cobbling and inadequate biting primarily in the first stand of the breakdown train.

Table 7 contains the analysis of pass parameters, coefficients K_p, K_m, K_α included, which give the ratio of actual values of the applied force, torque and angle of bite to the allowed values. These calculations are in full agreement with the actual mill operation. To improve the biting conditions the method of nothing was applied. Trapeziform grooves 3-5 mm deep were cut in the bottom of the first four passes parallel to the roll facilitating the bite. This led, though, to bulging out of trapeziform pyramids on the stock side in the fourth pass (after tilting) which later peel off or are rolled in forming artificial films. It may lead to the stock sticking in the tackle and subsequent cobbling.

2. The application of coupled box passes with a high ratio $b/h \approx 1.9$ before tilting is fraught with heavy consequences such as twisting. The smaller the cross section the more dangerous is this rolling technique. International metallurgical experience shows that the application of box passes for such dimensions should be avoided, the ratio must also lead to twisting in the

Table 7

Analysis of tecnological parameters of rolling SAFA mill 300

Stand	Pass	Pass shape	Elongation coefficient	Reduction ratio	Temperature oC	Rolling force kN	Rolling torque kNm	Angle of bite deg	Rolling speed m/s	Kp	Km	Ka	Specif. power consump kWh/t
	1	box	1.117	.13	1230.0	330	16	19.0	2.69	.47	.36	.73	.35
	2	box	1.294	.30	1223.2	567	36	24.3	2.97	.62	.84	.93	.97
	3	box	1.281	.28	1217.2	331	22	29.8	2.74	.48	.52	1.15	.88
	4	box	1.400	.34	1210.5	340	21	31.5	3.03	.38	.48	1.21	1.09
1	5	box	1.328	.33	1202.1	337	18	21.6	3.20	.31	.43	.83	1.19
	6	fl.oval	1.373	.37	1190.6	377	19	17.2	3.43	.30	.45	.72	1.49
	7	square	1.750	.61	1175.2	525	43	31.0	3.34	.50	.98	1.29	4.49
	8	fl.oval	1.240	.40	1159.5	295	16	17.6	3.48	.22	.36	.73	2.22
2	9	square	1.426	.51	1125.9	253	17	22.9	3.30	.25	.40	.95	3.25
3	10	oval	1.248	.39	1120.0	194	8	14.2	3.38	.16	.19	.59	2.35
4	11	square	1.374	.50	1106.4	183	11	19.5	3.33	.17	.25	.81	3.46
5	12	oval	1.276	.41	1096.7	149	6	12.8	3.41	.12	.14	.53	2.79
6	13	square	1.356	.50	1079.9	139	7	16.8	3.32	.12	.17	.70	3.96
7	14	oval	1.232	.41	1044.5	120	4	11.8	4.10	.12	.76	.49	3.47
8	15	square	1.281	.47	1036.1	109	5	15.7	5.24	.12	1.22	.65	4.74
9	16	oval	1.181	.38	1019.1	100	3	10.3	6.19	.10	.84	.43	3.90
10	17	square	1.195	.44	1014.1	92	4	13.7	7.41	.10	1.31	.57	5.11
11	18	oval	1.075	.28	1002.6	71	2	8.0	7.97	.07	.66	.33	3.14
12	19	square	1.344	.49	996.5	84	3	13.1	10.70	.09	1.61	.55	5.84
13	20	fl.oval	1.087	.33	1002.9	72	2	8.4	12.05	.07	.60	.35	4.20
14	21	reinforc	1.285	.47	1000.4	63	2	12.7	15.47	.06	.97	.53	6.05

third and fourth passes the threat of which being enhanced by the pass design.

3. The fact that the rolling train of the 13-th and 14-th stands (pinion-pinch rolls-flying shears) brings about numerous breaks in the rolling process due to the absence of synchronization.

4. Insufficient capacity devices in some stands (see Fig. 4) are overloaded due to the improper distribution of elongation between the stands. This overloading is not evident because of the long periods of idle time.

5. The roll diameter in the first stand of the breakdown train is a wrong choice (370-365-360 bottom dia) which results in excessive dia difference (up to 30 mm). The common value for this parameter in the world practice is 4-8 mm for this type of stand. It leads to heavy dynamic flows in the main train, increased wear of the bronze insects and breakage of spindles.

Concerning heating:

1.The absence of a thermocouple in the preheating zone and a pressure control device in the furnace makes it impossible to regulate the process of heating and reduce the metal losses to the minimum. Waste of metal in the furnace was not determined in the plant but visual inspection shows a thick layer of scale on the ingot. Pressure in the furnace is not controlled. Taking into account the considerable area of output and input windows on the front and back ends of the furnace we can assure that cold air is sucked in in great amounts which results in an increase of fuel consumption and metal waste.

2. The liquid fuel used is the gas-oil type which is a few times more expensive than mazout.

2.5. Comparative analysis of furnace heating by gas oil and mazout

The replacement a gas oil on a mazout as a fuel for heating the holding hearth leads to some impacts because differences between physical and thermophysical properties of gas oil and mazout.

The comparison some physical and thermophysical properties of the both kinds of fuel is presented in table 8.

As it follows from table 8 the most important difference between gas oil and mazout is more high viscosity of latter. That leads to some differences in transport conditions, spraying and combustion of these fuels.

As it is shown in figure 5 above viscosity of gas oil (dotted line) at all temperatures is lower than maximal available one for screw and gear pumps (line 1), piston pumps (line 2), centrifugal pumps of big productivity (line 4) in circulatory system (line 5). The limit values of viscosity for the mazout (dashed line) which used for heating hearths are respectively achieved for the mazout at temperatures 42,54,70,83 ^{o}C. Thus it is necessary to build mazout heating system with maximal temperature of mazout and steam in heater less than 110 ^{o}C (line 1) and 140 ^{o}C (line 2) correspondingly. There is a carbon precipitation at temperature

TABLE 8

Comparison of physical and thermophysical characteristics of different fuels.

Parameter	Gas oil	Mazout
Density at 20 ^{o}C ρ, kg/m^3	880,3	<1015
Coefficient of kinematic viscosity at 40 ^{o}C, ν, mm^2/s	10,3	240
Content of moisture W^p, %	0	3
The lowest heat of combustion, Q_l^p, kJ/kg	42329	39105
Volume of products of combustion, V_{pc}, m^3/kg	10,36	9,8
Enthalpy of products of combustion, I, kJ/kg	4082	4019
Content of RO_2 in products of combustion , %	15,6	16,2

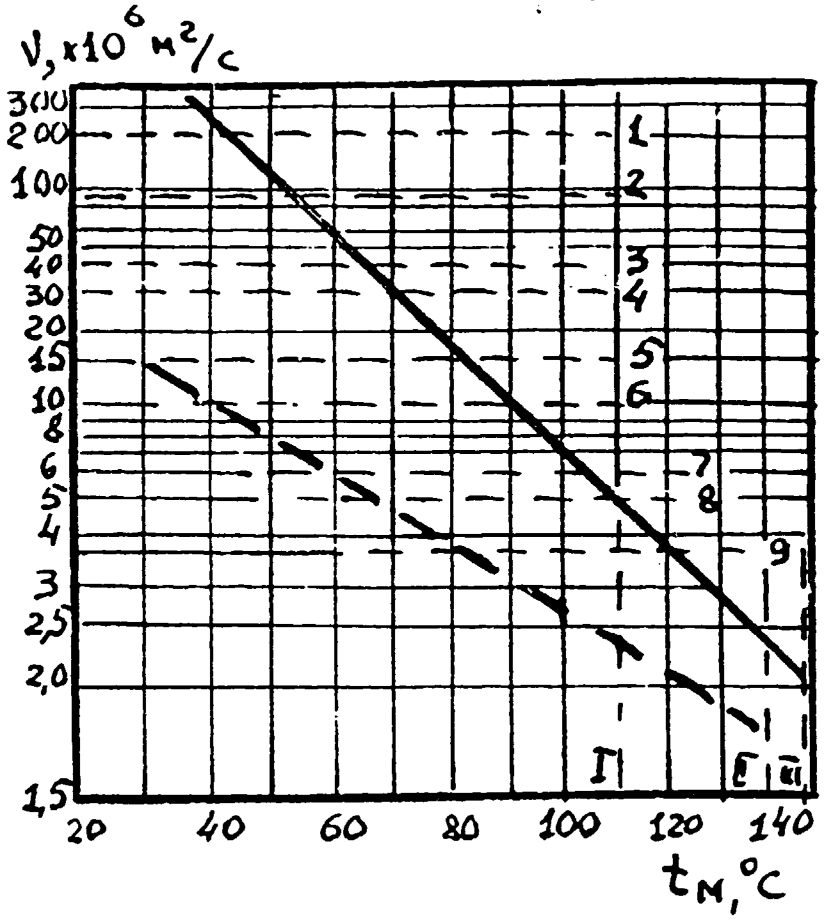
V, x10⁶ м²/с
300
200
100
50
40
30
20
15
10
8
6
5
4
3
2,5
2,0
1,5
1
2
3
4
5
6
7
8
9
I
II
III
20
40
60
80
100
120
140
tм, °C

Fig. 5

of heater 150 ^{0}C with velocity 0.5 mm per month.

The average viscosity of mazout for its delivery by pumps for flow corresponds to value ν = 40 10^{-6} m^2/s is achieved at mazout heating temperature 68 ^{0}C (line 3).

The different types of mechanical, steam-atomizing and air-atomizing burners can be used for mazout combustion, but choice one or another type of burner has to define by viscosity of this mazout, i.e. temperature of its heating.

If rotary type and steam-atomizing burners are used maximal viscosity of mazout would not be greater than value ν_{max}= 15 10^{-6} m^2/s (line 5), i.e. the temperature of mazout heating would not be below 82 ^{0}C.The maximal available value of viscosity of mazout for air-atomizing burners of low and high pressure is equal ν_{max}= 10 10^{-6} m^2/s (line 6).This value corresponds to the temperature of mazout heating 90 ^{0}C.The limit available viscosity for mechanical burners is more low (ν_{max}=6 $10^{-6}m^2/s$) and temperature of mazout heating can not be less than 105 ^{0}C (line 7). The values of temperatures of mazout heating are recommended for different types of burners presented in table 9.

Thus it is convenient to use for mazout combust on steam-atomizing or air-atomizing burners with preliminary fuel heating to 105-110 C.

As usually the purners of low and high pressure with steam

TABLE 9

The values of temperatures of mazout heating are recommended for different types of burners

Type of burner	The recommended temperature of heating ^{o}C	Note
Steam-atomizing	105	line 7
Air-atomizing	110	line 8
Mechanical	120	line 9

and pneumatic spraying are used for mazout combustion.

The compressed air or steam of high pressure are served as a sprayer in high pressure burners.The necessary air pressure for this is equal P= 400-600 kPa the specific flow of mazout is equal 1,0-1,5 kg/kg.The steam can be as dry saturated as superheated, its specific flow is equal 0,8-1,0 kg/kg.The high quality of spraying and effective combustion of mazout at sufficiently high limits of regulation are achieved due to use of high headed sprayer in burners of high pressure.In order to achieve long and steady flame one can use burners of high pressure with double spraying;if it is necessary to have more short and wide flame the short flame burners are used.

The air of low pressure which are used for combustion serves a sprayer in the burners of low pressure.Therefore the quality of spraying and combustion is worse and the limits of regulation are lower than in burners of high pressure.In addition burners of low pressure have lower flow capacity on mazout.

The advantage of burners of low pressure consists in these burners don't need in use of high head sprayer.These burners find place for its application in a little metallurgic hearths.

The comparative characteristic of burners of low and high pressure is shown in table 10.

Thus, based on data above we can recommend burners of low

The comparative characteristic of burners of low and high pressure TABLE 10

CHARACTERISTIC	BURNERS OF	
	LOW PRESSURE	HIGH PRESSURE
Sprayer	Ventilation air	1) Compressed air 2) Steam
Pressure of sprayer, kPa	3 - 9	1) 400 - 600 2) 700 - 1600
Flow of sprayer (air), % from all air needed for combustion	100	7 - 12
The flow of second air, % from all air for comb	100	1) 88 - 93 2) 100
Temperature limit of air heating , ^{0}C	300	Heating of second air is not limited
The specific flow of of sprayer per 1 kg of mazout, kg	-	1) 1,0 - 1,5 2) 0,8 - 1,0
Velocity of sprayer after the burner,m/s	50 - 80	330
Degree of spraying (diameter of drop),mm	0,5	0,1 - 0,2

pressure for mazout combustion in a given holding hearth.These burners were compared with ones of high pressure have next advantages:

1) The good mixture forming and available conditions for the perfect combustion of fuel at low coefficient of the air flow (n=1,1 - 1,5) are achieved due to delivery of air through the burner;

2) In spite of sprayer has more low pressure the good quality of spraying can be achieved because all air is used in spraying;

3) The flame of burners of low pressure is shorter and more convenient (i.e. less oxidational and sharp than in burners of high pressure) for the heated metal;

4) The cost of spraying is relatively low.

The disadvantages of burners of low pressure are the next ones:

1) The low productivity with limited possibilities for mazout flow regulation;

2) Impossibility of working in air heated more than 300 C.

As it is known there are many types of burners of low pressure whose characteristics are more or less equal.Therefore one has to lead economical consideration for choice type of burner of low pressure for the holding hearth reconstruction.

The flames formed at gas oil and mazout combustion differs by concentration of smoke black particles (μ,g/m^3 , degree of blackness (ε_b and hence by magnitude of the heat flow on the heated metal.

The concentration of smoke black particles in a flow fuel flame depends on air flow coefficient n and ratio amount of carbon to amount of hydrogen in the working mass of fuel (C^p/ H^p).

$$\mu = 0{,}068\ \gamma\ (2-n)\ C^p/\ H^p \qquad (1)$$

γ is a smoke black density,g/m^3.

When air flow coefficient at fuel combustion n is equal 1,15 which is usual for burners of low pressure the smoke black concentration in the mazout flame is equal μ_f = 1.65 g/m^3,in the gas oil flame μ_g=1.45 g/m^3

The optical thickness of smoke black particles flow can be defined by formula:

$$\tau_{sb} = 0{,}03\ (2-n)(1{,}6\ \ 10^{-3}T\ -0{,}5)\frac{C^p}{H^p}p\ l \qquad (2)$$

where p is pressure in working space of hearth,atm.;

K is temperature of flame,K;

l_{eff} is effective length of ray which can be obtained from relation:

$$l_{eff} = 3{,}6\ \frac{V}{F}\ m \qquad (3)$$

where V is the volume of working space of hearth,m^3;

F is the area of surface restricting this volume,m^2 .

For the present holding hearth:

$$l_{eff} = \frac{3.6(3.78*1.280*8660)}{2(3.78*\ 8660 + 1,280*8660)} = 1,68\ m$$

Taking temperature of flame T = 1875 K, p = 1 atmosphere we obtain accordingly expression (2) that optical thickness of mazout flame is equal τ_c^f = 2,94 and one for gas oil is equal τ_c^s=2,6.

The effective degree of flame blackness for liquid fuel combustion can be determined from :

$$\epsilon_{eff} = m\ \epsilon_{lum} + (1 - m)\ \epsilon_{nlum} \qquad (4)$$

which take account for relative filament of hearth volume m by luminous part of flame.The degrees of blackness for luminous and nonluminous parts of flame are defined by formulas :

$$\epsilon_{eff} = 1 - \exp\ (\tau_{lum} + \tau_{nlum});\epsilon_{nlum} = 1 - \exp\ (\ \tau_{nlum}\ )$$

where τ_{lum} and τ_{nlum} are the optical thicknesses of layer for smoke black particles and gaseous products of combustion flows (CO_2 and H_2O).

Taking m = 3 for holding hearths we obtain that the effective degree of blackness for mazout flame is equal ϵ_{eff}^f=0,334 and one for gas oil flame is equal ϵ_{eff}^s= 0,338 , i.e. difference isn't over than 2 percents.

These results show with respect to metal heating mode replacement gas oil on mazout would not lead to essential changes.

The flow of fuel can be increased in a little degree due to mazout heat of combustion is less than gas oil (see TABLE 8).In order to evaluate this increment one can carry out a heat balance for holding hearth (TABLE 11).

Thus replacement gas oil on mazout as a fuel for holding hearth does not change essentially conditions of metal heating in hearth (productivity of hearth) but requires to build mazout heating system for transportation and spraying of mazout and leads to some increment of fuel's flow (on 9%).

The economical efficiency of the such fuel replacement depends on prices on mazout and corresponding environment on the local market.

TABLE 11

The heat balance of holding hearth heated by mazout or gas oil

NN	Articles	Kw	%
1	2	3	4
	Delivery		
1	Heat of fuel combustion $Q_{chim} = B\ Q^p_h$	1862,5	95,19
2	Heat of exothermical reaction (oxidation of metal) $Q_{ext} = 5{,}65\ 10^6$ kJ p.q where Q = 0,02 kg/kg -- waste	94,1	4,81
	Consumption		
1	Useful heat expended on metal heating $Q_{total} = P\ (I^{beg}_m - I^{fin}_m)$ where I_m - enthalpy of metal kJ/kg	670,83	34,28
2	Heat lost with products of combustion $Q = B\ V_{pc}\ c_{pc}\ t_{pc}$ where V_{pc} - products of combustion volume ,m^3/kg; c_{pc} - products of combustion thermal heat capacity,kJ/m^3 K; t_{pc} products of combustion	931,2	47,59

1	2	3	4
	temperature, ^{o}C.		
3	Heat lost with mechanical imperfectness of fuel combustion $Q_{mech} = 0{,}01 \; B \; Q_h^p$	18,6	0,95
4	Heat lost from heat conductivity through break-lining $Q_{heat} = (t - t) F / (\Sigma_i (s_i / \lambda_i) + 1/\alpha)$	149,0	7,62
5	Unconsidered loss of heat $Q_{unc} = (0{,}05 - 0{,}15) \; Q_{del}$	186,97	9,01

Flow of fuel	mazout	0,048 (171,27)
kg/s (kg/h)	gas oil	0,044 (158,2)

3.CONCEPT OF PROJECT PROPOSALS ON REIFORCING EUIPMENT AND TECHNOLOGY OF PRODUCTION ON SAFA

Project proposals have been developed in accordance with preliminary recommendations and amendment.This proposals include some sudjestions on equipment modernasation and rolling technology improvement.Proposals are in Part II of Final Report.

3.1.Concept of project proposals on converting heating furnace from gas oil to mazout fuel

Now heating furnace is heated by gas oil combustion. But the gas oil price is considerably more than mazout price. Replacement gas oil on mazout as fuel for holding hearth will lead to increasement of production effectiveness. For replacement it will be necessary to build two reservoirs with a system of mazout preheating, two force-pumps, stand of mazout preparation to combustion and four affective acoustic burners.

Part II of Final Report includes project proposals, including acoustic burner for mazout combustion.

3.2. Concept of project proposals on improvement of roll pass design

Some reasons for rolling production low efficiency in SAFA rolling mill have been mentioned in section 2.4 of Part I of Final Report. Designed proposals were suggested and calculated in order to improve the rolling calibration for SAFA rolling mill.

Designed Proposal of improving the rolls calibration for the SAFA rolling mill is implemented to eliminate some shortcomings in the functionality of the mill. They seemed to be related with the passes construction. The purpose of this work is to increase the productivity, profitableness and output production quality of the mill. Designed Proposal is made on the basis of direct studying of the mill in realistic conditions of production and of the latter computer analysis of the working rolls calibration.

It was determined that main reasons of the low mill efficiency are connected with unsatisfactory bite conditions in the first stand of the breakdown train and also by frequent violations of the process while sticking of the stock in continuous stands groups and it's throw from the rolling train (cobbling).

Some technical proposals, calculations and new roll pass deign have been made in order to decrees standing idles and to increase the productivity and quality of final product. Part II of Final Report contains the proposals.

3.3.Concept of project proposals on rolling mill and flaying shear synchronization

It was written at the section 2.4 that nonsynchronized operation of finishing stands 13 and 14 and flying shear leads to breakdown of technology of rolling regime.

On the base of technical data investigation it's possibly to summarized:

- the flying shears drive is performed from DC engine powered by (which takes its current from) controlled tiristor transmitter with modern control system (with analog or, better, numerical regulators of rotation frequency),
- the power of drive engine would be sufficient to provide the convened cutting of the front edge in flying shears start-up regime from initial position or position set while running. The change of advancing would be excluded at back edge output from the stand N 12 due to use a loop regulator between stands N 12 - 13. While regulated loop the available acceleration would be chocked in accordance with dynamic parameters of shears drive.

Taking into account the electric drives of stands NN 13,14 are constructed with DC engines it is quite reasonable to use the same type of drive for the flying shears and feeding rollers. At least, this solution is considered more preferable than the used one with special AC engine and electromechanical regulator trough servo motor.

To realize the project proposals it's necessary to develop the project in details and to purchase equipment.

ИНТЕРМЕТ INTERMET
ИНТЕРМЕТ ИНЖИНИРИНГ INTERMET ENGINEERING

20049 (2 of 3)

Assistance to the Societe Arabe du Fer et de L'Acier Mauritanie (SAFA) in management and products diversification in the Islamic Republic of Mauvritania

FINAL REPORT

Part I
Volume 2

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La Societe Arabe du Fer et de L'Acier (SAFA)

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4. REINFORCING MANAGEMENT SYSTEM OF SAFA

The management structure of SAFA was created taking into consideration that SAFA is a division of SNIM concern.

Many managerial functions were undertaken by headquarters. For example, data processing for many components was carried out by SNIM computer center.

It is well known, that modern trend of development of Management system is a creation of Computerized Management Information System (CMIS), and this is one of the objectives of this project.

Introducing of CMIS require of certain preparation creation so called "information culture", in first line skilled personal.

SAFA has limited experience to work with computer system. Same computer calculation having been carried out in SLIM computer center (e.q. salary, inventory etc.).

In SAFA staff practically are not experienced and skilled programmers. In this connection, one of the task of subcontractor team was SAFA's personal training.

This on the job training has been a carried out by subcontractor team during the system installation.

This training however, give only the possibilities on some extent to support operating system out secure date input, reporting etc. As far us a system development is concern, troubles shutting etc., the experienced system programmer should be involved.

To the information culture belong also designing and construction computer rooms with air conditions. It is particularly important for MAURITANIA conditions, where the some particular of deserts' strand are always presents in the air. Such rooms suppose to be constructed by SAFA.

4.1. Analysis of current management methods

4.1.1. Functional and organizational structure

The management structure of SAFA can be subdivided into a number of basic departments: administration, commercial, financial and industrial departments (see Fig. 5). As was mentioned before, this structure was developed for joint operations with SNIM and included organisational and functional component.

Taking in consideration modern trend of management development, there several questions, which could be considered:

- Is it necessary to have so many departments and sections for relatively small plant?

- Is it reasonable to have, for example, management

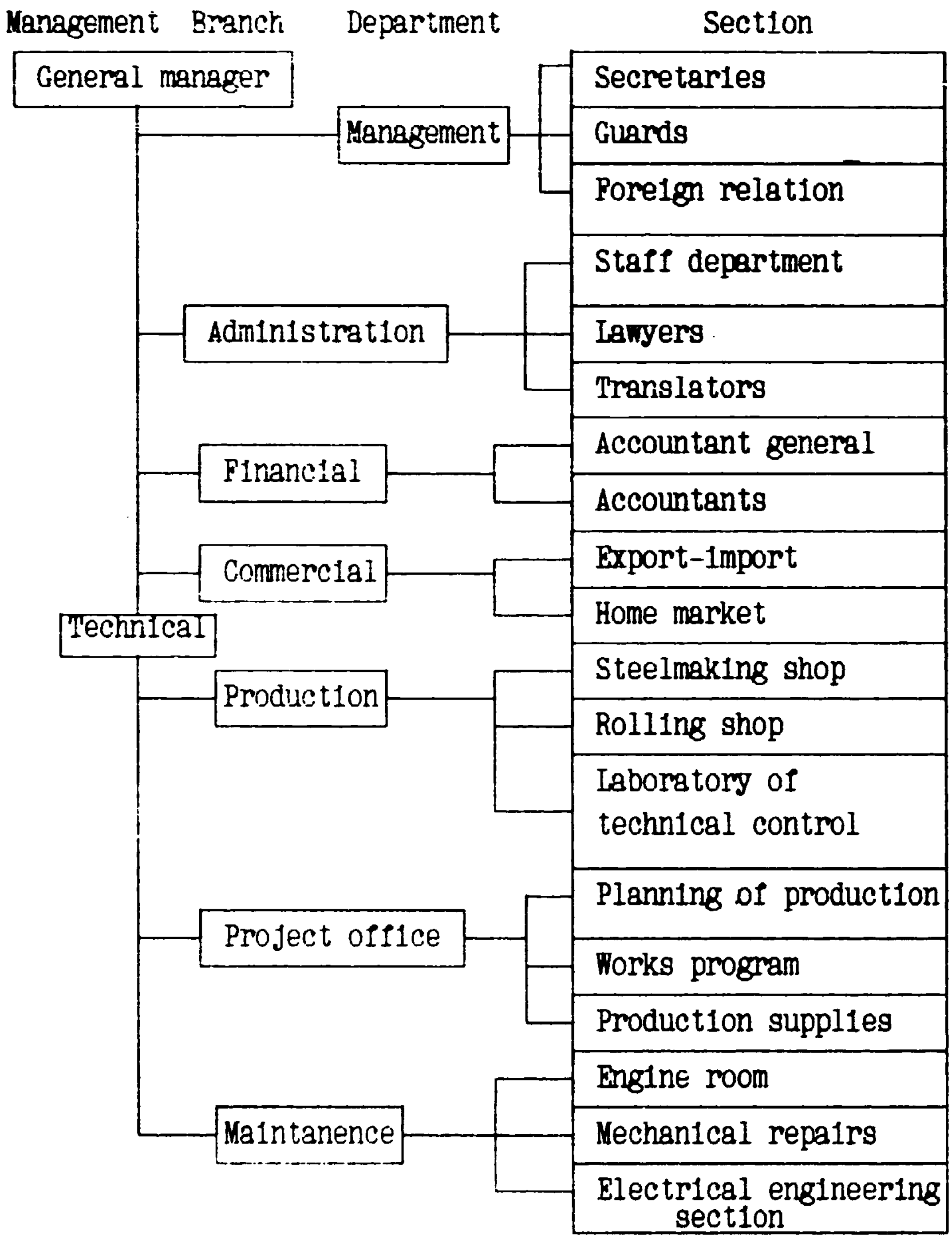

Fig. 5′
Current management structure of SAFA

department, which includes secretaries, guards and Foreign connections?

