

Production planning problem in small foundries

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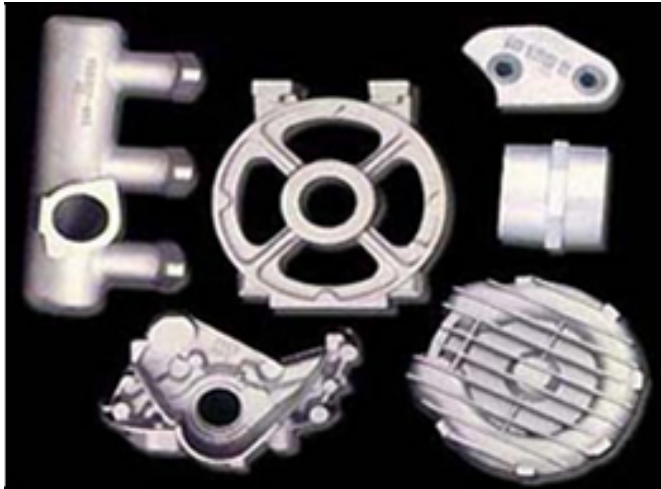
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Small foundry context

- Foundry in a small city of São Paulo State (Brazil)
 - produces exclusively for suppliers
 - many orders: often with different products made of different alloys
 - wide range of products with varying demand made of different alloys
 - only one furnace

