
MAGMA

MAGMA ECONOMICS

비용 절감, 품질 향상, 탄소 저감을 위한 새로운 기능

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MAGMA Engineering Korea Co., Ltd.

목차

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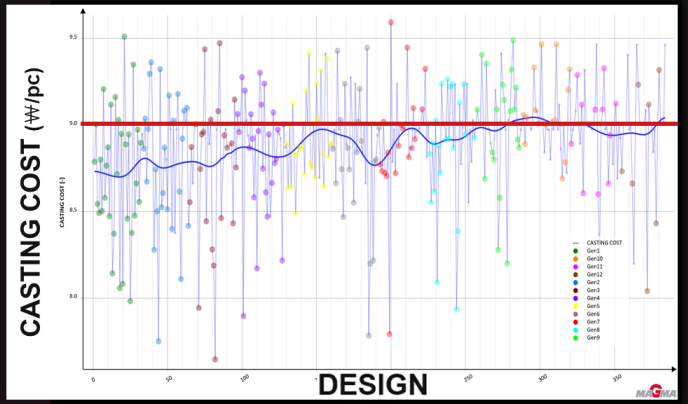


MAGMASOFT®를 선택하는 이유

주조 공정에 기여하는 가치

공정 및 품질 최적화를 위한 솔루션 :

- Reduce defects (결함 감소)
- Increase productivity (생산성 향상)
- Save time for development (개발 시간 단축)
- For learning & experimentation (학습과 실험)

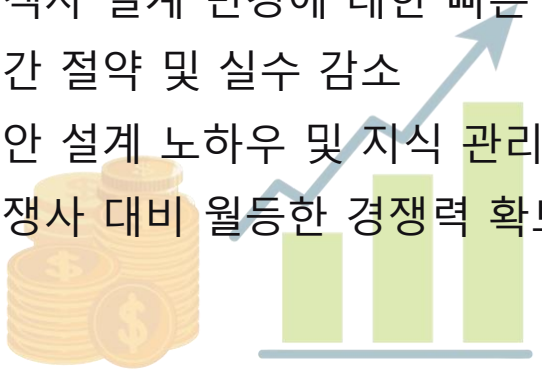
To make a sound technical decision

건전한 기술적 결정을 위한 솔루션

MAGMASOFT®를 선택하는 이유

현장에서 얻을 수 있는 실질적인 또 다른 혜택

- 효율적인 작업표준서 관리
- 타 팀 및 고객사와의 의사소통 개선
- 고객사 설계 변경에 대한 빠른 대비
- 시간 절약 및 실수 감소
- 방안 설계 노하우 및 지식 관리
- 경쟁사 대비 월등한 경쟁력 확보



- **생산효율 관리**
- **회수율 관리**
- **생산비용관리**
- .....
- **Reduce cost (비용 절감)**
- **Reduce CO_2 (이산화탄소 감소)**

Reduce costs, increase profits – 비용 절감, 기업 이윤 증가

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What? Why? What for?

¬ **제조 비용 및 환경(CO_2)**에 대한 영향을 추정하는 도구

Name		Scenario	
Total costs of cast alloy	$f(x)$	10.8985	€
Unit cost of cast alloy		100	€/t
Mass of Casting All IDs		46.6808	kg
Unit cost of melting		100	€/t
Mass of Cast Alloy		62.304	kg
Total costs of molding	$f(x)$	17.31	€
Unit cost of molding		0.1	€/kg
Mass of Cope Box All IDs		0	kg
Mass of Drag Box All IDs		0	kg
Mass of Sand Mold All IDs		173.1002	kg
Total costs of cores	$f(x)$	4.9767	€
Unit cost of mixed core sand		1	€/kg
Mass of Core All IDs		4.9767	kg
Total costs of sleeve(s)	$f(x)$	0	€
Unit cost of sleeve		10	€/kg
Mass of Sleeve All IDs		0	kg
Total costs of chills	$f(x)$	2.6819	€
Unit cost of chill		0.5	€/kg
M		5.3638	kg

제조 비용 시트

Name		Basis	
CO_2 Estimation of the Cast Material	$f(x)$	251.983	kg CO_2eq/part
CO_2 footprint of the cast alloy		5,398	g CO_2eq/kg
CO_2 footprint of the casting system (recycled)	$f(x)$	0	g CO_2eq/kg
Number of Casting Materials		1	
Shot weight	$f(x)$	56.4081	kg
Mass of Casting All IDs		46.6808	kg
Casting system	$f(x)$	9.7273	kg
Mass of Biscuit All IDs		0	kg
Mass of Runner All IDs		9.4387	kg
Mass of Gate All IDs		0.2885	kg
Mass of Overflow All IDs		0	kg
CO_2 Estimation of Melting	$f(x)$	16.968	kg CO_2eq/part
CO_2 emission factor of gas		227.561	g CO_2eq/kWh
Gas consumption of melting furnace		1.3	kWh/kg
Power consumption of melting furnace		0.01	kWh/kg
CO_2 Estimation of Preparation, Filling, Solidification	$f(x)$	1.992	kg CO_2eq/part
CO_2 emission factor of electricity		498	g CO_2eq/kWh
Total power consumption of die casting cell		4	kWh/cycle
CO_2 Estimation per			kg CO_2eq/part

CO2 발생량 시트

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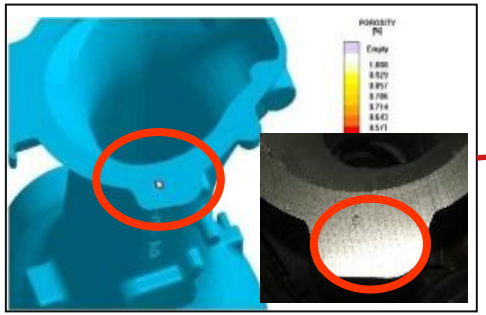
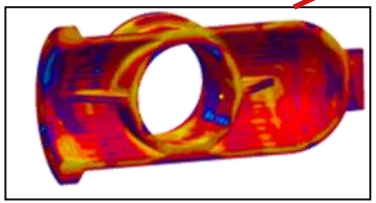
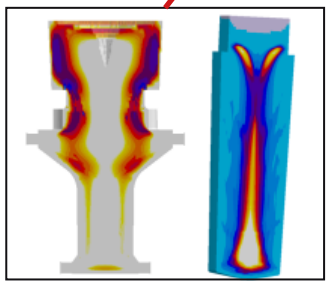
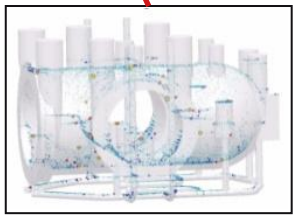
- Simulation 결과의 **경제적 측면 평가**

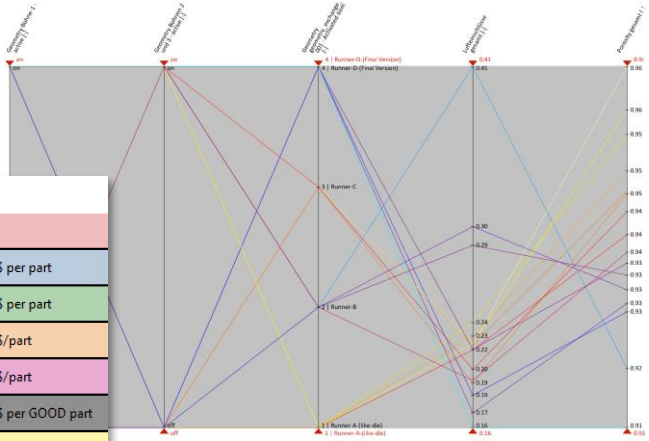








Name		Scenario	
Manufacturing Inputs			
Material Costs	$f(x)$	3.831	$ per part
Melt Costs	$f(x)$	0.102	$ per part
Tooling Costs	$f(x)$	7.3	$/part
Production Costs	$f(x)$	11.464	$/part
Scrap Costs	$f(x)$	1.51	$ per GOOD part
Per Part Cost	$f(x)$	24.21	$
Total Project Cost	$f(x)$	6,050,746.63	$
Projected Revenue	$f(x)$	10,000,000	$
Profit	$f(x)$	**3,949,253.37**	**$**