- Is it reasonable to divide organizational and functional structure?

Answer on this questions depends an SAFA policy and possibilities. It is also clear, that managerial structure reflecting traditions, experiences, character of each enterprise.

4.1.2. Current information system and data flow

Analysis of the management system made it possible to define the data, flows of primary importance in creating the system of automated management support. It must be noted that a certain part of the information is common for several departments although the output structure for each department is unique (see Fig. 6-8).

The technical department is concerned with the following data flows:

1. Control of metal transfer within the steel plant from scrap to finished product;

2. Transfer of materials in the stocking yard and workshops.

The first data flow includes the scrap storage, steelmaking

Data flow chart for suppliers, commercial and accountants activities

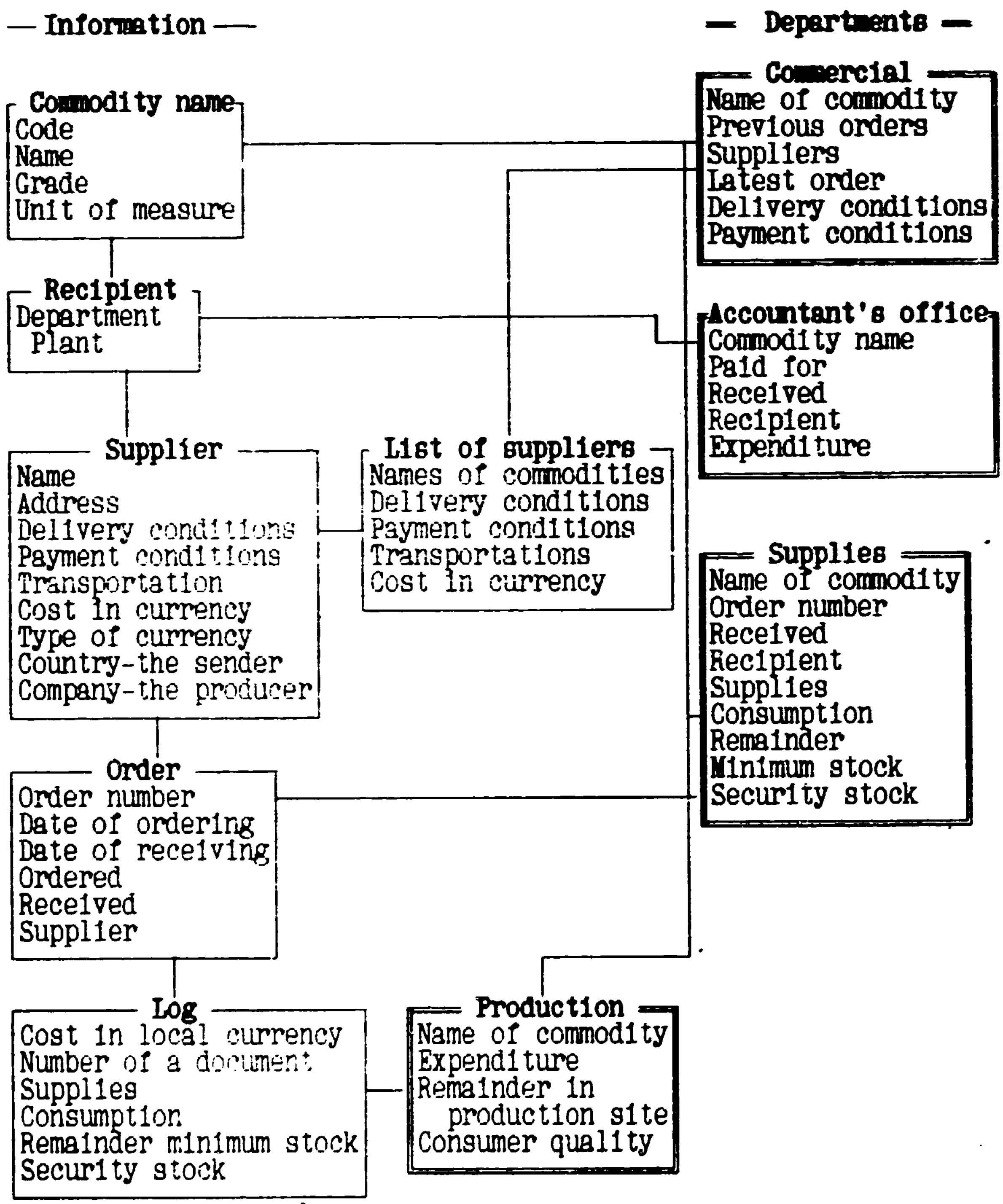

Fig. 6

Input information flow chart for the production department

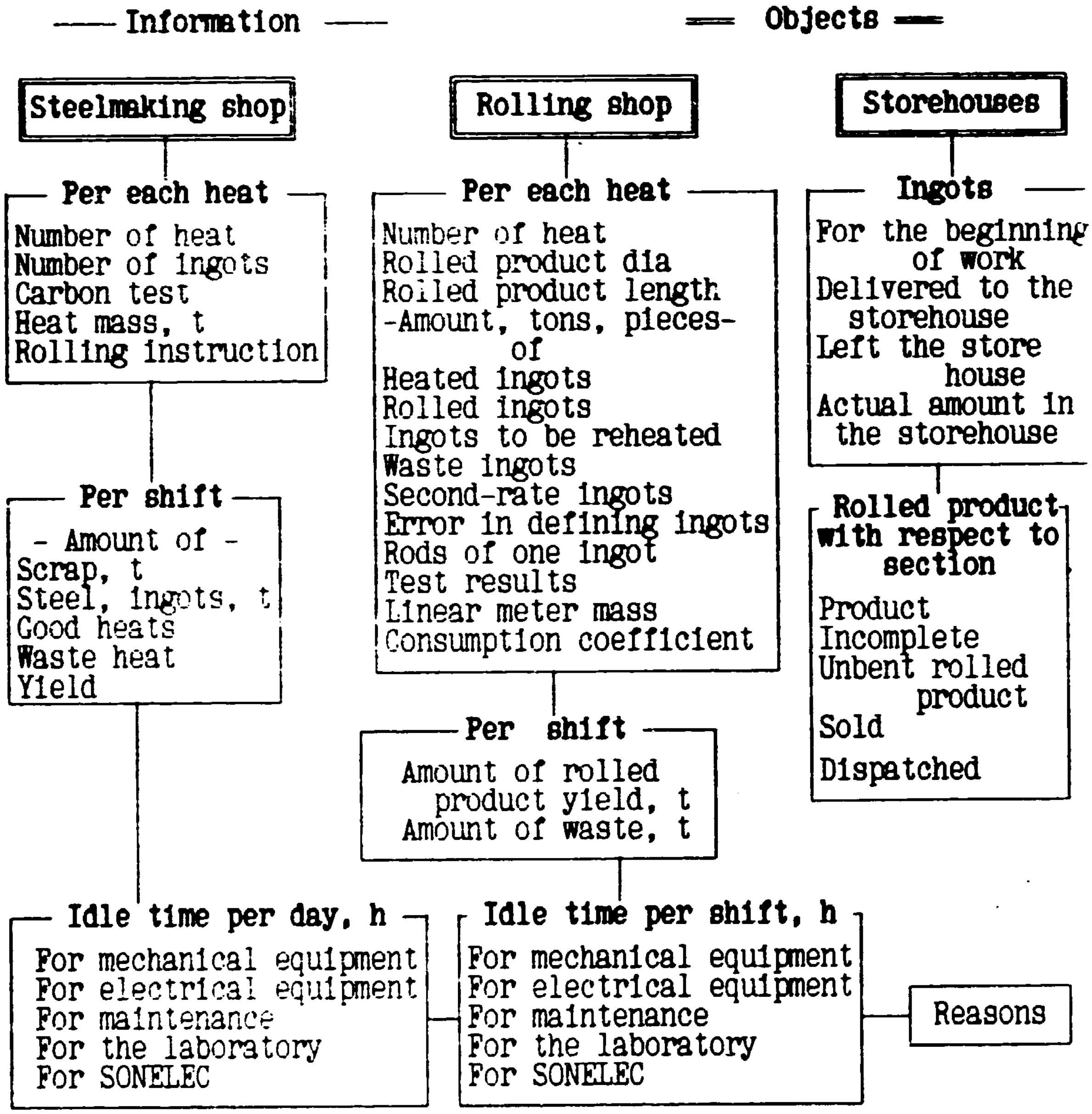

Fig. 7

Output data flow chart for the production

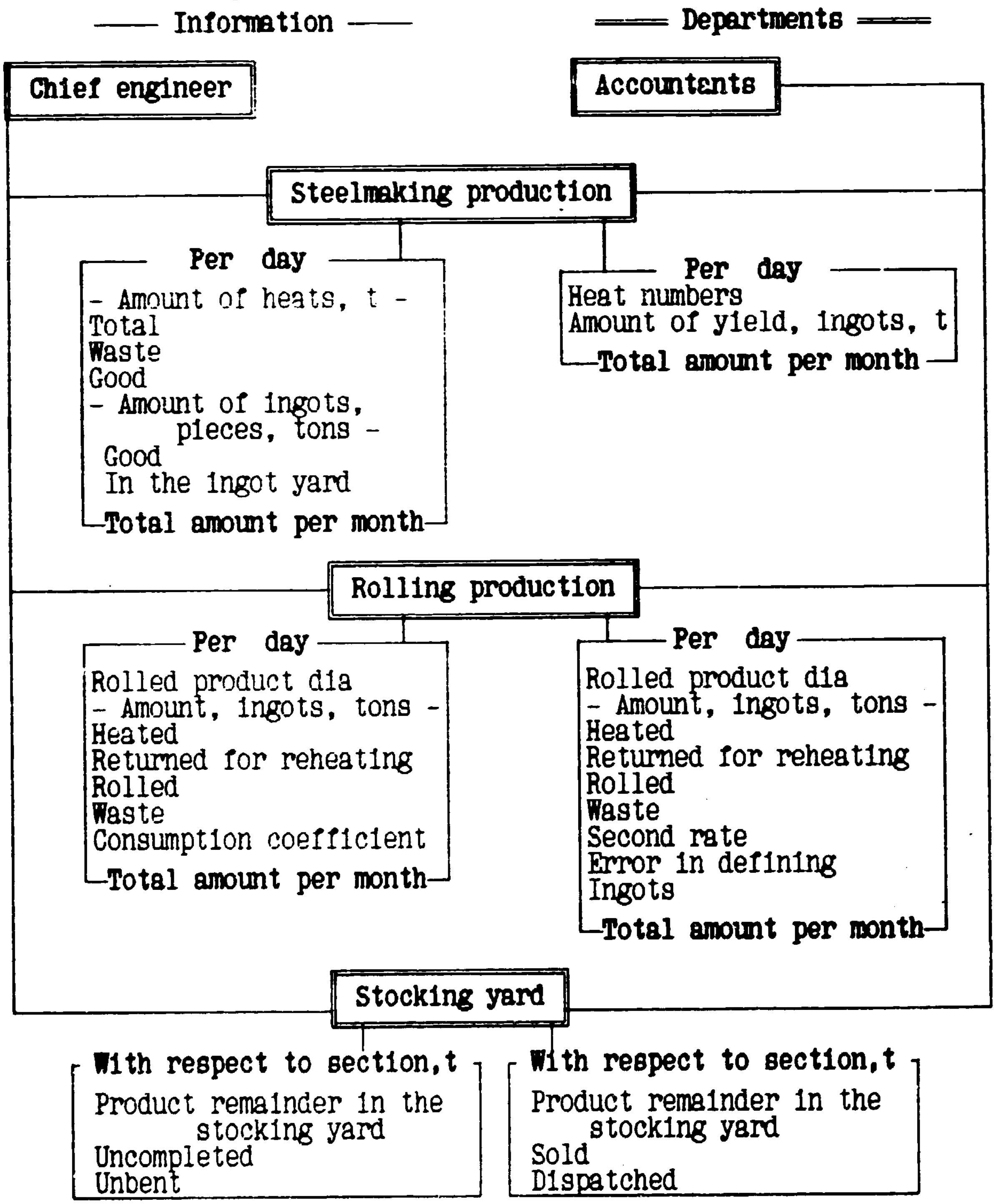

Fig. 8

shop, ingot yard, rolling shop and the stocking yard taking into account the total volume of production, yield, second-rate product, waste, return for re-heating, batches complete for sale and unfinished product. Data on idle equipment and reasons for that are stored and processed. The overall volume of information is grouped according to heat, shift, pass diameter per day and month. The current state of things in the plant is also registered.

The second flow includes delivery and consumption of material in stocking yard and workshops, fulfilling of supply orders, current remainder in the storehouse. It is necessary to take into consideration the actual demand for the product determined on the basis of minimum and safe values of the material stock from:

$$SN = K \cdot (D + TS)$$

where SN is safe value of stock, units of measure;

K - monthly consumption of material, units of measure/month;

D - delivery time, months;

TS - minimum stock, expressed in months of work (2-3 months)

Administration includes the data on staff, wages, working hours etc. Problems of this type were well developed and automated in the framework of the mother-company SNIM and the software after the required adjustment can be used in SAFA computers.

The information for the commercial department incorporates data on materials purchased by SAFA, data on suppliers including delivery conditions, prices, payment and transportation; data on delivery orders and their implementation.

The financial department is concerned with: daily data on the production process; cost of expenses with respect to departments and plants with subsequent estimate of cost price of the finished product (see Fig. 9).

Bank transactions with customers and suppliers (this part is automated by SNIM).

Factors common for all the departments affecting the management are to be noted here:

- low volume of production and small batches of the finished product;
- high cost price of the finished product;
- high rate of waste and idle time;
- necessity to import the main spare parts and consumed materials the number of commodity denominations purchased exceeds 2.000.
- shortage and high cost of electric power and water.

Problems arising from the above are:

- necessity of a certain amount of stock to provide regular

Account of consumption and cost price estimate of SAFA production

Total mill expenditure
- Electric power
- Water
- Auto transport

Consumed materials with respect to each department

Steelmaking shop
- Scrap
- Ferroalloys
- Electrodes and nipples
- Moulds
- Fuel
- Oxygen
- Thermocouples
- Limestone
- Refractories

Rolling shop
- Hardware and props
- Ingots
- Rolls
- Oxygen
- Fuel
- Refractories

Spare parts

For departments
- Workshop building
- Water purification
- Compressor
- Individual tools
- Shift technological transport
- Repair facilities
- Cranes
- Electric furnace
- Ladles
- Transformer
- Heating furnace
- Tables
- Train 350
- Train 300
- Shears
- Repeaters
- Cooling facilities
- Coilers

For each department
- Amortization
- Wages
- Business trip expenses
- Social insurance
- Communal expenditures
- Remaining expenditure
- Guard

Fig.9

operation and reducing it to the minimum;

- planning of purchase and selection of suppliers at optimum cost and delivery time;

- stock-taking, estimation of unfinished product, idle time, repairs and maintenance, planning and sales;

- estimation and reducing to minimum of expenditure on each production and plant.

4.2. General concept of introduction of Computerized Management Information System (CMIS)

The following components suppose to be included in the general concept of Introduction of modern CMIS:

- CMIS should reflect and to be in accordance with existing functional and organizational managerial structure of the enterprise.

- The managers of enterprise suppose to be prepared to adjust and adopt operating functional and organizational structure to new condition: to work jointly with CMIS.

- CMIS should be considered as a developing system, which is permanently enhancing, changing adopting new hardware elements and software parches.

- Special CMIS' department or group suppose to be set up to secure system operation and development.

- CMIS is based on modern Personal computer and software.

Recommended management system is shown on Fig 10. It is

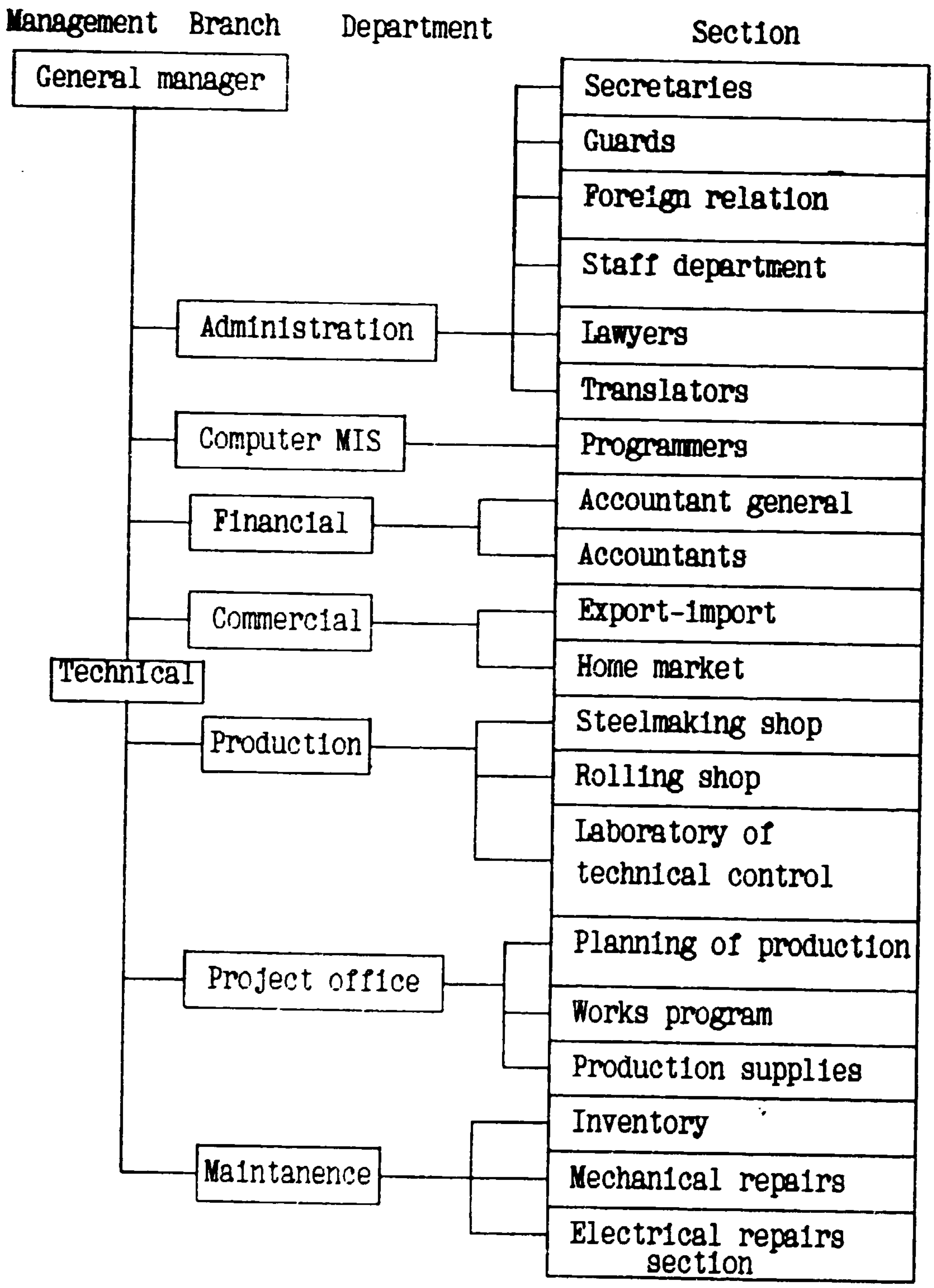

Fig. 10
Recomended management system of SAFA

based on eristing structure with some additional Department, namely Department of Computerized Management Information System, which should report directly to General manager. Besides the more section are integrated under administration.

4.3. Hardware system and software package

The following PC has been supplied and install in framework of this project:

TYPE	Parametres				
	Main store, MB	Hard disc, MB	Clock rate, MHz	Adapter	Quantity
PC/AT 386	16	320	33	VGA	1
PC/AT386SX	2	40	16	VGA	7

The computers are powerful enough to meet the SAFA requirements and allow to enhance the system being developed in view of forming a single network. Control system ensures data independence and convenient contract with the user, as well as use of high rate programming languages such as CLIPPER v 5.0 and MICROSOFT C v 6.1a.

The following standard software packages are supplied:

- Norton Commander, French

- Multiplan, French
- Multiedit, English
- Brief, French
- Foxbase plus, French
- Statgraphics, English
- UNISTAT
- AutoCAD, French

4.4. Functional structure of CMIS - Main menu

The followings subsystem are included in classical maine menu of CMIS, Fig 11:

- PRODUCTION
- MAINTENANCE
- FINANCIAL and COMMERCIAL
- ADMINISTRATION

The development and installation of such integrated system request a lot of resources. It is estimated, that for plant like SAFA with about 100 employs and annual production about 5000 t. is request 30-40 man/month. resources. Besides of that permanent support and development of the system is required, as well as additional hardware and software parches.

The maine menu and subsystem can have different structure depending on enterprise organization and functions.

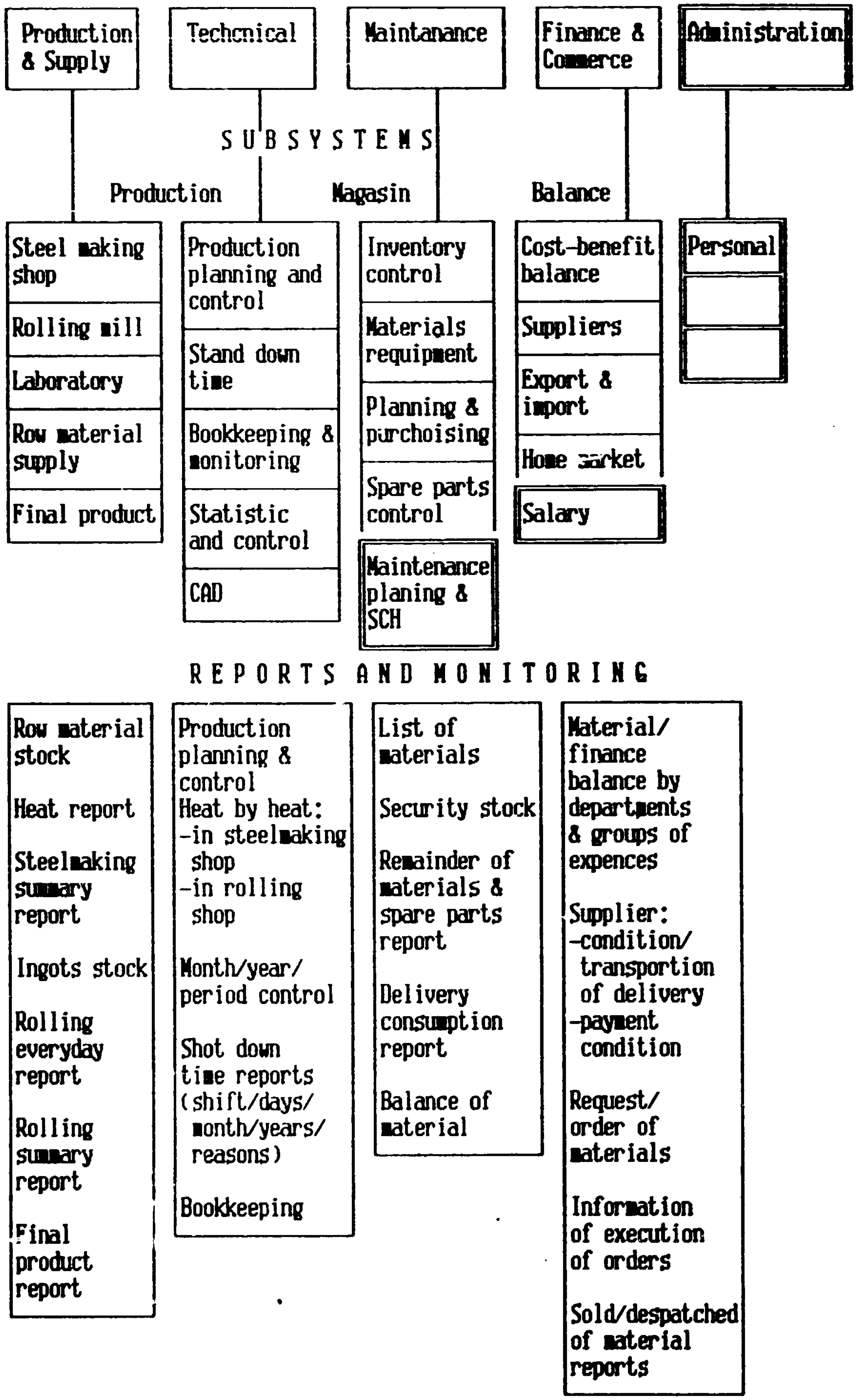

Fig.11.
Computerised management information system (CMIS)

The modules, which are the part of different subsystem are undertaking numbers of functions. The output data and reporting system are covering usually the demand of different departments and sections.

4.5. Operating subsystems SAFA's CMIS

SAFA's operating system developed in framework of this contract is shown on Fig. 11.

This system can be considered as a Phase 1 of System development.

Problems most important for producing the software, i.e. playing the key role in daily information, account and estimate of cost prices have been selected out of the total stock of problems. As basic programs they are designed to exchange data automatically, i.e. they are in fact the systems connected, in turn, to the single SAFA system with access to the common information.