Small foundry process



Different products made
of different alloys



www.google.com.br

Small foundry process



Define the alloy to be melted

Choose products to be made
with this alloy



www.google.com.br

Small foundry process



Making molds

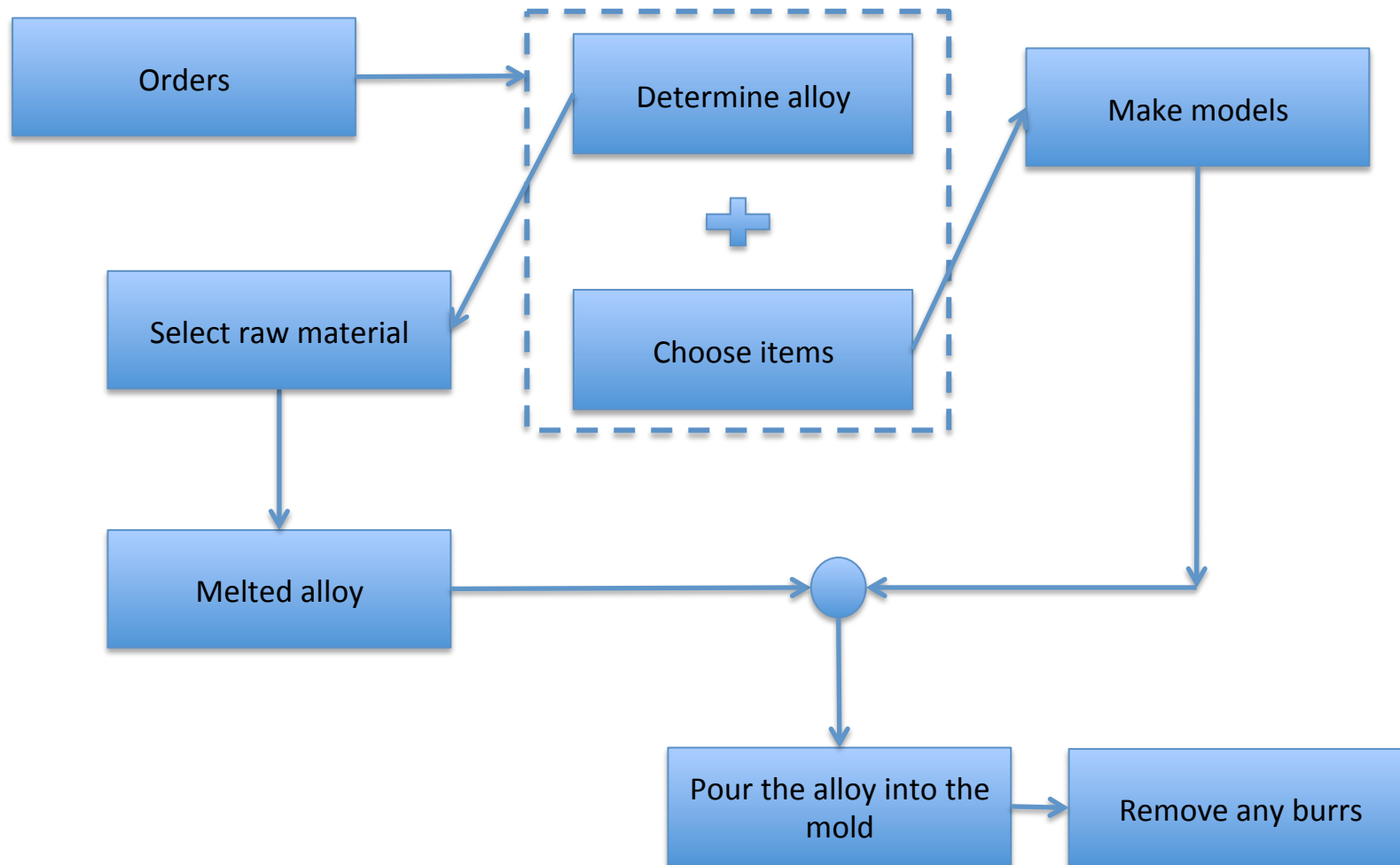
www.google.com.br



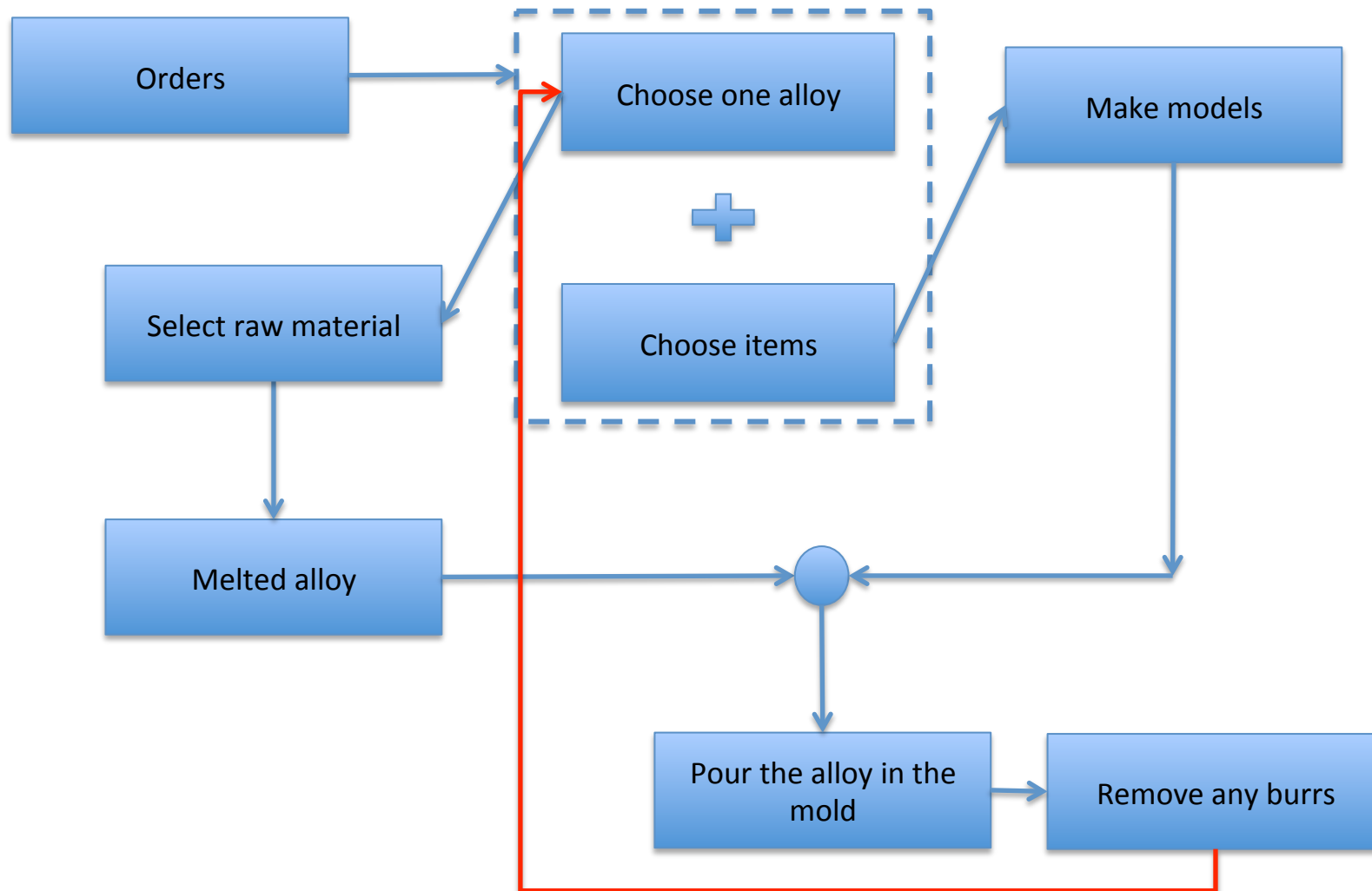