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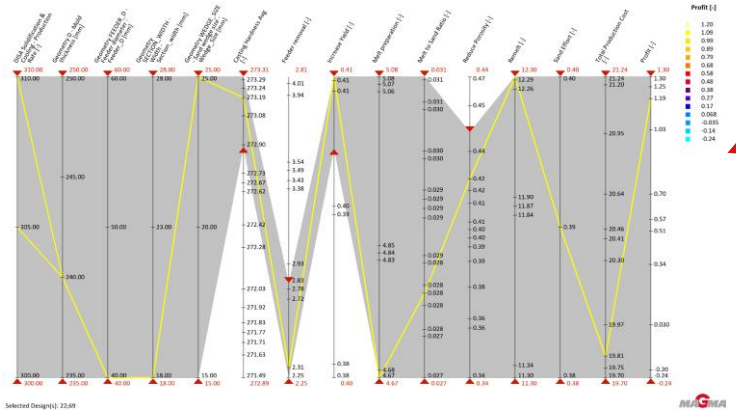
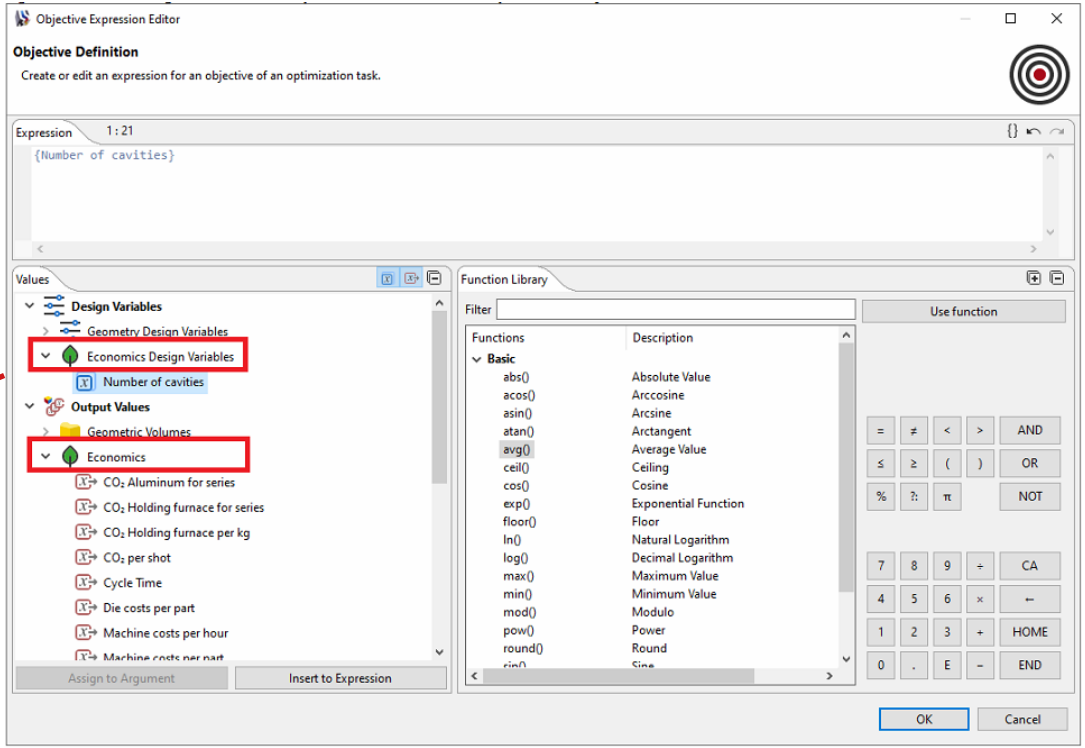
What? Why? What for?

- 최적화에서 **경제적 목표 고려** 가능





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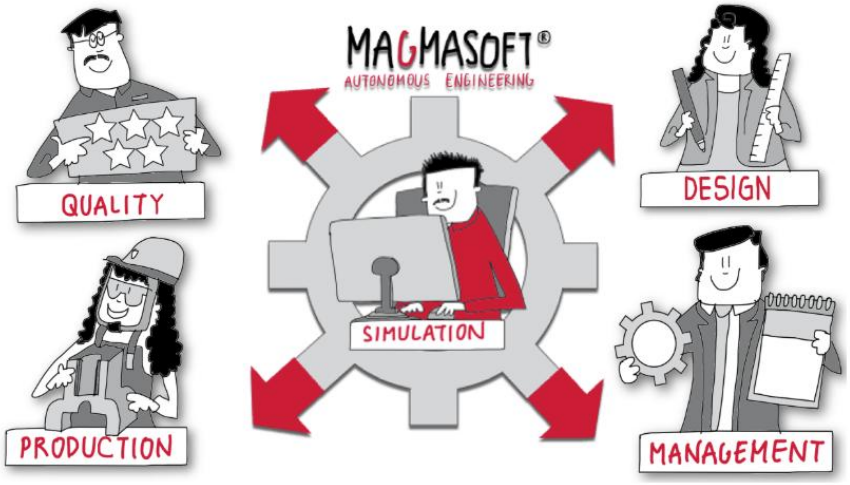
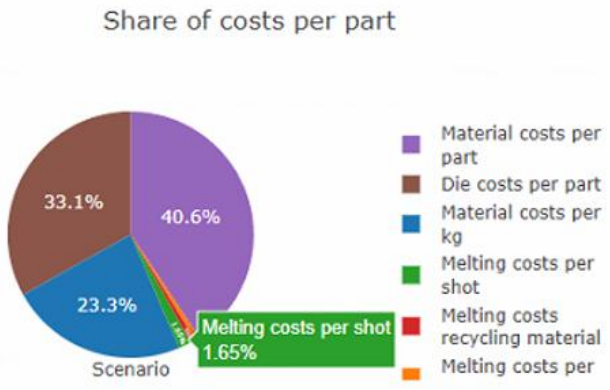
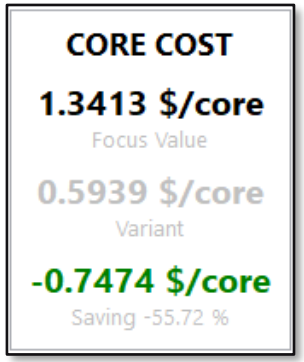
What? Why? What for?

- 조직 내 원활한 커뮤니케이션 제공
- 정량적 데이터를 통해 타 부서 및 고객사와의 소통에 유리







MAGMA ECONOMICS와 탄소 중립

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Net Zero of Tools = MAGMA ECONOMICS

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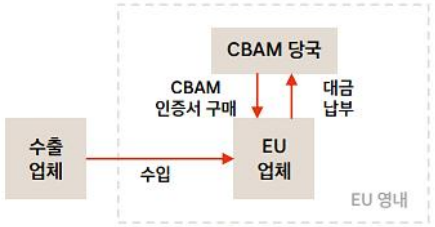
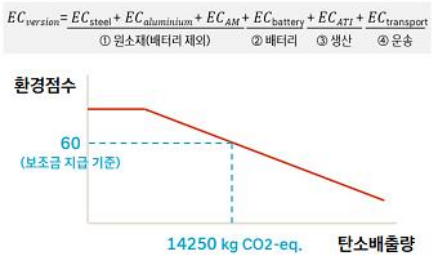
탄소국경조정제도 (CBAM)

- EU 영내에 수입 시 탄소배출량에 비례한 CBAM 인증서 구매 필요
- 단가: EU 탄소배출권 종가의 주간 평균가
- 대상: 철강, 알루미늄, 시멘트, 비료, 전기



프랑스 녹색산업법

- 전기차 보조금 지급 기준 개편
- 전기차의 원소재/제조/수송 단계의 탄소배출량 기반 보조금 지급여부 결정
- 중국/한국 등 동아시아 OEM 불리



자동차 탄소배출량 신고

- 탄소배출량 산정을 위한 자동차 LCA 방법론 제정 논의 (UN A-LCA, EU 등)
- LCA 기반 자동차 탄소배출량 신고 요구 (EU '26.6~)

상품성 규정	제품 간접규제	제품 직접규제	제품 직접규제	탄소중립 검증 관련 규정 별도 제정 예상	탄소중립
(Green NCAP)	(탄소국경조정제도)	(Battery Regulation)	(EU 자동차 탄소배출량 신고)		
2022	2023	2025	2026		2045

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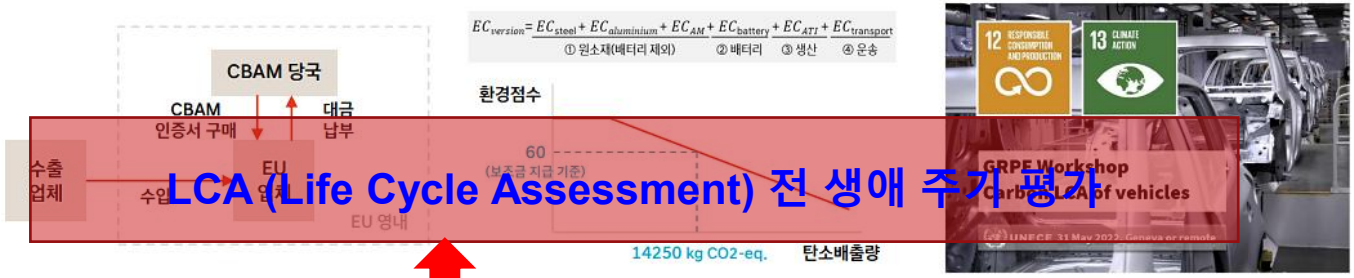
Net Zero of Tools = MAGMA ECONOMICS (탄소중립 규제 동향)

탄소국경조정제도 (CBAM)	프랑스 녹색산업법	자동차 탄소배출량 신고
- EU 영내에 수입 시 탄소배출량에 비례한 CBAM 인증서 구매 필요 - 단가: EU 탄소배출권 종가의 주간 평균가 - 대상: 철강, 알루미늄, 시멘트, 비료, 전기	- 전기차 보조금 지급 기준 개편 - 전기차의 원소재/제조/수송 단계의 탄소배출량 기반 보조금 지급여부 결정 - 중국/한국 등 동아시아 OEM 불리	- 탄소배출량 산정을 위한 자동차 LCA 방법론 제정 논의 (UN A-LCA, EU 등) - LCA 기반 자동차 탄소배출량 신고 요구 (EU '26.6~)



배터리 포함, 전기자동차 전 생애주기에 걸쳐 친환경성에 부합하지 못하면 해외 수출 불가!