Functional flow of the SAFA system includes:

1. Transfer, balance and stock-taking of the product from raw materials to the rolled product.

2. Transfer and balance of materials necessary to produce the finished product as well as production maintenance (spare parts, spare equipment, tools, etc.).

SAFA computerized management information system

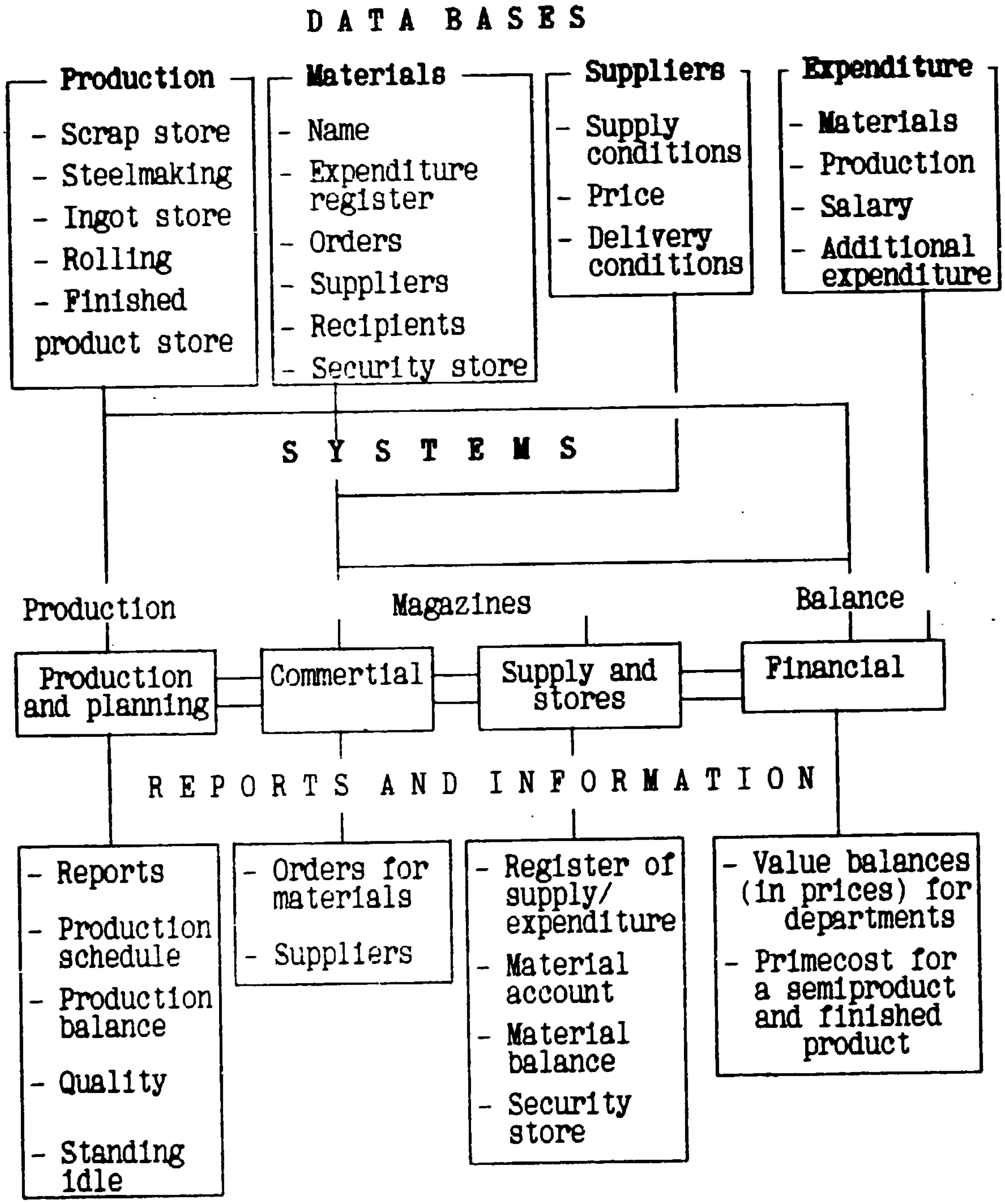

Fig. 11

3. Account of SAFA expenditure, including the materials in the storehouse and workshops with respect to plants and departments.

4. Calculation of cost price of the finished product for the steelmaking and rolling shops and for the plant as a whole.

5. Account and data on the stock of materials in the storehouse, calculation of minimum and safe amounts of the materials compared to the actual remainder in the storehouse.

6. Storage and output of reference information on suppliers, delivery conditions, prices, etc. for commercial activities.

7. Account of orders fulfillment for the department of sales and supplies.

8. Estimation and analysis of idle time.

9. Printing and monitoring of documentation, including daily reports from the workshops, logs of commodity transfer and expenditure, etc.

10. Design work making use of the AUTOCAD system.

11. Statistical application of the data with the use of STATGRAPHICS system.

12. Routine accounts with the use of the MULTIPLAN system.

The software being developed is to be used in personal IBM-compatible computers.

SAFA system software includes three basic subsystems:

storehouse: material supply and commercial activity, production control, expenditures and cost price calculations (balance). All of these subsystems can use common databases.

4.6. Storehouse subsystem

The subsystem information is used by administration, financial, commercial, supply departments and those sections of industrial department which are recipients of materials. Main menu of subsystem is shown in Fig. 12. Database structure of supply subsystem is presented in Fig. 13. Supply and industrial department entry data on materials, income and expenditure,execution of orders. Commercial department forms orders for materials and directs information about suppliers. The sections of industrial department have opportunity to form orders on materials. All departments receive information about transfer of materials, remainders in storehouse. Commercial department receives information about supplier,necessity in material, requests, history of orders execution (including conditions of delivery). The basic videograms are shown in Fig. 14-20.

The next functions are executed by subsystem: input and output data creating and processing functions, service functions, fast data access functions.

Main menu of STOREHOUSES system

STOREHOUSES
- -Create journal
- -Change name
- -Delete

JOURNALS
- -Delivery of material
- -Consumption of material
- -Revision
- -Delete book records
- -Balance
- -Print
  - wares in stock
  - remainders in stock

ORDERS
- -New order
- -Search & correct
- -Display
  - execution of orders
  - conditions of delivery
- -Print
  - execution of orders
  - conditions of delivery

MATERIALS
- -New material
- -Search & correct
- -Print data on material

SUPPLIERS
- -New suppliers
- -Search & correct
- -Print data on suppliers

SERVICE
- -Rest calculation
- -List of department correction
- -Make hard disk copy
- -Restore hard disk copy
- -Make floppy disk copy
- -Restore floppy disk copy
- -Restore index files
- -Configuration

Fig. 12

DATABASE STRUCTURE OF SUPPLY SUBSYSTEM

LIST OF STOREHOUSES

1. Code
2. Storehouse name

SENDERS

DEPARTMENTS

1. Code
2. Name

AGGREGATES

1. Code
2. Name

MATERIALS

1. Name
2. Cipher
3. Mark
4. Unit of measurement
5. Sender cipher department/aggregate
6. Consumption per unit of time
7. Delivery time
8. Minimal stock
9. Safety stock
10. Storehouse
11. Note

STOREHOUSES JOURNALS
STOREHOUSE 2
STOREHOUSE 1

1. Material name
2. Cipher
3. Mark
4. Cost, UG
5. Sender cipher department/aggregate
6. Supplier cipher
7. Order number
8. SQL
9. Income/expenditure date
10. Document number
11. Income/expenditure amount
12. Material stock on a given cost
13. All material remainder
14. Revision remainder

Fig. 13

ORDERS

1. Material name
2. Cipher
3. Mark
4. Order number
5. Order date
6. Delivery date
7. Execution time
8. Transportation cipher
9. Amount received per reception
10. Received in total
11. Will be received
12. Note

\- Supplier -

13. Supplier name
14. Answered yes/no
15. Address
16. Delivery conditions
17. Payment conditions
18. Transportation conditions
19. Cost in currency
20. Type of currency
21. Sender
22. Producer

SUPPLIERS

1. Supplier name
2. Material name
3. Material cipher
4. Answered yes/no
5. Address
6. Delivery conditions
7. Payment conditions
8. Transportation conditions
9. Cost in currency
10. Type of currency
11. Sender
12. Producer

Con. Fig. 13

Enter/Select &: <Tab>-Begin <F10>-Exit

Delivery of commodity in storehouse Sklad 1

Commodity

Cipher 0000001 Name Material 1

Mark Material 1 Dimension T

Recipient: Industrial department Steelmaking department

K= 200.00 D= 2.0 SS= 2.0 SN=K(D+SS)= 800.00

Order

Order number	0000000056
Date of order	28/03/1992
Date of delivery	06/06/1992
Difference in month	2.3
Transportation code	T
Ordered	10,000.00
Received	4,400.00
Will be received	5,600.00

Supplier:

Olivetti

Note:

Delivery

SCL		11
Date		06/06/1992
Document number		00000001
Cost UG		100.00
Amount		500.00
Received UG cost		50,000.00
Remainder:		
By cost	100.00 UG	500.00
In total		3,600.00

Enter SCL code

< >-Left/Right <Enter>-Entry <Esc>-Exit

Fig. 14.

```
     Enter/Select &:           <Tab>-Begin            <F10>-Exit
                     Consumption of commodity

 ----------------------------- Waybill -----------------------------
  Waybill number 00000001   Date 06/06/1992   Distributed by Zaitsev
                                              Received by   Vorobiev

 ---------------------------- Commodity ----------------------------
  Cipher 0000001                        Name Material 1
  Mark Material 1                                Dimension T
  K=      200.00      D= 2.0       SS= 2.0      SN=K(D+SS)=    800.00
  Cost        300.00 UG     Remainder: By cost     300.00 UG    120.00
                                   In total                  2,800.00

 =========================== Consumption ===========================
  SCL 11                                         Amount        300.00
  Recipient: Industrial department      Steelmaking department
   Note:

Enter SCL code
   <  >-Left/Right            <Enter>-Entry            <Esc>-Exit
```

Fig. 15.

Enter/Select &: <Tab>-Begin <F10>-Exit

Commodity

Cipher 0000001 Name Material 1

Mark Material 1 Dimension T

Recipient: Industrial department Steelmaking department

K= 200.00 D= 2.0 SS= 2.0 SN=K(D+SS)= 800.00

Заказ

Order number	0000000056
Date of order	28/03/1992
Date of delivery	06/06/1992
Difference in month	2.3
Transportation code	T
Ordered	10,000.00
Received	4,400.00
Will be received	5,600.00

Supplier:

Olivetti

Note:

Enter note to the order

< >-Left/Right <Enter>-Entry <Esc>-Exit

Fig. 16.

Enter/Select &: <Tab>-Begin <F10>-Exit

Conditions of delivery

Supplier Olivetti Answered YES

Commodity cipher 0000001 Commodity name Material 1

Address of supplier

Conditions of delivery

Conditions of payment

Cost in currency 300.00 Type of currency $

Conditions of transportation

Sender

Producer

Enter name and address of commodity's producer

< >-Left/Right <Enter>-Entry <Esc>-Exit

Fig. 17.

```
Enter/Select &:            <Tab>-Begin                <F10>-Exit
                               Revision

                               Document
 Document 00000001  Date 06/06/1992     Checked up by Vorobiev
                                        Received by   Zaitsev

                               Commodity
 Cipher 0000001                   Name Material 1
 Mark Material 1                               Dimension T
 K=      200.00       D= 2.0      SS= 2.0      SN=K(D+SS)=       800.00
 Cost        300.00 UG    Remainder: By cost   300.00 UG         300.00
                                     In total                  3,100.00

                                 Fact
 Actual remainder          100.00                 In total     2,900.00
 Note:

Enter note to revision
   <  >-Left/Right              <Enter>-Entry             <Esc>-Exit
```

Fig. 18.

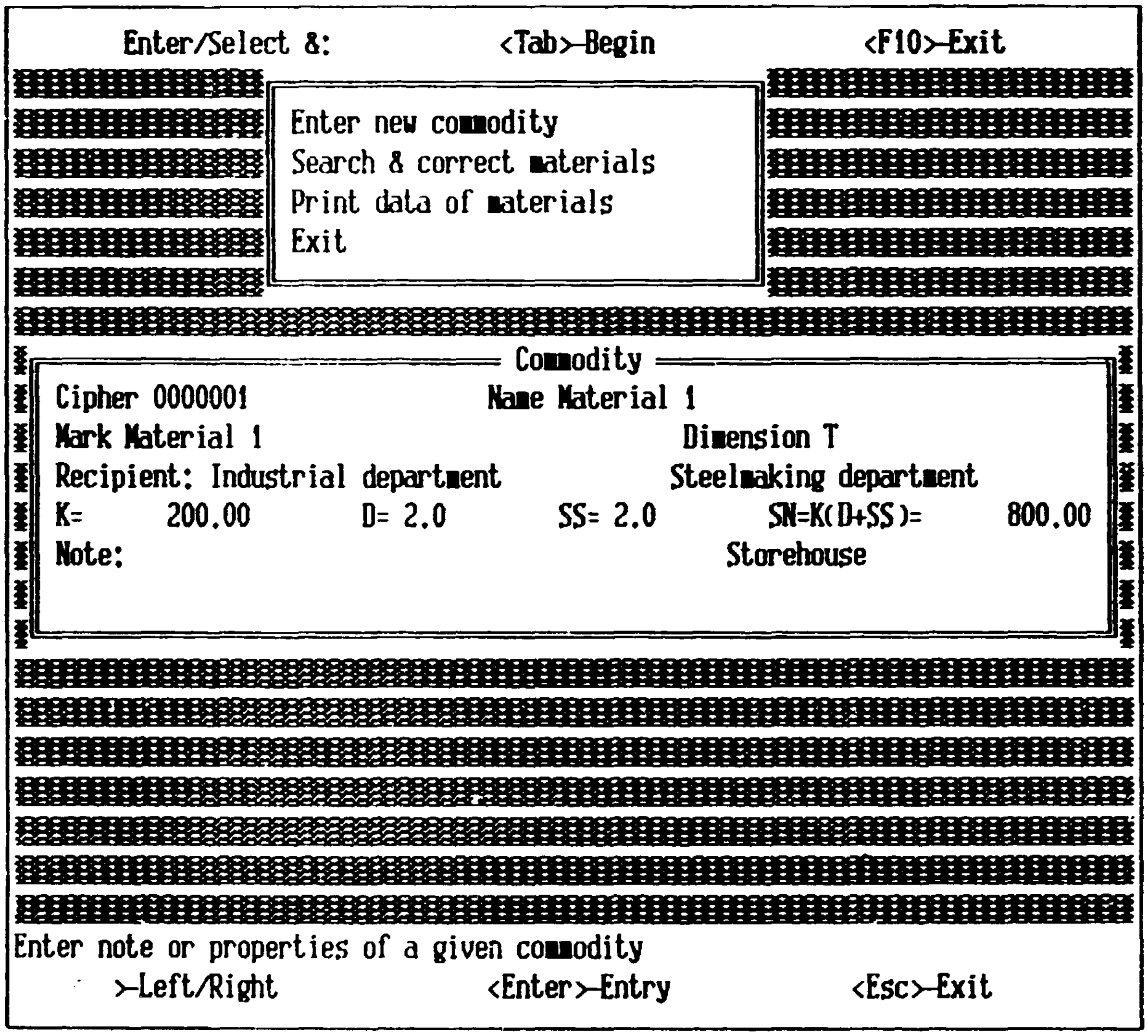
Enter/Select &: <Tab>-Begin <F10>-Exit
Enter new commodity
Search & correct materials
Print data of materials
Exit
Commodity
Cipher 0000001
Name Material 1
Mark Material 1
Dimension T
Recipient: Industrial department
Steelmaking department
K= 200.00
D= 2.0
SS= 2.0
SN=K(D+SS)= 800.00
Note:
Storehouse
Enter note or properties of a given commodity
>-Left/Right <Enter>-Entry <Esc>-Exit

Fig. 19.

Enter/Select &: <Tab>-Begin <F10>-Exit

Supplier

Supplier Olivetti Answered YES

Commodity cipher 0000001 Commodity name Material 1

Address of supplier

Conditions of delivery

Conditions of payment

Cost in currency 300.00 Type of currency $

Conditions of transportation

Sender

Producer

Enter name and address of commodity's producer

< >-Left/Right <Enter>-Entry <Esc>-Exit

Fig. 20.

4.6.1. Data input

- Create, change, delete journal of storehouse;
- Create, change, delete information about recipients (the list of departments/aggregates);
- On-line entry, change, delete material (only if records about material in journals of storehouses no exist);
- On-line entry, change, delete request (only for request on material) or order for material;
- On-line data entry about conditions of delivery in a claim from the list of suppliers;
- On-line data entry and change about suppliers;
- On-line data entry about delivery of material and order's execution;
- On-line data entry about consumption of material;
- On-line data entry about revision's results;
- Delete delivery/consumption/revision records from journal of storehouse;

4.6.2. Output data creating functions

- Display the the list of storehouses;
- Display the list of recipients (departments/aggregates);
- Display the list of materials;

- Display the list of materials which are in a given storehouse/out of all storehouses;
- Display and print data on materials which are in storehouse/out of all storehouses;
- Display and print data on storehouse's journal if remainder of material is less than safety;
- Display and print data on material remainder in the storehouse (if this one less than safety);
- Display and print waybill about consumption of material;
- Display information about remainder of material at entry data on delivery/consumption/revision;
- Display and print act of revision;
- Display and print balance of material at storehouse(s);
- Display the list of requests/orders for a given material in chronological order;
- Display the list of requests/orders for a given date;
- Display and print information about execution of orders;
- Display and print delivery conditions of material in the order;
-Display information about execution of order at entry data on delivery of material;
- Display the list of suppliers for a given commodity by a sign answered or not the present supplier on requests;
- Display and print information about suppliers;

- Display user's error diagnostics;
- Display help messages.

4.6.3 Data processing functions

-Control user's input data entry;
-Calculate remainder/all of material in stock by cost;
-Calculate safety remainder of material;
-Recalculate remainder after deletion of records from journal, revision or if data on material entry wasn't performed in chronological order;
-Strike storehouse's balance;
-Make up expense waybill;
-Make up act of revision;
-Sort journals of materials by name and cipher of material, by date of delivery/consumption/revision;
-Sort the list of orders by material's name,by date of order and date of material's delivery;
-Sort the list of suppliers by materials, by sign answered or not.

4.6.4. Fast data access functions

- Search material in storehouse's journal by a following attributes: name, cipher, delivery/consumption/revision operation date;

-Search material in the list of materials by storehouse/name/cipher;

- Search order/request by material's name, order number, date of order;

- Search supplier by material's name, by sign answered or not.

4.6.5. Service functions

- Make databases reserve copy on a hard disk;
- Restore information from hard disk reserve copy;
- Save databases on floppy disk;
- Restore information from floppy disk;
- Restore index files after hardware malfunction and databases restoring;
- System configuration;
- Display setup (color/background/open information windows);
- Print setup (pages/roll, font compressed/normal, number of rows, number of columns, left margin on a page);
- Sound signal at error diagnostics on/off.

4.6.6. Data output - reporting

The subsystem includes next output forms: journal of storehouse, summary of material's remainder in storehouse, expensive waybill, balance of storehouse(s), act of revision, summary of execution of orders, conditions of delivery in orders, summary of materials and summary of suppliers (Fig. 21-29):

4.7. Production control and monitoring subsystem

For this system the following departments are users of information: administration, finance, commerce, and subdepartments of production department: steel and rolling productions and the lab. Main system menu is presented by Fig. 30, information structure of database is on the Fig. 31. Steel production and rolling departments and the lab enter information about manufacturing of steel and rolling, products quality, scrap and ingots expenditure, transportation of finished products, and stores states. All departments receive information about metal movement through the plant, valid rests of products in the store (Fig. 32-38).

The system includes following functions: forming and processing of entering and exiting information, service, and

JOURNAL OF STOREHOUSE OUTPUT FORM

Delivery and consumption of wares from storehouse Sklad 1
from 28/03/1992 to 06/06/1992

Cipher 0000001 Name Material 1
Mark Material 1 Dimension T
Recipient Industrial department Steelmaking department
K= 200.00 D= 2.0 SS= 2.0 SN=K(D+SS)= 800.00

Order number	Document number	Delivery/ Consump-tion date	Delivery	Consumption	Remainder
0000000056	00000001	31/03/92	900.00		900.00
	04-audit	31/03/92			600.00
	003-out	01/04/92		300.00	300.00
Total			900.00	300.00	300.00

Fig. 21.

SUMMARY REMAINDERS IN STOREHOUSE OUTPUT FORM

Remainders of wares in storehouse Sklad 1 on 30/03/1992

Commodity cipher	Commodity name	K	D	SS	SN	Remainder
0000001	Material 1	200.00	2.0	2.0	800.00	500.00
0000045	Material 2	300.00	1.0	4.0	700.00	70.00

Fig. 22.

EXPENCSIVE WAYBILL OUTPUT FORM

Expensive waybill number 01239823 from 06/06/1992 Distributed by Vorobiev
Received by Zaitsev
Recipient Industrial department 003 Steelmaking department 004

Commodity name	Cipher	Cost	Amount	Sum	Note
Material 1	0000001	120.00	100.00	12000.00	Note
Material 1	0000001	300.00	50.00	15000.00	Note
Total					
			150.00	27000.00	

Signatures

Fig. 23.

BALANCE OF STOREHOUSE OUTPUT FORM

Stock balance in storehouse Sklad 1 from 30/03/1992 to 06/06/1992											
Commodity name	Cipher	Remainder on 30/03/1992		Delivery		Consumption		Remainder on 06/06/1992		Sum	
		Amount	Sum	Amount	Sum	Amount	Sum	Amount	Sum	Amount	Sum
Material 1	0000001	0.00	0.00	3900.00	630000.00	650.00	177000.00	3150.00	423000.00	-500.00	-90000.00
Total in storehouse			0.00		630000.00		177000.00		423000.00		-90000.00

Fig. 24.

CONDITIONS OF DELIVERY IN ORDER OUTPUT FORM

Conditions of delivery of commodity in order 401 from 01/02/1992

Cipher of material 0000001   Commodity name Material 1
Makr Material 1
Recip. Industrial department   003 Steelmaking department   001
K= 134.00   D= 1   SS= 2   SN=K(D+SS)= 402.00

Supplier Olivetti   Answered YES
Address of supplier

Delivery conditions

Payment conditions

Cost in currency 120.00   Type of currency $
Transportation conditions

Sender

Producer

Fig. 25.

SUMMARY OF MATERIALS OUTPUT FORM

List of materials in storehouse Sklad 1

Commodity cipher 0000001 Material name Material 1
Mark Material 1
Recip. Industrial department 003 Steelmaking department 004
K= 200.00 D= 2 SS= 2 SN=K(D+SS)= 800.00

Commodity cipher 0000045 Material name Material 2
Mark Material 2
Recip. Industrial department 003 Steelmaking department 004
K= 300.00 D= 1 SS= 4 SN=K(D+SS)= 700.00

Fig. 26.

ACT OF REVISION OUTPUT FORM

Commodities revision in storehouses from 06/06/1992	Checked by Vorobiev Recieved by Zaitsev								
Commodity name	Cipher	Cost	Remainder accor.document		Actual remainder		Sum		Note
			Amount	Sum	Amount	Sum	Amount	Sum	
Material 1	0000001	120.00	2900.00	348000.00	2800.00	336000.00	-100.00	-12000.00	Note
Material 1	0000001	300.00	250.00	75000.00	300.00	90000.00	50.00	15000.00	Note
In total				423000.00		426000.00		3000.00	

Signatures

Fig. 27.

ИНТЕРМЕТ INTERMET
ИНТЕРМЕТ ИНЖИНИРИНГ INTERMET ENGINEERING

20049 (1 of 3)

Assistance to the Societe Arabe du Fer et de L'Acier Mauritanie (SAFA) in management and products diversification in the Islamic Republic of Mauvritania

FINAL REPORT

Part I
Volume 1

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and Intermet Engineering

UNIDO PROJECT No. US/MAU/89/178
Activity Code: J 13208

MOSCOW-NOUADHIBOU-VIENNA
1992

SUMMARY OF EXECUTION OF ORDERS OUTPUT FORM

Execution of orders in storehouse Sklad 1   from 01/01/1992 to 06/06/1992

Commodity cipher 0000001   Material name Material 1
Mark Material 1
Recipient Industrial department   003 Steelmaking department   004
K= 1.00   D= 2   SS= 2   SN=K(D+SS)= 6.00

Order		Delivery			Amount			Note
Number	Date	Date	Dm	Kt	Ordered	Received	On order	
210	01/01/1992	30/01/1992	0.0		12500.00	0.00	12500.00	
		11/02/1992	1.4		12500.00	1300.00	11200.00	Note
		11/02/1992	1.4		12500.00	500.00	10700.00	Note
211	05/01/1992	27/01/1992	1.4		23000.00	0.00	23000.00	
		16/02/1992	1.4		23000.00	8000.00	15000.00	
		18/02/1992	1.5		23000.00	2000.00	13000.00	

Fig. 28.

SUMMARY OF SUPPLIERS OUTPUT FORM

Information about suppliers
Cipher of material 0000001 Commodity name Material 1 Makr Material 1 Recip. Industrial department 003 Steelmaking department 001 K= 134.00 D= 1 SS= 2 SN=K(D+SS)= 402.00

Supplier Olivetti Answered YES
Address of supplier

Delivery conditions

Payment conditions

Cost in currency 120.00 Type of currency $
Transportation conditions

Sender

Producer

Fig. 29.