Pouring the alloy into the
mold

www.infoescola.com/quimica/fundicao/

Small foundry process



Small foundry process

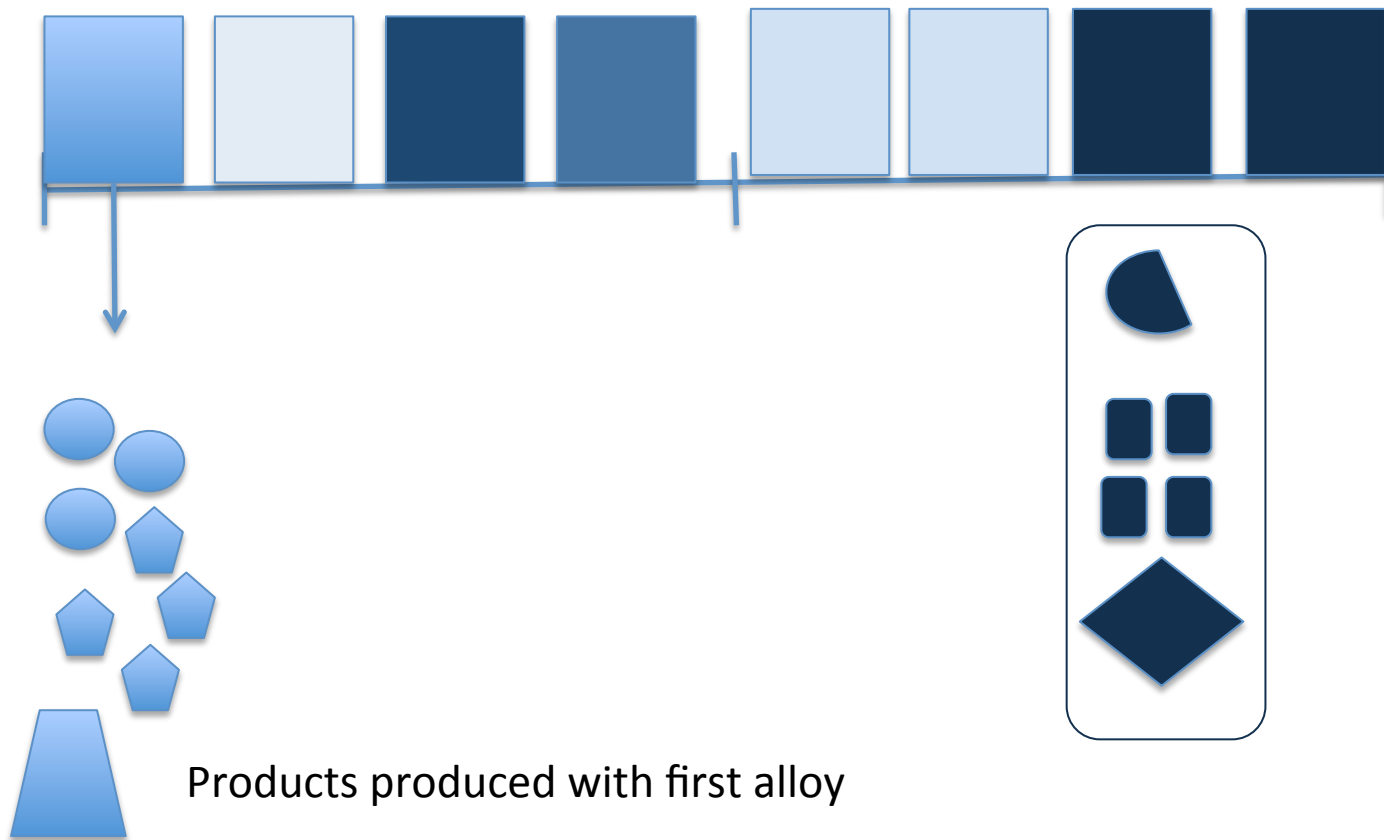


Literature approach

- Planning the production of products
 - Camargo et al. (2012)
 - Tonaki and Toledo (2010)
 - Araújo et al. (2008)
 - Duda (2005)