상품성 규정 (Green NCAP)	제품 간접규제 (탄소국경조정제도)	제품 직접규제 (Battery Regulation)	제품 직접규제 (EU 자동차 탄소배출량 신고)	탄소중립 검증 관련 규정 별도 제정 예상	탄소중립
2022	2023	2025	2026		2045

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Summary

- 설계 및 공정 변수 최적화에 대한 생산 비용 추정 도구
- Simulation 없이 변수를 수정하여 실시간 예상 가능
- DoE 또는 최적화 프로젝트에 완전히 통합
- 표 또는 다이어그램을 사용하여 MAGMASOFT® 결과에 직접 연관된 비용, 리소스 평가

- **EU CBAM, ESG, RE100 등 환경 규제 강화로 글로벌 시장은 품질 및 비용, 탄소중립 대응을 동시에 요구**
- **주조 방안 설계와 원가 절감을 통한 수익성 향상, 탄소 배출량에 대한 최적의 방안을 제안**
- **기존 비용 계산 도구의 대체 / 경쟁자가 아닌 MAGMASOFT®를 활용하는 새로운 관점의 도구입니다.**

MAGMASOFT®
autonomous engineering

MAGMA ECONOMICS 기능

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Estimation of Costs

… 하지만
MAGMASOFT®에서
이 비용 평가를
어떻게 하나요?

MAGMASOFT®
autonomous engineering

A new
MAGMASOFT®
Perspective

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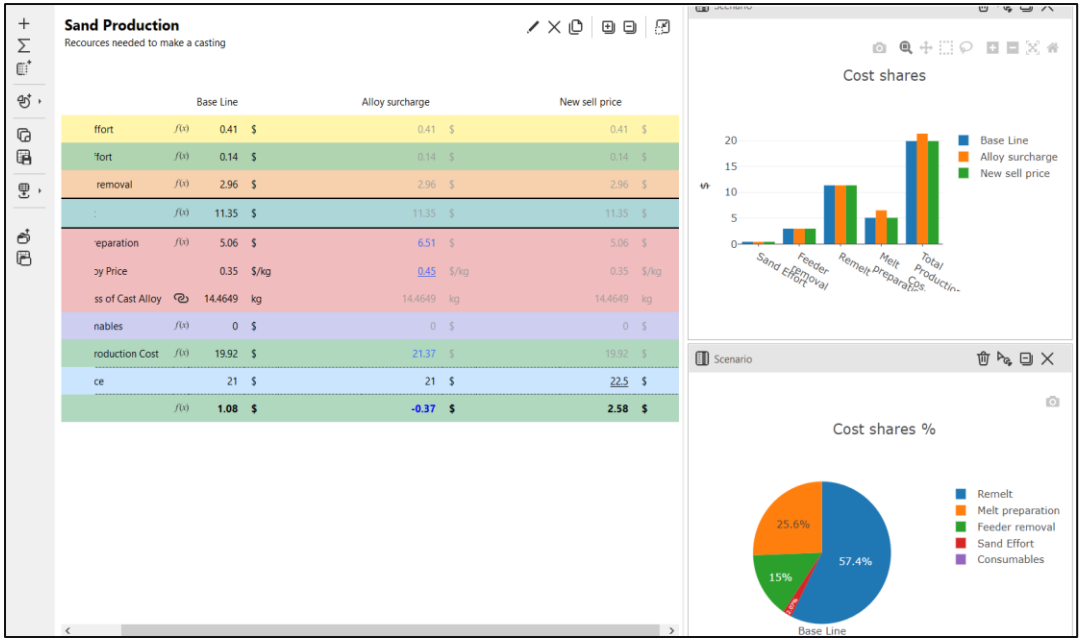
Estimation of Costs

- 비용을 계산할 수 있는 시트
- 처음부터 독립적/개별적으로 생성 가능
- 불러오기/저장 가능
- 만들어진 Template 사용 가능
- 개별 부서나 주조 공장의 상황에 맞게 커스터마이징 가능
- 보고서를 위한 그래프 및 차트 생성



MAGMA ECONOMICS – Cost sheet 비용표

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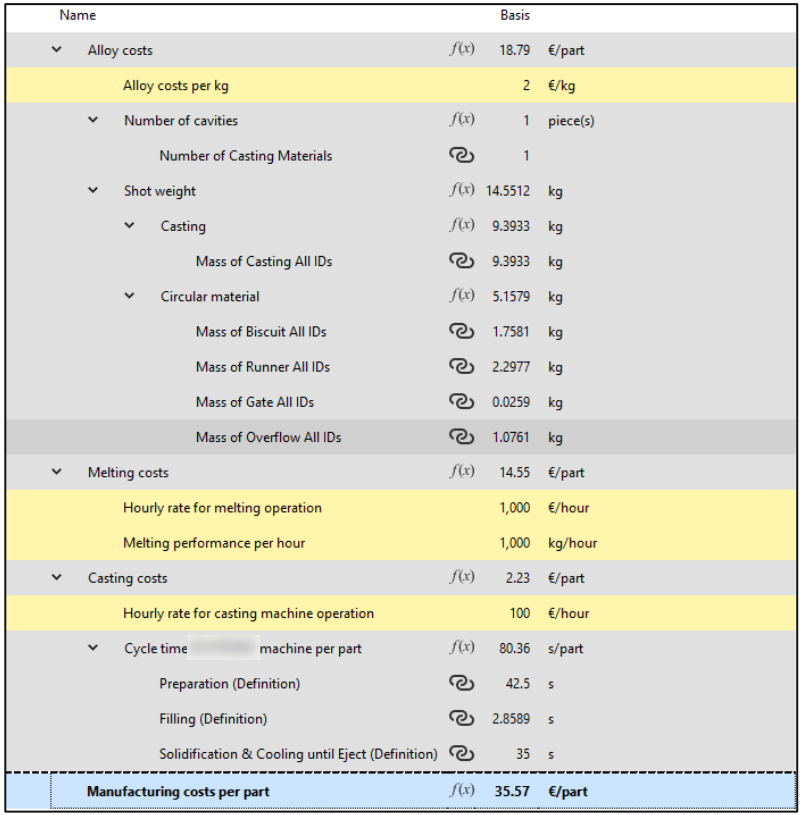
Example : Basic Cost Sheet

- 주요 프로세스에 대한 기본 Cost sheet 제공
- 모든 값은 기본값으로 사전 설정
- € 및 MAGMA/SI 단위 Sheet 제공
- 사용자는 노란색으로 강조 표시된 값들만 수정 (화폐, 재료 비용, 용해 비용, 주조 비용)
- 나머지 값은 모두 Simulation으로 부터 생성



Name		Basis	
Alloy costs	f(x)	18.79	€/part
Alloy costs per kg		2	€/kg
Number of cavities	f(x)	1	piece(s)
Number of Casting Materials		1	
Shot weight	f(x)	14.5512	kg
Casting	f(x)	9.3933	kg
Mass of Casting All IDs		9.3933	kg
Circular material	f(x)	5.1579	kg
Mass of Biscuit All IDs		1.7581	kg
Mass of Runner All IDs		2.2977	kg
Mass of Gate All IDs		0.0259	kg
Mass of Overflow All IDs		1.0761	kg
Melting costs	f(x)	14.55	€/part
Hourly rate for melting operation		1,000	€/hour
Melting performance per hour		1,000	kg/hour
Casting costs	f(x)	2.23	€/part
Hourly rate for casting machine operation		100	€/hour
Cycle time machine per part	f(x)	80.36	s/part
Preparation (Definition)		42.5	s
Filling (Definition)		2.8589	s
Solidification & Cooling until Eject (Definition)		35	s
Manufacturing costs per part	f(x)	**35.57**	**€/part**

모든 값은 기본값으로 자동 설정(회색)

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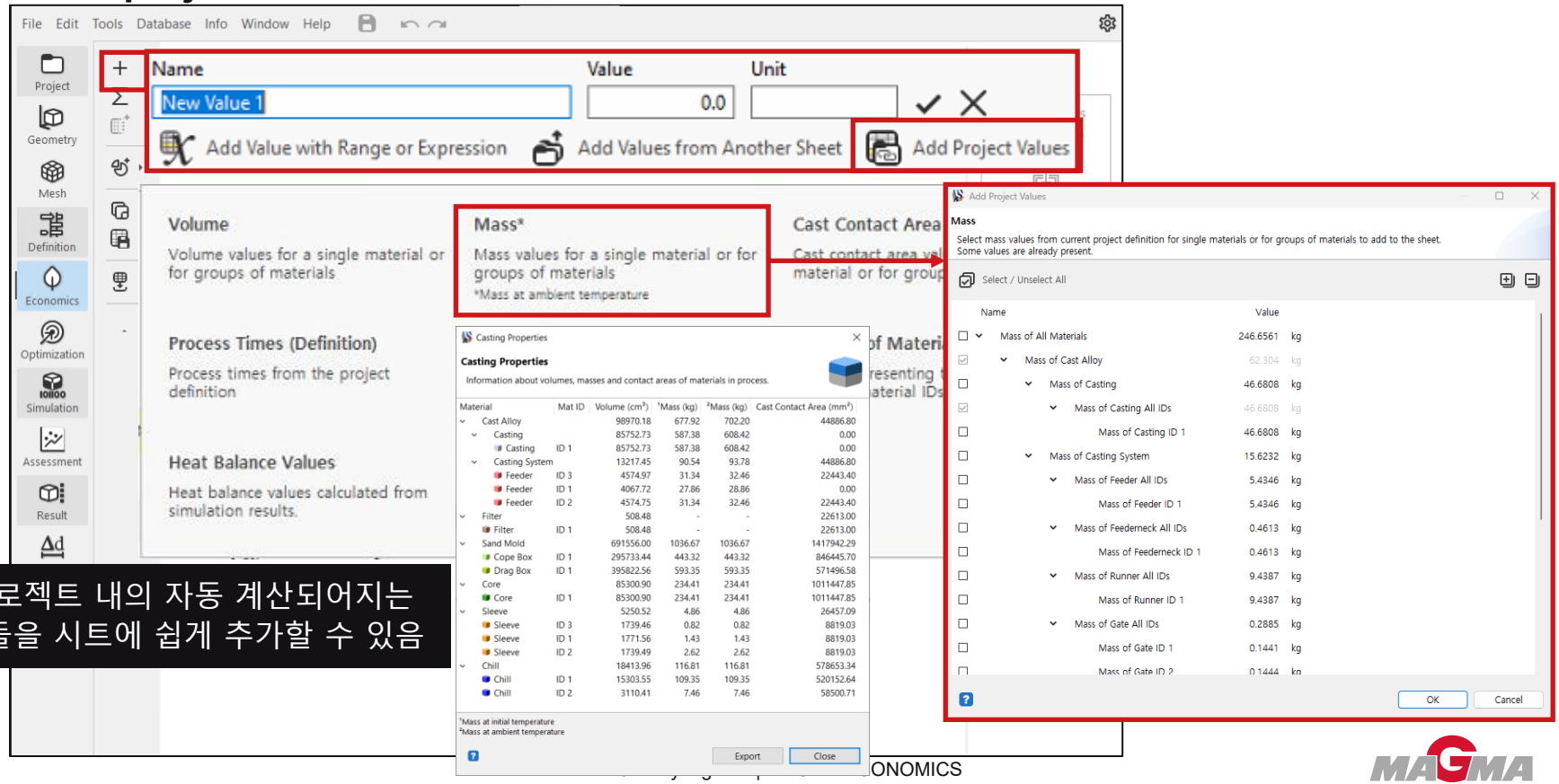
Add project values