Main menu of production subsystem

Fusion

- Data input about new fusions
- Searching/editing fusions data
- Detail report for main engineer and main accounter
- Summary report for main engineer and main accounter

Rolled metal

- Input data about rolling
- Editing data of rolling
- Detail report for main engineer and main accounter
- Summary report fo main engineer and main accounter

Idles

- Input steel production standing idles data
- Edit steel production standing idles data
- Report about steel production idles for 24 hours
- Report about steel production idles for the period
- Input rolled metal production standing idles data
- Edit rolled metal production standing idles data
- Report about rolled metal production idles for 24 hours
- Report about rolled metal production idles for the period

Ingots store

- Store data input
- Search/Edit of the store data
- Counting of the rest
- Ingot store report

Service

- Correction of handbooks
- Creation of reserve copy
- Restoration from reserve copy
- Copying data to diskettes
- Data restoration from diskettes
- File packing
- Restoration of index files
- Configuration

Rolled metal store

- Rolled metal store data input
- Rolled metal store data editing
- Rolled metal store report

Fig. 30

Database structure of production subsystem

STORE

Ingots store
1. Date
2. The rest to day
3. Income
4. Expenses
5. The rest after day

Rolled metal store
1. Date
2. Profile
-Mass:
3. Rolled
4. Finished
5. Incomplete
6. Unbent
7. Sold
8. Dispatched

REPORTING OF STEEL AND ROLLING PRODUCTION

Fusion
1. Date
2. Shift
3. Fusion number
4. Number of ingots
5. Mass of ingots
6. Mass of scrap
7. Eventual carbone
8. Setting of rolling
9. Quality of fusion
-Tests:
10. 1 Carbone
11. 1 Temperature
12. 2 Carbone
13. 2 Temperature
14. 3 Carbone
15. 3 Temperature

Rolled metal
1. Date
2. Shift
3. Profile diameter
4. Profile typesize
5. Type of steel framework
-Number of ingots
6. Heated
7. Rolled
8. Cold
9. Spoilt
10. Low sort
11. Error of number of ingots
-Mass of ingots
12. Heated
13. Rolled
14. Cold
15. Spoilt
16. Low sort
17. Error of mass of ingots
---
18. 1 meter mass
19. Length of cutting
20. Number of pieces
21. Carbone content
22. Fluidity limit
23. Solidity limit
24. Relative lengthening

STANDING IDLES

Steel production
1. Date
2. Reason
3. Duration
4. Description

Rolling mills
1. Date
2. Shift
3. Reason
4. Duration
5. Description

HANDBOOKS

Rolled typesizes
1. Rolled typesize
2. Complete name

Steel framework
1. Type of steel framework
2. Complete name

Reasons of idles
1. Steel production
2. Rolling mill

Fig. 31

1 SAFA 16/10/1992

Summary fusions report from 15/10/1992 to 21/10/1992 for main engineer										
Date	Number of fusions			Mass of		MM	Ingots		Ingots number in the store	Remark
	Total	Spoilt	Valid	Rolled metal	Spent scrap		Ingots number	Mass of an ingot		
10/1992	3	0	3	15.700	17.300	1.102	157	1.102	357	
1992	3	0	3	15.700	17.300	1.102	157	1.102	357	
Total for period										
	3	0	3	15.700	17.300	1.102	157	1.102	357	

Fig. 32.

1 SAFA 16/10/1992

Summary fusions report from 15/10/1992 to 21/10/1992 for main accounter						
Date	Number of ingots			Mass		
	Total	Spoilt	Valid	Total	Spoilt	Valid
10/1992	157	0	157	15.700	0.000	15.700
1992	157	0	157	15.700	0.000	15.700
Total for period						
	157	0	157	15.700	0.000	15.700

Fig. 33.

1 SAFA 16/10/1992

Ingot store report from 15/10/1992 to 21/10/1992					
Date	The rest to	Income	Expenses	The rest after	Remark
15/10/1992	200	0	0	200	
16/10/1992	200	102	0	302	
17/10/1992	302	55	0	357	
18/10/1992	357	0	0	357	
19/10/1992	357	0	0	357	
Total for the period					
	200	157	0	357	

Fig. 34.

1 SAFA 16/10/1992

Summary rolling report from 15/10/1992 to 21/10/1992 for main engineer

Date	Type-size	Number of ingots					Mass of metal			MM
		Heated	Retur-ned	Rolled	Hot waste	Good	Good	Good*MM	Waist	
10/1992	d10	50	5	45	1	44	4.400	4.498	0.100	1.022
	d12	105	26	79	8	71	7.100	8.808	0.800	1.241
Total for mounth		155	31	124	9	115	11.500	13.355	0.900	1.161
1992	d10	50	5	45	1	44	4.400	4.498	0.100	1.022
	d12	105	26	79	8	71	7.100	8.808	0.800	1.241
Total for year		155	31	124	9	115	11.500	13.355	0.900	1.161
Total for period										
	d10	50	5	45	1	44	4.400	4.498	0.100	1.022
	d12	105	26	79	8	71	7.100	8.808	0.800	1.241
Total		155	31	124	9	115	11.500	13.355	0.900	1.161

Fig. 35.

1 SAFA 16/10/1992

Summary rolling report from 15/10/1992 to 21/10/1992 fcr main accounter

Date	Type-size	Heated		Rolled		Returned cold		Spoilt		Low sort		Error	
		Ingots number	Mass of metal	Ingots number	Mass of metal	Ingots number	Mass of metal	Ingots number	Mass of metal	Ingots number	Mass of metal	Ingots number	Mass of metal
10/1992	d10	50	5.000	45	4.500	3	0.300	1	0.100	0	0.000	1	0.100
	d12	105	10.500	79	7.900	6	0.600	8	0.800	11	1.100	1	0.100
Total for mounth		155	15.500	124	12.400	9	0.900	9	0.900	11	1.100	2	0.200
1992	d10	50	5.000	45	4.500	3	0.300	1	0.100	0	0.000	1	0.100
	d12	105	10.500	79	7.900	6	0.600	8	0.800	11	1.100	1	0.100
Total for year		155	15.500	124	12.400	9	0.900	9	0.900	11	1.100	2	0.200
Total for period													
	d10	50	5.000	45	4.500	3	0.300	1	0.100	0	0.000	1	0.100
	d12	105	10.500	79	7.900	6	0.600	8	0.800	11	1.100	1	0.100
Total		155	15.500	124	12.400	9	0.900	9	0.900	11	1.100	2	0.200

Fig. 36.

1 SAFA 16/10/1992

Product store report from 15/10/1992 to 21/10/1992

Date	Profile	Product	Incomplete	Unbent	Total	Produced	Sold	Dispatched	Remark
18/10/1992	d10	5.000	3.000	4.000	12.000	4.400	6.000	2.000	
	d12	4.500	3.200	5.600	13.300	3.700	3.200	0.500	
Total for 24 houers		9.500	6.200	9.600	25.300	8.100	9.200	2.500	
19/10/1992	d12	5.500	3.800	4.500	13.800	3.400	2.300	1.200	
Total for 24 houers		5.500	3.800	4.500	13.800	3.400	2.300	1.200	
Total for period									
	d10					4.400	6.000	2.000	
	d12					7.100	5.500	1.700	
Total		5.500	3.800	4.500	13.800	11.500	11.500	3.700	

Fig. 37.

1 SAFA 16/10/1992

Steel production standing idles for 16/10/1992			
Reason of standing idles	Duration of s.id.	Description of reason of standing idles	Since the month 1st
Mechanic	2.50	Description 1	2.50
Electric	1.50	Description 2	1.50
Transport	0.50	Description 3	0.50
Total	4.50		4.50

Fig. 38.

obtaining quick access to the information (Fig. 39-43).

4.7.1. Data input and output

- enter, correction, deleting of rolling typesizes in typesizes reference book;
- enter, correction, deleting of rolling steel framework in the appropriate reference book;
- enter, correction, deleting of a type of steel production time waste;
- enter, correction, deleting of a type of rolling production time waste;
- enter, correction, twenty-four hours report of steel production;
- enter, correction, twenty-four hours report of rolling production;
- enter, correction of ingots store state data by the beginning and by the end of the day;
- enter, correction of finished rolling store state data by the beginning of the day;
- enter, correction of twenty-four hours time wastes of steel production;
- enter, correction of twenty-four hours time wastes of rolling production (including by each shift);

Fusion Ingots store Rolled metal Rolled metal store Idles Service Quit

Search/editing fusions data (date search)

<Insert> Record: 1/3

Fusion date	Shift number	Fusion number	Number of ingots	Mass of fusion	Mass of scrap	Eventual carbone
16/10/1992	1	12890	50	5.000	5.500	0.20
	2	12891	52	5.200	5.800	0.25
17/10/1992	3	12892	55	5.500	6.000	0.30

<Index>

Fig. 39.

Fusion Ingots store Rolled metal Rolled metal store Idles Service Quit

Ingot store data editing (searching by the date)

<Insert> Record: 3/5

Date	The rest to	Income	Expenses	The rest after	Inspection sign
15/10/1992	200	0	0	200	N
16/10/1992	200	102	0	302	N
17/10/1992	302	55	0	357	N
18/10/1992	357	0	0	357	N
19/10/1992	357	0	0	357	N

Fig. 40.

Fusion Ingots store Rolled metal Rolled metal store Idles Service Quit

Editing data about the rolling (search by the rolling date)

<Insert> Record: 1/3

Rolling date	Shift number	Fusion number	Profile diameter	Profile typesize	Type of steel framework	Number of the heated ingots
18/10/1992	1	12890	10.00	d10	AEA	50
	2	12891	12.00	d12	AEB	50
19/10/1992	1	12892	12.00	d12	AEB	55

<Index>

Fig. 41.

Fusion Ingots store Rolled metal Rolled metal store Idles Service Quit

Editing data about the rolling (search by the rolling date)

Record: 1/3

Mass of the heated ingots	Number of the rolled ingots	Mass of the rolled ingots	Number of the cold ingots	Mass of the cold ingots	Number of the spoilt ingots
5.000	45	4.500	3	0.300	1
5.000	40	4.000	4	0.400	3
5.500	39	3.900	2	0.200	5

Cont. Fig. 41.

Fusion Ingots store Rolled metal Rolled metal store Idles Service Quit

Editing data about the rolling (search by the rolling date)

Record: 1/3

Number of the low sort ingots	Mass of the low sort ingots	Error of number of the produced ingots	Error of mass of the produced ingots
0	0.000	1	0.100
1	0.100	2	0.200
10	1.000	-1	-0.100

Cont. Fig. 41.

Fusion Ingots store Rolled metal Rolled metal store Idles Service Quit

Editing of the rolled metal store data (searching for the date)

<Insert> Record: 1/3 <Bof>

Date of rolling	Rolling typesize	Mass of rolled metal	Mass of product	Mass of incompletion	Mass of unbent
18/10/1992	d10	4.400	5.000	3.000	4.000
	d12	3.700	4.500	3.200	5.600
19/10/1992	d12	3.400	5.500	3.800	4.500

Fig. 42.

Fusion Ingots store Rolled metal Rolled metal store Idles Service Quit

Editing of steel production standing idles data (date searching)

<Insert> Record: 1/3

Date of standing idles	Reason of standing idles	Duration of standing idies
16/10/1992	Mechanic	2.50
	Electric	1.50
	Transport	0.50

Fig. 43.

- examination on the display and print of the ingots store report;
- examination on the display and print of the steel production reports for production department;
- detailed report for the period with data of daily production of steel;
- sum report for the period with data of steel production with respect to months and years;
- examination on the display and print of the steel production reports for finance department;
- detailed report for the period with data of steel production with respect to each twenty-four hours and melting;
- examination on the display and print of the rolling production reports for production department;
- detailed report for the period with data of dryly production of rolled metal;
- sum report for the period with data of rolled metal production with respect to months and years;
- examination on the display and print of the rolled metal production reports for finance department;
- detailed report for the period with data of rolled metal production with respect to each profile;
- sum report for the period with data of rolled metal production with respect to months and years(with output of the error in

determination of ingots mass);

- examination on the display and print of the finished products store report for period with respect to twenty-four hours, months, years;
- examination on the display and print of the time wastes report of steel production;
- twenty-four hours report of time wastes with respect to reasons (mechanical, electrical, etc.);
- sum time wastes report for the period with respect to reasons, days, months, years;
- examination on the display and print of the time wastes report of rolled metal production;
- twenty-four hours report of time wastes with respect to reasons (mechanical, electrical, etc.) and shifts;
- sum time wastes report for the period with respect to reasons, shifts, days, months, years;
- giving out on the screen the remarks about the user's error;
- giving out on the screen the help massages;

4.7.2. Data processing functions

- test of validity of the initial information input;
- calculation of the rests of, income, expenditure of the ingots in a store;

- calculation of the rests of, income, expenditure of the rolled metal in a store of finished products;
- calculation of the rests of ingots and finished rolled metal after data correction in the reports;
- ingots and finished rolled metal stores test with respect to duplicating of the date;
- drawing up of the detailed and sum reports of steel and rolled metal production, of ingots and finished rolled metal stores ;
- sorting of steel and rolled metal production stockbooks with respect to date and melting number;
- sorting of ingots and finished rolled metal stores , and also time wastes stockbooks with respect to date;

4.7.3. Fast data access functions

- date search of information in store or time waste stockbooks;
- date or melting number search of information in steel and rolled metal production stockbooks;

The system service function is similar to the functions of commerce and supplies system.

The output forms include reports of stores, time wastes, and productions.

4.8. Balance - cost subsystem

For this system the following departments are users of information: administration, finance. The system is dedicated to expenses accounting with respect to departments, expenses groups, to further calculation of the prime cost. All departments of the plant are information suppliers for the system. Main system menu is presented by fig. 44, structure of expenses accounting and prime cost calculation is presented in the table below. An operator enters information about wages and other expenses in conversational mode, and material expenses are calculated automatically.

The system includes following functions: initial information input, processing and output on the screen\printer (Fig. 45-48).

4.8.1. Data input

- SAFA expenses estimate configuration with respect to departments and subdepartments (item estimate is drawing up, for the item department is entered, for the department the sign of material expenses, or wages, or other expenses is entered);
- summation groups determination;
- conversational mode input of wages and other expenses for each department;

PRIME COST system main menu

Prime cost	Service	Exit
-Balance drawing up -Balance editing -Counting the balance items again -Print of the balance -Exit	-Forming the estimate -Option of the groups for summation -Scrap and ingots determination -Reserve copy creation -Restoration from the reserve copy -Diskette reserve copy creation -Restoration from the diskette reserve copy -Restoration of the index files -Configuration	

Fig. 44

EXPENSES STRUCTURE OF SAFA IN PRIME COST CALCULATION.

cipher	department(expenses item)	expenses class		
		material	other	wage
1	2	3	4	5
001	All-plant expenses			
1	electrical energy	y	y	y
2	water	y	y	y
3	car park	y	y	y
002	General direction			
1	direction	y	y	y
2	meetings	y	y	y
3	membership payments to national metallurgists society	y	y	y
4	membership payments to arabic metallurgists society	y	y	y
5	visitors	y	y	y
6	service	y	y	y
7	water and electricity for habitation	y	y	y
003	Administration			
1	direction	y	y	y
2	insurance	n	y	n
3	medical service	n	y	y
4	cleaning	n	y	n
5	guarding	n	y	n
6	business trips	n	y	y
004	Finance			
1	direction	y	y	y
2	audition	n	y	y
3	information providing	y	y	y
4	business trips	n	y	y
005	Commerce			
1	direction	y	y	y
2	Nouakshot office	y	y	y
3	service	n	y	n
4	business trips	n	y	y
5	inside the country			

1	2	3	4	5
	transportation	n	y	n
6	abroad transportation	n	y	n
006	Technical department			
1	direction	y	y	y
2	service	n	y	n
3	store	y	n	y
4	lab	y	n	y
5	design office	y	y	y
6	business trips	n	y	y
007	Repairmen service			
1	direction	y	y	y
2	technological vehicles	y	n	y
3	personal tools	y	n	y
4	shop building	y	n	y
5	building of water purification	y	n	y
6	repairement equipment	y	n	y
7	business trips	n	y	y
008	Production department			
1	direction	y	y	y
2	business trips	n	y	y
009	Steel production			
1	direction	y	y	y
2	furnace	y	n	y
3	moulds	n	n	y
4	taps	n	n	y
5	scrap preparation	n	n	y
6	massons	n	y	n
7	amortization			
	Furnace repairement			
1	furnace	y	n	y
2	vault	y	n	y
3	scoops	y	n	y
4	pouring stove	y	n	y
5	electrodes and nipples	y	n	y
6	transformator	y	n	y
6	taps	y	n	y
	Spending materials			
1	scrap	y	n	n
2	ferro alloys	y	n	n
3	electrodes and nipples	y	n	n
4	moulds	y	n	n
5	fuel	y	n	n
6	oxigen	y	n	n
7	thermocouples	y	n	n
8	limestone	y	n	n
010	Rolling department			
1	direction	y	y	y

1	2	3	4	5
2	heaters	y	y	n
3	rollermen of line 350	y	y	n
4	rollermen of line 300	y	y	n
5	products store	y	y	n
6	winder workers	y	y	n
7	twisters	y	y	n
8	amortization	n	y	n
	Mill repairements			
1	heating furnace	y	n	y
2	rollgangs	y	n	y
3	line 350	y	n	y
4	line 300	y	n	y
5	shears	y	n	y
6	outline machine	y	n	y
7	refregerator	y	n	y
8	winder	y	n	y
9	tap	y	n	y
10	twisting machine	y	n	y
	Spending materials			
1	props	y	n	n
2	ingots	y	n	n
3	rolls	y	n	n
4	oxigen and acetylene	y	n	n
5	fuel	y	n	n

Department: Section 1 Cipher: 001
Subdepartment: Subsection 1 Cipher: 001
Expences item: Material 1

Editing of the expences balance from 10/10/1992 to 21/10/1992

Record: 1/36

Cipher	Material nomination/ expences item	Quantaty of the expence	Sum of the expence/ sum by the item
0000001	Material 1	200.00	60000.00
	Scrap	17.30	8650.00
	Subdepartment wages:		75000.00
	Subdepartment other expences:		45000.00
	Subdepartment total:		188650.00
0000002	Material 2	500.00	500000.00
	Ingots	12.40	0.00
	Subdepartment wages:		90000.00
	Subdepartment other expences:		87000.00
	Subdepartment total:		677000.00
	Department total:		865650.00
0000001	Material 1	200.00	60000.00

Fig. 45.

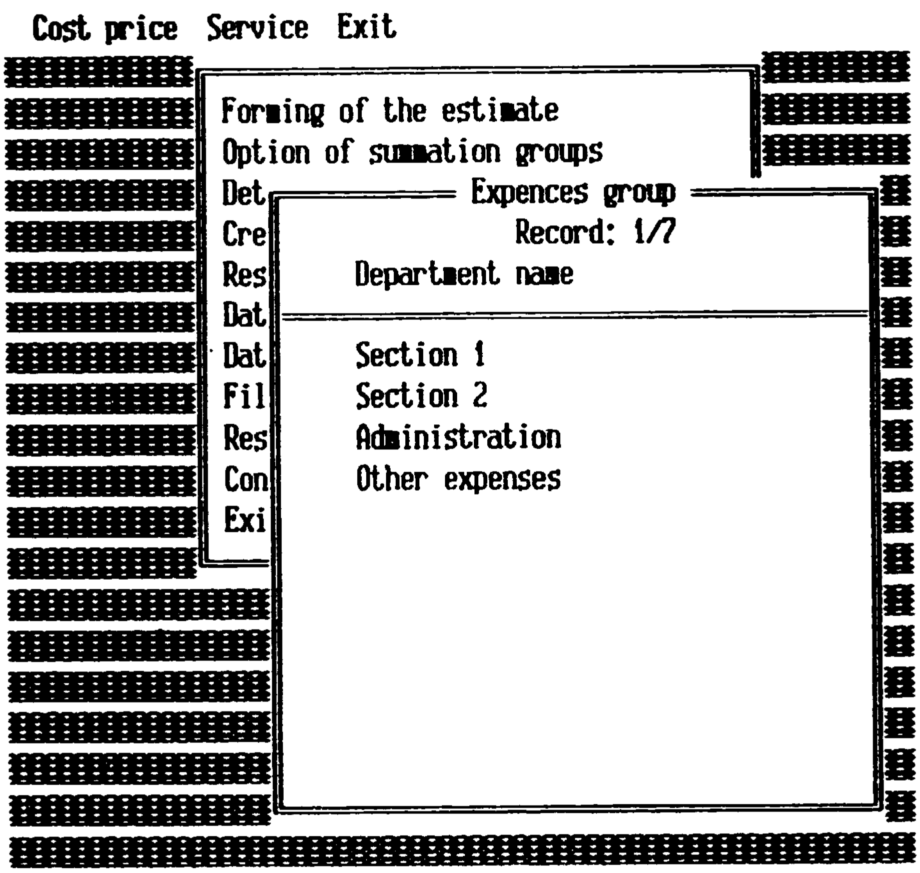
Cost price Service Exit
Forming of the estimate
Option of summation groups
Det
Cre
Res
Dat
Dat
Fil
Res
Con
Exi
Expences group
Record: 1/7
Department name
Section 1
Section 2
Administration
Other expenses

Fig. 46.

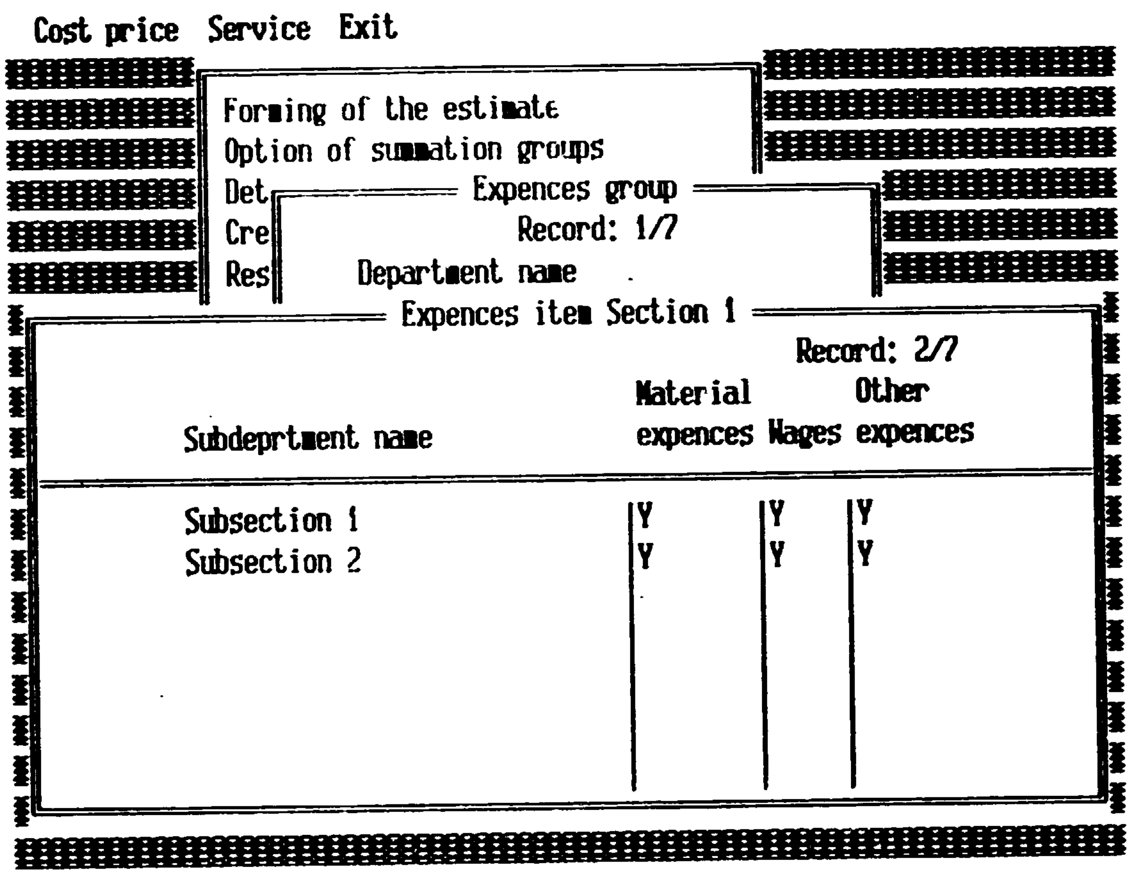
Cost price Service Exit
Forming of the estimate
Option of summation groups
Det
Cre
Res
Expences group
Record: 1/7
Department name
Expences item Section 1
Record: 2/7
Subdeprtment name
Material expences
Wages
Other expences
Subsection 1
Y
Y
Y
Subsection 2
Y
Y
Y

Fig. 47.

1 SAFA 16/10/1992

Expences balance from 10/10/1992 to 21/10/1992			
Cipher	Material nomination	Quantaty of spent material	Sum of expence by item

Department: Section 1		Cipher: 001	
Subdepartment: Subsection 1		Cipher: 001	
0000001	Material 1	200.00	60000.00
	Scrap	17.30	8650.00
	Subdepartment wages:		75000.00
	Subdepartment other expences:		45000.00
	Subdepartment total:		188650.00
Subdepartment: Subsection 2		Cipher: 002	
0000002	Material 2	500.00	500000.00
	Ingots	12.40	0.00
	Subdepartment wages:		90000.00
	Subdepartment other expences:		87000.00
	Subdepartment total:		677000.00
	Department total:		865650.00
Department: Section 2		Cipher: 002	
Subdepartment: Subsection 2		Cipher: 002	
0000001	Material 1	200.00	60000.00
0000003	Material 3	300.00	75000.00
	Subdepartment wages:		110000.00
	Subdepartment other expences:		67000.00
	Subdepartment total:		312000.00
	Department total:		312000.00
Sum by the items: Section 1 - Section 2			1177650.00
Department: Administration		Cipher:	
Subdepartment: Chief		Cipher:	
	Subdepartment wages:		70000.00
	Subdepartment other expences:		54000.00
	Subdepartment total:		124000.00
Subdepartment: Missions		Cipher:	
	Subdepartment wages:		78000.00
	Subdepartment other expences:		90000.00
	Subdepartment total:		168000.00
	Department total:		292000.00
Sum by the items: Section 2 - Administration			604000.00
Department: Other expenses		Cipher:	
Subdepartment: Transport		Cipher:	
	Subdepartment wages:		89000.00
	Subdepartment other expences:		77000.00
	Subdepartment total:		166000.00
Subdepartment: Water		Cipher:	
	Subdepartment wages:		67800.00
	Subdepartment other expences:		79000.00
	Subdepartment total:		146800.00
	Department total:		312800.00
Sum by the items: Administration - Other expenses			604800.00
	Total:		1782450.00

Fig. 48.