Production plan

Batches for different alloys



Decisions

- To determine which products to be produced in each furnace loading

Model proposed

- Minimizes the furnace's waste in each loading.

Objective

- Obtain software to support the decision maker in the production planning of furnace loading.

Requirements

- friendly interface
- make changes in the proposed solution
- regardless of commercial software

Two phases of the project

- Phase 1
 - production planning of one furnace loading
- Phase 2
 - Production planning of many furnace loadings

Adopted solution: *FundiAção Cargas*

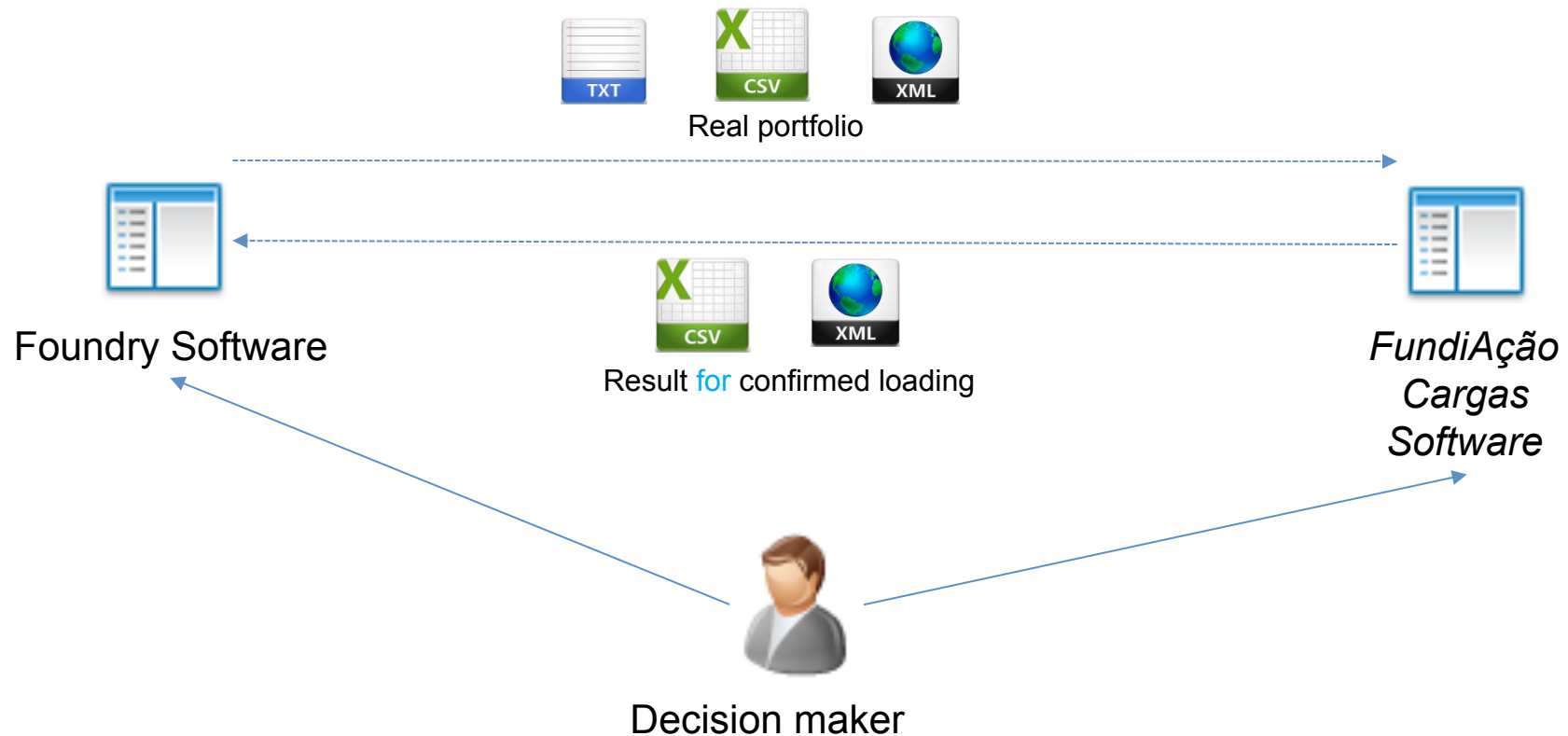


Image: www.softicons.com

Adopted solution: *FundiAção Cargas*

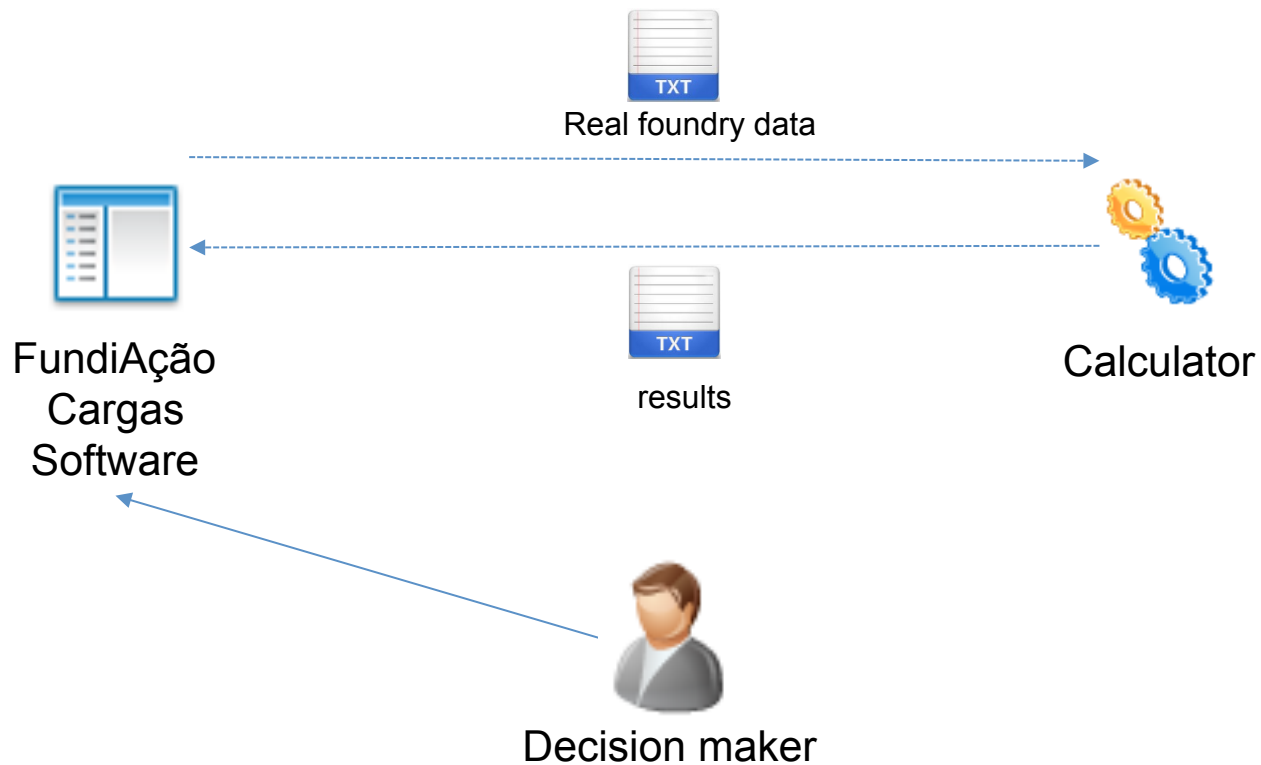


Image: www.softicons.com

Calculator

- The software solves many knapsack problems

$$\begin{aligned} &Max \quad \sum_{i=1}^n v_i x_i \\ &s.a \quad \sum_{i=1}^n \delta_i x_i \leq Cap \\ &\quad \quad x_i \in \mathbb{Z}^+ \end{aligned}$$