프로젝트 내의 자동 계산되어지는 값들을 시트에 쉽게 추가할 수 있음

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Optimization with Economics

Name		Basis	
Alloy costs	$f(x)$	18.79	€/part
Alloy costs per kg		2	€/kg
Number of cavities	$f(x)$	1	piece(s)
Number of Casting Materials		1	
Shot weight	$f(x)$	14.5512	kg
Casting	$f(x)$	9.3933	kg
Mass of Casting All IDs		9.3933	kg
Circular material	$f(x)$	5.1579	kg
Mass of Biscuit All IDs		1.7581	kg
Mass of Runner All IDs		2.2977	kg
Mass of Gate All IDs		0.0259	kg
Melting costs			
Hourly rate for melting operation		1,000	€/hou
Melting performance per hour		1,000	kg/ho
Casting costs	$f(x)$	2.23	€/part
Hourly rate for casting machine operation		100	€/hou
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Preparation (Definition)		42.5	s
Filling (Definition)		2.8589	s
Solidification & Cooling until Eject (Definition)		35	s
Manufacturing costs per part	$f(x)$	**35.57**	**€/part**

시트에서 바로 최적화 변수 및 목표로 적용 가능

Create Design Variable

Create Objective

Design Variables

	Design Variable	Lower Limit (€/hour)	Upper Limit (€/hour)	Step (€/hour)
☑	Hourly rate for casting machine operation	50.0	150.0	50.0

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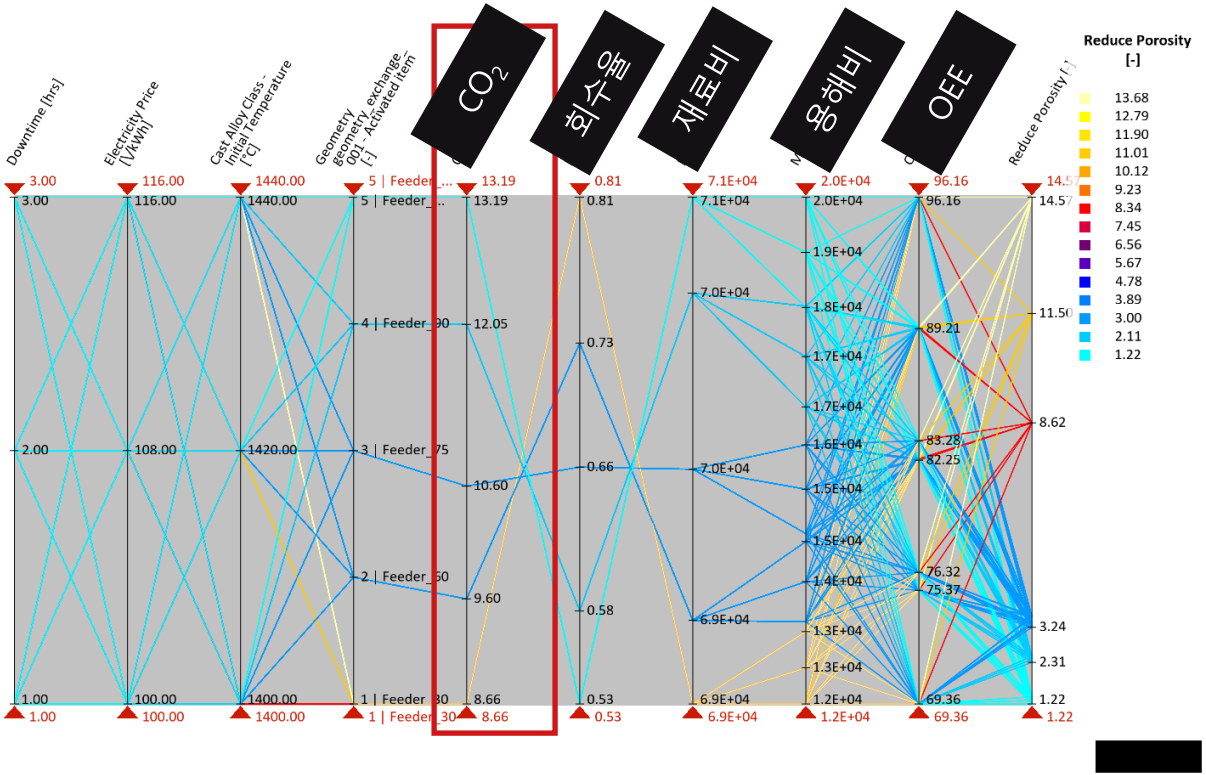
Net Zero of Tools = MAGMA ECONOMICS



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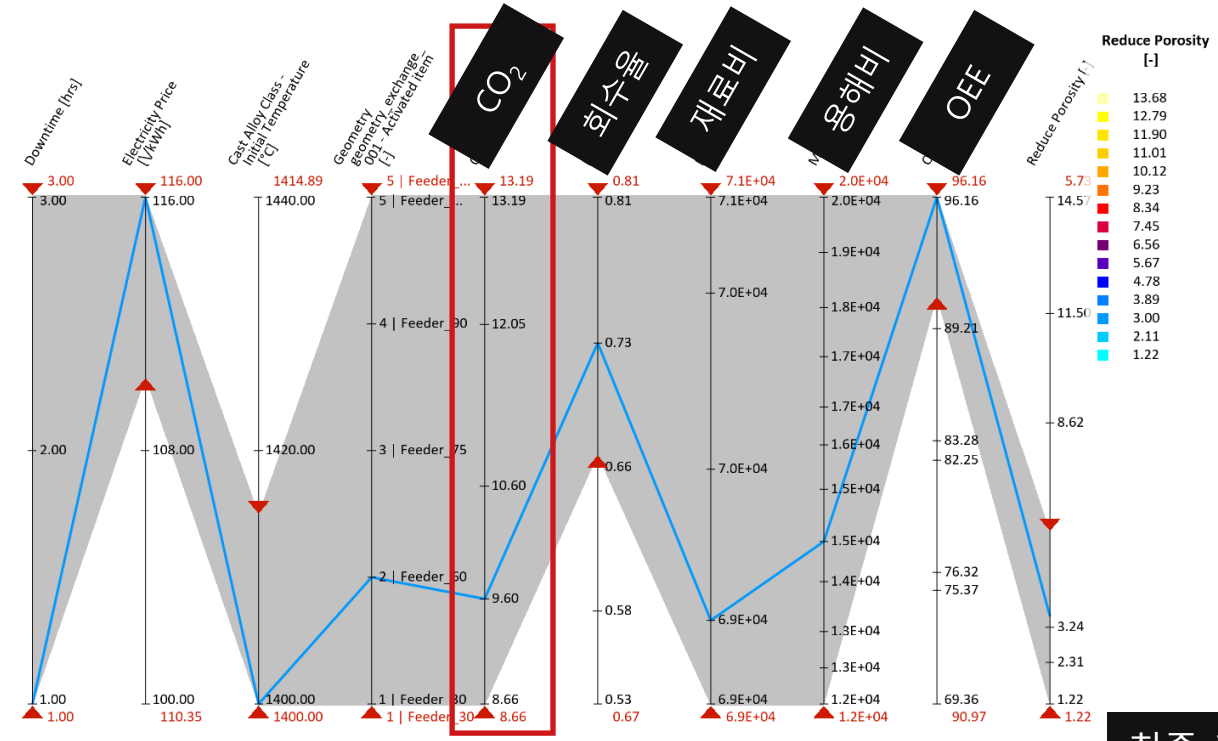
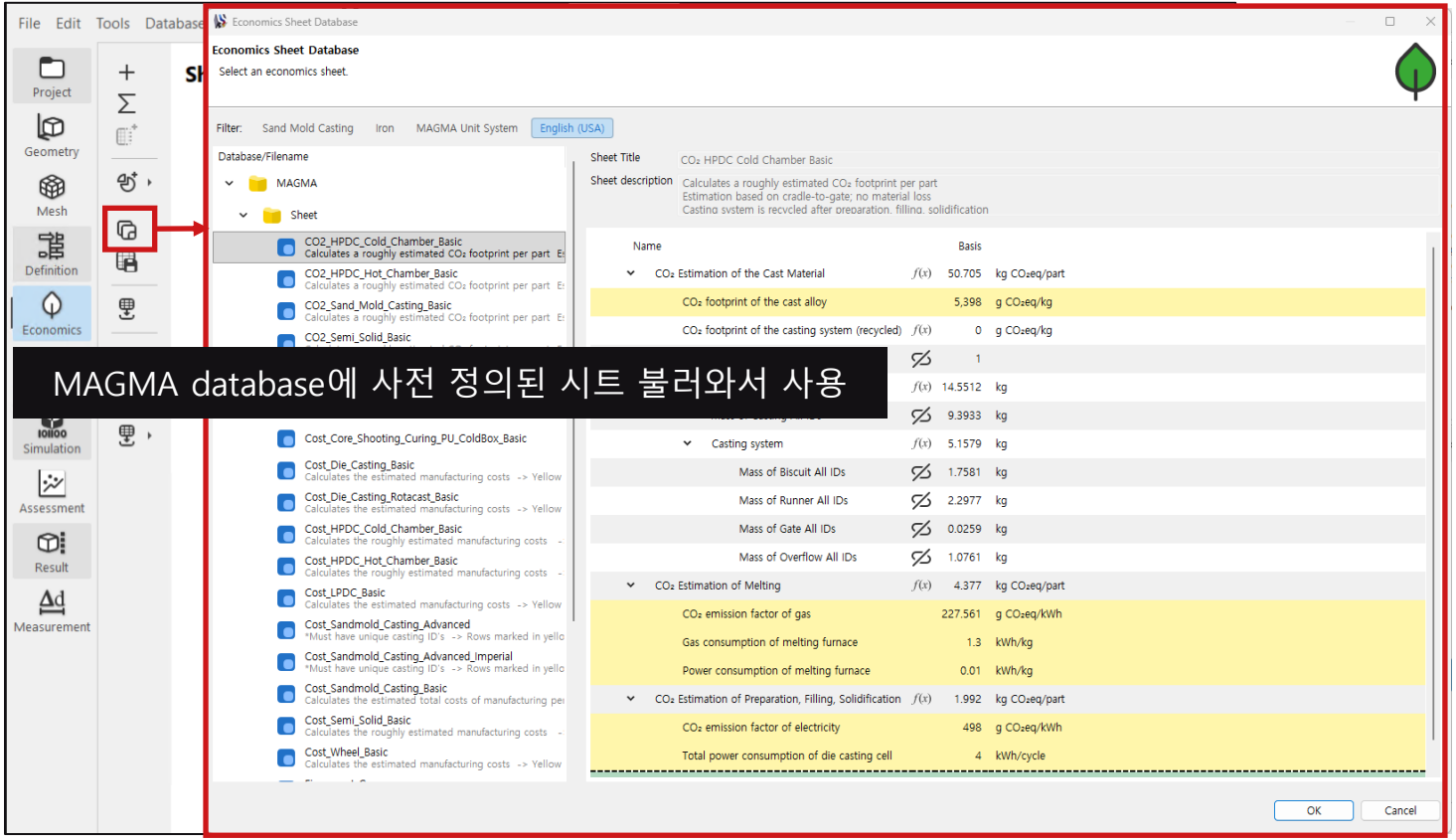
Net Zero of Tools = MAGMA ECONOMICS