- determination of scrap and ingots recipients;
- examination of store stockbook and information of material expenses for each department for balance calculation;
- determination of start and end date of balance drawing up;
- conversational correction of the expenses balance.

4.8.2. Information processing functions

- test of validity of initial information input;
- drawing up and calculation of the balance with respect to departments and store stockboos;
- drawing up and calculation of the total expenses estimate;
- expenses groups calculation;
- drawing up of the estimate report.

4.8.3. Fast data access functions

- search of material in store stockbook;
- search of material expenses in the balance with respect to recipient;
- sorting of the balance and the estimate with respect to recipient.

Service functions of the system is similar to material supplies system.

4.8.4. Data output - reporting

- examination on the display the list of departments/aggregates;
- examination on the display the estimate configuration;
- examination on the display the expenses items groups for additional summation;
- examination on the display the expenses estimate;
- print of the expenses estimate report.

5.FINDING AND RECOMMENDATIONS.

1.On the basis of carrent analysis of SAFA'S operations, maintenance activities, product quality WAS FOUNDED that technology and equipment, which implemented in steel plant and rolling mill are in accordance to requirement to reinforce bars.

2. The following activities are recommended for further improvement of production quality and effectiveness in the steel plant.

2.1 To install the express analysis of the chemical composition of the metal.

2.2. The temperature regime of heats in the electric furnace should be optimized; the tapping temperature of the metal should not exceed 1630-1650°C.

2.3. A strict control of the quantity and quality of metal scrap uses in the charge should be carried out.

3.The following project proposals and design has been carried out for rolling mill (in framework of contract amendment):

3.1.Project proposals and design to convert the preheating furnace from gas-oil fuel to mazout fuel (including measurement equipment for pressure control, thermocouple in preheating zone, recording potentiometer on control board etc.)

3.2.Project proposal and calculation for rolling pass design for rolling optimization.

3.3.Project proposal for synchronization the rolling mill and flying shears.

4. It was founded during first subcontractor mission, that SAFA jointly with SNIM has given experience using computerized system for spare part control and monitoring, financing etc.

5. To reinforce SAFA computerized system of management, production and quality control, the specification of equipment and software has been recommended. The following equipment and software accordingly were supplied , install and put in to operation by subcontractor team : PC AT 386SX -1 unit, PC AT 386 -7 units, microsoft mouse, printer EPSON FX-1050 -8 units, plotter HP-1745A, software, xerox.

6.The following subsystem has been developed, installed, customized and put in day-by-day operations:

6.1.Inventory control, Material Requirement.

6.2.Production control (including row material and energy consumption for each product and department).

6.3.Input-Output Balance (including cost calculation for each product and department).

7 On the-job training of SAFA personal was carried out by subcontractor team. It is recommended to set up SAFA's computer group. train or recruit one or two skilled system programmers to secure the system operations and development.

8.It is to consider CMIS as a developing system. which supposed to be permanently enhanced, modernized, customized to current and future needs of SAFA.

9.It is stated that SAFA has made essential step to introduce modern high technology - personal computer. However to reinforce the production effectiveness and quality improvement it is recommended to follow-up the project (e.g. as a Phase 11). The following activities are recommended to carry out in framework of Phase 11 (in prioritizes):

9.1.To develop and introduce the computer network for integration of different subsystem (production and quality control, maintenance, financing and cost analysis etc.). Additional equipment and software are required for this development.

9.2.To introduce measurement and control system forpreheating furnace for fuel saving, waste minimization, yield increasing.

9.3.To develop and introduce the measurement and control system in electric arc furnace department for row material and energy savings, yield increasing and cost minimization.

9.4.To develop and introduce the system of synchronization of rolling mill and flaying shares.

ИНТЕРМЕТ INTERMET
ИНТЕРМЕТ ИНЖИНИРИНГ INTERMET ENGINEERING

20049 (3 of 3)

Assistance to the Societe Arabe du Fer et de L'Acier Mauritanie (SAFA) in management and products diversification in the Islamic Republic of Mauvritania

FINAL REPORT

Part II

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for the
La Societe Arabe du Fer et de L'Acier (SAFA)

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MOSCOW-NOUADHIBOU-VIENNA
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CONTENT

PART I

PART II

1. INTRODUCTION

The present work was carried out according the contract between Intermet Engineering and UNIDO (Contract No.91/151, UNIDO project No.US/MAU/89/178) for Mauritania. The project objectives are: to improve the operating and maintenance activities and quality of finished product at the SAFA steel plant and rolling mill; to reinforce SAFA management through the introduction of new management methods and systems.

In conformity with the contract a team of Intermet experts went to Mauritania in December of 1991 on the first field mission. The experts studied the steelmaking and rolling technologies practiced in the plant and the main problems facing the plant engineers. They also studied in details the current system of management and planning.

Within the framework of the first mission the experts analyzed the current technology offered technical advice on steelmaking, ingot casting and rolling procedures to improve productivity and quality of steel products. They also suggested measures to improve maintenance procedures in the plant. Diagnostic and management audit was also performed. New methods and systems necessary to improve planning and production were defined. The equipment specification required for quality control, maintenance procedures and computerizing was made.

During second field mission the following subsystem have been developed, installed, customized and put in to day-by-day operations:

Inventory control,

Material Requirement,

Production control (including row material and energy consumption for each product and department).

Input - Output Balance (including cost calculation for each product and department).

On-the-job training of SAFA personal was carried out by subcontractor team. It is recommended to set up SAFA's computer group, train or recruit one or two skilled system programmers to secure the systems operation and development.

Intermet team discussed Finding and Recommendation with SAFA's staff and managers.

Part I of Final Report includes:

Reinforce bars' production analysis on SAFA. Concept of project proposals on reinforcing equipment and technology of production on SAFA.

Reinforcing management system of SAFA.

Part II of Final Report includes:

Project proposals on converting preheating furnace from gas-oil to mazout fuel.

Project proposals on improvement of roll pass design. Project proposals on rolling mill and flaying shear synchronization.

Basic data on the technology of steelmaking and rolling in SAFA works, as well as the current system of planning, management and control are reported bellow. The report contains a preliminary analysis of the data and technological recommendations.

The Intermet team expresses acknowledgements to the SAFA engineers and managers for their help. The team is grateful to the Director General Yahya Ould Hademine and the Chief of Technical Department Mouhameddin Baba, as well as engineers Mouhtarash and Hasan for their collaboration.

2.PROJECT PROROSALS ON CONVERTING HEATING FURNACE FROM GAS OIL TO MAZOUT

Liquid fuel combustion process is a composite complex of processes of fuel spraying, mixing with air, evaporation, and combustion itself. Rational choosing of liquid fuel combustion scheme is determined by perfect combustion of each fuel particle inside a heat aggregate.

Gas oil burning process is governed by combustion laws for light, completely evaporating fuels. Mazout is characterized by high-percent content of asphalt-resinous substances with high-temperature level of sublimation. Because of the fact mazout combustion simultaneously with evaporation of drops develops resin and asphaltenes polymerization processes with generating the soot carbon. Due to the reason, burners for heating the hearth by gas oil can not provide qualitative combustion of mazout, that inevitably leads to violation of technological requirements for metal heating.

To realize complete mazout combustion, it is necessary to provide more qualitative spraying and to create the conditions for oxidizer feed to each drop. It means one of the general factors determined the quality of mazout combustion is value of fuel-mist fineness reaching by spray process. However, as experiment shows, it is necessary but is not sufficient factor affecting completeness of mazout combustion.

Generally, now exploiting burners get all air necessary for liquid fuel combustion by the flame root. Principle defects of this scheme are sharply restricted rang of combustion stability and impossibility to suppress chemical and mechanical imperfect combustion. It is conditioned by some reasons. First, as stream of sprayed drops moves forming combustion products ballast the stream more and more and make still unburied drops difficult of access for oxidizer. Second, as the stream moves relative speeds of the drops and air streams are decreasing. That leads to appreciable fall of mixing intensity and, therefore, to appearance of unburied fuel particles. Beside, as far as periferical air-streams do not take a part in combustion reaction completely enough, it demands to increase excess of air and , thus, further decrease the combustion performance.

Rational mazout drops distribution depends on as form and diameter of mazout flame so the character of the fuel stream movement in the diffusion area of the fuel-air mixture. For example, turbulization made by means of application some sorts of turbulentor essentially improves forming of fuel drop-air mixture, however, does not remove forming of smoke-black particles.

One can reach the most perfect mixing of sprayed fuel with air by the way of creating distributed air delivery to different zones of the flame. It allows to essentially reduce duration of some stages of the combustion reaction and , therefore, reduce the probability of appearance of chemical and mechanical imperfect combustion. Beside, air supply in stages forms favorable conditions for decreasing of deleterious components concentrations (like nitrogen oxides) in products of mazout combustion.

Acoustic mazout burner (VAG-2M) is most completely according to the mentioned requirements to qualitative mazout combustion (table 2.1). Principle of acting such the burners is based on perfection process of spraying mazout due to application energy of acoustic oscillations. Increasing of burning performance of fine-dispersed mist is reached by system of step air delivery. A jet of compressed air by pressure 2-3 kg/sm2 generates powerful acoustic vibrations. The generation is based on the using instability of a gaseous stream, passing sequently through a set of profiled nozzles. In order to realize the scheme of developed aerodynamics structure of combustion products stream burner tunnel is constituent of the burner. Principle scheme of the acoustic mazout burner is shown by Fig.2.1,the specification of the complement equipment -- in table 2.2.

Fig.2.2 shows preliminary scheme of arranging the burners in the hearth. To reach required viscosity and purity of the

TABLE [illegible]

The technical characteristics of the acoustic mazout burner.

Fuel	mazout
Range of stable work, kg per hour	[illegible]–50
Specific air flow, kg per kg of fuel	[illegible].25–0.35
Pressure before the burner	
furnace oil, kg/sm²	0.5–[illegible].5
compressed air, kg/sm²	[illegible]
[illegible] air, kg/sm²	[illegible] 500
Extent of turning-out at the burner	
[illegible] output section, %	[illegible]–97
[illegible] of NO_x in combustion	
[illegible], mg/m³	[illegible]
[illegible]	[illegible]
[illegible]	
[illegible], mm	[illegible]
[illegible], mm	[illegible]
[illegible], mm	[illegible]
[illegible] depends on [illegible] combustion	
products speed, m	[illegible]–350

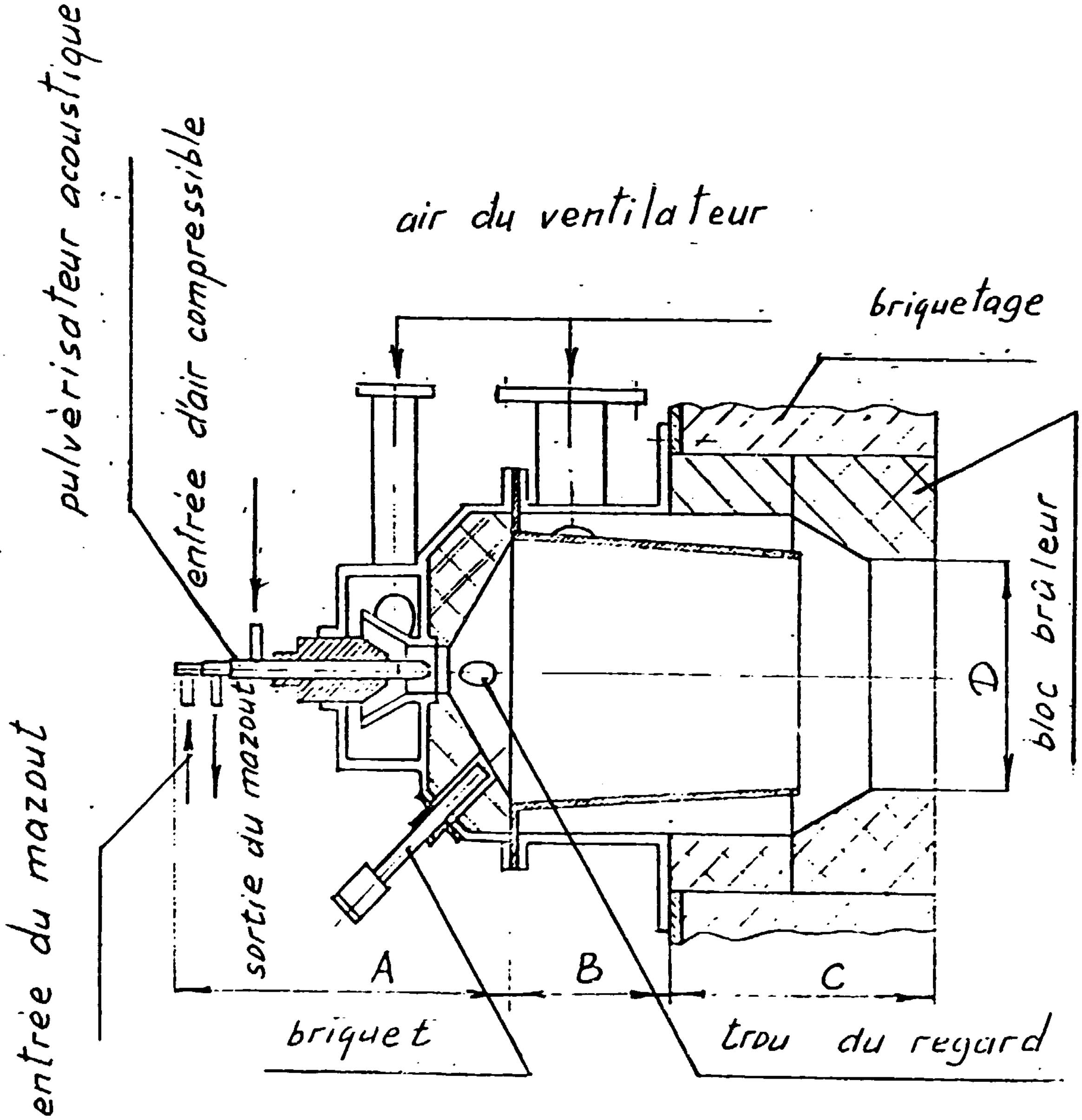


Fig.2.I Le schème de principe de brûleur acoustique du mazout VAG-2M

TABLE 2.2

The specification of the complement equipment for the modernization the holding hearth heating system by replacement gas oil on mazout.

nn	Denomination of equipment	Quantity
1	Reservoir with a system of heating	2
2	Force-pump	2
3	Stand of furnace oil preparation to combustion	1
4	Effective acoustic burner VAG-2M	4

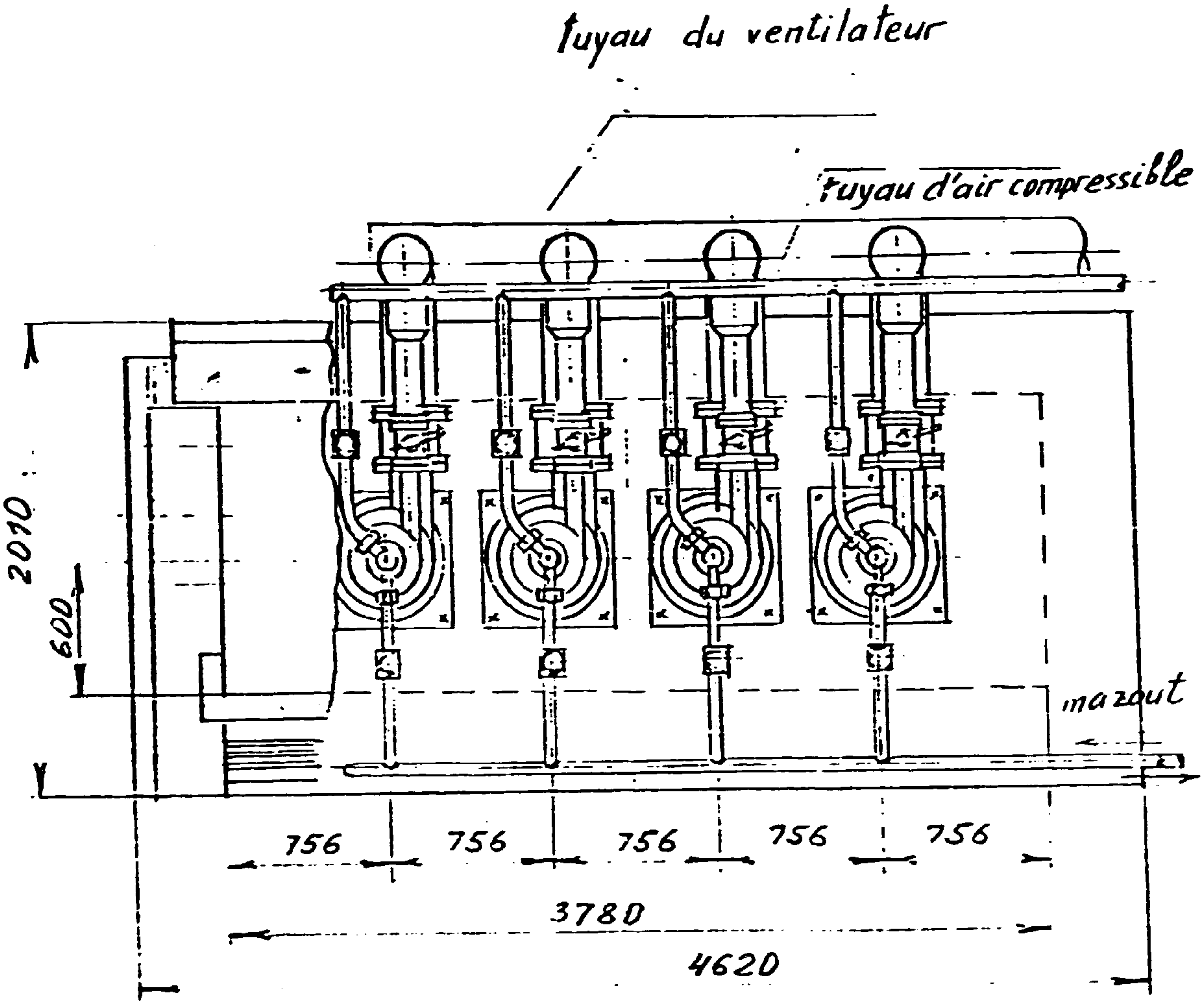


Fig.2.2 La schéme de montage de brûleur acoustique du mazout au four

mazout this complex of burners must be provided by the according devices: elements for heating and cleaning mazout, as well as equipment of automatic regularization of fuel parameters.

Realization of this recommendation makes it possibly to convert preheating furnace from gas oil to mazout fuel in shot time and effectively.

3.PROJECT PROROSALS ON IMPROVEMENT OF ROLL PASS DESIGN

The SAFA rolling mill includes the heating furnace, 14 working stands, cutting equipment and the cooler. (Fig.3.1). Six first stands of the mill: one three high stand and five variable two high ones are placed in a train. The other form four continuous groups, with two stands in each one.Transmission of the roll from one stand to another in the breakdown train and in roughing groups of stands is accomplished by means of repeaters. Rolls and main drive motors characteristic is given in Table 3.1.

Calibration of mill rolls provides the rolling in the first stand of the breakdown train (8 passings), in boxpasses (4 ones), preparatory and flat oval ones, in square and then in oval-square series of passes.

Designed Proposal of improving the rolls calibration for the SAFA rolling mill is implemented to eliminate some shortcomings in the functionality of the mill. They seemed to be related with the passes construction. The purpose of this work is to increase the productivity, profitableness and output production quality of the mill. Designed Proposal is made on the basis of direct studying of the mill in realistic conditions of

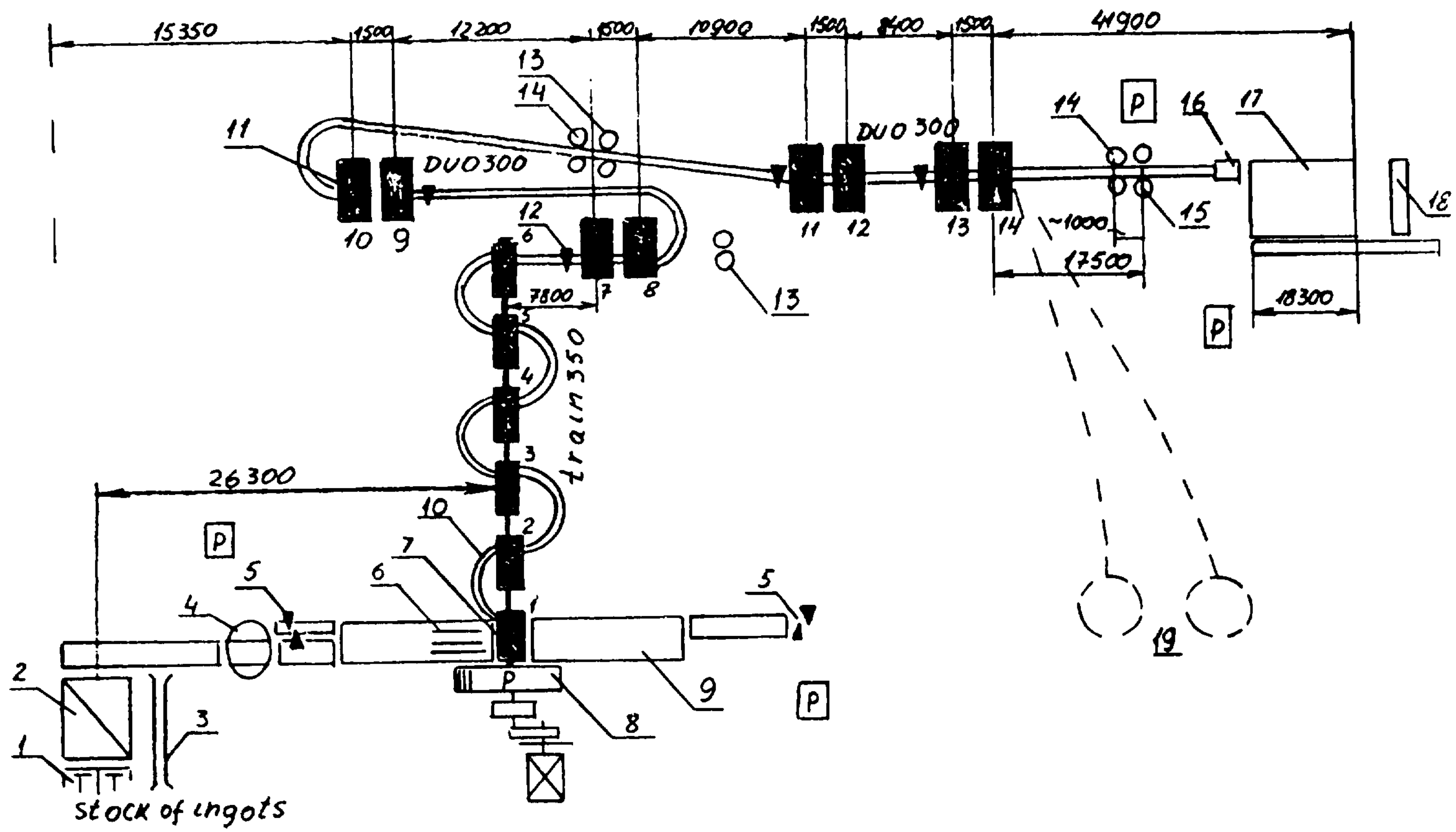


Fig.3.1

Layout of the rolling mill equipment

Table 3.

Pass dimentions for reinforcing rod of diam. 8 mm (SAFA mill 300)

Stand	Pass	Pass shape	Hк mm	Bк mm	R mm	f mm	Bd mm	S mm	Fк mm2
	1	box	88.0	130.0	15.0	3.0	125.0	5.0	10203.2
	2	box	62.0	130.0	15.0	3.0	125.0	5.0	6885.0
	3	box	90.0	68.0	12.0	3.0	62.0	5.0	5385.3
	4	box	65.0	68.0	12.0	3.0	62.0	5.0	3757.3
1	5	box	45.5	74.0	10.0	1.5	63.0	5.0	2681.5
	6	fl. ov.	31.0	84.0	35.0	-	30.4	6.0	1690.9
	7	square	49.2	50.0	6.0	-	-	5.0	1210.3
	8	fl. ov.	23.0	58.0	30.0	-	17.2	7.0	723.6
2	9	square	35.4	34.2	4.0	-	-	5.0	568.3
3	10	oval	17.5	41.0	38.0	-	-	5.3	341.7
4	11	square	27.2	26.4	3.0	-	-	3.7	338.3
5	12	oval	13.8	28.8	27.9	-	-	5.8	155.9
6	13	square	20.0	20.0	3.0	-	-	2.8	192.3
7	14	oval	9.8	25.7	27.9	-	-	3.5	109.5
8	15	square	16.0	15.7	3.0	-	-	3.0	117.2
9	16	oval	8.0	21.0	22.8	-	-	2.9	72.2
10	17	square	13.8	12.8	2.0	-	-	2.8	79.1
11	18	oval	7.2	15.7	12.6	-	-	1.7	59.0
12	19	square	11.0	10.0	2.0	-	-	2.8	47.4
13	20	fl. ov.	5.6	14.4	3.6	-	8.0	1.6	50.3
14	21	08 CR	7.45	8.28	-	-	-	0.6	34.6

production and of the latter computer analysis of the working rolls calibration.