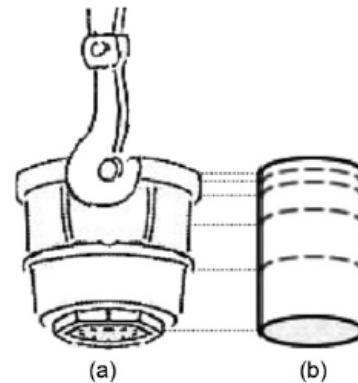
Calculator

- The software solves many knapsack problems

$$\text{Max} \quad \sum_{i=1}^n v_i x_i$$

$$\text{s.t.} \quad \sum_{i=1}^n \delta_i x_i \leq \text{Cap}$$

$$x_i \in \mathbb{Z}^+$$



www.google.com.br

Camargo et al., 2012.

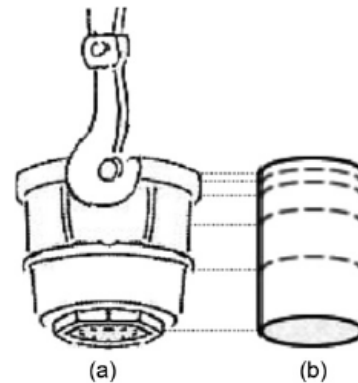
Calculator

- The value of products (v_i) should be defined ***appropriately***

$$\text{Max} \quad \sum_{i=1}^n v_i x_i$$

$$\text{s.t.} \quad \sum_{i=1}^n \delta_i x_i \leq \text{Cap}$$

$$x_i \in \mathbb{Z}^+$$



www.google.com.br

Camargo et al., 2012.

Calculator

- The value of products (v_i) should be defined *appropriately*
- Many rules are defined together with the decision makers from the foundry.

Calculator - software

- Step 0
 - Pre-processing data based on defined rules calculated the value of each product
- Step 1
 - It solves many knapsack problems for each alloy type
- Step 2
 - Decision maker can validate or change each loading

Furnace loading planning

Carteira de Pedidos											
Programação Uma Carga											
Configuração											
	Grupo	Material	OF	Produto	Cliente	Pedido	Program.	Quantid.	P.Bruto	P.Total	Observação
▶		Liga 1 (000001)	000001	Produto 1	Cliente 1	00.001/1	30/08/2012	5	8,00	40,00	Não informado
		Liga 1 (000001)	000002	Produto 2	Cliente 2	00.002/2	29/08/2012	3	15,00	45,00	Não informado
		Liga 1 (000001)	000003	Produto 3	Cliente 1	00.002/2	29/08/2012	30	5,00	150,00	Não informado
		Liga 1 (000001)	000004	Produto 5	Cliente 1	00.001/1	23/08/2012	5	18,00	90,00	Não informado
		Liga 1 (000001)	000005	Produto 7	Cliente 2	00.002/2	22/08/2012	23	5,00	115,00	Não informado
		Liga 1 (000001)	000006	Produto 12	Cliente 1	00.002/2	27/08/2012	12	55,00	660,00	Não informado

Planning of a foundry

The screenshot displays a software window titled 'Carteira de Pedidos' with three tabs: 'Carteira de Pedidos', 'Programação Uma Carga', and 'Configuração'. The 'Carteira de Pedidos' tab is active.

Filtro

Ligas sem grupos OU Grupos

	Material	OF	Produto	Cliente	Pedido	Program.	Quantid.	Quant.Limite	P.Bruto	P.Total	Obrigatoriedade

Total obrigatório (kg): 0,00 Calcular

Produção sugerida

	Material	OF	Produto	Program.	P.Bruto	Quant.Limite	Qtd. Produzir	Trocar	Qtd.Trocada

Total utilizado do forno (kg): 0,00 Cancelar Recalcular Confirmar

Planning of a foundry

Carteira de Pedidos

Programação Uma Carga

Configuração

Filtro

Ligas sem grupos

Liga 1 (000001)