최종 조건에서 CO_2 배출량 확인

MAGMA ECONOMICS

Load from Database



MAGMA database에 사전 정의된 시트 불러와서 사용

MAGMA ECONOMICS

Economics Database List

Sand Mold Casting	
CO2 발생량	CO2_Sand_Mold_Casting_Basic
비용	Cost_Sandmold_Casting_Basic
	Cost_Sandmold_Casting_Advanced
	Cost_Sandmold_Casting_Advanced_Imperial

Continuous Casting	
비용	Cost_CC_Basic

Core Shooting	
비용	Cost_Core_Shooting_Curing_Inorganic_Basic
	Cost_Core_Shooting_Curing_PU_ColdBox_Basic

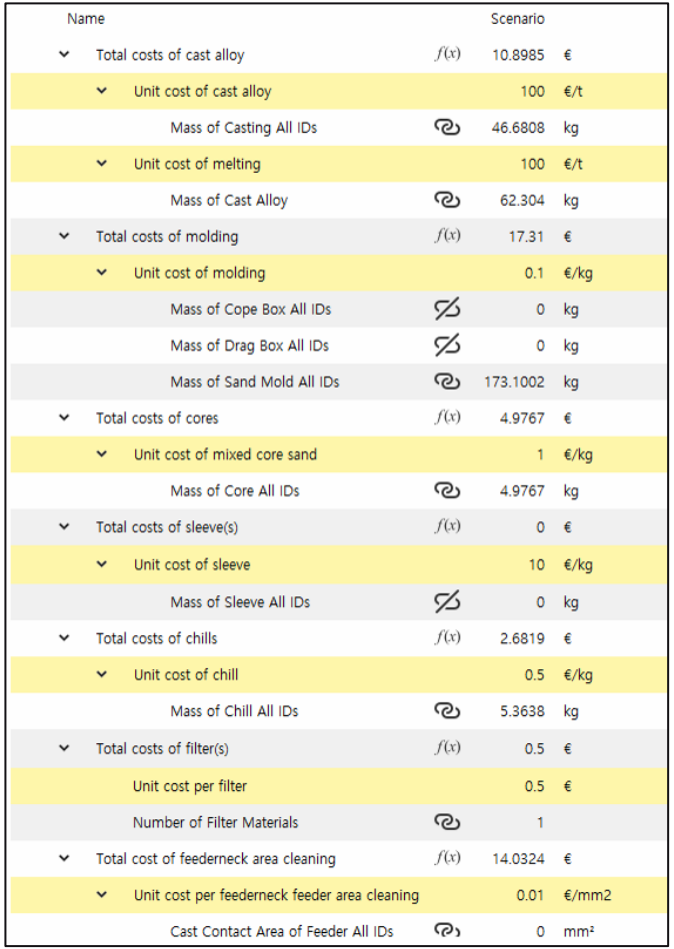
Function	
함수 시트	UTILITY_FUNCTION_IF_ELSE-IF_ELSE_Example
	UTILITY_FUNCTIOIN_IF_Example
	UTILITY_FUNCTION_SWITCH_Example

Diecasting	
CO2 발생량	CO2_HPDC_Cold_Chamber_Basic
	CO2_HPDC_Hot_Chamber_Basic
	CO2_Semi_Solid_Basic
비용	Cost_Die_Casting_Basic
	Cost_Die_Casting_Rotacast_Basic
	Cost_HPDC_Cold_Chamber_Basic
	Cost_HPDC_Hot_Chamber_Basic
	Cost_LPDC_Baisc
	Cost_Semi_Solid_Basic
	Cost_Wheel_Basic

MAGMA ECONOMICS

Example : Cost Sand mold Casting Basic

- **Sand mold casting 기본 비용 시트 구성 요소**
  - 합금 원재료
  - 주형(몰드)
  - 코어
  - 슬리브
  - 냉금
  - 필터
  - 피더 및 냉금 후공정 비용
- **추가로 고려할 수 있는 항목**
  - OEE 설비종합효율
  - 추가 생산 단계 – 후가공, 툴링 등
  - 운송 비용 – 배송비
  - 스크랩 비율 – 폐기 처리 비용



Name		Scenario	
Total costs of cast alloy	$f(x)$	10.8985	€
Unit cost of cast alloy		100	€/t
Mass of Casting All IDs		46.6808	kg
Unit cost of melting		100	€/t
Mass of Cast Alloy		62.304	kg
Total costs of molding	$f(x)$	17.31	€
Unit cost of molding		0.1	€/kg
Mass of Cope Box All IDs		0	kg
Mass of Drag Box All IDs		0	kg
Mass of Sand Mold All IDs		173.1002	kg
Total costs of cores	$f(x)$	4.9767	€
Unit cost of mixed core sand		1	€/kg
Mass of Core All IDs		4.9767	kg
Total costs of sleeve(s)	$f(x)$	0	€
Unit cost of sleeve		10	€/kg
Mass of Sleeve All IDs		0	kg
Total costs of chills	$f(x)$	2.6819	€
Unit cost of chill		0.5	€/kg
Mass of Chill All IDs		5.3638	kg
Total costs of filter(s)	$f(x)$	0.5	€
Unit cost per filter		0.5	€
Number of Filter Materials		1	
Total cost of feederneck area cleaning	$f(x)$	14.0324	€
Unit cost per feederneck feeder area cleaning		0.01	€/mm2
Cast Contact Area of Feeder All IDs		0	mm²