It was determined, that main reasons of the low mill efficiency are considerable standing idles, up to 50% of the working time, great metal losses during the production process (such as waste and hot spoilage) and large expenditure of fuel, electric power and another materials per ton of the output production.

The last reason stands in close relation to first ones, because the high expenditure of fuel, electric power and materials tends to be a result of compelled remelting and repeated altering of hot spoilage, as well as of repeated metal heating (8,67% during 9 months of the 1991) after returns in cases of rolling mill damages and low heating quality.

The greatest losses, however, are related to unplanned mill standing idles caused by unsatisfactory bite conditions in the first stand of the breakdown train and also by frequent violations of the process while sticking of the stock in continuous stands groups and it's throw from the rolling train (cobbling).

In the working rolls calibration (Table 3.2) an excessive unstability of deformation by passings distribution is permitted. An elongation coefficient tends to reach high values in the first stand of the breakdown train (1,38 on the third

Table 3.2

Parameters of roll pass design for reinforcing rod of diam. 8 mm (SAFA mill 300)

Stand	Pass	Pass shape	Dimensions of metal stock and passes: Side A, mm	Height H, mm	Width B, mm	Width of pass Bk, mm	Filling coef. X	Gap S, mm	Cross-section F, mm2	Parameters of deformation: Elongation coefficient	Reduction dH, mm	Spread dB, mm	Spread index dB/dH	Angle of bite, deg	Rolling speed, m/s	Rolling force, kN	Rolling torque, kNm	Temperature, oC
				103.0	103.0				10365.0									1240
	1	box		88.0	107.3	130.0	0.83	5.0	8791.2	1.179	15.0	4.3	0.29	18.9	3.45	343	14	1239
	2	box		62.0	117.9	130.0	0.91	5.0	6677.8	1.316	26.0	10.6	0.41	23.9	3.43	486	24	1233
	3	box		90.0	60.0	68.0	0.88	5.0	4843.6	1.379	27.9	-	-	26.1	3.43	219	11	1228
	4	box		65.0	66.2	68.0	0.97	5.0	4042.2	1.198	25.0	6.2	0.25	23.6	3.00	270	12	1218
1	5	box		45.5	67.9	74.0	0.92	5.0	2916.8	1.386	20.7	2.9	0.14	20.8	3.20	304	15	1209
	6	fl. ov.		31.0	82.0	84.0	0.98	6.0	2177.7	1.339	14.5	14.1	0.97	18.9	3.35	403	20	1195
	7	square	38.6	49.2	45.6	50.0	0.91	5.0	1381.3	1.577	32.8	7.6	0.23	29.9	3.27	416	31	1186
	8	fl. ov.		23.0	53.7	58.0	0.93	7.0	1025.5	1.347	15.6	15.1	0.97	19.5	3.45	267	13	1163
2	9	square	27.5	35.4	33.0	34.2	0.97	5.0	716.1	1.432	18.3	4.5	0.25	23.2	3.22	240	15	1156
3	10	oval		17.5	36.7	41.0	0.90	5.3	526.4	1.360	10.0	9.2	0.92	16.0	3.36	199	8	1143
4	11	square	21.1	27.2	24.5	26.4	0.93	3.7	413.8	1.272	9.5	3.6	0.38	17.3	3.24	154	7	1130
5	12	oval		13.8	27.9	28.8	0.97	5.8	315.4	1.293	7.3	6.8	0.93	13.7	3.36	145	5	1113
6	13	square	16.0	20.0	19.7	20.0	0.98	2.8	243.1	1.265	7.9	2.2	0.28	15.3	3.24	124	5	1097
7	14	oval		9.8	22.3	25.7	0.87	3.5	183.3	[illegible]	6.2	6.3	1.02	12.9	4.40	118	4	1079
8	15	square	13.1	16.0	14.7	15.7	0.94	3.0	156.2	1.232	6.3	3.3	0.52	14.4	5.26	101	4	1075
9	16	oval		8.0	17.3	21.0	0.82	2.9	118.0	1.280	5.1	[illegible]	0.82	11.1	5.90	88	[illegible]	1052
10	17	square	11.0	13.8	10.2	12.8	0.80	2.8	98.3	1.255	3.5	3.0	0.86	11.4	7.18	51	1	1047
11	18	oval		7.2	12.7	15.7	0.81	1.7	76.6	1.188	3.8	1.7	0.45	9.2	7.29	54	1	1028
12	19	square	9.0	11.0	9.5	10.0	0.85	2.8	66.7	1.199	1.7	1.8	1.06	8.5	8.59	33	1	1020
13	20	fl. ov.		5.6	12.2	14.4	0.85	1.6	57.6	1.159	3.4	[illegible]	0.94	6.3	10.64	33	1	1014
14	21	08 CR		7.6	9.2	8.28	1.00	2.0	49.7	1.158	4.6		-	10.7	11.49	49	1	1012

Angle of bite exceeds the allowed value: 7 pass.

Specific power consumption: 59.8 kWh/t.

passing and more then 1,50 on the seventh), though elongation values are sufficiently low in elongation passes of rough continuous ones (1,19 - 1,25). Such a deformation by passings distribution is not conditioned by mechanical equipment and main drive motors overloads. Some values of Kp, Km and Ka coefficients a replaced in Table 4 to help in analysis of mechanical and electrical equipment load and also of process by bite conditions possibility. These coefficients show the ratio of real calculated values for pull force (Kp), torque on the drive motor shaft (Km) and bite angle (Ka) to their permissible values on the every passing. As it is clearly seen (Tab.3.3-3.4 and diagrams from Fig.3.2 -3.5), the main mill equipment load level (Kp and Km) is sufficiently low (with the exception of some passings), but friction possibilities are close to their limit on first ones.

Keeping in mind, that the calculation is made for an average stock crossection and, of course, it does not take into account possible temperature oscillations, scale thickness and state and some another process conditions to influence upon the bite of metal by rolls, we can make a conclusion that bite conditions are not satisfied in reality on the third, fourth and seventh passings. We must also take into account some features of the mill rolls material for the first stand - the high carbon steel.

Table 3.3

Analysis of tecnological parameters of rolling SAFA mill 300

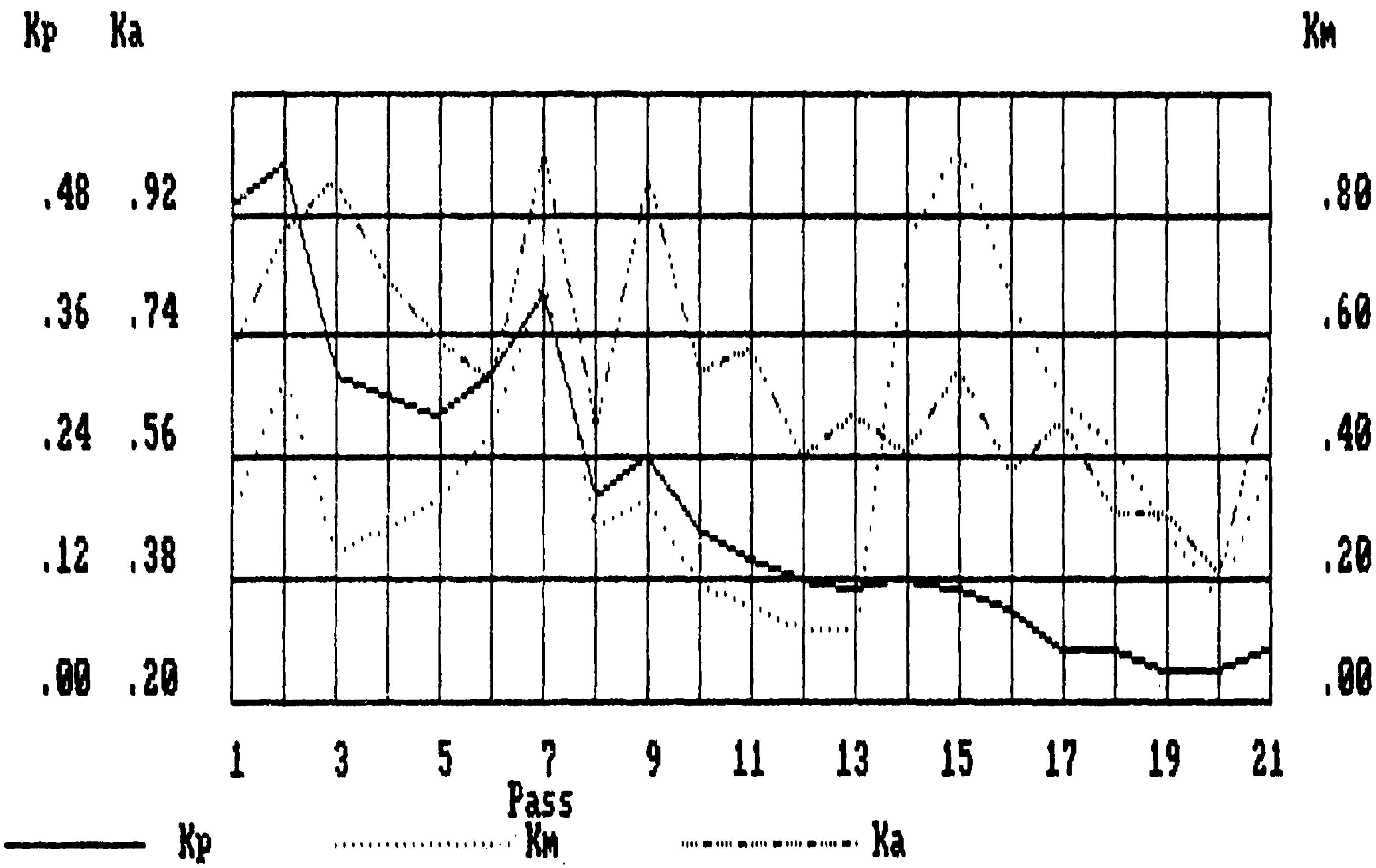
Stand	Pass	Pass shape	Elongation coefficient	Reduction ratio	Temperature oC	Rolling force kN	Rolling torque kNm	Angle of bite deg	Rolling speed m/s	Kp	Km	Ka	Specif. power consump kWh/t
	1	box	1.18	0.15	1239	343	14	18.9	3.45	0.49	0.31	0.72	0.56
	2	box	1.32	0.30	1233	486	24	23.9	3.43	0.53	0.53	0.90	1.00
	3	box	1.38	0.24	1228	219	11	26.1	3.43	0.32	0.24	0.97	1.02
	4	box	1.20	0.28	1218	270	12	23.6	3.00	0.30	0.28	0.82	0.83
1	5	box	1.39	0.31	1209	304	15	20.8	3.20	0.28	0.33	0.73	1.37
	6	fl.ov.	1.34	0.32	1195	403	20	18.9	3.35	0.32	0.44	0.67	1.57
	7	square	1.58	0.40	1186	416	31	29.9	3.27	0.40	0.70	1.02	3.37
	8	fl.ov.	1.35	0.40	1163	267	13	19.5	3.45	0.20	0.28	0.60	2.31
2	9	square	1.43	0.3	1156	240	15	23.2	3.22	0.24	0.33	0.98	3.03
3	10	oval	1.36	0.37	1143	199	8	16.0	3.36	0.17	0.19	0.68	2.85
4	11	square	1.27	0.26	1130	154	7	17.3	3.24	0.14	0.16	0.72	2.80
5	12	oval	1.29	0.35	1113	145	5	13.7	3.36	0.12	0.12	0.56	3.06
6	13	square	1.27	0.28	1097	124	5	15.3	3.24	0.11	0.12	0.62	3.28
7	14	oval	1.31	0.39	1079	118	4	12.9	4.40	0.12	0.75	0.57	4.05
8	15	square	1.23	0.28	1075	101	4	14.4	5.26	0.11	0.92	0.69	4.13
9	16	oval	1.28	0.39	1052	88	2	11.1	5.90	0.09	0.66	0.54	4.64
10	17	square	1.26	0.20	1047	51	1	11.4	7.18	0.05	0.49	0.61	2.96
11	18	oval	1.19	0.35	1028	54	1	9.2	7.29	0.05	0.42	0.48	4.59
12	19	square	1.20	0.13	1020	33	1	8.5	8.59	0.03	0.28	0.48	2.24
13	20	fl.ov.	1.16	0.38	1014	33	1	6.3	10.64	0.03	0.17	0.39	3.81
14	21	08 CR	1.16	0.17	1012	49	1	10.7	11.49	0.05	0.39	0.69	4.31

Table 3.4

Parameters of rolls and main drive motors (SAFA mill 300)

Stand	Rolls						Motor			
	Barrel		Neck		Material	Hardness SHR	Type	Power kW	RPM	Gear ratio
	D, mm	L, mm	d, mm	l, mm						
1	360	1100	210	220	Steel	22(*)				
2	350	800	195	220	Iron	60/65				
3	350	800	195	220	Iron	68/72	AC	810	990	5.43
4	350	800	195	220	Iron	68/72				
5	350	800	195	220	Iron	68/72				
6	350	800	195	220	Iron	68/72				
7	300	600	160	135	Iron	68/72	AC	132	980	3.65
8	300	600	160	135	Iron	68/72	AC	132	980	2.92
9	300	600	160	135	Iron	68/72	AC	132	980	2.70
10	300	600	160	135	Iron	68/72	AC	132	1480	3.20
11	300	600	160	135	Iron	68/72	AC	132	1480	3.25
12	300	600	160	135	Iron	68/72	AC	132	1480	2.68
13	300	600	160	135	Iron	71/74	DC	220	1850	1.93
14	300	600	160	135	Iron	71/74	DC	220	1850	1.60

(*) - The allowed bending stress


Kp Ka
Km
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.12 .38
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1 3 5 7 9 11 13 15 17 19 21
Pass
Kp
Km
Ka

Fig. 3.2

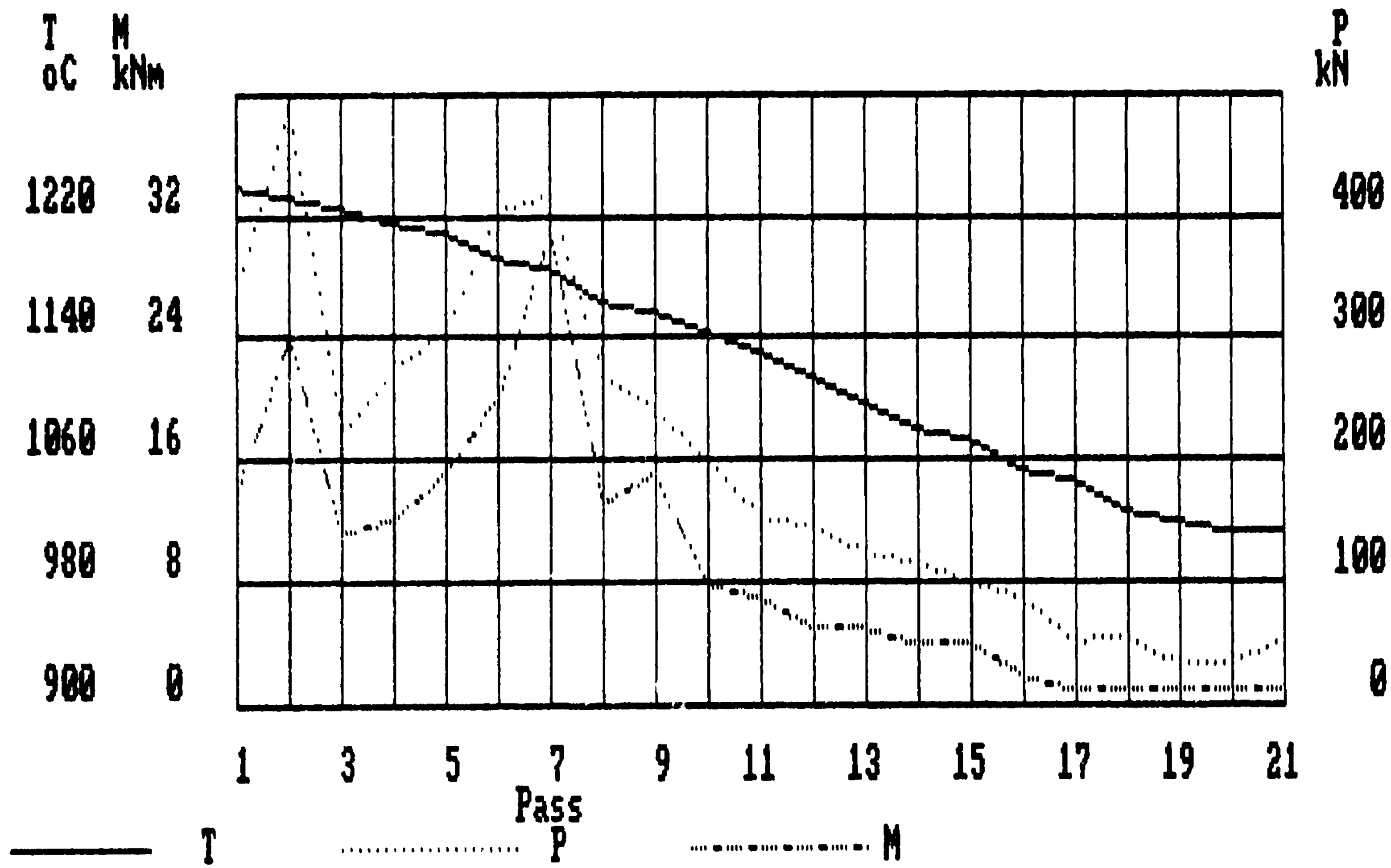
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Fig 3.3

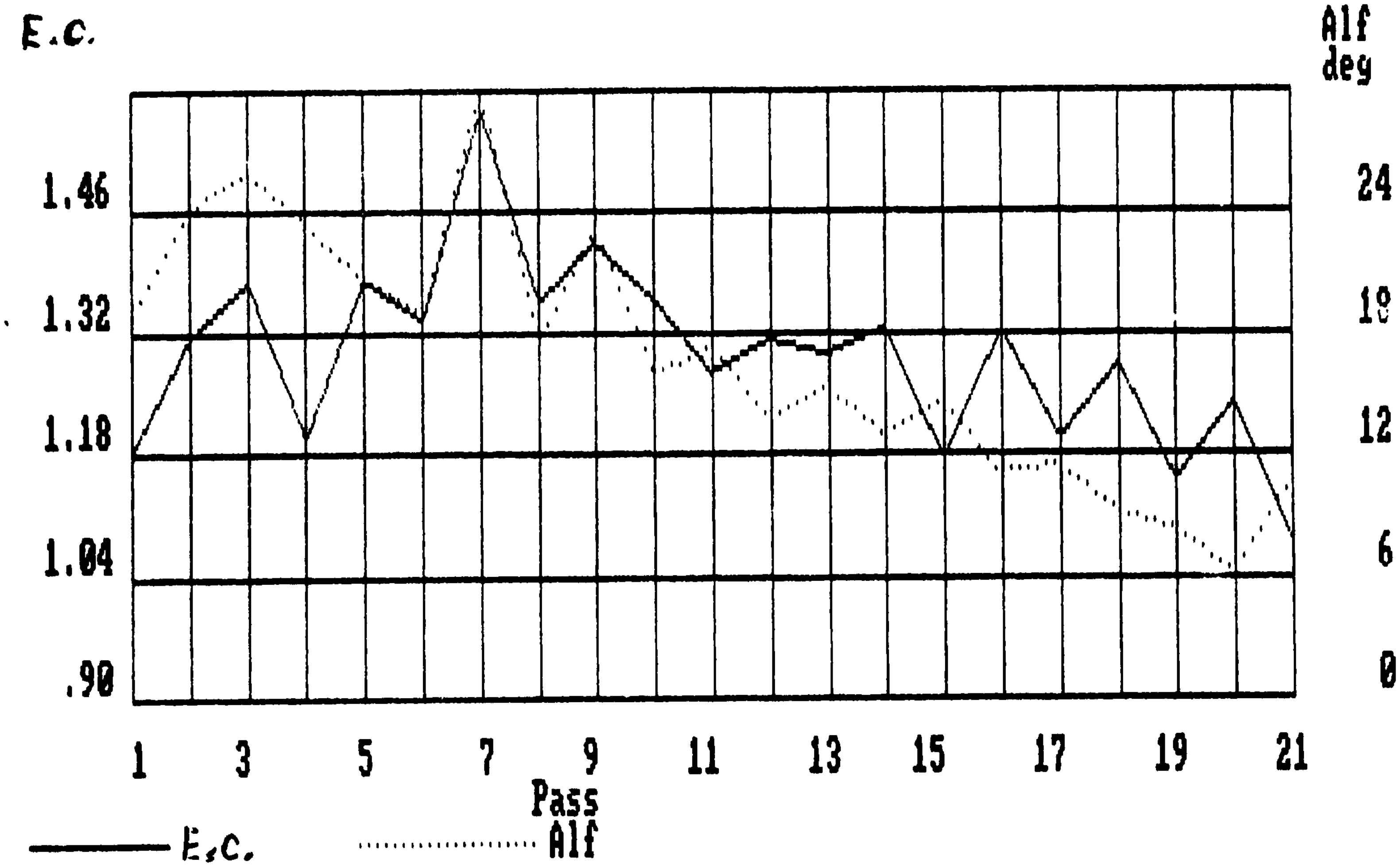
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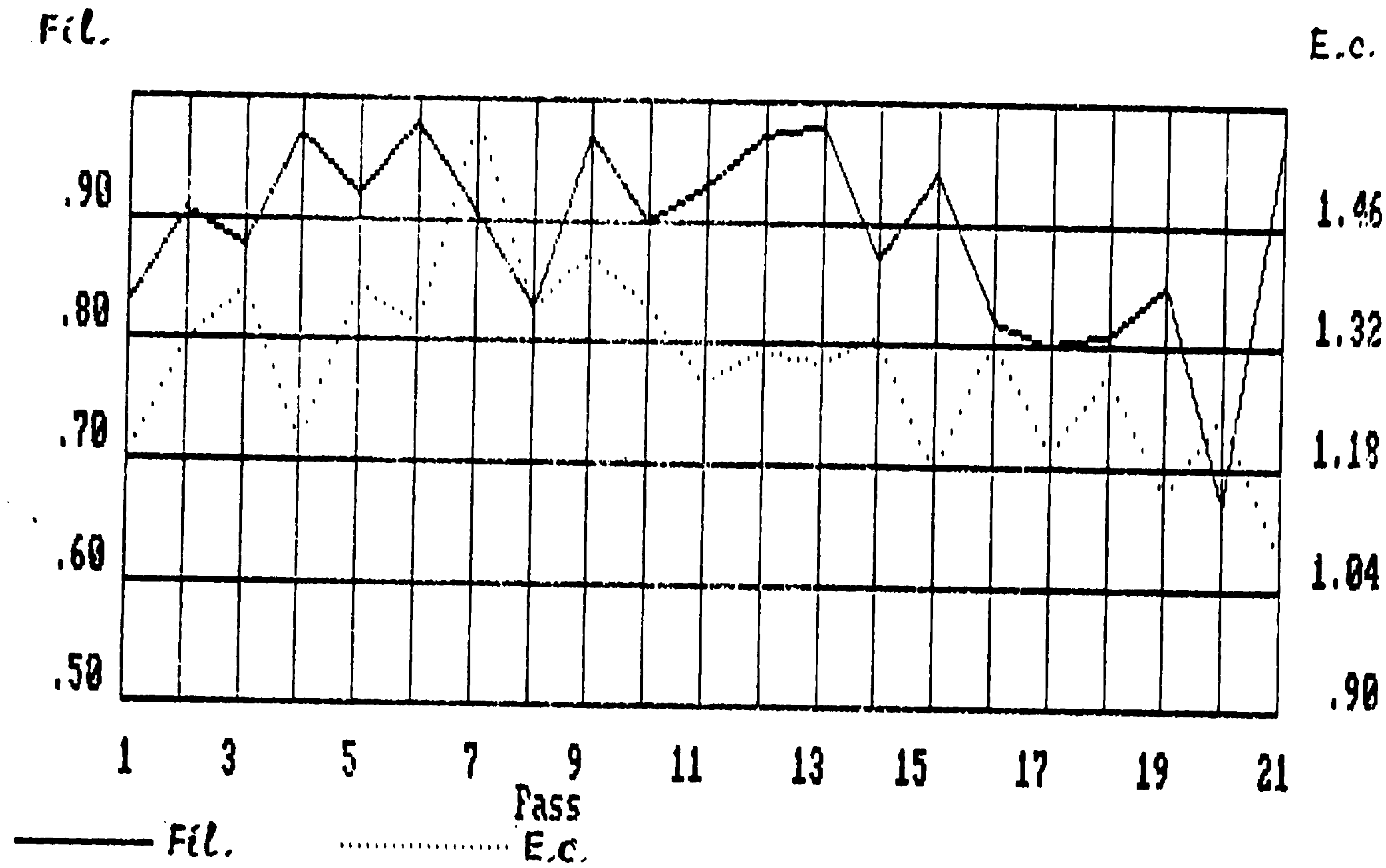
Fig 3.3



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Pass
Fil.
E.c.

Fig 3.5

The mill working practice confirmed these calculations. To improve bite conditions one use a rolls denting, i.e. dent some notches along the bottom of first four box passes parallel to their axes, the correction of each notch has a form of trapeze. This technique simplifies the bite action considerably, but leads to appearance of a comb on the contact surface of the stock, its height is about 3 - 5 mm. After the tilting and rolling in the third and fourth passes combs are rolled, but unrolled combs rests with truncated pyramid shape remain on the side surface, at the section which is free from contact with rolls (by the parting line),i.e. in the places of the pass contour and interior gap crossing.

During the further process these pyramidal formations are rolled, causing artificial scabs. The latter exfoliate after the contact with rolling guides, it leads to sticking of the roll and then to its cobbling. Thus using of denting is one of the factors to promote mill standing idles and hot spoilage appearance.