OU Grupos

	Material	OF	Produto	Cliente	Pedido	Program.	Quantid.	Quant.Limite	P.Bruto	P.Total	Obrigatoriedade
▶	Liga 1 (000001)	000001	Produto 1	Cliente 1	00.001/1	30/08/2012	5	5	8,00	40,00	Indiferente ▼
	Liga 1 (000001)	000002	Produto 2	Cliente 2	00.002/2	29/08/2012	3	3	15,00	45,00	Indiferente ▼
	Liga 1 (000001)	000003	Produto 3	Cliente 1	00.002/2	29/08/2012	30	30	5,00	150,00	Indiferente ▼
	Liga 1 (000001)	000004	Produto 5	Cliente 1	00.001/1	23/08/2012	5	5	18,00	90,00	Indiferente ▼
	Liga 1 (000001)	000005	Produto 7	Cliente 2	00.002/2	22/08/2012	23	23	5,00	115,00	Indiferente ▼
	Liga 1 (000001)	000006	Produto 12	Cliente 1	00.002/2	27/08/2012	12	12	55,00	660,00	Indiferente ▼

Total obrigatório (kg):

0,00

Calcular

Produção sugerida

	Material	OF	Produto	Program.	P.Bruto	Quant.Limite	Qtd. Produzir	Trocar	Qtd.Trocada

Total utilizado do forno (kg):

0,00

Cancelar

Recalcular

Confirmar

Planning of a foundry

Carteira de Pedidos

Programação Uma Carga

Configuração

Filtro

Ligas sem grupos

Liga 1 (000001)

OU

Grupos

	Material	OF	Produto	Cliente	Pedido	Program.	Quantid.	Quant.Limite	P.Bruto	P.Total	Obrigatoriedade
▶	Liga 1 (000001)	000001	Produto 1	Cliente 1	00.001/1	30/08/2012	5	5	8,00	40,00	Indiferente ▼
	Liga 1 (000001)	000002	Produto 2	Cliente 2	00.002/2	29/08/2012	3	3	15,00	45,00	Indiferente ▼
	Liga 1 (000001)	000003	Produto 3	Cliente 1	00.002/2	29/08/2012	30	30	5,00	150,00	Indiferente ▼
	Liga 1 (000001)	000004	Produto 5	Cliente 1	00.001/1	23/08/2012	5	5	18,00	90,00	Indiferente ▼
	Liga 1 (000001)	000005	Produto 7	Cliente 2	00.002/2	22/08/2012	23	23	5,00	115,00	Indiferente ▼
	Liga 1 (000001)	000006	Produto 12	Cliente 1	00.002/2	27/08/2012	12	12	55,00	660,00	Indiferente ▼

Total obrigatório (kg): 0,00

Calcular

Produção sugerida

	Material	OF	Produto	Program.	P.Bruto	Quant.Limite	Qtd. Produzir	Trocar	Qtd.Trocada
▶	Liga 1 (000001)	000003	Produto 3	29/08/2012	5,00	30	2	☐	0
	Liga 1 (000001)	000005	Produto 7	22/08/2012	5,00	23	23	☐	0
	Liga 1 (000001)	000004	Produto 5	23/08/2012	18,00	5	5	☐	0
	Liga 1 (000001)	000006	Produto 12	27/08/2012	55,00	12	3	☐	0

Total utilizado do forno (kg): 380,00

Cancelar

Recalcular

Confirmar

Software validation

- Efficiency and efficacies
 - Many computational experiments were conducted to validate the results obtained by our software (compared with commercial software)
 - Large and small instances were used
- Quality of obtained solution
 - Based on real portfolios (book orders)
 - Compare the solution obtained from the FundiAção:Carga with decision maker solution

Results

- Based on one month of data, we can conclude:
 - 5% of loadings were changed by a decision maker (the furnace capacity was increased by him for most of them)
- Advantage
 - Time of FundiAção:Carga: on average 10 minutes
 - Time of decision maker: 2 hours

References

- Araujo, S. A., Arenales, M. N., and Clark, A. R. (2008). Lot-sizing and furnace scheduling in small foundries. *Computers & Operations Research*, 35, 916– 932.
- Camargo, V. C. B., Mattioli, L., and Toledo, F. M. B. (2012). A knapsack problem as a tool to solve the production planning problem in small foundries. *Computers and Operations Research*, 39, 86 – 92.
- Duda, J. (2005). Lot-sizing in a foundry using genetic algorithms and repair functions. In *EvoCOP Lecture Notes in Computer Science* (pp. 101–111). Springer.
- Tonaki, V. S., and Toledo, F. M. B. (2010). An approach to solving the lot-sizing and scheduling problem in market-driven foundries. *Journal of the Operational Research Society*, 61, 108 – 114.

Thanks for your attention!

Any questions?