MAGMA ECONOMICS

Example : CO2 HPDC Cold Chamber Basic

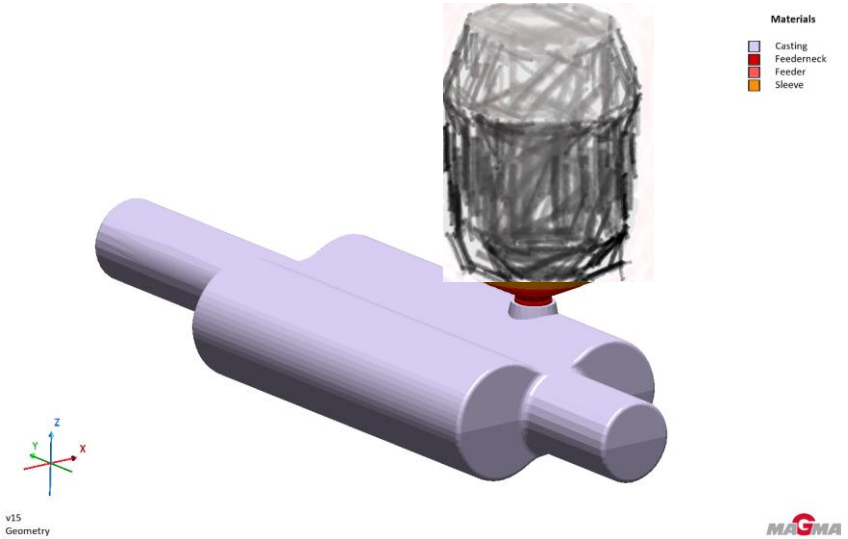
- **HPDC CO2 기본 시트 구성 요소**
  - 주조품 및 주조 방안 탄소 배출량
    - 합금 및 주조 방안 생산 과정에서 발생한 탄소
  - 용해 과정 중 발생하는 탄소 배출량
    - 가스, 전력, 용해 효율
  - 사출, 충진, 응고, 장비 가동에서 발생하는 탄소
    - 충전, 사출, 응고하는 동안 장비가 소모한 전력

Name		Basis	
CO_2 Estimation of the Cast Material	$f(x)$	251.983	kg CO_2eq/part
CO_2 footprint of the cast alloy		5,398	g CO_2eq/kg
CO_2 footprint of the casting system (recycled)	$f(x)$	0	g CO_2eq/kg
Number of Casting Materials		1	
Shot weight	$f(x)$	56.4081	kg
Mass of Casting All IDs		46.6808	kg
Casting system	$f(x)$	9.7273	kg
Mass of Biscuit All IDs		0	kg
Mass of Runner All IDs		9.4387	kg
Mass of Gate All IDs		0.2885	kg
Mass of Overflow All IDs		0	kg
CO_2 Estimation of Melting	$f(x)$	16.968	kg CO_2eq/part
CO_2 emission factor of gas		227.561	g CO_2eq/kWh
Gas consumption of melting furnace		1.3	kWh/kg
Power consumption of melting furnace		0.01	kWh/kg
CO_2 Estimation of Preparation, Filling, Solidification	$f(x)$	1.992	kg CO_2eq/part
CO_2 emission factor of electricity		498	g CO_2eq/kWh
Total power consumption of die casting cell		4	kWh/cycle
CO_2 Estimation per Part	$f(x)$	**270.943**	**kg CO_2eq/part**

MAGMA ECONOMICS 국내 사례

주입 온도 변화에 따른 주조 비용 절감 사례

Geometry 및 공정조건



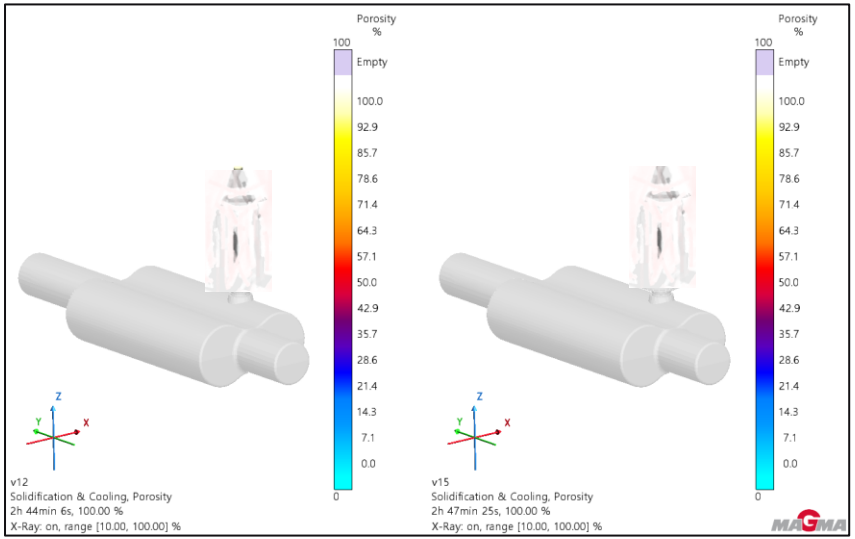
- FCD400
- 주입온도 : 1,370도
- 합금성분

구분	C	Si	Mn	P	S
기준	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MIN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MAX	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

- Sleeve : FEEDEX A type

주입 온도 변화에 따른 주조 비용 절감 사례

해석 경향성 확인



기존 조건

비용절감조건

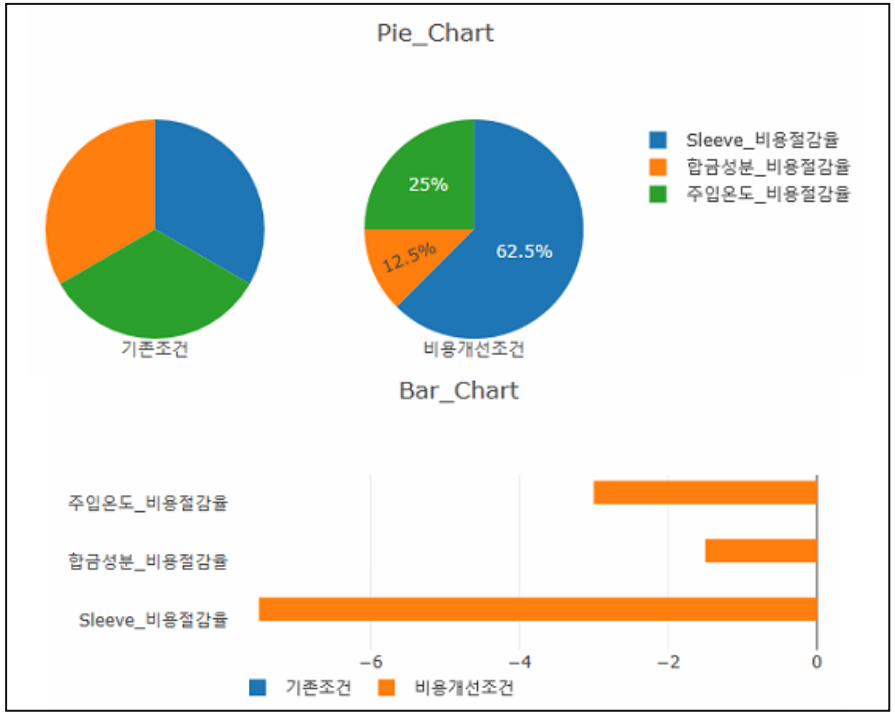
- 기존 조건에서 제품 내 수축결함 경향 X
- 개선 목표 :
  - 생산 비용을 최소화하면서 품질은 그대로 유지
- 1차 최적화 해석
  - Sleeve : FEEDEX A Type -> FEEDEX B Type
  - 주입온도 : 1,370 / 1,355도
- 2차 해석
  - 수축결함 문제 없는 경우 악 조건에서의 합금성분 Min값 적용

주입 온도 변화에 따른 주조 비용 절감 사례

MAGMA ECONOMICS

Name		기존조건		비용개선조건	
Sleeve FEEDEX		[redacted]	원	[redacted]	원
Sleeve_비용절감율		0	%	-7.5	%
합금성분		[redacted]	원	[redacted]	원
합금성분_비용절감율		0	%	-1.5	%
주입온도		1,370	도	1,355	도
비용		[redacted]	원	[redacted]	원
주입온도_비용절감율		**0**	**%**	**-3**	**%**
최종비용	$f(x)$	[redacted]	원	[redacted]	원