Another factor related to rolls calibration is to be mentioned. After the rolling in first two coupled box passes the ratio of width and length of the stock reaches the 1,9 value. It leads to the stock steadiness loss in the third and fourth box passes and to roll twisting in the case of its insufficient keeping in rolling guides.

The normal ratio of the rectangle roll dimensions to provide the process stability must not exceed the 1,7 - 1,75 value. Furthermore, the box pass construction, the angle of sides value, the presence of pass bottom convexity, in which the preliminary deformed stock with barreled sides (it worsens steadiness conditions, too) comes after the tilting,is of great importance.

While considering the new rolls calibration one must take into account, that the SAFA rolling mill is intended to process a wide assortment of small-scale profiles, but nowadays the real assortment of the mill includes the only profile - the fixtures steel rolled in some dimensions of profile. The working rolls calibration provides the fixtures steel rolling with the nominal diameter from 8 to 32 mm. The rolling technical scheme is implemented for the 8 mm dimension of profile. One decrease the number of passings,i.e.replace the last pair of roll-down ones by corresponding finishing and leader passes for each following dimension of profile (in increasing order). That's why the Designed Proposal is implemented as a kind of working rolls calibration to roll the fixtures steel with a 8 mm diameter.All the following dimensions of profile can be obtained directly during the exploitation process using working finishing passes. The breakdown train calibration is general for the whole assortment, of course.

The new rolls calibration is presented by the passes sizes table (Table 3.5) and by the draft of the rolls calibration for the first stand of the breakdown train. (Fig.3.6) Calibration parameters, stock sizes in every passing, the gap value and some technological parameters (speed , pull force, torque and rolling temperature) are placed in Table 3.6.Table 3.7 contains an analysis of the main mechanical and electrical equipment load, some data for the evaluation of choice and deformation by passings distribution. Designations to be used in these Tables are given in Fig.3.7.

Following preliminary conditions were accepted and kept during the new rolls calibration elaboration.

1.The rolling scheme and the displacement of passes at the breakdown train rolls was maintained. It allows to maintain the tilting sheets in front of the mill construction also and makes it realistic to calculate the new calibration.

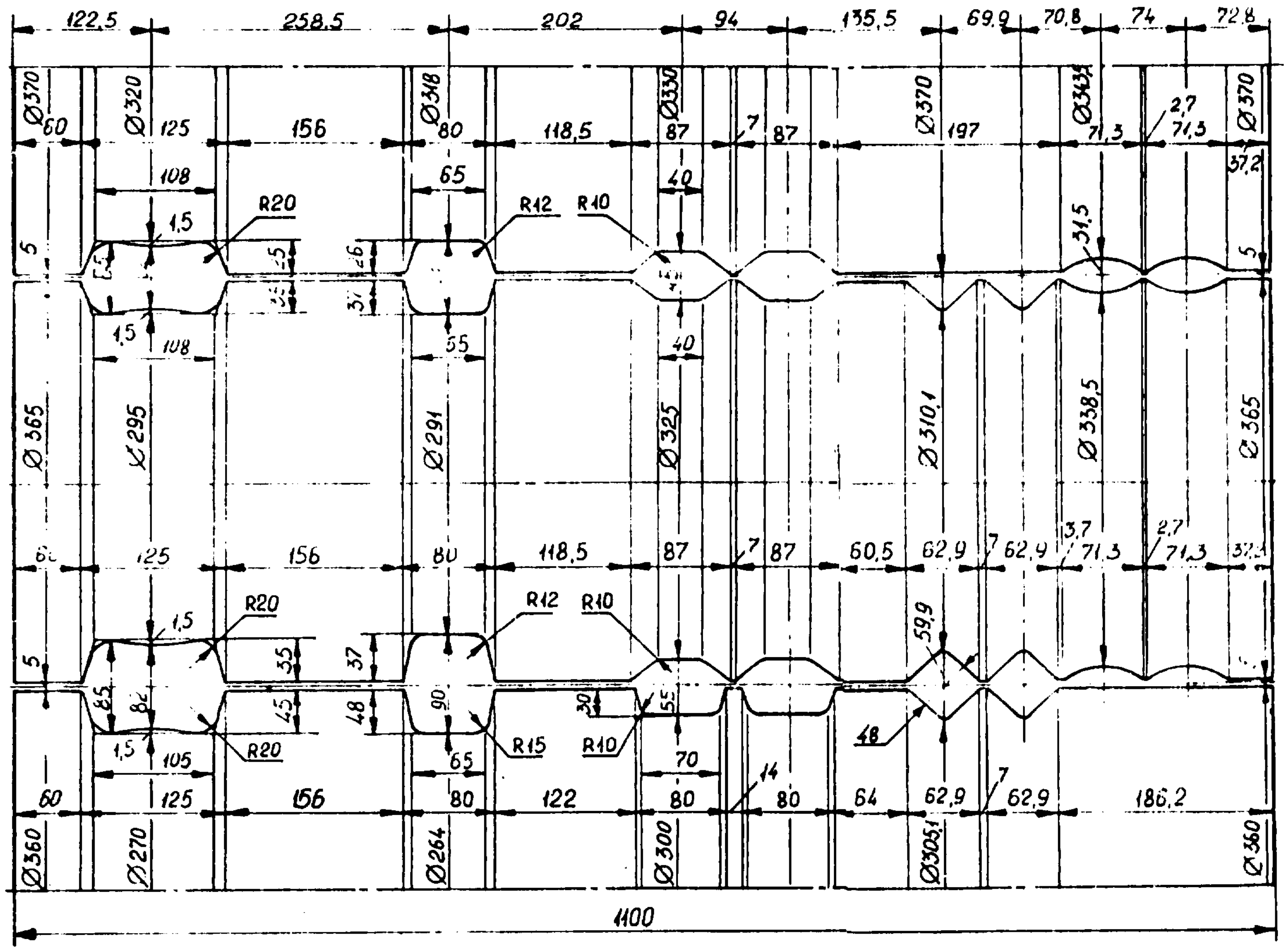
2.Reduction ratio is kept invariable in rough stands groups, which are to provide the hard stretches ratio between passings, it will ensure the specified value of tension between stands of each group (less then 10%) and making loops between groups. Observance of this condition contradicts the main direction of changes - the stretch redistribution. It must be mentioned, that reduction ratio stipulated by the drive motor construction were selected unsuccessfully during the mill

Table 3.5

Pass dimentions for reinforcing rod of diam. 8 mm (SAFA mill 300)

Stand	Pass	Pass shape	Hк mm	Bк mm	R mm	f mm	Bd mm	S mm	
	1	box	85.0	125.0	20.0	3.0	105.0	5.0	
	2	box	65.0	125.0	20.0	3.0	108.0	5.0	
	3	box	90.0	80.0	15.0	-	65.0	5.0	
	4	box	68.0	80.0	12.0	-	65.0	5.0	
1	5	box	55.0	80.0	10.0	-	70.0	5.0	
	6	hex	45.0	87.0	10.0	-	40.0	5.0	
	7	square	59.9	62.9	9.6	-	-	5.0	
	8	oval	31.5	71.3	54.0	-	-	5.0	
2	9	square	42.5	43.1	6.8	-	-	5.0	
3	10	oval	21.6	51.2	41.6	-	-	4.0	
4	11	square	30.1	30.1	4.8	-	-	4.0	
5	12	oval	14.6	37.5	35.7	-	-	4.0	
6	13	square	21.4	21.3	3.5	-	-	3.0	
7	14	oval	12.2	24.9	19.1	-	-	3.0	
8	15	square	17.0	17.2	2.7	-	-	2.5	
9	16	oval	9.7	19.9	15.7	-	-	2.5	
10	17	square	13.7	13.6	2.2	-	-	2.0	
11	18	oval	8.2	16.1	12.0	-	-	2.0	
12	19	square	11.5	11.5	1.8	-	-	1.5	
13	20	fl. ov.	5.6	14.4	3.6	-	8.0	1.6	*)
14	21	08 CR	7.45	8.28	-	-	-	0.6	*)

*) The sizes of leader and finishing passes are taken according to the SAFA existing roll pass design



ROLLING MILL SAFA / ПРОКАТНЫЙ СТАН SAFA			
Roll pass - designer	В.С. Берковский V. S. Berkovski В.Б. Шишко V. B. Shishko	Roll pass design of breakdown stand № 1 Калибровка валков обжимной клети № 1	Масштаб 1:4 25.06.92
INTERMET, MOSCOW / ИНТЕРМЕТ, МОСКВА			

Table 3.6

Parameters of roll pass design for reinforcing rod of diam. 8 mm (SAFA mill 300)

Stand	Pass	Pass shape	Dimensions of metal stock and passes: Side A (mm)	Height H (mm)	Width B (mm)	Width of pass Bk (mm)	Filling coef. X	Gap S (mm)	Cross-section F (mm2)	Parameters of deformation: Elongation coefficient	Reduction dH (mm)	Spread dB (mm)	Spread index dB/dH	Angle of bite (deg)	Rolling speed (m/s)	Rolling force (kN)	Rolling torque (kNm)	Temperature (oC)
				103.0	103.0				10365.0									1240
	1	box		85.0	108.0	125.0	0.86	5.0	8818.0	1.18	18.0	5.0	0.28	21.0	2.62	419	21	1238
	2	box		65.0	115.0	125.0	0.92	5.0	7044.6	1.25	20.0	7.0	0.33	21.2	2.85	489	27	1231
	3	box		90.0	69.5	80.0	0.87	5.0	6004.1	1.17	25.0	4.5	0.18	25.1	2.57	340	20	1224
	4	box		68.0	75.0	80.0	0.94	5.0	4766.1	1.26	22.0	5.5	0.25	22.4	2.82	367	21	1217
1	5	box		55.0	75.0	80.0	0.94	5.0	3872.3	1.23	20.0	7.0	0.35	21.0	3.06	365	20	1206
	6	hex		45.0	82.0	87.0	0.94	5.0	2853.4	1.36	10.0	7.0	0.70	14.3	3.16	311	13	1196
	7	square	48.1	59.9	59.9	62.9	0.95	5.0	2234.3	1.28	22.1	14.9	0.67	21.9	3.18	353	22	1188
	8	oval		31.5	65.3	71.3	0.91	5.0	1583.7	1.41	16.6	17.2	1.03	20.5	3.33	450	31	1174
2	9	square	34.0	42.5	42.5	43.1	0.88	5.0	1116.3	1.42	22.1	9.0	0.48	21.1	3.14	300	16	1168
3	10	oval		21.6	47.8	51.2	0.93	4.0	790.4	1.41	12.4	13.8	1.11	17.5	3.12.	351	20	1158
4	11	square	24.1	30.1	30.1	30.1	1.00	4.0	560.9	1.41	17.7	8.5	0.48	18.7	3.10	235	11	1148
5	12	oval		14.6	35.3	37.5	0.94	4.0	407.1	1.38	9.5	11.2	1.19	14.7	3.17	222	10	1135
6	13	square	17.2	21.4	21.5	21.3	1.01	3.0	285.7	1.42	13.9	6.8	0.49	16.4	3.15	151	7	1122
7	14	oval		12.2	24.1	24.9	0.97	3.0	223.6	1.28	5.0	7.0	1.39	12.3	4.13	132	5	1084
8	15	square	13.6	17.0	17.0	17.2	0.99	2.5	178.5	1.25	7.2	4.8	0.67	12.7	5.14	103	3	1077
9	16	oval		9.7	20.1	19.9	0.97	2.5	144.8	1.23	3.9	5.8	1.48	10.8	5.61	113	3	1056
10	17	square	11.0	13.7	13.7	13.6	1.01	2.0	116.8	1.24	5.7	4.1	0.71	11.3	7.11	86	2	1053
11	18	oval		8.2	15.7	16.1	0.97	2.0	97.9	1.19	2.8	4.7	1.68	9.3	7.05	89	2	1035
12	19	square	9.2	11.5	11.5	11.5	1.00	1.5	81.7	1.20	4.2	3.3	0.78	9.6	8.53	72	2	1032
13	20	fl.ov.		5.6	12.2	14.4	0.85	1.6	57.6	1.16	3.6	3.0	0.83	8.9	9.41	46	1	1022
14	21	08 CR		7.6	9.2	8.28	1.00	2.0	49.7	1.16	4.6	-	-	10.2	10.86	49	1	1019

Overfilling of passes: 11 13 17 19 passes.

Specific power consumption: 59.8 kWh/t.

Table 3.7

Analysis of technological parameters of rolling CAFA mill 300

Stand	Pass	Pass shape	Elongation coefficient	Reduction ratio	Temperature °C	Rolling force kN	Rolling torque kNm	Angle of bite deg	Rolling speed m/s	Kp	Km	Ka	Specif. power consump. kWh/t
	1	box	[illegible]	[illegible]	[illegible]	419	21	21.0	2.62	0.57	0.49	0.73	0.56
	2	box	1.25	0.24	1231	489	27	21.2	2.85	0.55	0.60	0.75	1.00
	3	box	[illegible]	[illegible]	1274	340	20	25.1	2.57	0.50	0.45	0.92	1.02
	4	box	[illegible]	[illegible]	[illegible]	367	21	22.4	2.82	0.43	0.48	0.78	0.83
1	5	box	1.25	[illegible]	1206	365	20	21.0	3.06	0.40	0.45	0.73	1.37
	6	hex	1.36	[illegible]	1190	311	13	14.3	3.16	0.31	0.29	0.49	1.57
	7	square	1.28	[illegible]	1188	353	22	21.9	3.18	0.39	0.49	0.74	3.37
	8	oval	1.41	0.35	1174	450	31	20.5	3.33	0.38	0.67	0.69	2.31
2	9	square	1.42	0.35	1168	300	16	21.1	3.14	0.33	0.36	0.90	3.02
3	10	oval	1.41	0.36	1158	351	20	[illegible]	3.12	0.31	0.46	0.75	2.35
4	11	square	1.41	[illegible]	1148	235	11	18.7	3.10	0.22	0.25	0.79	2.80
5	12	oval	1.35	0.39	1135	222	10	14.7	3.17	0.18	0.24	0.62	3.06
6	13	square	1.40	0.39	1122	151	7	16.4	3.15	0.13	0.15	0.67	3.26
7	14	oval	1.28	0.59	1084	137	5	12.3	4.13	0.12	0.93	0.55	4.05
8	15	square	1.25	0.30	1077	103	3	12.7	5.14	0.11	0.80	0.61	4.13
9	16	oval	1.33	0.29	1056	113	3	10.8	5.61	0.12	1.09	0.53	4.64
10	17	square	1.24	0.59	1053	86	2	11.3	7.11	0.09	0.96	0.61	2.96
11	18	oval	1.19	0.25	1035	39	2	9.3	7.05	0.09	0.64	0.49	4.59
12	19	square	1.20	0.51	1032	72	2	9.6	8.53	0.08	0.67	0.55	2.24
13	20	fl. ov.	1.10	0.39	[illegible]	46	1	[illegible]	9.41	0.04	0.25	0.53	[illegible]
14	21	08 CE	1.16	[illegible]	1019	49	1	10.2	10.86	0.05	0.38	0.67	[illegible]

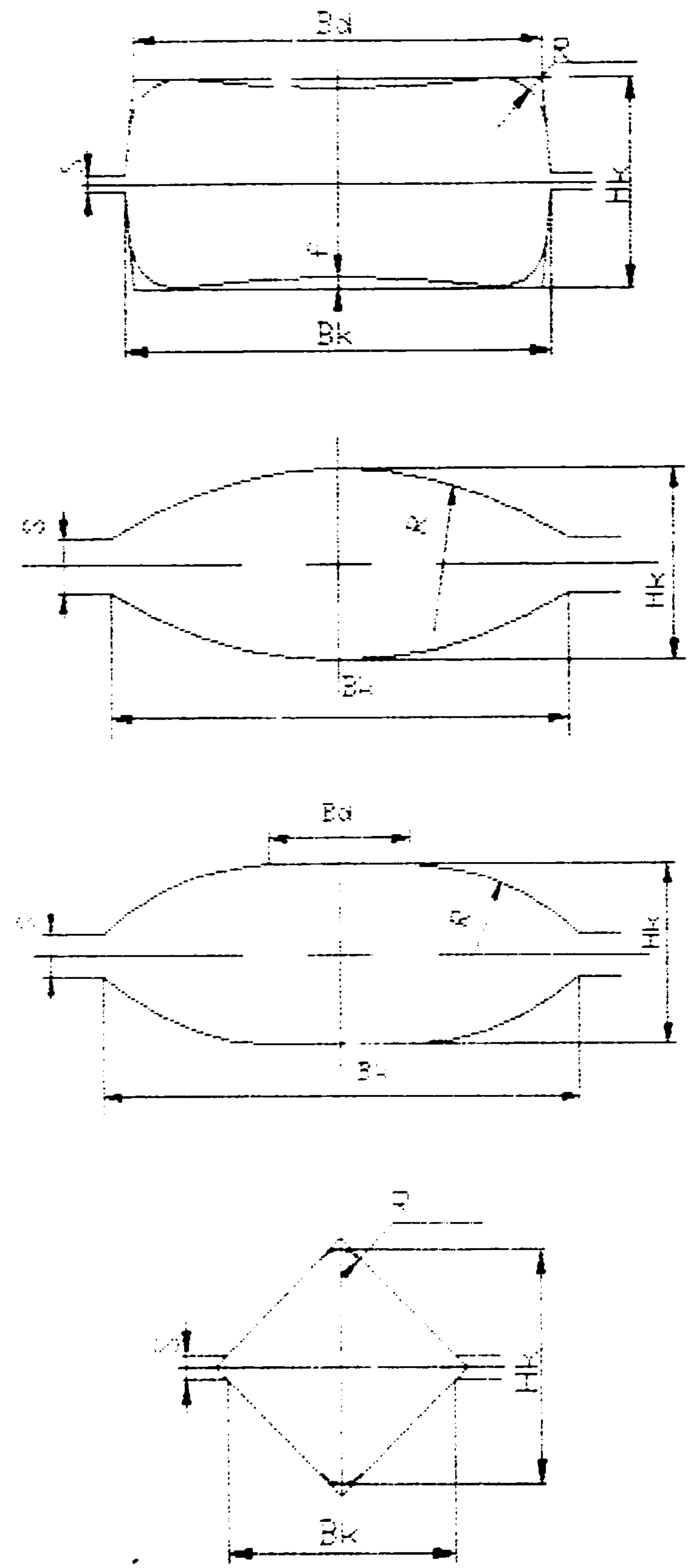


Fig 3.7 Pass designations

projecting. An analysis of working rolls calibration (see Table 3.7) illustrates unmotivated stretch oscillations by passings and corresponding main mechanical and electrical equipment load. Change of the rolling speed mode, for example, by replacing of belt drive pulley or main drive motors will allow to improve the rolls calibration in future.

The main direction in the present Designed Proposal of improving the rolls calibration is a redistribution of deformation by passings with the aim of decreasing a breakdown, making bite conditions in the third and fourth passes of the breakdown three high stand better, and also of increasing the roll steadiness. The last reason will cause an elimination of rolls denting.

Unloading of the first stand, where a square of 48 mm size was suggested in the new calibration instead of the 38,6 mm square in the seventh passing, was achieved mainly by increasing of the stretch in second - sixth stands. The calculation of stock length in the every moment of rolling in the breakdown train and of passes number it is rolled through was made. Thus the passes combination was taken into account for the stands and motors load calculation.

The construction of box passes in the first breakdown train was changed. Angle of sides increase, elimination of denting and possible stock asymmetry caused by inexact tuning of rolling guides, decreasing of the width to height ratio after the rolling in the second pass up to 1,76, another constructive changes will allow to improve the rolling steadiness and bite conditions.

Square passes construction is simplified, and the apex angle is accepted as 90^0, r/a ratio is equal to 0,2, where r is a radius of the square pass curve, and a is its side length. Oval passes were recalculated to improve their filling.

We recommend to maintain finishing and leader passes from the working calibration to simplify the assimilation, but later it would be expedient to correct them. The calibration constant is calculated in such a way, that it provides a little tension between continuous group stands, excluding 15 and 16, 17 and 18 ones, where the loops appearance is envisaged.

It should be mentioned in conclusion, that some computer programs used for calculation and analysis of rolls calibration are based on original methods, elaborated by authors. Some formulas for the calculation of spread, pull force and rolling torque are printed in the book: (V.Masterov, V.Berkovsky "Theory of plastic deformation and metal working", M., Metallurgy, 1989).

4.PROJECT PROROSALS ON ROLLING MILL AND FLAYING SHEAR SYNCHRONIZATION

The present technical proposal relates to the wire-rod mill "300', which is intended for wire-rod and fixtures production of wide assortment. The layout of continuous rolling mill equipment is shown in figure 4.1.

The technological process of rolling allows to deliver output production from the different stands. If it is happened before the finishing stands number N 13, 14 then as it seems to exploitation personnel, the process is sufficiently stable. The violation of the technological process is taken place mainly when rolling is in the production sector with finishing stands number N 13, 14, driving rollers and flying shears (fig.4.2).The several mechanisms simultaneously work at the continuous rolling process.

It is caused by violation of the optimal speed regime such that speed of the metal output from the each stand has to be consistent with the one of metal input in the next stand. In a practice the achievement of this situation is not always possible without use of the special automatic devices because the continuous change of deformation conditions (temperature, coefficient of friction, size of initial stock, wearing of passes). The change of these parameters influences on advancing

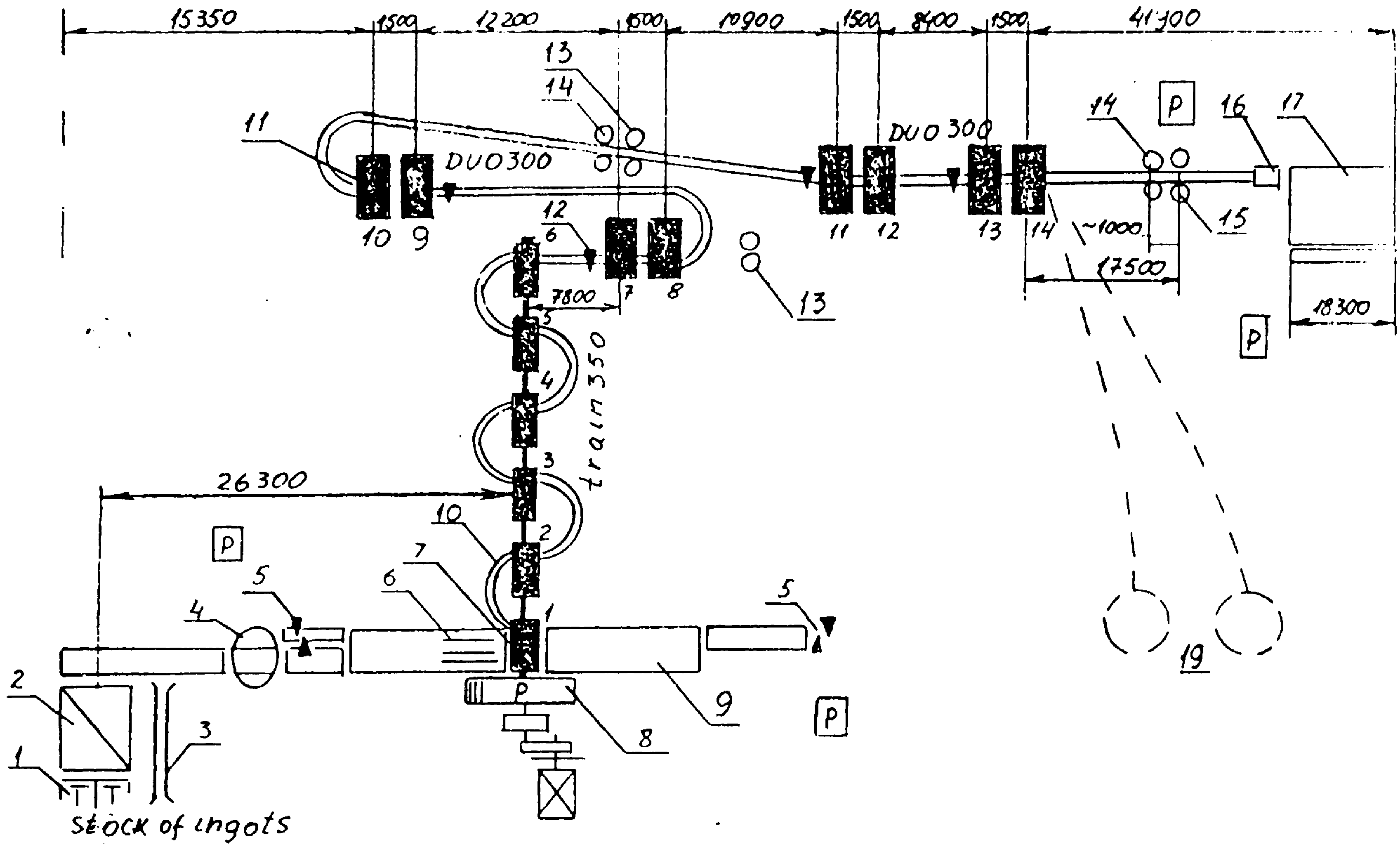


Fig. 4.I

Layout of the rolling mill equipment

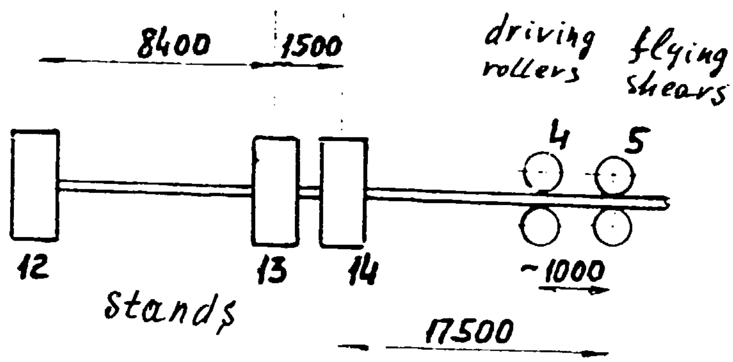


Figure 4.2·The existing layout of equipment in a finishing group region.

and crossection area in the every stand and leads to the loop formation or to the rise of strong tension.