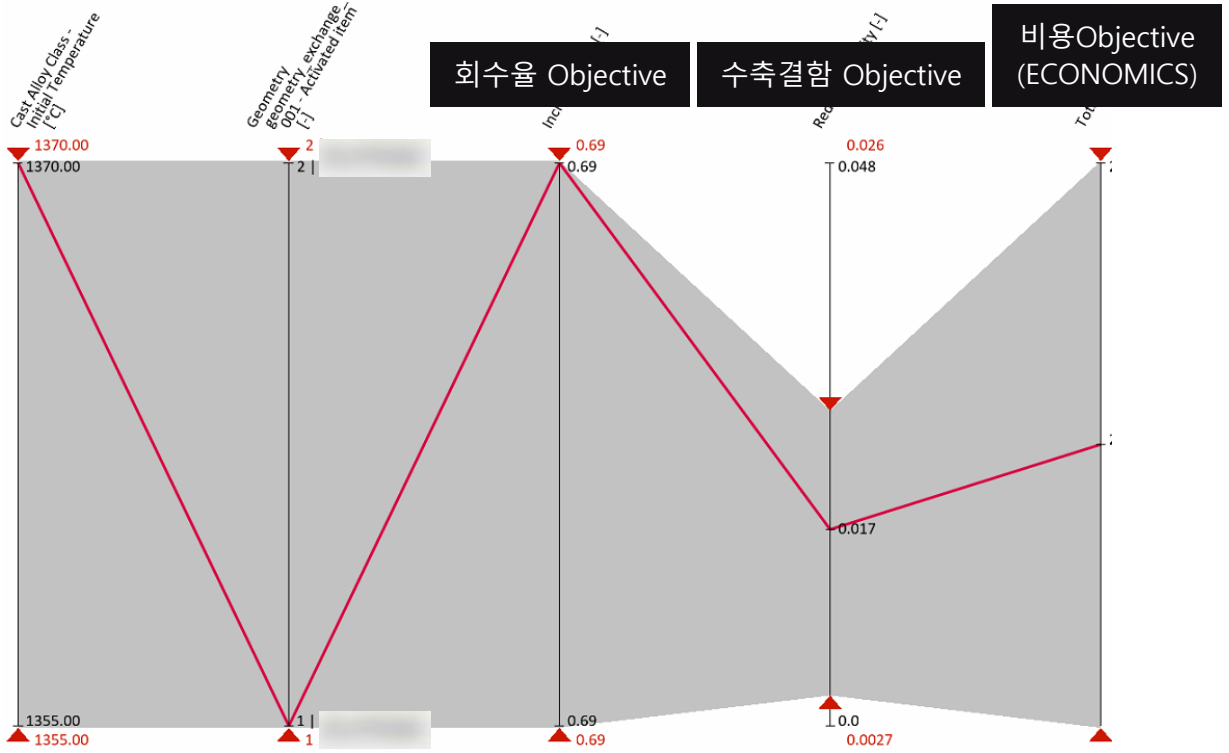
Sleeve type, 합금성분, 주입온도로 절감되는 비용



각 항목 별 비용절감 비율

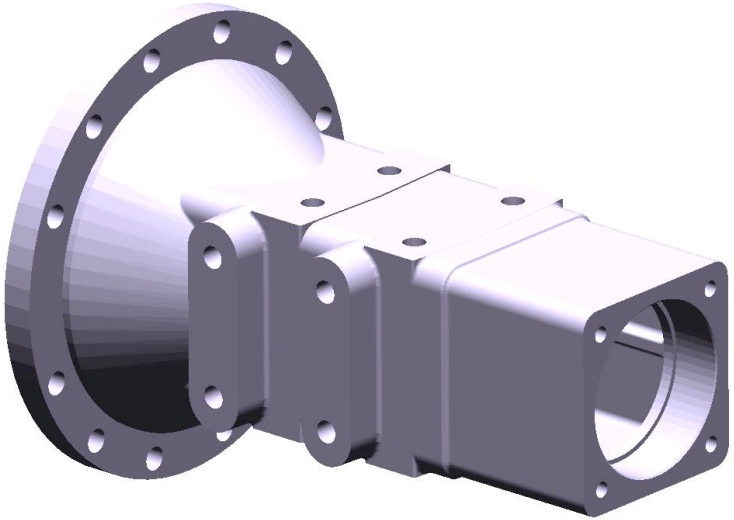
주입 온도 변화에 따른 주조 비용 절감 사례

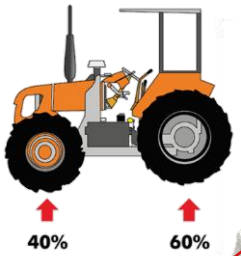
MAGMA ECONOMICS

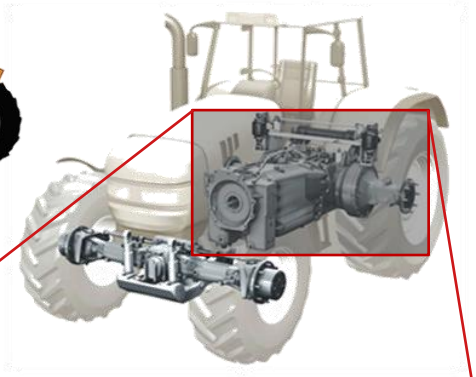


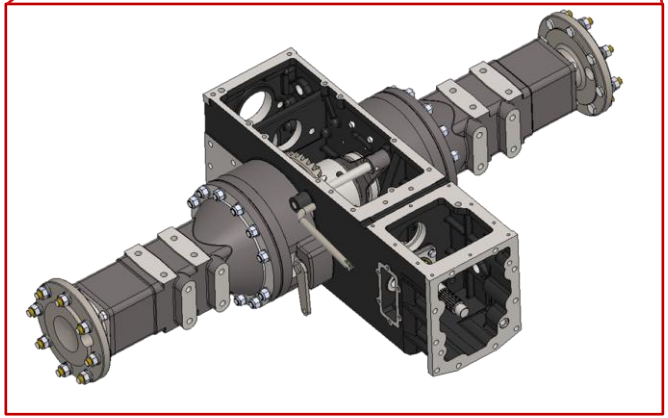
MAGMA ECONOMICS 해외 사례

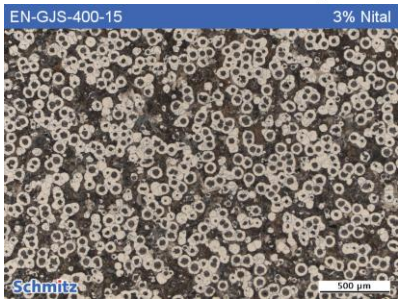
REAR AXLE HOUSING





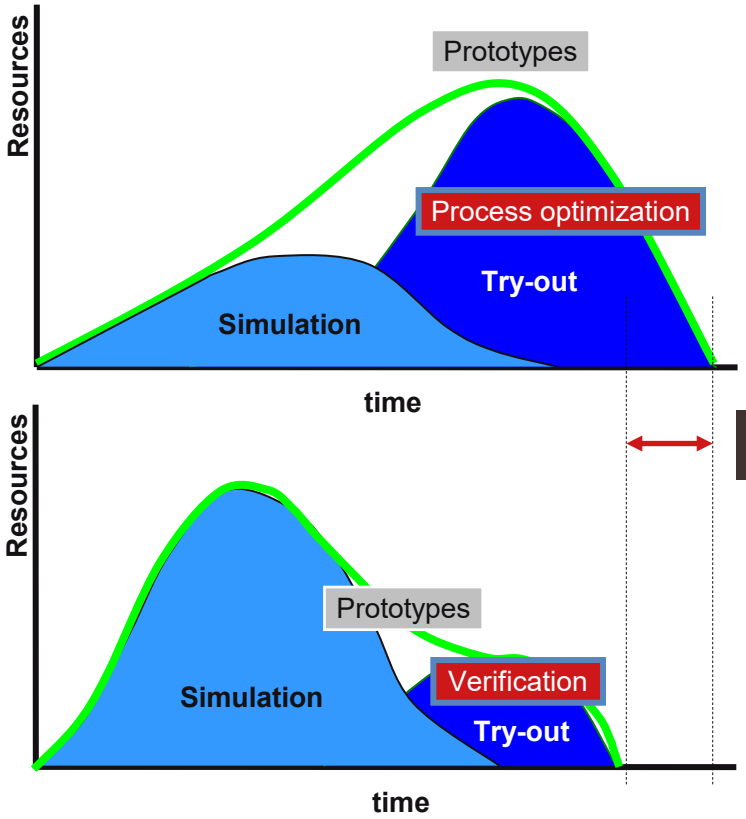






v08
Geometry

SIMULATING THE PROCESS WITH MAGMASOFT®



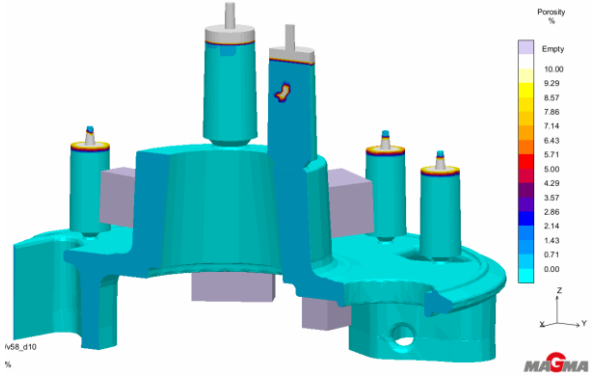
Conventional Development

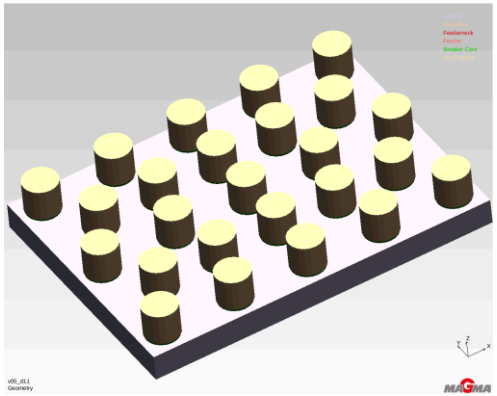
- Based on practical tests
- Sequential optimization

Reduce time and costs

Optimized Development

- Simultaneous optimization
- No prototypes





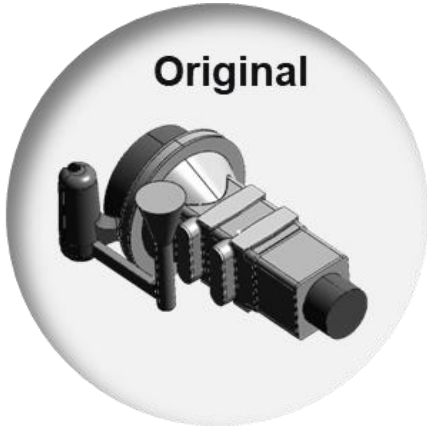
MAGMA

MAGMA ECONOMICS

Identifying costs

- Step 1:
  - To identify the costs associated with the manufacturing process

- Total casting alloy costs
- Total molding costs
- Total core making costs
- Total machining costs
- Melting costs
- Overpouring melting costs



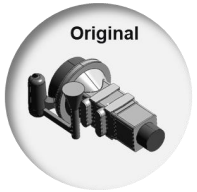
Step 2:

To define the costs on each stage

MAGMA ECONOMICS

Cost Breakdown

부품당 제조 비용
R$ 676.01 = ₩ 181,500



- Step 2:
  - Defining the costs of each stage

Total casting alloy costs		278.9624	R$
Cost per ton of alloy		4,370	R$/t
Mass of Casting All IDs		23.8036	kg
Total cost of raw materials		4,370	R$/t
Mass of cast Alloy		40.0322	kg

합금 원재료비

Total molding costs		262.9985	R$
Molding costs per unit		1	R$/kg
Mass of Cope Box All IDs		0	kg
Mass of Drag Box All IDs		0	kg
Mass of Sand Mold All IDs		262.9985	kg

주형 제작비

Total core making costs		26.7677	R$
Core costs per unit		1	R$/kg
Mass of Cores All IDs		26.7677	kg
Mass of Chill All IDs		0	kg

코어 제작비

Total machining costs		66.5038	R$
Machining costs per unit		0.06	R$/mm2
Number of Casting Materials		1	

가공비

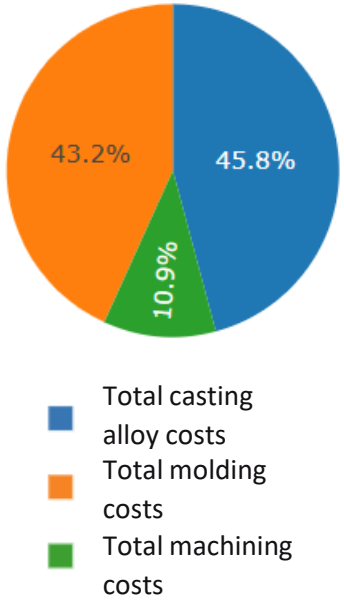
Melting costs		40.03	R$/part
Cost per furnace hour		1,000	R$/hour
Performance per hour of melting		1,000	kg/hour
Melting cost per part	$f(x)$	40.03	R$/part

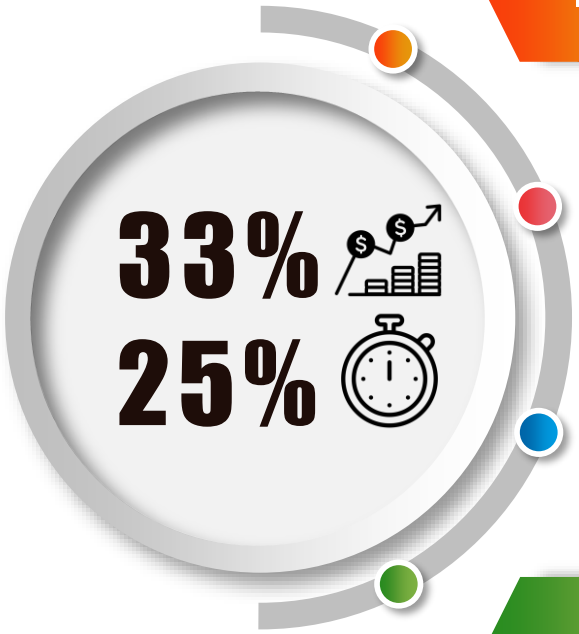
용해비

Overpouring melting costs		0.3755	R$
Loss of molten		8	%
Overpouring costs	$f(x)$	0.751	R$/kg
Cost to melt the overpour	$f(x)$	0.671	R$/kg

과투입 손실비

Overall manufacturing cost per part





- Try-out

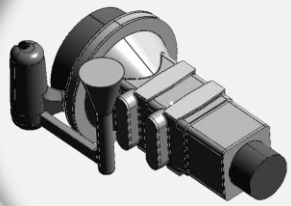
16% Metal yield

64% Sand/Metal ratio

+ Improved quality

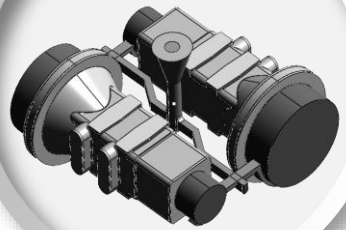
TECHNICAL/FINANCIAL RESULT

Original



1	72,1%	7,5/1	20 %
Part / mold	Metallic Yield	Sand to metal ratio	Burning the resin

Optimized

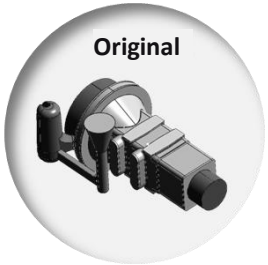


2	88,2%	3,3/1	68 %
Parts / mold	Metallic Yield	Sand to metal ratio	Resin burning

MAGMA ECONOMICS

Cost comparison

38% cheaper parts



Total casting alloy costs	$f(x)$	278.9624	R$
Total molding costs	$f(x)$	262.9985	R$
Total core making costs	$f(x)$	26.7677	R$
Total machining costs	$f(x)$	66.5038	R$
Melting costs	$f(x)$	40.03	R$/part
Overpouring melting costs	$f(x)$	0.751	R$
TOTAL PART MANUFATURING COST	$f(x)$	676.0133	R$

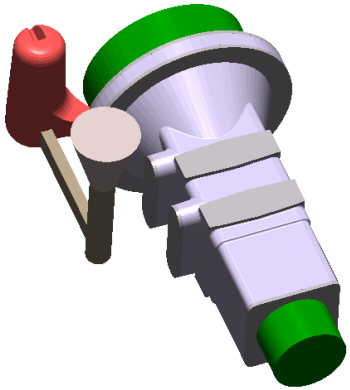
Metal yield
72%
USD 112.67 / piece

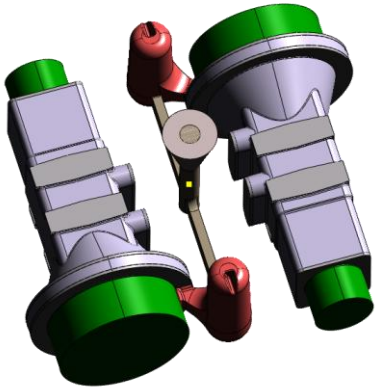
Total casting alloy costs	$f(x)$	543.2523	R$
Total molding costs	$f(x)$	240.1403	R$
Total core making costs	$f(x)$	53.7018	R$
Total machining costs	$f(x)$	130.8119	R$
Melting costs	$f(x)$	76.8	R$/part
Overpouring melting costs	$f(x)$	0.3755	R$
TOTAL PART MANUFATURING COST	$f(x)$	522.5409	R$

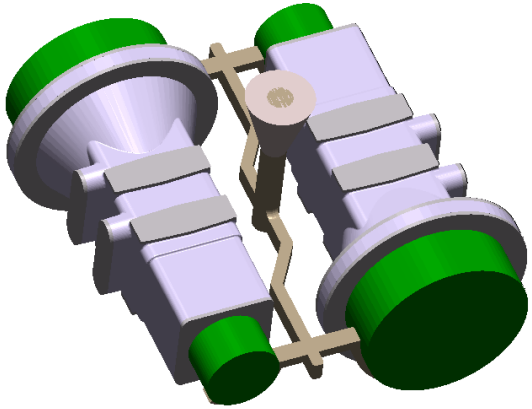
Metal yield
75%
USD 87.09 / piece

Total casting alloy costs	$f(x)$	497.346	R$
Total molding costs	$f(x)$	210.5545	R$
Total core making costs	$f(x)$	53.5008	R$
Total machining costs	$f(x)$	0	R$
Melting costs	$f(x)$	66.26	R$/part
Overpouring melting costs	$f(x)$	0.3755	R$
TOTAL PART MANUFATURING COST	$f(x)$	414.0184	R$

Metal yield
88%
USD 69.00 / piece



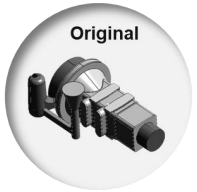




CO emissions$_2$

MAGMA ECONOMICS

Carbon footprint



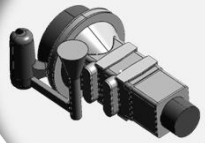
With MAGMA ECONOMICS, it is also possible to estimate CO^2 emissions per manufactured part.

Estimated CO_2 per part	$f(x)$	6.784	kg CO_2eq/part
CO2 emission factor		285	g CO_2eq/kg
Estimated CO_2 emissions per melt	$f(x)$	12.958	kg CO_2eq/part
Electric furnace energy consumption		650	kWh/t
CO_2 emission factor from the electricity		498	g CO_2eq/kWh
Estimated CO_2 emissions during filling and solidification	$f(x)$	1,296.375	kg CO_2eq/part
CO_2 emission factor of silica sand		19.9	g CO_2eq/kg
Estimated CO_2 emissions during core and mold production		1,295.842	kg CO_2eq/part
Overall estimated CO_2 emissions per part	$f(x)$	1,316.117	kg CO_2eq/part

MAGMA ECONOMICS

42% less CO_2

Original



Estimated CO_2 per part	**6.776**	kg CO_2eq/part
Estimated CO_2 emissions per melt	**10.724**	kg CO_2eq/part
Estimated CO_2 emissions during filling and solidification	**1,072.968**	kg CO_2eq/part
Overall estimated CO_2 emissions per part	**1,090.468**	kg CO_2eq/part

CO_2 eq 1090 kg / part

Estimated CO_2 per part	6.784	kg CO...
Estimated CO_2 emissions per melt	12.958	kg CO...
Estimated CO_2 emissions during filling and solidification	1,296.375	kg CO...
Overall estimated CO_2 emissions per part	1,316.117	kg CO...

CO_2 eq 658 kg / part

Optimized

Estimated CO_2 per part	6.771	kg CO_2eq/part
Estimated CO_2 emissions per melt	12.43	kg CO_2eq/part
Estimated CO_2 emissions during filling and solidification	1,243.539	kg CO_2eq/part
Overall estimated CO_2 emissions per part	1,262.74	kg CO_2eq/part

CO_2 eq 631 kg / part

Thank you for your attention.

Joo-Hyung Lee

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