The present technical proposal contains the recommendations which to be realized would allow to stabilize the speed regime of the continuous rolling and avoid the violation of technological process on the finishing stands - flying shears production sector. While solving the problem it was took into account the technical difficulties as well as economical considerations: we have wanted to avoid waste expenditures and make the most use of existing equipment. In a part, the next materials for technical proposal development was used:

- the layout of equipment for sectors from the linear group of the stands to the cooler,
- the fixtures N 8 rolling program,
- the layout of the drives control and the data for engines of the stands N 13, 14 and flying shears,
- the layout describing the construction principles of the flying shears engine.

Besides, the next data was used:

- the rolling is conducted by tension in the stand production sector,
- the flying shears are a cylinder type,
- the accidents often occur in production sector: stands 13, 14, feeding rollers, flying shears.

4.1. THE SYNCHRONIZATION OF SPEED REGIME ON THE FINISHING STAND PRODUCTION SECTOR

The existing scheme of equipment position in the region of the finishing group is shown in figure 4.2.

The cause of technological process violence can be determined from this figure. The main factor of this violence is the instability of speed regime which called froth the absence of the synchronization system for the speed of the stand spindles and others executive mechanisms.

The finishing stand N 12 has AC electric drive whose regulation properties of velocity is limited. Two next finishing stands N 13, 14 has DC electric drive. The tiristor transformer is used as a power source. Thus, drive of the mentioned stands unlike to drive of the stand N 12 has a good regulations possibilities but those ones do not use through the absence of corresponding control system. At these conditions the speed regime at the continuous rolling in the finishing group has a random behavior.

If the speed of metal output from the stand N S becomes greater than one of metal input in the next stand the loop is formed. The tensions of rolling can be happened too. The violation of speed regime can be taken place due to change of the stretch, advancing and erroneous definition of the initial speed of the adjacent stands rolling and the velocity change of the stand N 12 at the rolling moments change (drive works with the natural mechanical characteristic of induction engine).

In order to stabilize the speed regime on the finishing stands production sector we have obtained the next way of solution (fig.4.3).

It is known the rolling with regulating loop is the method which allows to exclude the tension between the stands and automate the control process for the speeds regimes of the rolling-mill.

The transmitter of loop value and regulator are the basic elements of the loop regulation system.

The working quality of stabilization system depends on the working accuracy of measurement devices and transmitters of the rolling loop value. The different types of transmitters are used in the wire-rod mill: capacity ones, based on the measurement principle of condenser capacity which consist of rolling and measurement plate, photoelectric ones and others.

The main advantage of the photo impulse transmitters is the high measurement accuracy and independence from the external conditions.

One can use laser devise for the loop measurement. As to regulation of the rolling loop value we give preference to the contactless photoelectric and laser transmitters due to their

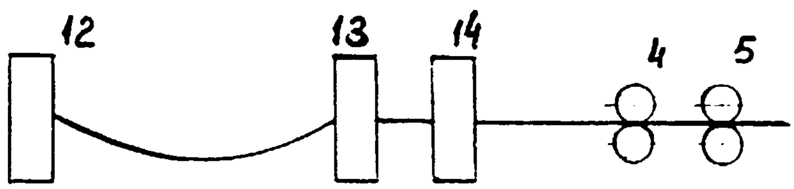


Figure 4.3 The layout proposed for the equipment in a finishing stand group region.

reliability, accuracy and fast working. We recommend for application the transmitters by ASEA (Sweden) and AEC (Germany) firms. It is necessary to know the correct installation of photoelectric transmitter has the strong influence on work regulator quality. It is convenient the optical axis of photobulb would be perpendicular to the plane of loop. That allows to receive the linear dependence of the output photo bulb signal from the value of rolling loop. For the most part the loop regulation systems are based on the deviation principle of regulation (fig.4.4).The controlling influences are transmitted to the next drives of the stands N 13, 14. The necessary rolling regime between the finishing stands N 13 and N 14 is provided with a given relation of speed. The consistent speed regime of rollers can be obtained from the condition of constancy of the second volumes:

$$\omega_1 = \omega_{1-1} \frac{D_k(1-1)(1+S_{1-1})}{D_k 1(1+S_1)} \lambda_1 ,$$

where

ω_1 -rotation frequency of spindles of the next stand

ω_{1-1} -rotation frequency of spindles of the previous stand

D_k- diameter of rollers

λ- rolling stretch value

S - advancing

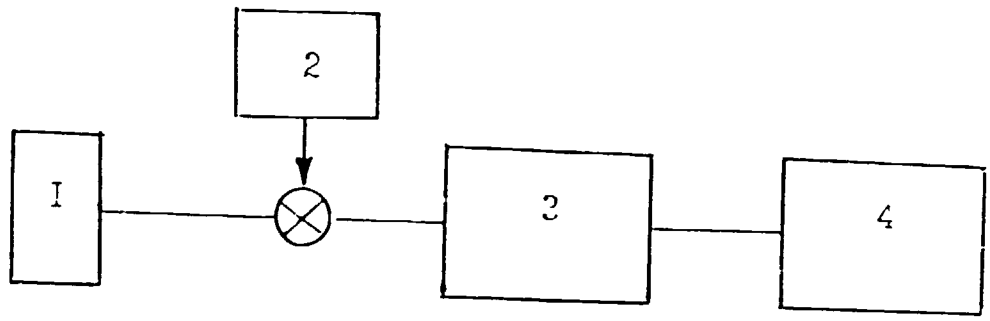


Figure 47. The structural scheme of loop regulation system.

1.The loop transmitter;

2. Device for loop value assignment.

3.The loop regulator;

4. The control system for velocity regime of the finishing stands.

There is an opportunity to correct drive speed of the stand N 14 relative to the stand N 13. It is important to note there are two working regimes for loop regulation system. The first regime is the loop stabilization at the main part of roll. The second one presents the transitional regimes at rolling input and output. The most important thing is the loop formation at the metal input.

The stabilization regime differs greatly from the one of initial loop formation by the rolling length. It does necessary to divide this functions and use for their executing separate subsystems.

In order to form the rolling loop and eliminate the unfavorable situations (rise of tension) the subsystem of loop formation would allow the installation of the definition of the adjacent stands speed relation. Thus for the rolling with loop regulation it is convenient to provide the control system of speed regime with devices of the initial (input) speed of stands spindles correction. These devices have to be responsible for the change of the rolling conditions.

The most simple work algorithm for the initial loop formation's subsystem at metal input is that [illegible]ed of the loop range's next stand decreases in the fro[illegible] of roll and increases in the back edge due to signals from the metal presence transmitters. One way to correct the input speed is to stabilize the roll's bending value. In that case bending regulator's signal is stored at roll's output from the previous stand and acts upon velocity drive's regulation system up to the input in next stand of the next roll. That allows every time before rolling of the each roll to receive the most near to initial speed regime for adjacent stands that leads to reducing of time it takes for a specified value of roll's bending to be achieved.

The most simple way for realization of this suggestions is at the use of microprocessor control system.

4.2.THE SYNCHRONIZATION SYSTEM FOR SPEED OF THE FEEDING ROLLERS AND FLYING SHEARS

4.2.1. The feeding rollers drive.

The electric drive of the feeding rollers has to provide for accident-free working of the technological process :

- the linear speed of feeding rollers and roll left the output rolling mill's stand synchronization. The electric drive allows no loop formation between rollers and output stand from one side and rollers slippage on the roll from other side.
- the roll transportation after it left the output rolling mill's stand.

The first of these requirements rises the necessity of work with roll's tension in the sector between the output stand and feeding rollers. The tension value would not be greater than one leads to slippage, i.e.:

$$0 < T < T_1$$

where T is the tension in the output stand - feeding rollers section.

T_1 is the limiting tension for the slippage does not rise.

The limiting tension is equal:

$T_1 = 2P\mu_1$(at condition that both of the rollers are feeding) where P - rollers tension pressure on the roll,

μ_1- the friction coefficient between rollers and roll.

For the hot roll $\mu_1 = 0.3$.

The rollers drive must provide the pull force T_t during transportation:

$$T_t \leq G_{roll}\,\mu_2,$$

where G_{roll} is the weight of the transported roll,

μ_2 is the friction coefficient roll on transportation way.

$$\mu_2 = 0.3.$$

Then minimal value of pressure by feeding rollers on roll would be equal to:

$$P_{min} = \frac{T_t}{2\mu} = \frac{G_{roll}\mu_2}{2\mu_1}$$

$$\text{at } \mu_1 = \mu_2 \quad P_{min} = \frac{G_{roll}}{2}$$

For the presented layout, e.g., the length of transported roll at output from stand N 10 round ⌀ 20 can be equal :

L_{max} = 60 m, its weight - G_r = 150 kg.

Then P_{min} is greater or equal to 75 kg.

As usually, P is taken equal greater than P_{min}. For example in present case P ≃ 150

This pressure does not lead to the roll's geometry deformation, but for providing so small pressure it is necessary to use feeding rollers whose construction allows to regulate the rollers pressure on a roll and breakage between them separately (fig.4.5).

If the roll's deformations rise at pressure "P" then in order to increase the area of rollers and roll contact and decrease the specific pressure the rollers with "broken" pass are used instead of smooth ones. No rollers can be used which allow for only breakage regulation and the necessary pressure adjustment through it. The small change of breakage lead to great changes of pressure at this construction which rise to either roll's form deformation or slippage rollers on roll, i.e., to violation of synchronization of the rollers and roll linear speeds. The power of drive engine is determined from condition:

$$N_{eng} = \frac{T_1 V_{max}}{102\ \eta_m},$$

where V_{max} (m/s) - maximal linear speed of roll,

η_m- mechanism efficiency included loss in bearings of rollers and reducer.

In our case, e.g., the power would be equal:

$$N_{eng} = \frac{150 \cdot 8}{102 \cdot 0.9} = 13 \text{ kV, where } V_{max} = 8 \text{ m/s, } \eta_m = 0.9$$

While drive adjusting the rotation frequency of rollers is

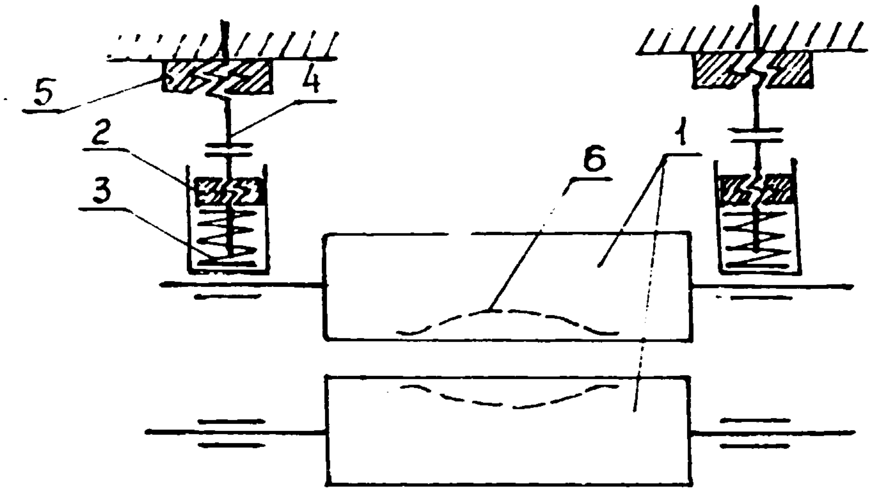


Figure 4.5 The feeding rollers construction.

1 - rollers;

2 - adjusting tension nut

3 - spring

4 - adjusting nut

5 - nut

6 - pass

The balancing of upper roller is not shown.

installed so that linear velocity of rollers at idling would be some greater than roll one. Therefore at the roll input the rotation frequency of rollers decreases and the necessary roll tension is provided. If the engine moment is proportional to the armature current as it is taken place in DC engines with separate excitation then operator can easily judge about tension value "T" by the "I" current value (fig.4.6).

The layout, presented in fig. 4.7, provides synchronization of speed of the output stand spindles and feeding rollers through use of speed regulator wherein the feedback is performed from tachogenerator of rollers - TG, and speed assignment is done from the output stands tachogenarators - 1TG, 2TG, 3TG actuated(connected) by contacts - 1C, 2C, 3C at the output stand choice for a given roll's profile. Using potentiometer - R an operator, based(guided) by amperemeter's readings - A, that is, in a fact voltage value, can regulate rollers velocity.

The suggestions on feeding rollers reduce in principle to the next points:

a) To analyze the feeding rollers construction for providing the separate regulation of the tension of pressure rollers to the roll and breakage between the rollers (it is impossible to carry out this analysis based on the presented materials).

b) To replace the AC drive on DC electric drive by CTT-E

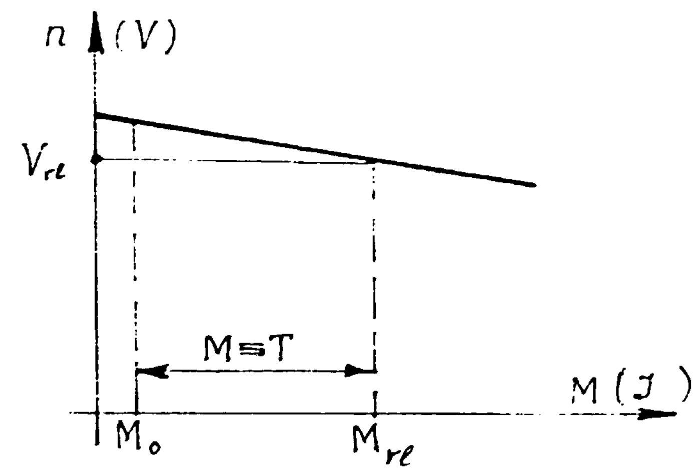


Fig. 4.6

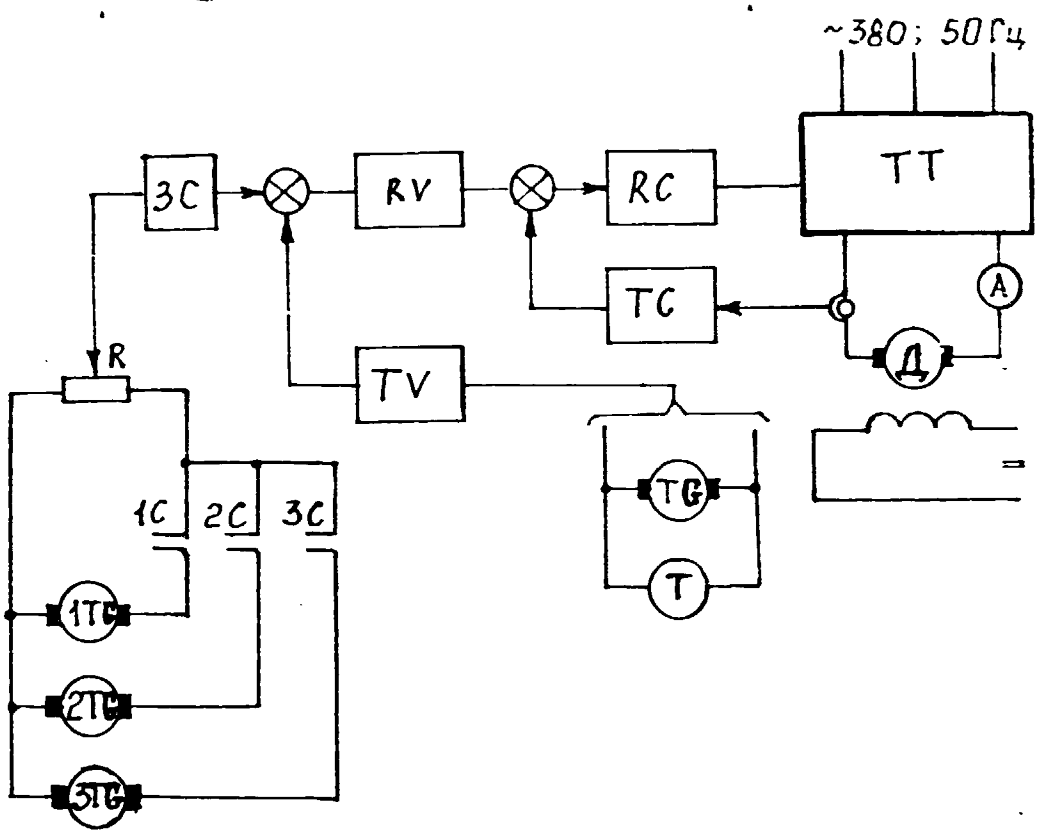


Figure 4.7

E - engine; TT - tiristor transmitter;
TG - tachogenerator of rollers drive;
T - tachovoltmeter; TC, TV - roller's current and velocity transmitters; RC, RV - rollers current and velocity regulators; AV - device for rollers velocity assignment; 1TG,2TG,3TG - tachogenerators of the mill's output stands; 1C,2C,3C - rele contacts turned on to "AV" tachogenerator of the mill's output stand; R - potentiometer.

system (controlled tiristor transmitter - engine). This replacement allows to tune tension value by armature engine current easily and provide more fast working in comparison with the existing drive which regulates speed with servomotor. The last advantage is essential because it minimized the unconsistency of speed is in transient regimes when for whatever reason a speed of output stand is changed. With loop regulator between stands NN 12 - 13 the such speed oscillations are inevitable.

4.2.2. The flying shears drive.

The choice of electric drive and control system for flying shears depends on construction and basic parameters of the ones. In a given case, as stated above the limited amount of information was presented by customer:

- flying shears is a cylinder type,
- length of the one cut L_{cut} = 12 m,
- drive is provided by AC engine with servo motor regulation of rotation frequency,
- engine parameters - 17 kVt, 1830 revolutions per minute.

Taking cooler length L_c = 18,3 m and distance from cutting line to cooler L_{cl-c} = 6,1 m the maximal speed of rolling motion can not be greater than

$$V_{max} = \left[(L_c + L_{cl-c} - L_{cut}) \cdot 2 \cdot g \cdot \mu \right]^{1/2}$$

where μ = 0.25...0.3 is the coefficient of friction of hot rolling on cooler's valves.

According to figure 4.1,

V_{max} = (18,3 + 6,1 −12)·2·0.3·9.81 = 8.5 m/s

In order to create breakage between the cutted pieces which delivered to cooler it is necessary the speed of rolling would be less than one of delivery to the cooler on (10...20)%.

Then the maximal rolling speed for profiles cutted by flying shears can not be greater than:

V_{rmax} = (0.8...0.9)·V_{max} = (0.8...0.9)·8.5 = (6.8,...7.65)m/s

Thus rolling velocity on cooler at cutting would be equal:

$$V_r \le 7.5 \text{ m/s}.$$

The cut length of cylinder flying shears is defined from relations between rotation frequencies of feeding rollers and flying shears. The linear speed of rollers (rolling velocity) is equal:

$$V_{rl} = \frac{\pi \cdot D_{rl} \cdot n_{rl}}{60},$$

where D_{rl} - roller's diameter, m

n_{rl} - roller's rotation frequency, revolution per minute.

The linear speed of flying shears bit is equal

$$V_c = \frac{\pi D_c n_c}{60},$$

where D_c - diameter of cylinder flying shears cutter bit, m.

The cutter speed would be greater than rolling one in a cutting sector. In opposite case the bending of the front edge of cutted rod and stop of roll in shears would be happened.

Hence,

$$V_s = k_0 V_c$$

where k_0 is passing coefficient.

The length of the rods cutted by flying shears at the constant rotation frequencies of rollers and shears cylinders is equal to:

$$L_{cut} = \pi D_c \frac{K_1}{K_0} \longrightarrow \pi D_c = \frac{L_{cut} K_0}{K_1},$$

where K_1 is a number of revolutions per cut.

Taking into account, $\pi D_c = \dfrac{L_{cut} K_0}{K_1}$, one can write:

$$\frac{\pi D_{rl} n_{rl}}{60} = \frac{\pi D_c n_c}{60 K_0} = \frac{L_{cut} n_c K_0}{60 K_0 K_1}$$

Hence:

$$L_{cut} = \pi D_{rl} K_1 \frac{n_{rl}}{n_c}$$

i.e., cut length is defined by construction parameters of rollers and shears and relation between their rotation frequencies $\frac{n_{rl}}{n_c}$ has to satisfy condition $V_S=K_0V_c$ at $K_0>1$.The passing coefficient can not be great at cutting on cooler the rods which are sufficiently long and have small longitudinal stability, otherwise the bending of the back edges of cut ted rods would be taken place.

Then as a rule

$$K_0 = 1,02...1,05,$$

i.e. linear speed of cutter is greater than rolling one on (3...5)%. The number of cylinder's revolution per cut "K_1" is defined by shears construction and provided with either special mechanism or shears using with cylinders of different diameters. For example, if $\frac{D_{cu}}{D_{cl}} = \frac{5}{6}$, then cut is happened after 6 revolutions of upper cylinder and 5 revolutions of lower one.

The relations pointed above allow to form the main requirements to the electric drive and flying shears control system:

- the rotation frequencies of shears and rollers would be synchronized for the $\frac{n_{rl}}{n_c}$ relation's execution with high accuracy(precision) because the violation of one leads to change of cut length,

- the specified relation $\frac{n_{rl}}{n_c}$ would be constant as rolling speed changes (one of rollers - changes too) at least with precision excludes appearance of regime with $V_c < V_{rl}$,

- in order to provide requirement stated above either drive and shears control system would be design with the corresponding dynamic parameters or the possible temp changes would be limited.

The investigations of this data allow to present some conclusions:

- the feeding rollers and flying shears drive does not provide necessary dynamic parameters at roll speed change because the power of rollers and shears drive is unsufficient and the control system has low speed.

- while rolling with uncontrolled tension between the stands NN 12 - 13 the sufficient sharp increment of roll speed can be happened at output from the stand N 1 from the metal advancing and engine's rotation frequency increasing at roll output from stand N 12.

- the regime of the roll front edge can not be provided from power of flying shears engine drive 17 kVt. If the roll front edge has random length the accidents are possible behind the flying shears.

The final conclusions can be made only after all the data investigation. However, the next suggestions can be presented at the level of technical proposal:

- the flying shears drive is performed from DC engine powered by (which takes its current from) controlled tiristor transmitter with modern control system (with analog or, better, numerical regulators of rotation frequency),

- the power of drive engine would be sufficient to provide the convened cuttinq of the front edge in flying shears start-up regime from initial position or position set while running. The change of advancing would be excluded at back edge output from the stand N 12 due to use a loop regulator between stands N 12 - 13. While regulated loop the available acceleration would be choiced in accordance with dynamic parameters of shears drive.

Taking into account the electric drives of stands NN 13,14 are constructed with DC engines it is quite reasonable to use the same type of drive for the flying shears and feeding rollers. At least, this solution is considered more preferable than the used one with special AC engine and electromechanical regulator trough servo motor. done on higher stages of engineering.

To realise the project proposals it is nesasery to develop the project in details and to purchase needed equipment.

5.FINDING AND RECOMMENDATIONS.

1.On the basis of carrent analysis of SAFA'S operations, maintenance activities, product quality WAS FOUNDED that technology and equipment, which implemented in steel plant and rolling mill are in accordance to requirement to reinforce bars.

2. The following activities are recommended for further improvement of production quality and effectiveness in the steel plant:

2.1 To install the express analysis of the chemical composition of the metal.

2.2. The temperature regime of heats in the electric furnace should be optimized; the tapping temperature of the metal should not exceed 1630-1650°C.

2.3. A strict control of the quantity and quality of metal scrap uses in the charge should be carried out.

3.The following project proposals and design has been carried out for rolling mill (in framework of contract amendment):

3.1.Project proposals and design to convert the preheating furnace from gas-oil fuel to mazout fuel (including measurement equipment for pressure control, thermocouple in preheating zone, recording potentiometer on control board etc.)

3.2.Project proposal and calculation for rolling pass design for rolling optimization.

3.3.Project proposal for synchronization the rolling mill and flying shears.

4. It was founded during first subcontractor mission, that SAFA jointly with SNIM has given experience using computerized system for spare part control and monitoring, financing etc.

5. To reinforce SAFA computerized system of management, production and quality control, the specification of equipment and software has been recommended. The following equipment and software accordingly were supplied , install and put in to operation by subcontractor team : PC AT 386SX -1 unit, PC AT 386 -7 units, microsoft mouse, printer EPSON FX-1050 -8 units, plotter HP-1745A, scftware, xerox.

6.The following subsystem has been developed, installed, customized and put in day-by-day operations:

6.1.Inventory control, Material Requirement.

6.2.Production control (including row materiel and energy consumption for each product and department).

6.3.Input-Output Balance (including cost calculation for each product and department).

7. On the-job training of SAFA personal was carried out by subcontractor team. It is recommended to set up SAFA's computer group, train or recruit one or two skilled system programmers to secure the system operations and development.

8.It is to consider CMIS as a developing system. which supposed to be permanently enhanced, modernized, customized to current and future needs of SAFA.

9.It is stated that SAFA has made essential step to introduce modern high technology - personal computer. However to reinforce the production effectiveness and quality improvement it is recommended to follow-up the project (e.g. as a Phase 11). The following activities are recommended to carry out in framework of Phase 11 (in prioritizes):

9.1.To develop and introduce the computer network for integration of different subsystem (production and quality control, maintenance, financing and cost analysis etc.). Additional equipment and software are required for this development.

9.2.To introduce measurement and control system forpreheating furnace for fuel saving, waste minimization, yield increasing.

9.3.To develop and introduce the measurement and control system in electric arc furnace department for row material and energy savings, yield increasing and cost minimization.

9.4.To develop and introduce the system of synchronization of rolling mill and flaying shares.